Enhancing Nitrogen Use Efficiency in Potato Production: Environmental and Economic Impacts of Implementing Seed Sensing Technology to Reduce "Skips" and Greenhouse Gas Emissions

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It is imperative that we improve the efficiency of N use in agriculture to achieve economic, agronomic, and environmental goals. Improved N use efficiency can be achieved by the implementation of 4R Nutrient Stewardship and similar programs that adjust the rate, time, source, placement of N fertilizer and implement sustainable rotations to increase the efficiency of N use and build soil health.

One important element in improving nitrogen use efficiency is ensuring the crop is present and able to take up the nitrogen being supplied. This involves the selection of appropriate varieties, planting density, disease and drought management. A uniform and consistent plant stand is essential in this regard. Missing plants, or what is commonly referred to as “skips”, results in no plant being present to take up the fertilizer and other inputs being supplied to the crop. This reduces the area yield but perhaps more importantly exposes the unused N to a dramatically increased potential for losses such as greenhouse gas emissions and nitrate leaching to groundwater. It is useful to attempt to quantify and manage the magnitude of loss that “skips” represent in a potato production system. The Bluefield seeding sensing technology (SST) provides the opportunity to monitor and reduce “skips” in potato production systems. What is the environmental impact of using this technology?

In 2022 Genesis Crop Systems conducted an evaluation of the SST technology in Prince Edward Island and observed the SST system increased marketable yield by 2.8%, total yield by 2.5% and crop value by 4-6% for the same rate on N fertilizer applied (180 lbs N/ac).

The rate of fertilizer nitrogen application to both treatments was the same (180 lbs N/ac), so in the greenhouse gas accounting framework currently used by the Government of Canada, the emissions would be the same as they are simply based on the amount of fertilizer N applied. One metric that is often cited for greenhouse gas emissions is the impact on the emissions intensity. That is the amount of greenhouse gas emitted per unit of product produced (e.g., g CO_2e/tonne of potato).

The major impact of “skips” on N_2O emissions is not merely the reduction of the average yield for the field, but more importantly the percentage of the field has been fertilized, but there is no plant taking up that fertilizer N. In these portions of the field the potential for N loss is doubled (Lebender et al., 2014). As the rate of fertilizer N applied exceeds plant nitrogen uptake the emission coefficient of N_2O loss increases exponentially. This observation is supported by several observations taken from the literature:

1. Nitrous oxide emissions increase nonlinearly with nitrogen fertilizer application rates, especially when rates exceed crop requirements (Maaz et al., 2020; Wallman et al., 2022).
2. There is often a threshold effect, where N_2O emissions rise sharply once nitrogen inputs surpass plant uptake capacity (Maaz et al., 2020; Pan et al., 2022).

3. Meta-analyses have found exponential relationships between nitrogen fertilizer rates and N_2O emissions across many agricultural systems (Maaz et al., 2020; Wang et al., 2021).
4. The nonlinear response is attributed to excess soil nitrogen being more prone to losses through nitrification and denitrification processes that produce N_2O (Wallman et al., 2022; Pan et al., 2022).
5. Emission factors (percent of applied N lost as N_2O) tend to increase at higher N rates, indicating a disproportionate rise in emissions (Maaz et al., 2020; Glenn et al. 2021).

This exponential trend highlights the importance of matching nitrogen inputs to crop needs and ensuring uniform crop establishment to minimize excess N and associated N_2O emissions.

The trial conducted by Genesis Crop Inc. found that the use of SST reduced skips on 4.75% of the acres planted and thus the potential for loss would be doubled (Lebender et al., 2014) on 4.75% of the field.

That amount of N would result in 180 lbs N/ac = 202 kg N/ha * 0.0063 kg N_2O-N/kg N * 44 kg N_2O/28 kg N_2O-N * 265 (kg CO_2e/kg N_2O) *.0475 = 25.17 kg CO_2e/ha of avoided GHG emissions (6,112 kg CO_2e/y on a 600 acre farm).

At $50/tonne of CO_2e that equates to 25.17 * $50/tonne CO_2e * 1 tonne CO2e/1000 kg CO2e = $1.26 CO_2e/ha ($3.11/a). On a 600 acre farm this represents $1,866 worth avoided CO_2e emissions. The value of carbon is projected to increase to $170/tonne of CO_2e which would result in the value increasing to 4.28/ha ($10.58/ac) in avoided emissions. On a 600 acre farm this represents $6,346 worth avoided CO_2e emissions.

There would also be a reduced potential for nitrate leaching (~ 9.58 kg N/ha * 0.06 = 0.57 kg N/ha), but it is difficult to assign a dollar value to these avoided emissions.

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