

# Utilising the pre-crop effect of grain legumes

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The pre-crop effect of legumes is the positive effect a legume crop has on the performance of the following crop. This effect on the following crop, usually a cereal, is often presented as a reason to grow legumes. Full use of this pre-crop effect requires a good understanding of its size and its causes. Factors affecting this include the site conditions, crop management practices, cropping sequences (rotation), and the legume species and cereals grown. Making efficient use of the pre-crop effect can save considerable amounts of nitrogen fertiliser, enable reduced tillage and pesticide application, enhance soil structure, and increase the yield and quality parameters of the following cereal crops. These effects allow cost, energy and time savings, and increase production and revenues for the farmer. It reduces impacts on the environment.

## Components of the pre-crop effect

The pre-crop effect includes two elements: the nitrogen effect and the break crop effect. The **nitrogen effect** is the provision of nitrogen to the following crop through the nitrogen carried over in the residue from the previous crop. The size of the nitrogen-related effect depends on residue quantity and quality from the legume crop.

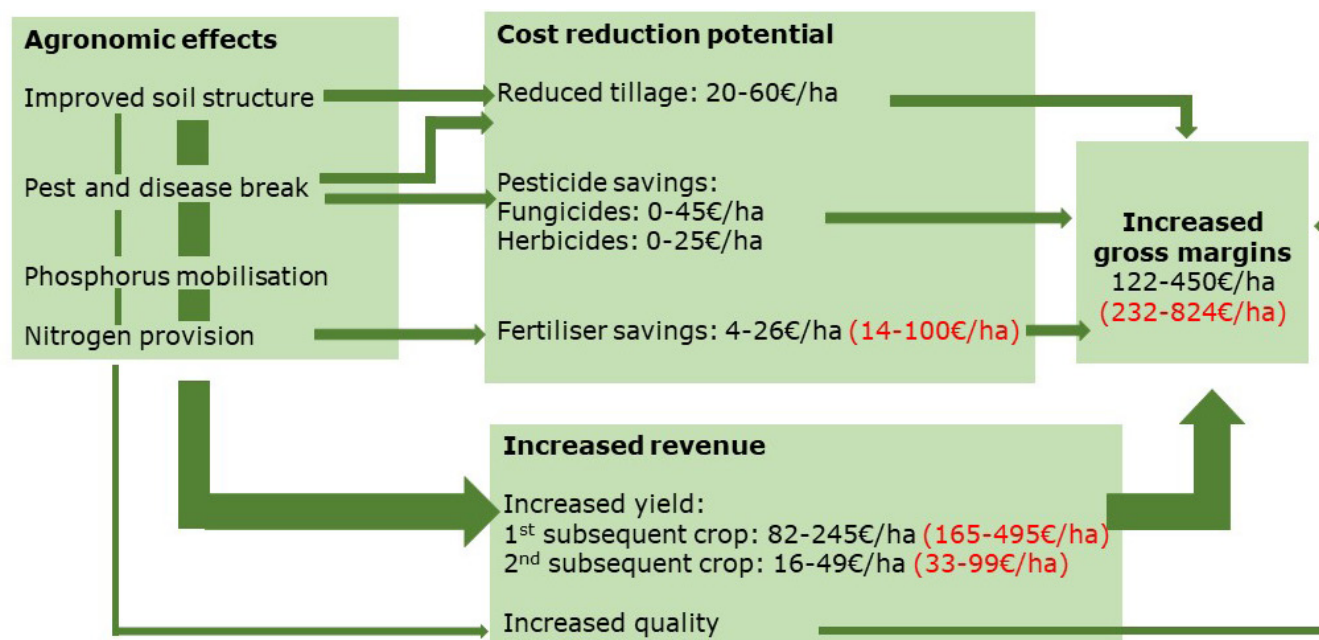
The **break crop effect** is due to the reduction in the risk of diseases, pests and weeds in cropping sequences otherwise dominated by another plant family, usually grasses (cereals). These biotic risks are reduced as their life cycles are "broken". Legumes also improve soil structure and enhance soil microbial processes, which in turn may increase the availability of some nutrients, e.g., phosphorus. Deep rooting in some legumes species such as lupin reduces soil compaction and increases water-holding capacity of soil for the following crop. Phosphorous availability for subsequent crops can also be improved because some legumes are able to mobilise reserves of phosphorus in the soil that are less available to other crops.



Flowering field pea in farmers field. Photograph: Moritz Reckling

## Farm-level implications

Growth and yield of cereals following legumes is often increased and incidences of pests, diseases and weeds are reduced. In situations where soil mineral nitrogen supply is enhanced by legumes, nitrogen fertilisation can be reduced. This is directly translated into increased revenues and reduced costs for fertilisers and pesticides. In addition, improved quality such as higher protein content can increase the market value of the following cereal crop. Better soil structure caused by tap roots supports higher yields and allows reduced tillage. For instance, no ploughing is needed before the seed bed preparation for the crop following grain legumes such as lupin or soybean. This reduces machinery costs.



**Figure 1.** Increased gross margin resulting from pre-crop value of grain legumes to subsequent cereals compared to cereal pre-crops. Size of arrows indicates farm-economic relevance. Figure adapted from Preissel et al. 2015. Values from Alpmann and Schäfer 2014, Tab. 5, with average prices from 2016-2019 of wheat -> 163€/t and N fertilizer (CAN) -> 0.75 €/kg N and average prices during extreme situation from Feb-March 2022 of wheat -> 330€/t and N fertilizer (CAN) -> 2.86 €/kg N (Prices from MIO Marktinformation Ost).

Quantification and valuation of the effects on crop inputs and outputs are difficult since they are dependent on a range of interacting agronomic and economic variables. Variations in yield effects can be high and current producer prices, costs for fuel, fertilisers and pesticides also largely impact the value of the effect. Additionally, increased revenues and cost reductions are not always realised simultaneously. However, estimations of pre-crop values of grain legumes to subsequent cereals compared to cereal pre-crops allow us to sort the farm-economic relevance of the effects roughly and price scenarios enable us to assess the potential value of the effects in different market situations (Figure 1). The most important

effect is the yield increase in the subsequent crop compared with the yield in a sequence without the legume. This translates into increased revenues. Depending on the current market prices, revenues from the first subsequent crop can be several hundred Euros higher as a result of the break crop effect of the legume. Positive effects were found even in second cereals after the break crop. Cost reductions from reduced tillage, reduced nitrogen fertilisation and pesticide savings are also relevant. The effect of the fertiliser savings increases as prices for fertilisers increase, as we are currently seeing in markets. Potential effects through increased quality of following crops can be very variable and below economic relevance.

**Table 1.** Average pre-crop effect of faba bean and pea on following cereal yield, nitrogen inputs and tillage costs compared to cereal pre-crop based on conventional farmers' estimations in 2016-2019 (Zerhusen-Blecher et al., 2022)

	Faba bean		Pea	
	Quantity kg/ha	Value €/ha	Quantity kg/ha	Value €/ha
Yield effect in the subsequent cereal crop	+700	116	+560	90
Savings in nitrogen fertilisation	29	21	28	20
Savings from reduced tillage		31		14
Total pre-crop value		168		124

In the context of the individual farm, a simplified calculation of the pre-crop value of grain legumes can support the estimation of potential effects at the farm level - as it was done on the demonstration farms of the network for cultivation and utilisation of field peas and faba beans in Germany (Table 1). The assessment of the pre-crop value is key to getting a more realistic picture of a grain legume's economic value. Therefore, adequate profitability measures such as expanded gross margins that credit the pre-crop value on subsequent crops to the legume's gross margin itself or even an economic assessment of whole cropping systems are necessary.

A range of experiments, reviews, and surveys of farmers provide estimates of the size of the pre-crop effect of grain legumes. Cereal crops often yield 0.5–1.6 t per ha more after grain legumes than after cereals in Europe (Preissel et al., 2015). However, several aspects need to be taken into account when estimating the effects for a specific farming context. The estimated values differ depending on the **reference pre-crop** chosen for comparison. Largest effects can be found when legumes are compared to cereal crops as pre-crops. In contrast, other broad-leaved crops can have a pre-crop effect on cereals that is similar to that of legumes. The management of the following crop also influences the magnitude of the pre-crop effect from the preceding crop. **Management practices** such as tillage, residue treatment, and the application of nitrogen fertiliser impact on the magnitude of the pre-crop effect. The importance of nitrogen carried over from the previous crop is reduced as the nitrogen fertiliser application increases. The yield effect declines from +2.2 t per ha without fertilisation to +1.5 t per ha when 100–200 kg of N fertiliser is applied to the following cereal (Preissel et al., 2015). Therefore, the nitrogen-related effect of the legume is highest in systems with low N fertilisation such as in organic farming. **Site and climatic conditions** such as soil characteristics, water availability and temperature also greatly influence the pre-crop effect. Differences in mineralisation of organic nitrogen in the pre-crop residues is one reason why there are considerable differences in the nitrogen saving potentials on different sites. The pre-crop effects are likely to be relatively larger



High-biomass legume crop – faba bean. Photograph: Tim O' Donovan (Seedtech)

on sites with a low yield potential than on sites with a higher yield potential. Besides, the pre-crop effect varies depending on the particular legume species. **Legume species** such as faba bean have a high-biomass and deep root system. These leave more crop residues with available nitrogen than low-biomass legumes such as lentil. Lastly, the effects of grain legumes as pre-crops depends on the **rotations** in which they are introduced and are highest in cereal-dominated rotations. The disease and weed-related break crop effects are particularly large in these systems.

### Key practice points

- Grain legumes reduce input costs and increase the yield of subsequent crops because of a combination of nitrogen and break crop effects.
- High fertiliser prices increase the relevance of the pre-crop effect.
- Cereal-dominated cropping systems respond most to the pre-crop effect of introducing legumes.
- The increase in yield of the subsequent cereal crop ranges often from 0.5–1.6 t per ha.
- The yield increase from the pre-crop effect declines (from 2.2–1.5 t per ha) with increasing N fertilisation (from 0–200 kg).
- Estimation of the economic value of the pre-crop value is useful in assessing the effect on an individual farm.
- Models such as ROTOR can help in evaluating the pre-crop effect in rotations.



## Further information

Software tool ROTOR - download: [www.zalf.de/de/forschung\\_lehre/software\\_downloads/Documents/oekolandbau/rotor/ROTOR.zip](http://www.zalf.de/de/forschung_lehre/software_downloads/Documents/oekolandbau/rotor/ROTOR.zip)

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