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Topic 1 - Ecological approaches to systems' health

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HETEROGENEOUS POPULATIONS VS. PURE LINE VARIETIES FOR ORGANIC WINTER WHEAT PRODUCTION IN GERMANY - PRODUCTION RISK

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Preferred Presentation Method: Oral or poster presentation

Full Paper Publication: Yes

Abstract: Heterogeneous composite cross populations (CCP) may enable winter wheat producers to cope with increasing biotic and abiotic pressure due to climate change. An economic farm model based on a cost benefit analysis was established to compare net return and production risk of organic winter wheat production with CCP and pure line varieties. Two CCPs with both yield- and quality-oriented parent varieties (YQI and YQII) are compared with ten reference varieties (4 conventional cultivars, 4 from organic breeders, 1 hybrid, 1 feed wheat). The organic production system was modelled with a stochastic approach (Monte Carlo simulation) based on trial data, market prices and standard data. Using iterative simulations (20,000 model calculations), possible results of the target variables were calculated according to the probability distributions of the individual input parameters. Yield distributions were estimated from trial data from the INSUSFAR project (2016 and 2017) using maximum likelihood statistics. Discrete distributions were defined for machinery and labor costs. The individual results of this stochastic simulation can be presented cumulatively as a curve with the corresponding probabilities of occurrence, the risk profile. Risk profiles were used to compare the agronomic options. The evaluation of risk profiles was based on the concept of stochastic dominance. The populations showed a high stability with a moderate economic performance (net return; €/ha). The conventional cultivar 'Achat' dominates the CCP YQI (1st order stochastic dominance) and so do 'Hybery', 'Elixer' and 'Kerubino'. The varieties 'Genius' and 'Poesie' as well as 'Capo' showed a higher net return but also a higher variance and therefore lower stability. Without knowledge of the individual risk-benefit function of decision makers, no recommendation can be given here. The organic varieties 'Butaro' and 'Wiwa' are dominated by the CCP with 2nd order stochastic dominance. If risk neutrality or aversion is assumed, CCPs are preferable here. Both CCPs showed a relatively low variance of results. CCP YQII dominated half of the reference varieties in the N-fertilization treatment. Especially in the scenario with N-fertilization a trade-off between stability and yield was observed. The hybrid variety 'Hybery' and the feed variety 'Elixer' had a high net return and therefore, despite higher variance, dominated the other varieties and the two CCPs.

Introduction: Functional (genetic) diversity is said to be especially important for resilient cropping systems (Howden et al. 2007). Genetically heterogeneous composite cross populations (CCP) of winter wheat show high adaptability (Döring et

al. 2015) and yield stability (Brumlop et al. 2017). Therefore, composite cross populations may enable winter wheat producers to cope with increasing biotic and abiotic pressure due to climate change. However the question will be whether higher yield stability can economically offset the reduced yield potential.

Material and methods: An economic farm model based on a cost benefit analysis was established to compare net return and production risk of organic winter wheat production with CCP and pure line varieties. Two CCPs with both yield- and quality-oriented parent varieties (YQI and YQII) are compared with ten reference varieties (4 conventional cultivars, 4 from organic breeders, 1 hybrid, 1 feed wheat). The organic production system was modelled with a stochastic approach (Monte Carlo simulation) based on trial data, market prices and standard data. Using iterative simulations (20,000 model calculations), possible results of the target variables were calculated according to the probability distributions of the individual input parameters. Yield distributions were estimated from trial data from the INSUSFAR project (2016 and 2017) using maximum likelihood statistics. Discrete distributions were defined for machinery and labor costs.
The individual results of this stochastic simulation can be presented cumulatively as a curve with the corresponding probabilities of occurrence, the risk profile. Risk profiles were used to compare the agronomic options. The evaluation of risk profiles was based on the concept of stochastic dominance.

Results: The populations showed a high stability with a moderate economic performance (net return; €/ha). The conventional cultivar 'Achat' dominates the CCP YQI (1st order stochastic dominance) and so do 'Hybery', 'Elixer' and 'Kerubino'. The varieties 'Genius' and 'Poesie' as well as 'Capo' showed a higher net return but also a higher variance and therefore lower stability. Without knowledge of the individual risk-benefit function of decision makers, no recommendation can be given here. The organic varieties 'Butaro' and 'Wiwa' are dominated by the CCP with 2nd order stochastic dominance. If risk neutrality or aversion is assumed, CCPs are preferable here. Both CCPs showed a relatively low variance of results. CCP YQII dominated half of the reference varieties in the N-fertilization treatment. Especially in the scenario with N-fertilization a trade-off between stability and yield was observed. The hybrid variety 'Hybery' and the feed variety 'Elixer' had a high net return and therefore, despite higher variance, dominated the other varieties and the two CCPs.

Table 1: Model input parameters that are subject to Monte-Carlo-Simulation

Model input	Unit	Probability distribution	Comments
Yield	t/ha	continuous	estimated from field trial data (Maximum-Likelihood)
Quality	% Protein	continuous	estimated from field trial data (Maximum-Likelihood)
Market prices	€/ha	continuous	estimated from historical data (Maximum-Likelihood)
Machinery costs	€/ha	discrete	estimated based on field trial effects
Labor costs	€/ha	discrete	estimated based on field trial effects

Discussion: CCP economically outperform organically bred high quality varieties. Composite-cross populations show equal performance compared with varieties popular in organic farming (‘Capo’). However, even though they show lower variance CCP are economically inferior to modern high-yielding varieties.

References: Brumlop S, Pfeiffer T, Finckh MR (2017): Evolutionary Effects on Morphology and Agronomic Performance of three Winter Wheat Composite Cross Populations Maintained for Six Years under Organic and Conventional Conditions. Organic Farming 3(1).

Döring TF, Annichiarico P, Clarke S, Haigh Z, Jones HE, Pearce H et al. (2015): Comparative analysis of performance and stability among composite cross populations, variety mixtures and pure lines of winter wheat in organic and conventional cropping systems. Field Crops Research 183, 235-245.

Howden SM, Soussana JF, Tubiello FN, Chetri N, Dunlop M, Meinke H (2007): Adapting agriculture to climate change. Proceedings of the National Academy of Sciences 104, 19691–19696.

Image:

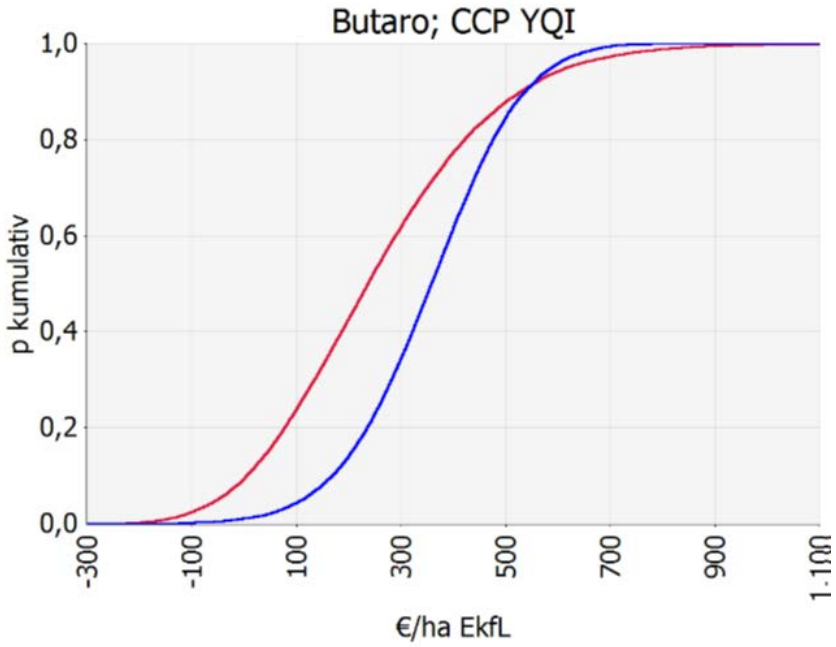
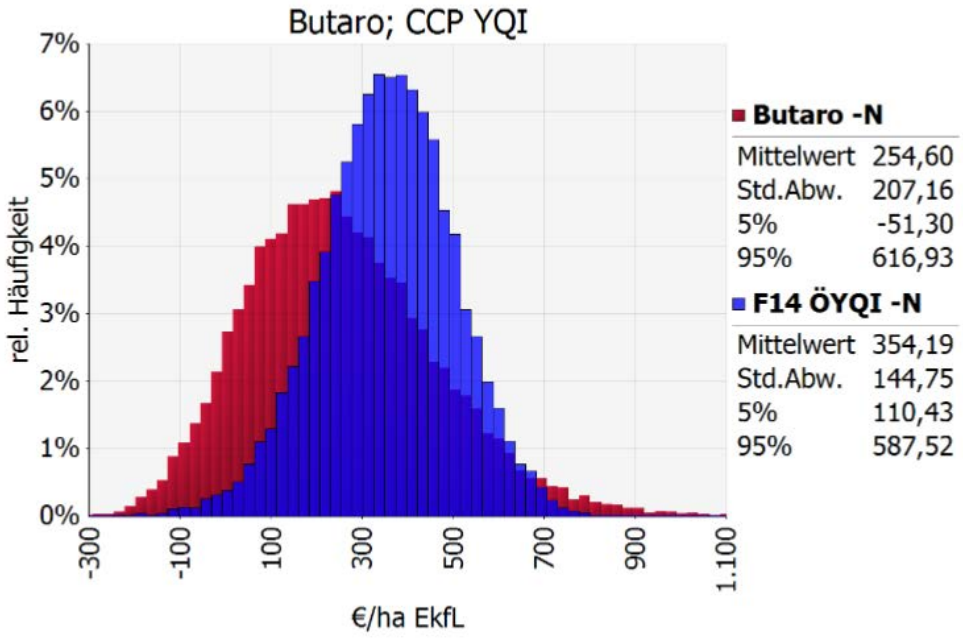


Image 2:



Disclosure of Interest: None Declared

Keywords: net return, organic agriculture, risk simulation, Triticum aestivum, yield stability