Abstract ESA

Title

Dutch case study shows that large variability in farmers' input use and efficiency provides scope to maintain potato productivity levels while using less inputs.

Keywords

Yield gap; resource use efficiency;

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Abstract

High intensive agricultural systems use large amounts of nutrients and pesticides, often accompanied with high yields. In the Netherlands, ware potato production is an example of such a system, with an actual ware potato yield at ca. 70% of the potential yield. However, the input use also comes at a cost of larger nutrient and pesticide residue losses to the environment. An often used argument to keep using large amount of inputs, is the uncertainty that ware potato productivity may decline when inputs are reduced. However, reducing input use and thereby increasing efficiency is essential to move towards a more circular and sustainable agriculture. In this study, based on farm data, we quantified nutrient use efficiencies and surpluses, calculated the environmental impact of pesticide use and analysed potential trade-offs between yield and input use for Dutch potato fields.

In 2020 and 2021, we collected data from 96 different ware potato fields throughout the Netherlands equally divided over sandy soils (cv. Fontane) and clay soils (cv. Innovator). Each field was visited biweekly for taking measurements. Nitrogen use efficiency (NUE_{tot}) was calculated as nitrogen output divided by total nitrogen input from spring and fall applications. Effective nitrogen use efficiency (NUE_{eff}) was calculated similarly to NUE_{tot} but considering nitrogen fertilizer replacement values used by the Dutch government. Nitrogen (N), phosphorus (P) and potassium (K) surpluses were calculated as the difference between nutrient input and nutrient output. The Environmental yardstick for Pesticides was used as a tool to calculate the environmental impact of pesticide use (EIP) in each field. Drought stress was used as a covariate in the regression models and estimated using the model SWAP-WOFOST.

Average gross Fontane yield was 64 t/ha in 2020 and 69 t/ha in 2021. Average gross Innovator yield was 66 t/ha in 2020 and 56 t/ha in 2021. Across the two years, Fontane yields ranged from 41 to 89 t/ha. Innovator yields ranged from 36 to 80 t/ha indicating large variability among ware potato fields. Median NUE_{eff} was 0.83 kg N/kg N on sandy soils, which was significantly higher than 0.54 kg N/kg N on clay soils. Considering the EUNEP framework - EU Nitrogen Expert Panel - and effective nitrogen application, 65% of the ware potato fields were within the desired NUE range and 52% of the fields were below the N surplus threshold of 80 kg N/ha. However, considering NUE_{tot} only 59% of the ware potato fields were within the

desired efficiency range and only 16% of the ware potato fields were below the N surplus threshold. P and K output was in balance with P and K input on sandy soils with a median P surplus of 1.2 kg/ha and a median K surplus of 1.63 kg/ha. On clay soils median P and K balances were positive with a median P surplus of 27.3 kg/ha and median K surplus of 58.9 kg/ha. There was a large and significant difference in the median EIPs of pesticide use between the two varieties with 2708 EIPs for Fontane and 1868 EIPs for Innovator. No correlation was observed between N inputs and yields, indicating an oversupply of N on part of the fields. This was confirmed by the significant negative correlation between yield and nutrient surplus. Moreover NUE showed a negative correlation with nitrogen input and drought stress. These results suggests that there is scope to reduce average resource use without declining yields in high input systems, such as ware potato production in the Netherlands. In addition, improving management, for instance through irrigation, can lead to a more efficient use of applied inputs, especially nitrogen.