Diverse crop rotation: What does it achieve and cost?

Crop rotation diversity is the most important agronomical answer for a wide range of current challenges – reaching from plant protection issues, extreme weather conditions to the amendment of current fertiliser regulations. Thus, are crop rotations with less lucrative plant varieties viable? How does it influence humus content and nitrogen balance? Sven Böse evaluated different crop rotations.

Usually crop rotations are planned in order to maximise the gross margin. However, the continuously increasing fixed costs have to be covered, especially the exorbitant rise in rental prices. Therefore, over the last decades crop rotations have been constantly shortened. Extensive crops like summer cereals and legumes were replaced by oilseed rape, winter wheat and maize. Yield stagnation, pest, weed and disease problems as well as administrative requirements like greening and the amendment of current fertiliser regulations put the present crop rotations in question.

In demand are crop rotations which are able to fulfil agronomical, ecological and economical requirements. In this report crop rotations are analysed, which

- have a sufficient economic feasibility by including an adequate amount of high profitable crops.
- are using the advantages of crop rotation in relation to field sanitation and pest occurrence, rotating cereals, legumes, root crops and broad-leaved arable crops as well as winter and spring crops.
- have a positive impact on the environment in terms of humus content and nitrogen balance as well as integrated plant protection.

The examples are calculated for a moderate site according to the German agricultural land classification. On sites prone to drought the analysed crop rotations have to be altered. Wheat has to be replaced by hybrid rye or triticale, broad beans by field peas and oats by spring barley or durum.

This is how we calculated

The net costs information were taken from the KTBL (independent German agricultural advisory and research office) and the county agricultural advisory departments added by self-research. Of course, the height of the costs is farm individual. In contrary the cost relations of the crops differ much less. This also applies to the expected crop prices: Reference values (in €/t) are for the marketing year 2018, 180.00 € for soft wheat, 400.00 € for oilseed rape, 229.00 € for broad beans, 33.00 € for sugar beet, 30.00 € for forage maize (ex-field, with return delivery of fermentation residues).

The individual farm yields differs the most. The data shown in the tables is exemplary for average growing conditions.

N fertilisation is taken according to the maximum possible application rates of the new fertilisation regulations. The Nmin values are examples. N requirement of forage maize and catch crops are covered organically if possible. 10 % of the applied total N amount is deducted in the following year. Humus balance was drawn up according to the more conservative “upper values” of the VDLUFA (German agricultural analysis and research association). For most German regions those are more practical than the “lower values” applied in cross compliance.

Three-year rotation with winter crops - initial situation

The initial situation, used as standard of comparison, is the most common crop rotation on arable farms (oilseed rape/ winter wheat/ winter barley). Neither spring crops nor catch crops are grown. High work peaks at harvest and drilling time are used to justify an over-early start of wheat drilling. In many places second wheats have been replaced again by winter barley in order to fulfill greening requirements. Therefore oilseed rape profits immensely as it can be drilled timely and more accurately into a seedbed with less straw residues. Nevertheless, in the example it cannot reach 4 t/ha anymore: After decades of short crop rotations the fields are showing stagnating yields which cannot be improved by more plant protection and definitely not by applying more nitrogen.

The example farm is able to account for an average gross margin (- permanent labour costs) of 470€ in this standard crop rotation. Because of many harvest residues the humus balance is significantly positive. The N balance with only +23 kgN/ha is at an environmental friendly level. However, from an agronomical point of view it is a critical one as it derives of the very small surplus of only 7 kg in winter wheat. The winter wheat is only allowed to be fertilised with 166 kgN/ha as oilseed rape was the preceding crop and the Nmin soil content is at 55 kg Nmin at a soil depth of 0 to 90 cm. Additionally the N supply of oilseed rape and barley seems to be very low.

<table>
<thead>
<tr>
<th>Crop</th>
<th>1 t/ha less grain or 2 % less protein</th>
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<tr>
<td>Wheat</td>
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<td>Winter wheat</td>
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<td>Oilseed rape</td>
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According to the new fertiliser regulations the maximum allowed amount of fertiliser is at least 20-30 kgN lower for the described crop rotation than at present. The restricted N input is an instrument of the new fertiliser regulation in order to reduce the N surplus and the N output, respectively. Calculative if the winter wheat really takes up 20-30 kg less N/ha it would result in either 0.8 – 1.2 t/ha less grain or 1.7 to 2.5 % less crude protein.

Taking a base yield of 8 t/ha baking wheat with 13 % protein.

If the (grain nitrogen %) yields shall not drop up to 10 to 15 % in the near future the cultivation system for wheat has to meet two challenges:

- Improving N use efficiency through genetics and cultivation systems. Sorely through variety choice 10 (-15) kgN/ha more grain N concentration can be achieved while the level of applied N remains constant. According to the German recommended list for cereals the new varieties NORDKAP, Kashmir and Hybride Hyvento as well as the older varieties GENIUS and JB Asano belong to the 10 most N efficient varieties. Additionally cultivation systems which improve the performance of the crop also increase the grain N concentration and therefore affect the nitrogen balance positively. Ecology and economy are not contradicting each other.
- Improved nitrogen efficiency is only sensible in the long-term if the increased removal does not lead to the depletion of the soil N pool. Therefore, as also sought by the new fertiliser regulation, the nitrogen losses should be reduced in the above mentioned ratio. Innovative techniques from slurry injection to site specific or better placed mineral fertiliser application as well as crop rotation extend the leeway of N supply.
Pulling one over on the fertiliser regulations

Spring crops, especially maize, sugar beet and oats, are able to make use of soil N particularly well. The N need of later root crops profits from the time course of mineralisation and oats from their extremely efficient root system. Legumes will also become increasingly important for our crop rotations. For example, broad beans assimilate from the air throughout the vegetation period with their symbionts approx. 50 kg nitrogen per t of grain yield (field peas 44 kg, soy beans 53 kg). These are on the base of conservative yield estimation 40 kg more than the removal. Therewith only 10 kgN/ha were credited due to the preceding crop adjustment factor. The remainder increases the N soil pool as long as leaching is prevented by a suitable subsequent crop.

The cultivation techniques "dry farming" uses less efficient extensive crops in order to save water for the main crops. This strategy is also conceivable in regard with nitrogen because oats, malting barley or spelt manage with less N fertiliser than allowed by the fertiliser regulations. If quality wheat, for example due to extreme weather conditions, receives 10 % more nitrogen (in accordance with the fertiliser regulation), it is possible to deduct the same amount without any disadvantages from extensive crops. The farm gate nitrogen balance stays balanced!

Getting down to the root of the trouble

Oilseed rape yield is stagnant in many places due to fungal crop rotation diseases. In a four-year rotation oilseed rape achieves higher and more reliable yield with concurrently lower cultivation costs. If the above described three-year crop rotation is lengthened it should be ideally done with a spring crop as they are an effective measure in order to control winter annual grass weeds, especially black grass.

In the tables 2 and 3 two different crop rotations were analysed with spring crops in between 1st wheats after oilseed rape and winter barley as the last crop in the rotation.

- In climatically suitable regions, where maize can either be self-used or marketed lucratively, due to increasing numbers of biogas plants, it has become an important asset within these arable farming regions. The gross margin (- permanent labour costs) increases due to higher and more reliable yields in this healthier crop rotation even despite a lower oilseed rape ratio. Advantages like lower weather conditions risks, better field sanitation and better work load spread, are not taken into account. The calculative nitrogen balance is set to 0, especially due to the high forage maize uptake. The crop rotation is even longer if a second cereal is grown in between maize and barley, e.g. rye or triticale as whole crop cereal silage or a second wheat on arable farms.

- The gross margin (- permanent labour costs) cannot keep up fully in the crop rotation with oats and broad beans instead of maize. Because of the expected higher yields of the other crops within the rotation they can compete with the three-year winter crop rotation nonetheless. The contribution of this crop rotation to less soil compaction and erosion as well as to humus and mobile nitrogen accumulation (available to other crops) should also be taken into account. All three aspects have not been here evaluated. Additionally, oats and legumes are generally found to be more economically lucrative than with this conservative evaluation. However, only on sites with good soil water storage and if the use and the marketing conditions are favourable. As both crops cannot be grown in short rotations it is best to switch them within the rotation resulting in a 8 year break. If broad beans or alternatively peas are supposed to be grown every year the crop rotation has to be lengthened by at least another crop.

At last a five-year crop rotation with sugar beet, oilseed rape, twice wheat and barley. The crop rotation is agronomical, economic and ecological very attractive with 40 % broad-leaved arable crops, 20 % catch crop and 20 % spring crops. With only a one year break, wheat is still threatened by take-all disease. However, due to the low soil temperatures at drilling of the 1st wheat after sugar beet this crop rotation disease should not be a problem. Winter wheat after late sugar beet has the advantage that it can be drilled in spring if the autumn weather conditions are unfavourable and the risk of soil compaction is too high. Like in all examples, the preceding crop before oilseed rape is an early winter barley which leaves enough time for an optimal straw management. Due to the multi-resistant oil radish variety, grown as a catch crop, high performing BCN tolerant sugar beet varieties can be used.

Higher yields and fertility with catch crops

Longer crop rotations make more catch crop cultivation possible which leads to higher soil fertility, better field sanitation and plant health. In the past years it has shown that catch crops do not have a negative impact on water supply for the subsequent crop. In contrary, the improved soil structure increases soil water capacity and therefore the use of winter rainfall.

Catch crops have to be evaluated multi-dimensional with regard to the oncoming amendments of the fertiliser regulations. They increase the possibilities of nitrogen input within the crop rotation: They can be fertilised with 60 kg organic N/ha of which 30 kg/ha have to be balanced in the harvest year, 10 % of the total amount have to be deducted in the subsequent crop, 20 kgN/ha is available to the second subsequent crop. However, a successful catch crop removes up to 100 kgN/ha. It reduces effectively nutrient leaching and increases the soil N pool by building up the organic matter content, instead. In contrary to stable humus, after mineralisation organic matter is readily available to the subsequent crops and therefore maintains the necessary nitrogen availability in the soil. An humus balance of the crop rotation with for example + 200 kg/ha equals an increase of the carbon content by 116 kg/ha. With a 1:15 C/N ratio of organic matter, approx. 8 kgN/ha are additionally available to the N pool.

Summary

Diverse crop rotations have no economical disadvantages in many places if higher and more reliable yields, e.g. of oilseed rape, a higher product quality, less plant protection and work process advantages are also evaluated. The oncoming amendments of the fertiliser regulations are another reason to reconsider the present crop
More diverse and healthier crop rotations result in higher N efficiency and offer more leeway concerning the plant nutrition.

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1 Soil organic matter is determined by the organic carbon content. About 58% of the mass of organic matter exists as carbon (Total organic carbon % x 1.724 = Organic matter %)

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