Fine tuning N fertilization to target wheat yield components: toward a spatially and temporally explicit approach

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Nitrogen is a central element in European crop productions. Price volatility and environmental concerns are some of the reasons to seek to maximize Nitrogen Use Efficiency (NUE).
Great efforts have been made to understand nutrient dynamics and mechanisms of winter wheat yield elaboration. These researches have allowed to target specific phenological stages to ensure optimal N allocation and maximization of yield. However, homogeneous conditions met in experiments are seldom observed on the field. Precision agriculture aims to help farmers diagnose and manage spatial heterogeneity at the field scale. An interesting method was developed by Blackmore (2000) to analyze spatial and temporal trends of yields and delineate management zones. Yield is considered as the integrative response of crop to soil and climate interactions and their combined limiting effects. Management zones are characterized by the level and stability of yield observed over years. Thus, three zones are generated: (i) the unstable, (ii) the low and stable and (iii) the high and stable. Basso et al. (2011) suggested to manage N within each zone combining strategic and tactical approaches to optimize N supply. Strategic approach aims to define N supply response to pedoclimatic tendencies whereas tactical approach considers real-time conditions to adjust N applications. Strategy and tactics complete each other temporally by the factors considered in decision. Including the impact of N supply on yield components within these approaches could lead to manage precisely N fertilization spatially and temporally.
Trials analyzing the influence of N management on wheat yield, yield components and N losses were conducted between 2010 and 2019 on a loamy soil in Wallonia (Be). N was supplied in three applications: at tillering stage, stem extension and flag leaf. Total N supply ranged from 0 to 360 $kgN.ha^{-1}$. Final yield, thousand-kernel-weight and ear density have been measured as well as residual N in the soil. From measured yield components, grain density and number of kernels per ears were calculated.
Strong correlations were observed between yield, ear density and grain density. These findings highlight the importance, in this agronomical context, to supply crop at tillering stage and at the beginning of stem elongation to ensure ear emergence and spike growth. N supplied at the end of stem elongation is less correlated to yield but is still necessary to maintain wheat flower fertility and grain number. First N application is the highest, from 60 to 100 $kgN.ha^{-1}$. Second application could be weaker, but sum of the two first applications should reach 120 $kgN.ha^{-1}$. The total supply ranges between 160 and 180 $kgN.ha^{-1}$. 180 $kgN.ha^{-1}$ is a common N supply in the region whereas environmental part of the analysis reveals that total N supply should not exceed 140 $kgN.ha^{-1}$.
These experimental results will now be used in the frame of a crop model. Once calibrated on their yield components part, simulations will be conducted to analyze the impact of N fertilization schemes on wheat yield elaboration and N losses in each management zone. This multicriteria analysis, combined with strategic and tactical approaches will lead to define decision rules to adapt N fertilization practices spatially and temporally and improve NUE.

Basso, B., Ritchie, J. T., Cammarano, D. & Sartori, L. A strategic and tactical management approach to select optimal N fertilizer rates for wheat in a spatially variable field. European Journal of Agronomy 35, 215–222 (2011).
Blackmore, S. The interpretation of trends from multiple yield maps. Computers and Electronics in Agriculture 26, 37–51 (2000).