Optimization of nitrogen use from precision fertilization on barley

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Precision fertilization is a promising mitigation strategy to increase nitrogen use efficiency (NUE) of agricultural crops while reducing environmental impacts linked to nitrogen (N) overuse on soil (acidification), water (leaching) and atmosphere (greenhouse gasses emissions - GHG). It is reported that from 20 to 70% of applied N-fertilizers are lost into the environment. Recent literature states that there is no specific dose of N that causes N_2O emissions; rather it is the application methods, fertilizer amounts, and the environmental conditions that have a greater influence on such fluxes. For these reasons, and to meet the demands of the European Green Deal to reduce the use of N by at least 20% by 2030, the rationalization of N fertilization represents a crucial challenge for agriculture. In this study, we tested different precision fertilization approaches on barley (*Hordeum vulgare* L.) to evaluate the yields responses and the N use of crops. The assessment of environmental impacts of different fertilization methods was conducted through the monitoring of soil GHG emissions during the three weeks after fertilization to evaluate the short-term response of the system. Tested treatments were: (i) no fertilization (Control - 0 kgN ha^{-1}), conventional fertilization (CF – 150 kgN ha^{-1}), variable N application rate based on optical sensor measurements (GreenSeeker Handheld – Trimble Inc.) with ammonium nitrate (VN) and variable N application rate based on optical sensor measurements using a foliar liquid N fertilizer (VFN - Cifo®). A N-rich strip, with an abundant N supply (200 kgN ha^{-1}), was used as a reference for calibrating the GreenSeeker. The technology used by GreenSeeker is the Normalized Difference Vegetation Index (NDVI), which provides information on the plant's N content and the amount of fertilizer required. This ensures that the nutritional needs of the crop are met while avoiding over-application. Based on GreenSeeker measurements, the estimated N rate for both VN and VFN was 35 kgN ha^{-1}, corresponding approximately to 1/5 of CF. By matching the reference NDVI (NDVIref) with the NDVI measured from the variable-rate samples, the normalized rate value was obtained. This normalized rate value was then multiplied by the crop factor for barley to determine the N rate required by the crops. Precision fertilization (both VN and VFN) resulted in higher grain yields compared to CF, despite the absence of significant differences observed (between 5.45 and 6.86 t ha^{-1}). Similar observations were made regarding the biomass production of barley (straw). Nevertheless, both variable-rate fertilization methods, led to a higher accumulation of N within the grain compared to CF (140 and 109 kgN ha^{-1}, respectively), confirming the environmental losses associated with this approach. The ability to supply N at the time of the crop's maximum demand minimizes environmental losses and increases NUE. The monitoring of GHG emissions provided unclear results showing similar emissions between fertilization treatments despite the differences in N rate. This could be due to the short period of monitoring suggesting that longer monitoring periods and the study other environmental factors are necessary to explain the GHG fluxes dynamics.

Keywords

NDVI; proximal sensing; cereals; environmental impact; sustainability

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