Technology adaptation to environmental change: German seed producers' response to pest shocks

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Background

Climate change affects agricultural production in various ways. Changes in pest pressures are the least understood, but remain a persistent threat to the global food system(1). Beyond applying pesticides farmers counter pests by growing pest resistant varieties. But pests mutate and breach resistant varieties, leading to pest outbreaks. We explore a unique dataset of crop trials and seed multiplication area to examine how changing pest pressure influences acreage responses for seed variety multiplication.

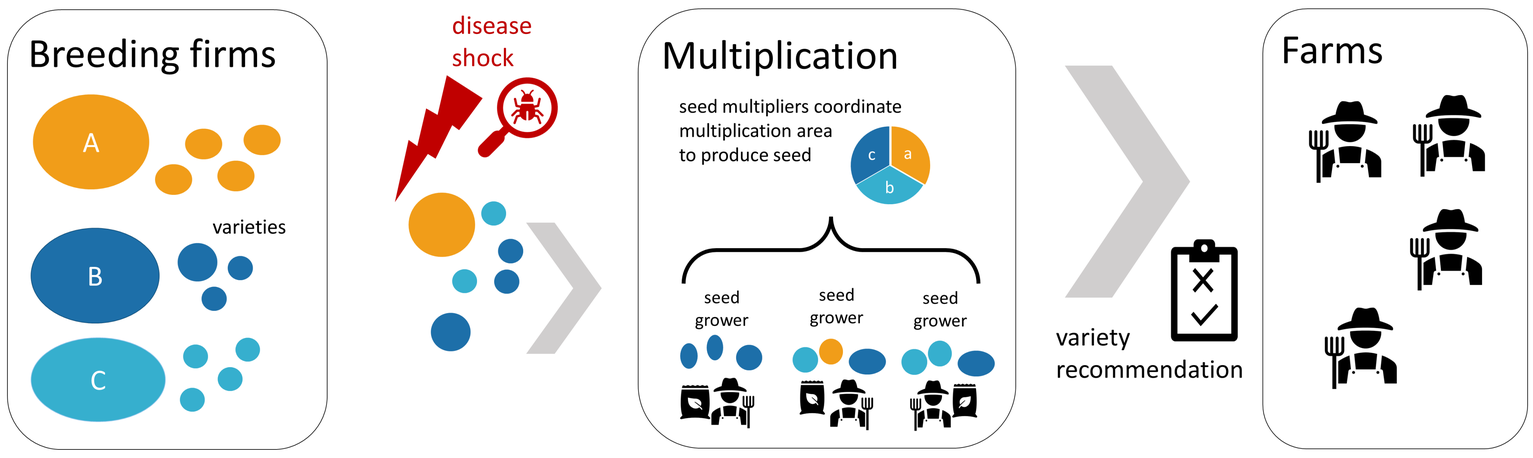


Fig. 1: Overview of the German Seed System

Crop breeders produce new seed varieties in small quantities which are insufficient for commercial dissemination. As a result certified growers produce commercial-level quantities sold to farmers. This production step is called multiplication. Multiplication organizations allocate the acreage for each certified variety and coordinate German seed growers. The multiplication organizations subcontract individual seed varieties from crop breeders and decide the area that certified seed growers allocate to producing a new variety, called the multiplication area. Results from government variety trials are available to all players in the supply chain potentially influencing contracting and multiplication area. These trials provide information on disease resistance and yields. Government officials conducting the trials recommend varieties to each region and provide this information to farmers and multiplication organizations. In contrast to other countries like the U.S., German universities are only involved in basic breeding research while extension information on varieties is provided by the government.

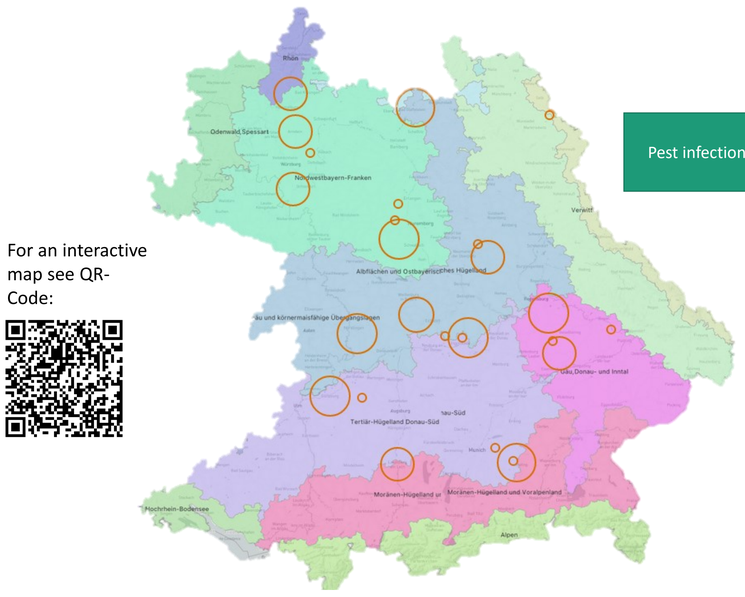
Research Question

What is the effect of pathogen shocks on seed multiplication portfolios?

We analyze whether seed multipliers respond by adjusting their variety portfolios following pathogen outbreaks by increasing the acreage of pest-resistance seed varieties.

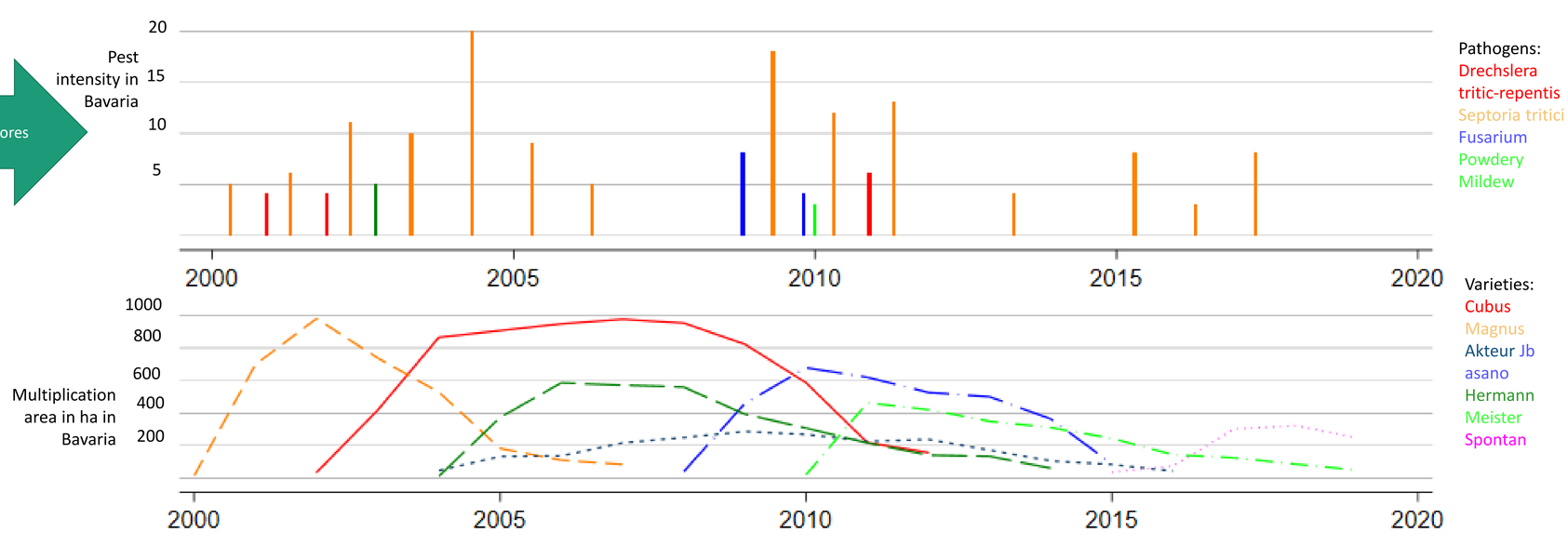
Data

Fig. 2: Bavarian State Variety Trial Locations



Sites of Bavarian State Variety Trials by pedo-climatic zone for year 2001; bubble size represents number of varieties

Fig. 3: Pest intensity and multiplication area in Bavaria



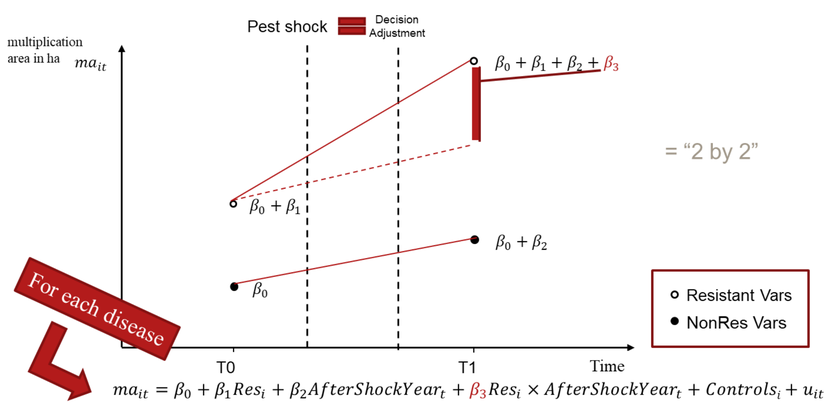
Pest intensity is the average pest occurrence with score over 4 multiplied by cropping density category of the respective site and then aggregated for the state of Bavaria. Multiplication area is measured in ha per variety aggregated for the state of Bavaria.

The data are winter wheat state-level multiplication area. These are matched by variety with performance outcomes of variety trials. In the sample are 25 testing sites over the years 2001 - 2019 where up to 66 varieties were tested per testing site; totaling 209 varieties. We used the multiplication area for of the certified seed to represent the area of varieties which will be sold to German farmers. Variety trial data is non-orthogonal data, where each year varieties will enter and leave testing based on their agronomic performance. The typical evolution of the variety multiplication area follows a common technological adoption life cycle depicted in Fig. 3. Multiplication area varies between 3 and 985 ha.

Empirical Approach

Our empirical logic follows a difference-in-difference (DiD) approach with a twist, taking care of multiple occurrences of the shocks over the years. Following the rational of Callaway and Sant'Anna (2) we went about this in multi-step process: First, we identified the time-location combinations of pest outbreaks. Second we threw all those observations out of our respective sample for each disease, where multiple shocks occurred in consecutive years to ensure that we had clean 2by2-shock occurrences within the data from the locations that we look at. Third, we conducted DiD estimations according to the Intervention logic depicted in Fig. 4.

Fig. 4: Intervention logic

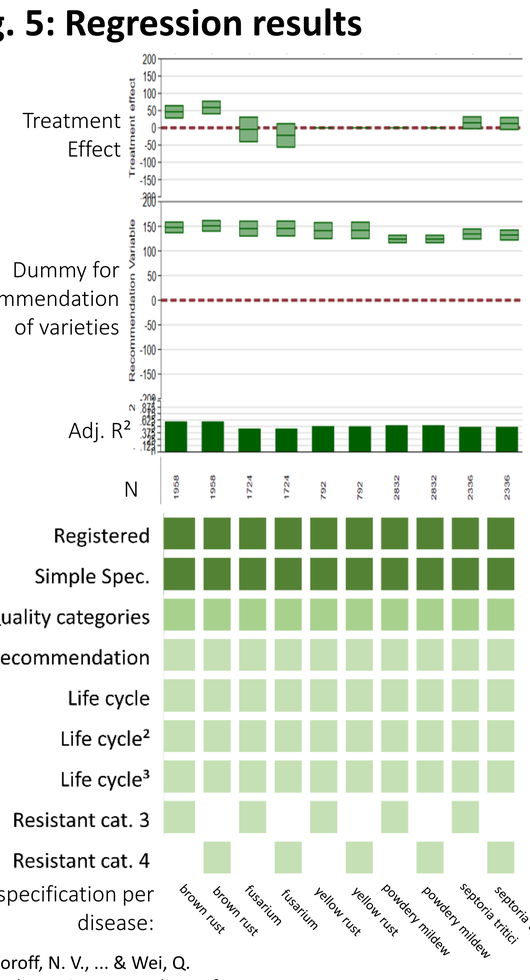


Variety lifecycle variables and wheat quality categories were added as controls.

Preliminary Results

Our preliminary results show that pest outbreaks only in brown rust are correlated with slight increases in the supply of resistant varieties. Fusarium, yellow rust, septoria tritici and powdery mildew do not bring about any c.p. changes in multiplication acreage. Recommendation of varieties, however, has an effect of ~150 ha in multiplication area, after an outbreak. Information provisioning to the multiplication actors in the supply chain seems to work out and have a stronger effect on acreage allocation than the outbreaks themselves

Fig. 5: Regression results



(1) Ristaino, J. B., Anderson, P. K., Bebber, D. P., Brauman, K. A., Cunniffe, N. J., Fedoroff, N. V., ... & Wei, Q. (2021). The persistent threat of emerging plant disease pandemics to global food security. *Proceedings of the National Academy of Sciences*, *118*(23), e2022239118.
(2) Callaway, B., & Sant'Anna, P. H. (2021). Difference-in-differences with multiple time periods. *Journal of Econometrics*, *225*(2), 200-230.

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