

Final Report for: Optimizing Nitrogen Use in Michigan Wheat: The Economic Impact of Variable Spring Applications

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Project goals and value for Michigan Wheat Growers

This project focused the continued effort by the Basso Lab in using a novel suite of digital agriculture technologies to simulate wheat production and assess the environmental and economic impact on wheat fields in Michigan.

Results of Project

Michigan wheat growers recognize the importance of applying adequate N, both in the fall during planting and spring when temperatures start to increase. Variable rate (VR) applications have potential to greatly reduce N losses to the environment while improving economic return on investment by placing it within parts of the field that will have a high probability of producing greater yields.

One Paragraph Summary of the Project

Split applications of nitrogen (N) in the spring are highly recommended to ensure wheat receives adequate N during critical stages of the growing season. By analyzing historical data from participating growers and integrating these data with simulations of a process-based crop model, we determined optimal N rates that were applied with VR applications in late-spring. Results showed that VR applications reduce total N in areas where crop yield response is consistently low. In contrast, some high-yielding zones received greater N rates than would have been applied under traditional uniform application.

Recommendations from the Project

Uniform N rates should be considered for planting and early-spring applications, as favorable spring conditions can create strong yield potential later in the season. Modern equipment with precision monitors and rate controllers that support VR applications should consider reducing N rates in and around headlands, field edges, waterways, and erosion buffers. Reduced N showed a savings between 10-20 lb N per acre from VR applications leading to savings between \$7 and \$14 per acre assuming a N cost of \$0.70 per lb.

Future Work

Nitrogen fertilizer is essential to successful wheat growth and accounting for spatial variations through VR applications allows economic outcomes to be quantified and evaluated at a fine spatial scale. Historical productivity data can help to interpret soil test results that support VR applications of phosphorus (P) and potassium (K).

Results of the Project

In 2025, VR prescriptions for N applications were created for over 1,852 acres of wheat across 5 different farms in Michigan. Cooperators shared historical yield monitor data that were used to create yield stability maps, which delineate productivity zones within the field in low and stable, medium and stable, high and stable, and unstable categories (Figure 1).

Example Field

Total area: 152.03 ac
16 years of yield data

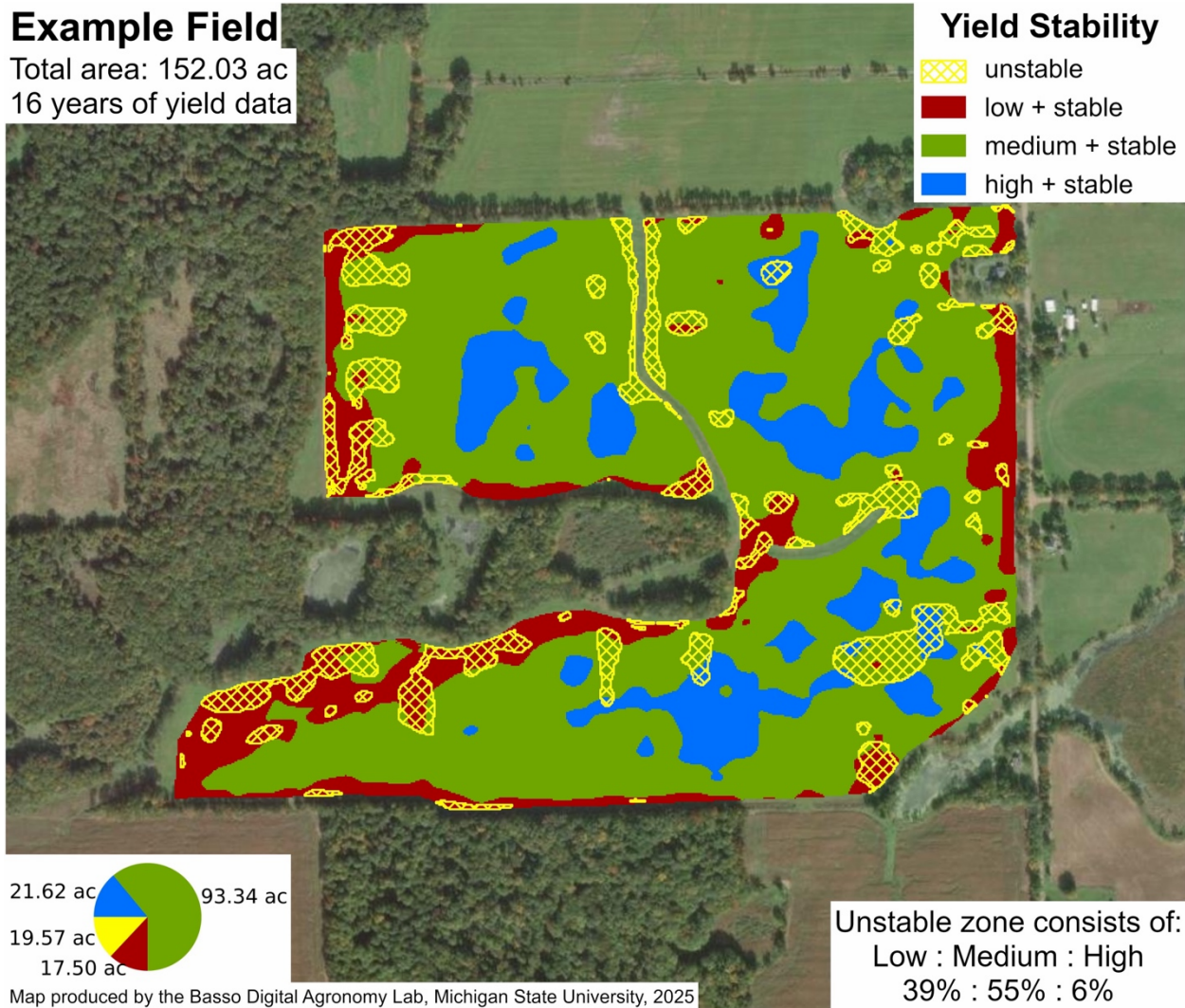


Figure 1. Yield history of example field leads to yield stability map.

In the example field, the farmer applied 75 lb N per acre uniformly with his drill across the field (Figure 2, left) during planting in the fall. In the spring around early April, another 20 lb N per acre was uniformly applied (Figure 2, center). The third N application in May was varied according to the spatial response of N as simulated by the process-based crop model, SALUS. The map (Figure 2, right) illustrates the VR application pattern, with lighter colors indicating areas where less N was applied in the low yielding zones and darker colors indicating higher N rates in the high yielding zones. Table 1 summarizes the N rates for each application, along with the total N applied according to the prescription used for the final application.

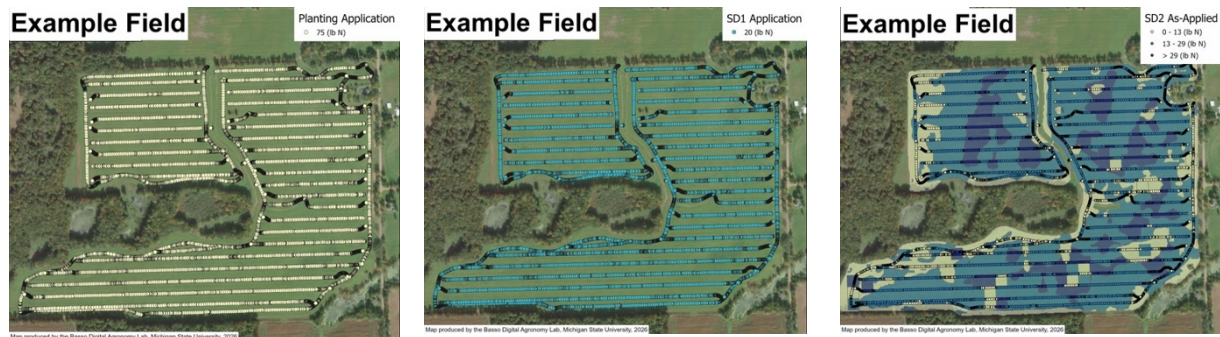


Figure 2. Planting and fertilizer application (left), first top-dress application in early spring (center), and final variable rate application in late-spring (right).

Zone	N at Planting	N at 1 st Spring Application	N at 2 nd Spring Application	Total N (lb N per acre)
Low yielding	75	20	0	95
Medium yielding	75	20	20	115
High yielding	75	20	40	135

Table 1. N rate table for example field in units of lb N per acre.

In Figure 3, the crop simulation modeling indicated that high and stable yielding zones responded significantly to an additional 40 units of N per acre. Medium and stable yielding zones showed a smaller response, requiring only 20 units of N per acre. In contrast, low and stable yielding zones showed no measurable yield response to additional N and therefore received no extra N in the final application.

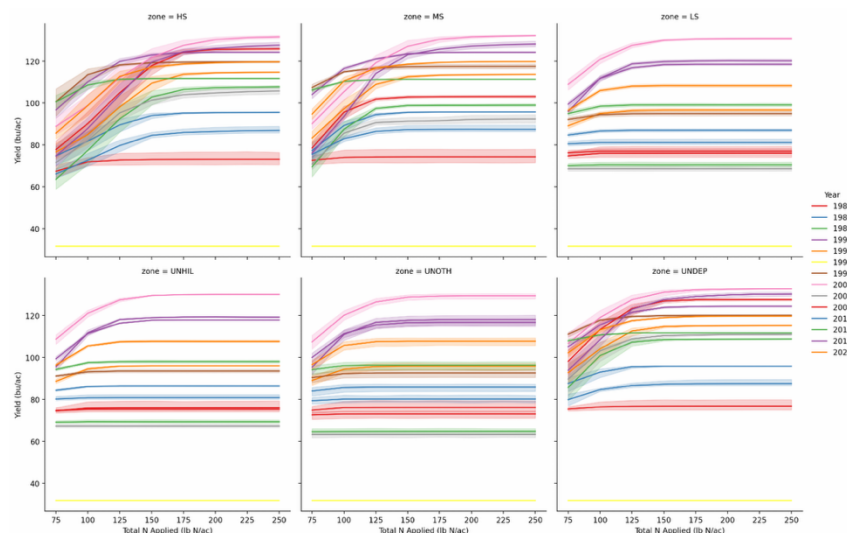


Figure 3. Yield response curves from crop simulation modeling to obtain optimal nitrogen rates across the yield stability zones.

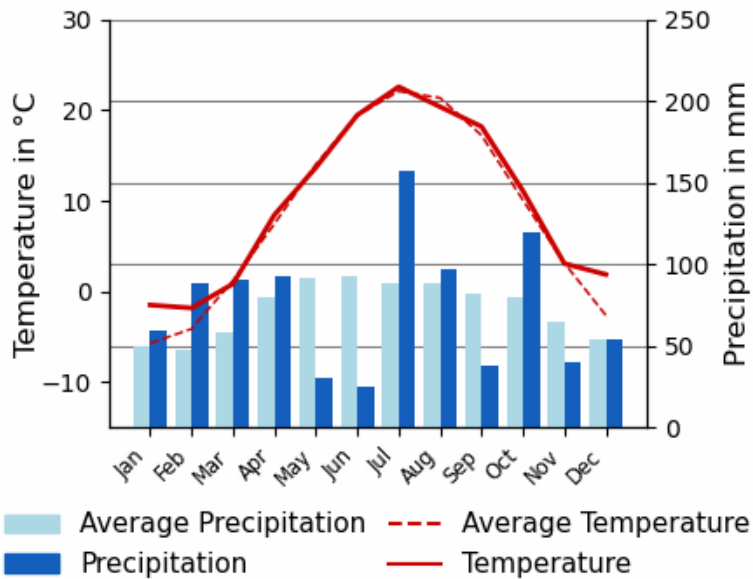


Figure 4. Current season precipitation and temperature and 30-year average precipitation and temperature for the example field.

A visual representation of seasonal weather trends is shown in Figure 4. The light blue columns represent the 30-year average precipitation, while the darker blue columns show the actual precipitation recorded at the field for the year of interest. In this field, early summer precipitation accumulation in June and July was about a 1/3rd of average. This lack of moisture during grain fill and maturity prevented the wheat from reaching full yield potential.

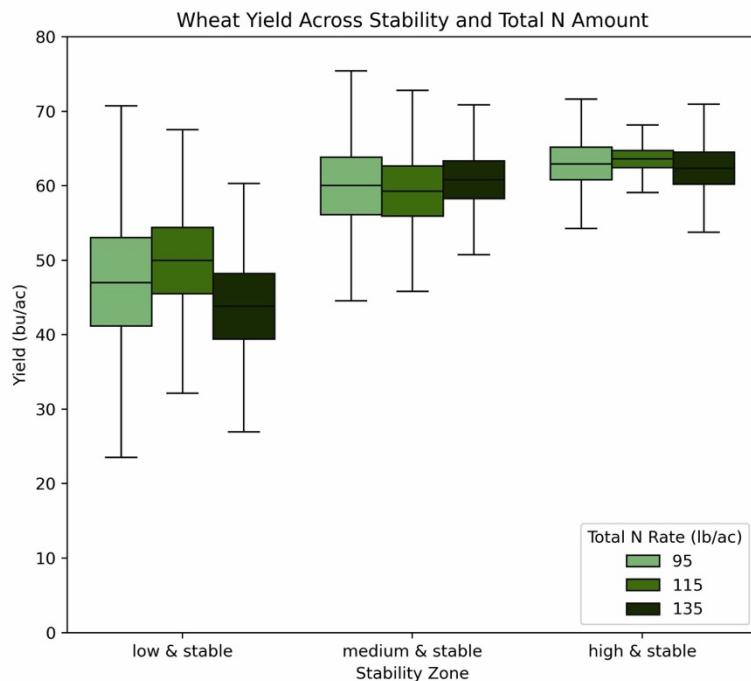


Figure 5. Wheat yield at each yield stability zone under varying total nitrogen rates.

Yield data obtained from the combine grain yield monitor after harvest show that stability zone was the primary factor influencing the wheat's response to total N applied (Figure 5). In this figure, we analyzed test boxes where we applied multiple N rates per stability zone in small boxes to test the validity of the VR map. In the low and stable zones, all N rates produced similar yields of approximately 45-50 bushels per acre. Medium and stable zones achieved around 60 bushels per acre across all rates, while high and stable zones reach about 63 bushels per acre regardless of N rate.

Conclusions

Even in this example field, the expectation that average precipitation in June and July following the final N application would support higher yields. However, rainfall during this period was lower than expected, which reduced final yield potential. These results show that yield stability zone was a stronger predictor of final yield than total N applied, suggesting that future N management decisions should rely more heavily on yield stability methods rather than simply increasing N rates.