N-Rich Reference Zone Case Study: Yolo County (irrigated) 2020-21

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Nitrogen (N) rich reference zones were implemented in a 75-acre wheat field in Yolo County where grain yields and grain protein are typically 6500 lb/ac and 11.5%, respectively. This field is located on deep, fertile soils, and had been a walnut orchard until recently. Winter rainfall averages 18 in. at the location, and the grower only irrigates winter cereal crops if needed. The previous crop was sunflowers, grown during the summer of 2020 with irrigation.

N-rich reference zone creation:
Typical N management for this grower is to apply approximately 100 lb/ac N preplant and occasionally topdress an additional 50 lb/ac if/when needed. The grower was prepared to apply 50 to 100 lb/ac N as ammonium sulfate prior to planting. A pre-plant soil sample was taken from the top 1 0-12 in. of soil on 10/23/20. The soil nitrate quick test indicated that there was approximately 79 lb/ac nitrate-N fertilizer equivalent in the top foot of soil. As a result, the grower applied no N fertilizer pre-plant. The field was planted on 11/13/20. On 11/16/20 three 90ft x 180ft N-rich reference zones were created. In each zone, 60 lb/ac N in the form of urea was broadcast with a belly grinder prior to a rain event on 11/17/20.

Early season conditions:
There was only one rainfall event in November (11/17-11/18/20), which resulted in approximately 0.6 in. of rain. The next rain event was not until mid-December. As a result of the dry conditions, a portion of the planted seeds (those planted at shallower depths) germinated but did not successfully establish. The remainder of the seeds (those planted deeper) germinated after the mid-December rain event and successfully established. The resulting stand was patchy in patterns that followed the action of the planter and the field-scale soil moisture trends. Approximately 80-85% of the planted seeds established successfully. Between planting and mid-January, the field had received 2.2 in. of rainfall (27% of average to that date). A rainfall event of more than 2 in. at the end of January brought the seasonal rainfall totals to approximately half of normal. In addition to the early-season water limitations, there was notable weed pressure from chickweed and volunteer sunflowers. An herbicide application on 2/11/21 achieved acceptable control of these broadleaf weeds.

Figure 1. Weak stand due to early season moisture limitations. Effects were not equal across the field and followed broader, field-level trends in soil moisture availability. On average, the early-season stand was approximately 80-85% of normal.

SITE INFORMATION

Location: Yolo County
Soil type: Brentwood silty clay loam
Previous crop: sunflower
Variety: AP Octane (wheat)
Seeding method: Grain drill
Seeding rate: 1.2 million s/ac
Planting date: 11/13/20

Pre-plant N Management

Field rate: 0 lb/ac
N-rich zone: 60 lb/ac
N Form: urea in N-rich zone

Plant and Soil Measurements:
In-season soil and canopy measurements were taken during the early vegetative growth stages. Soil nitrate-N measured from the top foot of soil on 1/16/21 was unchanged from the pre-plant soil sample. Over 2 in. of rain fell between 1/27 and 1/28/2021. A subsequent measurement of soil nitrate-N after this rainfall event on 2/9/2021 indicated that concentrations were approximately half of the earlier samples (42 lb/ac N fertilizer equivalent N). In addition, canopy NDRE and NDVI measurements were recorded via drone and satellite on 2/9/2021, when the crop was just beginning to tiller and again on 2/26/2021, when the crop was mid-tillering. These measurements were expressed as a Sufficiency Index (SI). A SI is the ratio of the measurements taken from the broader field to the measurements taken in the N-rich zone. SI values less than 0.97 indicate possible crop N deficiency, and values less than 0.93 indicate likely crop N deficiency. The SI values were less than 0.93 in two of the three N-rich reference zones and the field average was 0.92 on 2/9/2021 (Figure 2). These values indicated that the crop was likely deficient in N.

OUTCOMES:

- In-season N fertilizer application recommended?
  - Yes: 60 lb/ac
- In-season N fertilizer applied by grower?
  - Yes: 50 lb/ac
- Yield results
  - Field yield = 5500 lb/ac
  - Yield increased 1100 lb/ac over the control plots as a result of the in-season N fertilizer application.
- Estimated crop N removal
  - 120 lb/ac
- Total N fertilizer applied
  - Pre-season: 0 lb/ac
  - In-season: 50 lb/ac

Fertilizer recommendations and in-season management actions:
Crop response to in-season N application was likely if followed by sufficient rainfall or irrigation to meet crop water demand. Given the dry conditions and the fact that more than 85% of the seasonal N uptake had yet to occur, the grower decided to irrigate the field and fertilize with N ahead of the irrigation. To account for the patchy stand, the early-season weed competition, and the uncertainty about rainfall, the target yield was reduced by 1000 lb/ac. With an expected yield of a 5500 lb/ac at 11.5% protein, approximately 120 lb/ac N uptake remained in the season. Given the soil nitrate-N levels and the degree of plant deficiency measured from the crop canopy, a N application of 60 lb/ac was recommended. The grower applied 50 lb/ac N as ammonium sulfate prior to irrigating at the end of February. The Nitrogen Fertilizer Management Tool for California Wheat predicted that 50 lb/ac N applied at this stage would increase yield 650 lb/ac ± 350 and protein 1% ± 0.2%. This prediction assumes that the crop is not water-limited and that sufficient rainfall or irrigation would follow the application to both incorporate the N fertilizer into the soil and meet crop water demand during the rest of the season. In addition to the irrigation in February, the grower irrigated in early-April. Total rainfall for the season was 7 in. and the two irrigation events totaled approximately 14 in. However, the distribution uniformity of the irrigation was poor, and some parts of the field were drought stressed for most of the season.

End of season results:
The in-season application of 50 lb/ac N fertilizer increased yields 1100 lb/ac ± 250 compared to control zones where this application was excluded. Protein concentrations were not different between the field and the control. As such, the total change in N uptake predicted at the time of application was accurate, but the distribution was more heavily skewed toward increases in yield versus increases in both yield and protein. The protein measurements were generally low and highly variable. This is partly a result of the heterogeneous moisture in this field, which makes it difficult to draw certain conclusions about the effects of the fertilizer application on protein. In all, the grower applied 50 lb/ac N out of a typical budget that ranges between 100 and 150 lb/ac N.

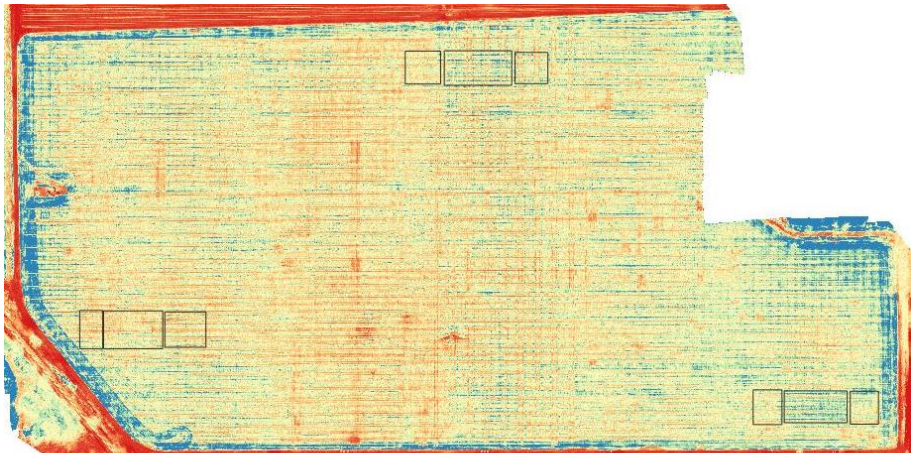

Figure 2. NDRE recorded on 2/9/20 via drone mounted multi-spectral camera indicating increased crop vigor in N-rich zones (large boxes) relative to nearby field rate (small boxes) in two of three N-rich reference zones (topmost, rightmost).

The information provided by the N-rich reference zone and associated measurements and decision support tool resulted in fertilizer savings and the increases to crop productivity equivalent to approximately $133/ac.