Generating EU-wide endogenous crop yield responses to nitrogen to predict the impact of environmental policies on farm-level cropping systems

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The 2013 EU Common Agricultural Policy (CAP) has put more focus on environmental sustainability of the EU agricultural sector. It is particularly interesting from an economic and nutritional perspective to predict how farmers may alter their cropping system when a policy change requires the reduction of a major agricultural input such as nitrogen (N). To enable EU-wide predictions, yield response curves were generated for each region at the 2nd level of the Nomenclature of Territorial Units for Statistics (NUTS-2). As NUTS-2 regions can be very large and therefore exhibit heterogeneous soil characteristics, we first divided each NUTS-2 region into existing homogenous soil mapping units (HSMU), for which soil characteristics are available from the EU Soil Database. Due to differences in soil organic matter content between arable land, orchard and grassland within each HSMU, we differentiated as well between these land use classes. Other soil parameters were calculated using pedotransfer functions. We then ran the EU-rotate_N model at HSMU level for different doses of organic manure and mineral N fertilizers, each time without and with irrigation, in amounts controlled by the soil water deficit. Target yields, which are maximum attainable yields required to run the EU-rotate_N model, were defined as the 90% quantiles of the EU Farm Accountancy Data Network for each NUTS-2 region. As a test-case, simulations were run and yield response curves were generated for soft wheat, barley, grain maize, oilseed rape, potatoes, sugar beet and permanent grassland in the NUTS-2 regions Andalusia, Calabria and East-Flanders. For each crop, average yield response functions at the NUTS-2 level were created by a weighted regression of all HSMU simulations with weights equal to the ratio between the crop area on HSMU level and the total crop area on NUTS-2 level. Regression was done between the yield and the applied inorganic and organic N using linear and quadratic functional forms. There was no distinct best fitted functional form over all crops and regions, but yield functions were more responsive to applied inorganic N than to organic N. Irrigation in Andalusia and Calabria increased potato yields up to 100% but had only a small effect on cereal yields, probably due to the early development of cereals under less dry conditions and resulting in deeper rooting systems. Taking into account the variation within each NUTS-2 region, comparison of the simulated yield response curves with site-specific field measurements from literature and simulated results from another model (CAPRI) did indicate that the overall output was reliable. However, we observed an overestimated response for grassland and potatoes in East-Flanders, while the response for wheat and potatoes was underestimated in the Mediterranean regions. Further calibration of the target yield will help to increase the accuracy of our results. Feeding the yield response functions to e.g. the EU Individual Farm Model (IFM-CAP) would enable to make combinations of yields and financial benefits and estimate the impact on a farm economic level. The chosen approach is therefore promising to contribute to a better assessment of the implications of new environmental policies on farm-level decisions across the EU.

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