Using farmer's field data and crop modelling to benchmark resource use efficiencies of arable crops in The Netherlands

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Introduction

Arable farming systems in The Netherlands exhibit relatively small yield gaps (Silva et al., 2017). These are the result of up-to-date technologies and intensive use of inputs, which often translate in undesirable environmental impacts. Thus, it is important to understand the scope to maintain current yields while improving resource use efficiency. This study aims to quantify the crop yield (gap), resource use efficiency and environmental impacts for the main arable crops in The Netherlands. These are ware potato (WP), seed potato (SP), starch potato (StP), sugar beet (SBt), spring onion (SO), winter wheat (WW) and spring barley (SB).

Materials and methods

Individual farmer field data from Dutch arable farms during the period 2015 – 2017 containing information on crop management and actual yields (Ya) were used. The sample consisted of a total of 5651 fields located in the main agricultural regions of The Netherlands. A crop modelling framework based on crop coefficients (kc) was used to estimate the potential yield (Yp; Villalobos & Fereres, 2017), and associated yield gaps (Yp – Ya), for each crop. Water productivity (WProd) was estimated as the ratio between Ya and total seasonal water availability (TSWA, the sum of growing season rainfall, applied irrigation, capillary rise and available soil water at sowing). Finally, the framework of the European Union Nitrogen Expert Panel (EUNEP, 2015) was applied to benchmark nitrogen use efficiency (NUE = N output / N input) and N surplus (Ns = N input – N output, which represents environmental impacts). N output equals Ya times the N concentration in the harvested product and N input consists of plant available N applied, atmospheric deposition and N in seeds.

Results

Yield gaps were less than 20% of Yp for SBt, between 30 – 40% of Yp for WP, SO, WW and SB and between 40 – 50% of Yp for StP and SP (Figure 1A). Ya and Yp were on average 86.5 and 93.7 t/ha for SBt and 58.9 and 90.5 t/ha for SO. Consistent differences in Ya and Yp were observed for potato production systems: yields were greatest for WP (Ya = 52.7 and Yp = 78.5 t/ha), intermediate for StP (44.8 and 76.1 t/ha) and lowest for SP (36.6 and 71.9 t/ha). For cereals, Ya and Yp were on average 9.6 and 15.3 t/ha for WW and 6.7 and 10.1 t/ha for SB. WProd was generally greater for the horticultural crops than for cereals (Figure 1B). For the former, WProd ranged between 20.9 for SBt and 13.7 kg DM/ha/mm for SO, with potato fields having an average WProd of 16.1 kg DM/ha/mm. For cereals, WProd was ca. 9.3 kg DM/ha/mm. NUE was within the desirable range of 0.5 – 0.9 kg N/kg N for most fields of all crops except SO and SB, for which greater values were common (Figure 1C). NUE values were associated with high Ns (> 80 kg N/ha) for WP, StP and WW and relatively low Ns for the other

crops. This suggests there is scope to increase NUE and decrease Ns for arable crops in The Netherlands.

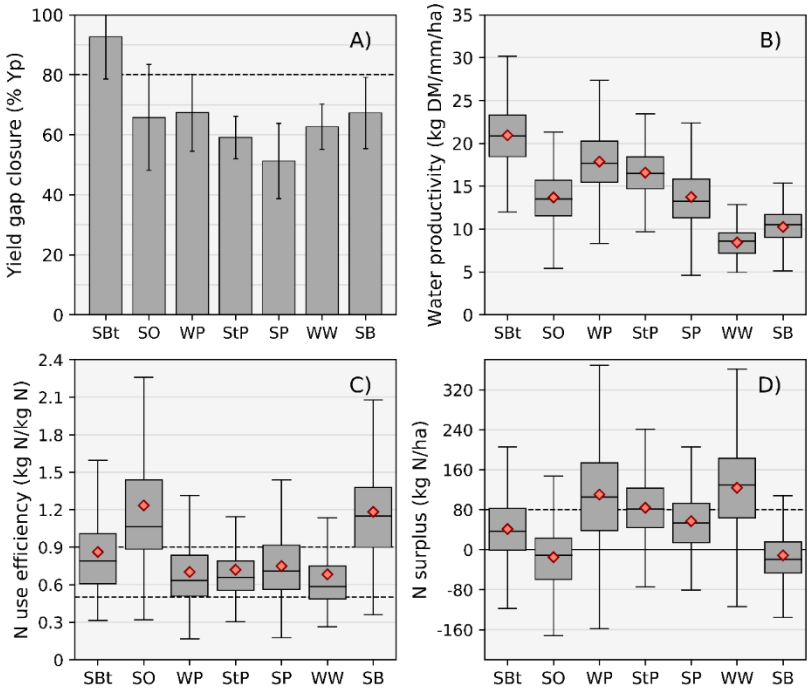

Figure 1. Yield gap closure (% Yp), water productivity (kg DM/ha/mm), N use efficiency (kg N/kg N) and N surplus (kg N/ha) for the main arable crops in The Netherlands. Error bars in A) show the standard deviation of the mean. Dashed lines in C) and D) show the NUE and Ns thresholds proposed by EUNEP. Red symbols in B), C) and D) show the mean of each indicator for a given crop.

Conclusion

This study shows how crop models can be used in the benchmarking of crop performance in farmers' fields. Yield gaps were relatively small for most crops, ranging between 10% Yp for SBt and 50% for SO. WProd values were rather low, partly due to yield gaps and water surplus in most fields. Regarding N, it is clear that high efficiency does not always translate into low losses. Our findings further suggest that improving NUE while reducing Ns is best achieved through reductions in N applied.

References

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