Field Crops Research 115 (2010) 217–233

Contents lists available at ScienceDirect

Field Crops Research

journal homepage: www.elsevier.com/locate/fcr

Review

Ecological services of faba bean

Ulrich Köpke [a,*], Thomas Nemecek [b]

[a] IOL – Institute of Organic Agriculture, University of Bonn, Katzenburgweg 3, D-53115 Bonn, Germany
[b] Agroscope Reckenholz-Tänikon Research Station ART, Reckenholzstrasse 191, CH-8046 Zurich, Switzerland

ARTICLE INFO

Article history:
Received 25 February 2009
Received in revised form 8 October 2009
Accepted 10 October 2009

Keywords:
Faba bean
Biological nitrogen fixation
BNF
Precrop effects
Break crop
Diversification
Intercropping
Environmental off-site benefits

ABSTRACT

The key environmental benefits of faba bean are its ability to fix atmospheric nitrogen symbiotically under a broad spectrum of environmental conditions and making this renewable resource available to show positive precrop effects in diversified crop rotations. Non-nitrogen precrop effects entail potential benefits via increased availability of soil phosphorus to the subsequent crops. Faba bean acts as a break crop in intensive cereal-dominated crop rotations.

Faba bean enables diversification of the agroecosystem, i.e. planned biodiversity in time via diversified crop rotations and in space via intercrops, indirectly enhancing associated diversity of wild flora, wild fauna and soil microbes that may affect the sustainability of agricultural systems. Nevertheless, most effects are indirect effects on soil fertility, productivity, and system stability, as well as resilience of the entire agroecosystems, effects that can seldom be attributed solely to this crop.

The environmental impacts of grain legumes have been studied at different levels by means of life cycle assessment (LCA). Considering the individual crops, it can be shown that faba bean enables savings of energy and reductions of greenhouse gas emissions, but it is difficult to assess all precrop effects at the individual crop level. First, comparisons of whole crop rotations with and without grain legumes show reductions of energy consumption, global warming, ozone formation, and acidification and ecotoxicity in intensive cereal-rich crop rotations. Eutrophication was at a similar level, with a tendency for increased nitrate leaching and a decrease of other N emissions. Replacement of imported soybean meal by locally produced pulses could have a favourable effect, particularly for pulses produced and used on-farm. However, depending on the raw materials used to replace soybean meal, the effects can also be unfavourable. Finally, shifting the human diet toward less reliance on meat has the potential to reduce environmental burdens, but care must be taken that the plant products are not too highly processed.

Contents

* Corresponding author. Tel.: +49 228 735616; fax: +49 228 735617.
E-mail addresses: iol@uni-bonn.de, ukiol@uni-bonn.de (U. Köpke).

0378-4290/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.fcr.2009.10.012

1. Introduction

Faba bean responds to and changes its environment by altering on-site soil fertility, microclimate, and co-habitats of wild flora and fauna. Besides its worldwide use for food and feed, extensive knowledge exists about its ability to symbiotically fix and add nitrogen to the soil, making additional soil nitrogen available and thereby enhancing and sustaining soil productivity. Much less is known about the services performed by faba bean that provide additional environmental on-site and off-site benefits apart from nitrogen effects, either by avoiding impacts that are linked with other crops or by regulating functions that may result in higher resilience of the agroecosystem. By identifying and managing these functions that faba bean may perform, its ecological and environmental services for vital and sustainable agroecosystems can be estimated and managed at their full value and may contribute to a new appreciation of the particular value of faba bean that has been observed for decades worldwide. Besides giving an overview on the benefits related to faba bean, this contribution also aims to deliver information on relevant environmental processes related to faba bean cultivation that are insufficiently described in the literature and thus need more research.

2. Biological nitrogen fixation (BNF)

2.1. BNF: potential and limitations

The principal agronomic advantage of faba bean is its ability to fix nitrogen by symbiosis with *Rhizobium* bacteria, and thereby substantially contribute to the supply of protein for human food and animal feed and greatly reduce dependence on energy-consuming mineral N fertilizers. It is an advantage that in contrast to other legumes, faba bean can maintain high rates of BNF in the presence of high amounts of available N in the soil (Hardarson et al., 1991; Schwenke et al., 1998; Turpin et al., 2002), a fact that can be attributed to its low rooting density and rooting depth compared with other pulses and most notably fodder legumes. Up to 96% of the N taken up by the crop has been measured as nitrogen derived from atmosphere (NdfA) (López-Bellido et al., 2006). For fertile soils, NdfA values between 60% and 80% have been reported several times for temperate regions or with irrigation (Carranca et al., 1999; Peoples et al., 2009). This share is mainly determined by the amount of soil nitrogen available and accessible for uptake by faba bean.

The literature reports values of symbiotically fixed N under field conditions ranging from 15 (Schwenke et al., 1998) to 648 kg N/ha (Sprent et al., 1977). The high variation is a result of variation in specific growing conditions, genotypic variations, and variations in the methods used for determining BNF. For practical purposes the various methodological obstacles for the accurate appraisal of BNF (Bergersen, 1980; Peoples and Herridge, 1990; Unkovich and Pate, 2000; Peoples et al., 2009) can be overcome by rough estimation of the amount of N symbiotically fixed based on the fact that for mature faba bean, BNF is correlated with grain yield and more closely with the amount of nitrogen bound in the grain (Fig. 1; Hauser, 1992; Köpke, 1987/1996a, 1995; Schulz et al., 1999a).

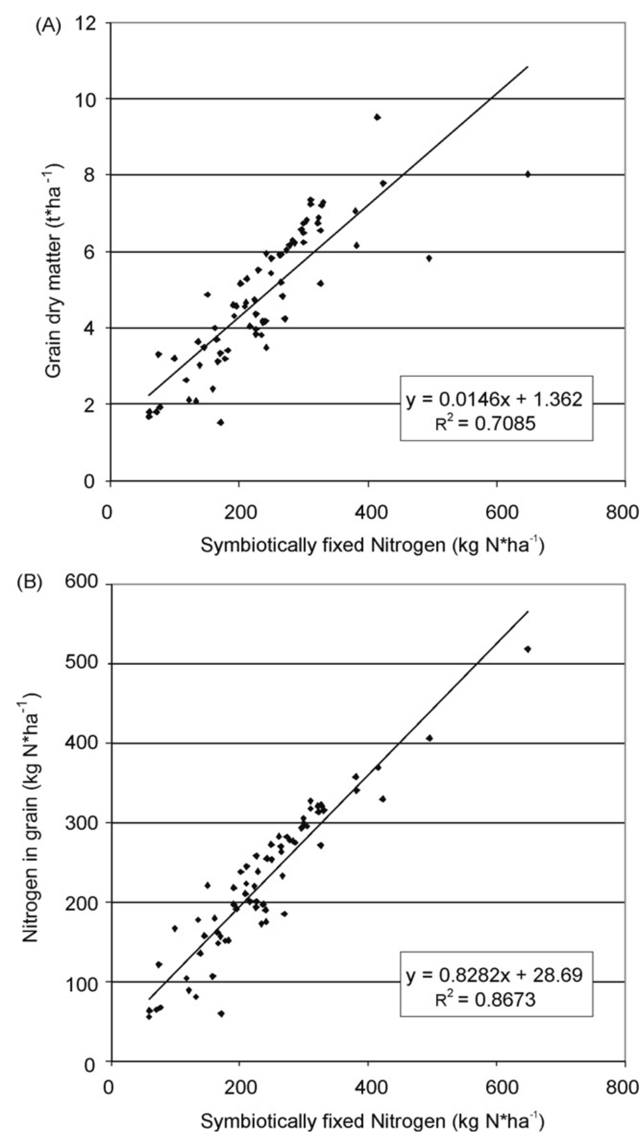

Fig. 1. Relationship between symbiotically fixed nitrogen and grain dry matter yield (A) and grain nitrogen (B).Data derived from Hauser (1987) (all available data from the literature until 1987 amended by own data (Hauser, 1987; Köpke, 1987/1996a).