Integrated modelling of policy scenarios to control Western Corn Rootworm in Austria

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***Abstract* - In recent years, the Western Corn Rootworm (WCR) became a major pest to maize in some Austrian production regions. In this study we apply an integrated modelling framework (IMF) to assess impacts of policy scenarios which restrict maize shares in crop rotations. The policies aim at the reduction of Western Corn Rootworm (WCR) populations in Austria. The IMF sequentially links a crop rotation model, a bio-physical process model and a bottom-up linear land use optimization model. It reveals optimal land use choices and opportunity costs at 1km pixel resolution for Austrian cropland. The highest WCR infestation is observed in regions with high shares of maize on cropland, which also have high opportunity costs in complying with maize production restrictions.**

BACKGROUND

In recent years, the Western Corn Rootworm (WCR, *Diabrotica virgifera virgifera*) became a major crop pest to maize in some Austrian crop production regions. The adult beetles of the pest are highly mobile and feed on maize silks, whereas WCR larvae feed on maize roots and can cause severe damage to maize production. Hence, continuous maize cropping on the same field provides favourable conditions for WCR larval development.

In order to control this threat, some Austrian provinces established regulations on the cultivation frequencies of maize on a particular field. Farmers are obliged to rotate maize, i.e. to cultivate another crop after one or a limited number of years of maize, and to adopt additional measures (e.g. chemical pest control) according to the regulation in their province. The aim of these regulations is to interrupt the life cycle of WCR, and to suppress the overall WCR population level in Austria. The ban of active substances for seed coats[2] as well as the EU Directive on sustainable pesticides use[3] confirm the need for alternative pest control options. Figure 1 depicts WCR infestation in all Austrian cropping regions from monitoring data. The spread of the pest has been observed from the South-Eastern border of Austria from 2002 onwards.

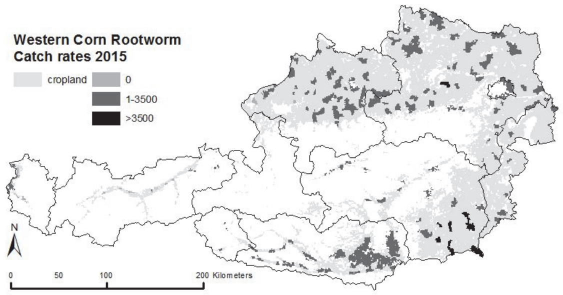

Figure 1. Identification of WCR adults by catch rates per trap from 2015. Note: Municipalities with monitoring sites (215 traps altogether) are shown. 26 of all traps remained empty. Own figure based on AGES (2016).

RESEARCH AIMS

Maize is a major crop in Austria due to favourable cropping conditions and its importance as livestock feed. In the last 25 years, the share of maize (including grain maize, CCM and silage maize) on total Austrian cropland has fluctuated around 20%, with a slight increase in area from 2000 onwards (WIFO, 2014). A high variability of maize shares in crop rotations is observed in regions with high livestock densities. The processing industry also demands maize for producing glucose, ethanol and starch (WIFO, 2014).

In this study, we analyse the impacts of policy scenarios that reflect provincial regulations on maize production in Austria. The scenarios cover the range of upper limits of maize in crop rotations, which range between mandatory rotation after three years of maize (e.g. in Upper Austria for regions where WCR is established)[4] and mandatory rotations after each year of maize (e.g. in Vienna on infested fields)[5].

Opportunity costs of rotational limitations to control WCR populations result from shifting towards alternative crops, crop rotations and crop management variants. In particular, grain sorghum is included in the model to investigate the potential expansion area and economic performance of this currently uncommon crop. From 2012 to 2014, the share of sorghum on total Austrian cropland increased from 0.6% to 0.9%. Nevertheless, experts propose grain sorghum to be an appropriate crop to

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[2] Commission implementing regulation (EU) No 485/2013
[3] Directive 2009/128/EC of the European Parliament and of the Council
[4] OÖ Maiswurzelbohrer-Verordnung 2004, Fassung vom 28.4.2016
[5] Verordnung des Magistrates der Stadt Wien betreffend die bekämpfung von Diabrotica virgifera Le Conte

replace maize in cropping sequences on selected locations and in livestock feeding diets.

DATA AND METHODS

We employ an integrated modelling framework (IMF) to assess impacts of the policy scenarios at national level. The bio-physical process model EPIC is used to simulate crop yields at 1km pixel resolution, based on historical climate data for the period 1975-2005, soil, topographic, and management data. The latter include crop rotations, which have been computed by the CropRota model (Schönhart et al., 2011). CropRota generates typical crop rotations at municipality level and provides alternative rotations for the alteration of maize-based cropping systems in this study. Data on historical crop shares, which are input to CropRota, are available from IACS at the municipality level (BMLFUW, 2015). The policy scenarios define upper levels for maize shares in crop rotations, which are part of the regulations of the provinces. Up to six different crop rotations are available for each pixel from EPIC simulations and are combined to four crop management variants. Three different fertilization intensity levels and optional irrigation are considered. The bottom-up linear land use optimization model for Austria (BiomAT) is used to maximize total crop gross margins (Stürmer et al., 2013). Land use is constrained by observed cropland endowments per pixel – derived from IACS data – in order to seek for optimal crop rotational and management choices. Cereals and grain sorghum serve as substitutes for maize. We calculate gross margins for 23 crops and four management variants using the standard gross margins catalogue (AWI, 2016) and EPIC crop yield simulations. Gross margins for grain sorghum are based on data from field experiments and expert judgments, because standard gross margins are not available yet.

ANTICIPATED RESULTS

The optimization considers regionally different cropping conditions and induced variation in economic performance of cropping activities. Figure 2 shows maize shares on cropland per municipality of Styria, Upper and Lower Austria. Three levels of upper limits of maize shares concerning crop rotation policies are displayed and suggest that gross margins from crop rotations are more likely to change in Styria than in other regions. In one out of four Styrian municipalities, more than 60% of cropland is dedicated to maize production. Crop diversity is consequently at a low level in several areas. Those regions are at risk of high pest infestation.

The evaluation of opportunity costs is supplemented by catch rates analyses to take into account possible regional yield losses from WCR infestation. The presented approach does neither consider farm level impacts nor impacts on livestock production. However, we can conclude that livestock producing farms which rely on maize for feed are more affected than more flexible cash crop farms.

CONCLUSIONS

Model results show that total gross margins of crop production decrease under restrictive crop rotation

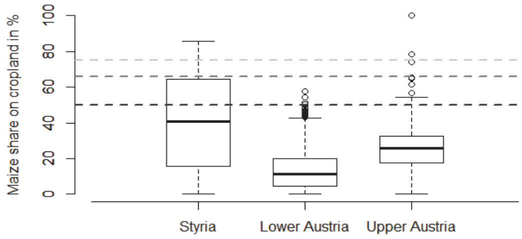

Figure 2. Average maize shares on cropland (2012-2014) of municipalities of three provinces. Dotted lines exemplify upper limits of maize shares (at 50%, 66%, 75%). Own figure based on IACS data.

regulations in highly specialized cropping regions. In return, it is expected that crop loss risks from WCR decline in the respective regions. Future analyses will focus on alternative cropland management strategies in order to assess if cooperative reallocations of crop rotations may support the region to keep certain production levels. Coupling of the IMF with a WCR population model created by Mark Szalai et al. (2014) is proposed to explore spatial impacts of crop rotations and to investigate integrated pest management options.

ACKNOWLEDGEMENTS

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