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Lucerne management in an organic farming system under dry site conditions

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Abstract

Biological nitrogen fixation (BNF) as a result of the legumes–rhizobia symbioses is the main source of nitrogen in organic farming systems. Lucerne (*Medicago sativa* L.), used as green manure or as forage legume, is important on arable farms under dry site conditions. In a field experiment on organically managed agricultural fields, we examined the impacts of the utilisation system (harvested = forage production versus mulched = green manure) and the crop composition (pure lucerne crops versus lucerne–grass mixtures) on yield, biological nitrogen fixation (BNF), soil inorganic N content, N balance and water consumption of autumn-cultivated lucerne crops. The study was conducted at the University of Natural Resources and Applied Life Sciences, Vienna, in eastern Austria—a region characterized by pannonian site conditions (9.8 °C mean annual temperature, 545 mm average total precipitation) and stockless farming systems. Our results indicate that the utilisation system and the crop composition had no marked influence on above- and below-ground dry matter (DM) and N yield, soil inorganic N contents, BNF, or water use efficiency of lucerne. The level of symbiotically fixed N_2 in harvested lucerne was 89–125 kg N ha^{-1} (27–33% Ndfa = nitrogen derived from atmosphere) in the first year and 161–175 kg N ha^{-1} (47–49% Ndfa) in the second year of the study. The high soil inorganic N supply in the first year increased the N uptake from soil by lucerne and led to a reduced BNF. Under the dry and unfavourable conditions in both study years, the nitrogen release from the legume mulch was retarded and BNF in mulched lucerne was not reduced. Assuming low gaseous N losses by mulching (15–30 kg N ha^{-1}), the green manure system reached a positive N balance (+137 to +186 kg N ha^{-1}) for the subsequent crops because abundant residues remained on the field.

Keywords: Forage legumes; Green manure; Lucerne; Nitrogen fixation; *Medicago sativa*; Water use efficiency

1. Introduction

Organic farming has to be self-sufficient in nitrogen because the use of mineral nitrogen fertilisers is excluded. The cornerstone for soil fertility in organic farming is the use of legumes to fix atmospheric N_2. The task is to find a balance between the supply and demand of N by using these fertility-building crops in the rotation. Lucerne (*Medicago sativa* L.) is an important fodder legume in organic farming systems, mainly under dry site conditions. This plant improves the yield and quality of following crops by fixing nitrogen from the air (Bruulsema and Christie, 1987), reduces diseases and weeds, increases soil organic matter contents and improves water infiltration (Meek et al., 1990; Campbell et al., 1990). The annual nitrogen fixation rates of lucerne range broadly from 85 to 360 kg N ha^{-1} (Frame et al., 1998). The resulting N benefit to succeeding crops is very variable, depending on the performance of the lucerne crop.

Environmental factors and management practices (e.g. cutting and removal versus cutting and mulching) affect the fixation process and the amount of N_2 fixed (Cuttle et al., 2003). Fluctuations in weather patterns influence legume growth and N_2 fixation activity by causing environmental stress phases (e.g. drought, high temperatures). These phases limit nitrogen fixation, directly by effects on nodule formation or function, indirectly through the host plant's ability to supply nutrients (Cuttle et al., 2003). Soil factors also play an important role in legume growth and N_2 fixation (e.g. nitrogen and other nutrients). The negative relationship between mineral-N contents in soil and nitrogen fixation rates is well known.

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