The performance of yields in organic and conventional cropping systems

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Sufficient and stable crop yields are the basis for feeding a growing world population. Limited cropland, climate change, loss of soil quality and biodiversity coupled with excessive use of non-renewable resources require new solutions for future cropping systems beyond existing management practices. Here we compare the yield performance of organic and conventional cropping systems.

Average yields of organic cropping systems achieve 80% of conventional systems. However, large differences exist between crop types. Organic non-legumes yields achieve 75%, but legumes 90% of the conventional level. In high yielding regions where *potential yields* are approximately achieved the yield gap can be much greater. Organic systems achieved only 50% of cereal and 55% of potato farm yields in Germany. Also within the group of non-legumes, the yield gap differs largely. An evaluation of long-term cropping system experiments with a duration of more than 15 years show that wheat achieved about 70 %, potatoes 75%, but maize 82% of conventional yields.

Beside sufficient yield levels, a key question is how crop yield development performs in the long-term in different cropping systems. In addition, temporal yield stability is crucial for regional food security. Organic cropping systems show here, per unit yield, a 15% lower temporal static stability. Fertilisation, mainly nitrogen, is the main driver for the yield gap between the systems. However, results from the DOK experiment show that for the yield level, crop protection and fertilisation was important, stability was mainly determined by crop protection and not by fertilisation. An evaluation of the yield gap clearly showed that a high gap was caused by lower organic yields and comparatively constant conventional yields.

Yield trend analysis in the DOK experiment reveal positive or stagnating trends in all systems for wheat and maize over a data series of 40 years. Surprisingly the clover-grass ley yields tended to decrease over time in all systems and at different fertilisation levels. Neither a significant increase nor decrease in yield gap between organic and conventional systems could be observed. This finding is confirmed by the yield trends in organic-conventional long-term comparisons (≥ 15 years), which show in most cases constant or slightly increasing yields under organic management. However, also farm yields of wheat and maize under conventional management showed no positive yield development in regions with high yield levels like Central and North Europe since the 1990ies.

The future challenge will be to reduce the yield gap between organic and conventional systems by a substantial yield increase in organic systems without trade-offs between productivity and sustainability of agricultural management. The comparison of the regular fertilised mixed cropping systems in the DOK experiment with reduced fertilisation (50% of regular) clearly demonstrates the reasons for yield limitations of organic systems. The conventional system with reduced fertilisation gained higher or similar yields over all crops compared to the regular fertilised organic systems but it received less absolute amounts of nutrients with fertilisers. However, the conventional system received a higher amount of mineral nitrogen forms and it was treated with pesticides. Hence, the main drivers to reduce the yield gap are an improvement of nitrogen availability and a synchronisation between supply and crop demand. Further improvements in weed control by new technologies and crop protection by cultivars that are more resistant or by crop diversification will be a key measure of future management.