Journal of Integrative Agriculture 2018, 17(1): 220–230

Available online at www.sciencedirect.com

ScienceDirect

RESEARCH ARTICLE

Nitrogen uptake and transfer in broad bean and garlic strip intercropping systems

TANG Qiu-xiang[1, 2], Haile Tewolde[3], LIU Hong-bin[2], REN Tian-zhi[4], JIANG Ping-an[1], ZHAI Li-mei[2], LEI Bao-kun[5], LIN Tao[6], LIU En-ke[7]

[1] *College of Agronomy, Xinjiang Agricultural University, Urumqi 830052, P.R.China*
[2] *Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences/Key Laboratory of Nonpoint Source Pollution Control, Ministry of Agriculture, Beijing 100081, P.R.China*
[3] *Crop Science Research Laboratory, USDA-ARS, MS 39762, USA*
[4] *Agro-environmental Protection Institute, Ministry of Agriculture, Tianjing 300191, P.R.China*
[5] *Institute of Agriculture Environmental Resources Research, Yunnan Academy of Agricultural Sciences, Kunming 650205, P.R.China*
[6] *Institute of Industrial Crops, Xinjiang Academy of Agricultural Sciences, Urumqi 830091, P.R.China*
[7] *Institute of Environment and Sustainable Development in Agriculture, Chinese Academy of Agricultural Sciences, Beijing 100081, P.R.China*

Abstract

Utilization and transfer of nitrogen (N) in a strip intercropping system of garlic (*Allium sativum* L.) and broad bean (*Vicia faba* L.) have been investigated rarely. The objectives of this study were to quantify N uptake and utilization by intercropped broad bean and garlic and determine the magnitude of N transfer from broad bean to garlic. Field and pot trials were carried out in the Erhai Lake Basin in China using ^{15}N tracer applied to the soil or injected into broad bean plants. Strip intercropping of garlic and broad bean increased N absorption (47.2%) compared with sole crop broad bean (31.9%) or sole crop garlic (40.7%) and reduced soil residual N. Nearly 15% of ^{15}N injected into petioles of broad bean intercropped with garlic was recovered in garlic at harvest, suggesting that N could be transferred from broad bean to strip intercropped garlic. The findings provide a basis for evaluating legumes' role in optimizing N fertilization when intercropped with non-legumes.

Keywords: legumes, sole crop, ^{15}N abundance, nitrogen isotope, rhizoshpere

1. Introduction

Intercropping, which is the practice of growing two or more crops simultaneously on the same field, is the essence of Chinese traditional agriculture. Legumes are involved in 70% of more than 100 intercropping systems in China (Xiao *et al.* 2005). Broad bean (*Vicia faba* L.), which has a good ability to fix N_2 and adaptability to a wide range of soils, is planted on up to 2 million ha worldwide (Unkovich and Pate

Received 23 January, 2017 Accepted 4 August, 2017
TANG Qiu-xiang, Mobile: +86-15299175098, E-mail: 790058828@qq.com; Correspondence REN Tian-zhi, E-mail: rentianzhi@caas.cn

© 2018 CAAS. Publishing services by Elsevier B.V. All rights reserved.
doi: 10.1016/S2095-3119(17)61772-6

2000) and has attracted attention of researchers in the last 20 years (Rochester *et al.* 1998; Unkovich and Pate 2000; Mayer *et al.* 2003).

Nitrogen (N) transfer from legumes to non-legumes has been reported extensively. For instance, Li *et al.* (2003) found that the N absorption of intercropped maize (*Zea mays* L.) and broad bean was higher than that of a sole crop maize or broad bean. ^{15}N tracer approach can be used to measure the N-fixing ability of legumes in an intercropping system directly and N absorption from different sources such as soil, fertilizer, and air (Zhu and Yang 1992). Using the ^{15}N tracer approach, the study of Danso *et al.* (1993) revealed that intercropping, compared with sole crop, improved N absorption by 26.3% and biomass by 21%. Fujita *et al.* (1990) found N transfer from pea (*Pisum sativum* L.) to sorghum (*Sorghum bicolor* L.) accounted for 32–58% of the total N absorption of sorghum in a pea-sorghum intercropping system. In other crops, the transfer of N from legumes to non-legumes was found to range from 2 to 17% in pea and oat (*Avena sativa* L.) (Papastylianou and Danso 1991), alfalfa (*Medicago sativa* L.) and bromegrass (*Bromus riparius* Rhem.), alfalfa and timothy-grass (*Phleum pratense* L.) (Ta *et al.* 1989; Tomm *et al.* 1994), maize and cowpea (*Vigna unguiculata* L.) (Eaglesham *et al.* 1981), and subterranean clover (*Trifolium subterraneum* L.) and annual ryegrass (*Lolium rigidum* Gaud.) (Ledgard *et al.* 1985). In the clover-ryegrass mixed stand, N transfer contributed strongly to the N budget of the companion ryegrass, especially in the stands where leaf fall contributed to the transfer. The uptake of clover-derived N by a companion grass may have implications for ley composition and feeding value as well as for the effects of mixed green manure and catch crops in agriculture (Dahlin and Stenberg 2010). Sierra and Desfontaines (2009) studied N transfer using ^{15}N leaf feeding method and concluded that N transfer from root exudates of jackbean (*Canavalia ensiformis* L.) would be a useful but minor process compared with N release from root turnover in soil. Other studies indicated that non-legums can benefit from the N transfer from legumes in an intercropping system (Giller *et al.* 1991; Zhu and Yang 1992; Frey and Schüepp 1993; Høgh-Jensen and Schjoerring 2000), but the amount of N transfer varies greatly depending on crop species.

Garlic (*Allium sativum* L.) is another crop grown in the same regions where broad bean is grown in China, the two crops are rarely intercropped although both crops may benefit from intercropping. Our earlier work revealed that intercropping of garlic and broad bean is suitable for planting in China because the practice improved yield and land use efficiency with land equivalent ratio of 1.15 (Tang *et al.* 2012, 2013). The basis for these benefits may be attributed to complementary N utilization and transfer between these two crops in an intercropping system. However, this has not been thoroughly investigated. The objective of this study was to use the ^{15}N tracer method to quantify N uptake and utilization by intercropped broad bean and garlic and determine the magnitude of N transfer from broad bean to garlic. The findings are expected to provide theoretical basis for evaluating role of legumes in N accumulation and optimizing N fertilization in an intercropping system of these two crops but also of other legumes and non-legumes.

2. Materials and methods

2.1. Experimental site

The study was carried out from September 2009 to May 2010 in a black loam soil in the Erhai Lake basin, China (100°13´E, 25°35´N). The location has a monsoon climate receiving an average of 800 to 1 100 mm annual rainfall, concentrated mostly in April to September. Other climatic characteristics of the location include 2 440 h annual sunshine duration, 240 frost-free days, about 15°C annual average temperature, and 69% annual average relative humidity. Garlic is the main crop in this region.

The study consisted of three complementary tests, two in the field in 1-m^2 mini-plots and one in the greenhouse in pots. The same soil was used in all three tests. Prior to initiating the study, the soil had 82.2 g kg^{-1} organic matter, 4.32 g kg^{-1} total N, 2.49 mg kg^{-1} ammonium N, 2.5 mg kg^{-1} nitrate N, 30.5 mg kg^{-1} Olsen-P, and pH 6.46.

2.2. Experimental design

Mini-plots The first of the two mini-plot tests, which is referred hereafter as Test 1, had three treatments, which included broad bean sole crop (Fig. 1), garlic sole crop (Fig. 2), and garlic-broad bean strip intercrop (Fig. 3). The design was a randomized complete block with four replications. Garlic cultivar Hongqixing and broad bean cultivar Yundou 06 were selected as the plant materials for the test. The sole crop broad bean mini-plots were planted with primed seeds at a spacing of 0.15 m between rows and 0.15 m between plants within a row. The sole crop garlic mini-plots were planted with cloves at a spacing of 0.08 m between rows and 0.06 m between cloves within a row. The planting of the intercropped mini-plots had a pattern of four rows of garlic (4G) after two rows of bean (2B) for a total of four rows of broad bean and eight rows of garlic (2B-4G-2B-4G). All mini-plots in the test had a dimension of 1 m×1 m each of which was established in the center of a larger plot measuring 5 m×4.8 m. The larger plots within a replication were spaced 0.3 m apart and, therefore, the mini-plots within a replication were spaced 4.3 m apart.

Download English Version:

https://daneshyari.com/en/article/8875751

Download Persian Version:

https://daneshyari.com/article/8875751

Daneshyari.com