Study on Nitrogen Surplus in Organic, Low-Input and Conventional Cropping Systems in Greenhouse

HUI HAN[1], RUIHUA GUO[2], YUBAO YANG[3], JI LI[4]

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Abstract:

This study was based on a long-term field trials of three different vegetable cropping systems (organic (ORG), low-input (LOW) and conventional (CON)) in greenhouse initiated in 2002. The apparent nitrogen (N) surplus which equals to N input (N of fertilizer, manure, transplants and irrigation) minus N output (N of the eggplants) was compared to provide the reference for the development of high-yielding and sustainable cropping system. The main conclusions were as follows: The net N surplus in ORG, LOW and CON systems was 971 kg ha^{-2}, 1046 kg ha^{-2} and 1317 kg ha^{-2}, respectively, and ORG system was 7.2% and 26.3% lower than LOW and CON systems, respectively. The eggplant production in ORG system was 0.1% higher than LOW system and 3.6% higher than CON system. These data showed that ORG system tends to be higher yield and lower net N surplus, leading to higher N use efficiency when compared with LOW and CON systems.

Introduction

Since the 1970s, many ecological problems have been caused by excessive N application in China. Thus some alternative agriculture has been put forward and organic agriculture is one of them. Recently, China's production of greenhouse vegetable has become the biggest in the world (Duan et al. 2010). In the major areas of China, N fertilizer application rates are about 1100-1500 kg ha^{-1} in the north (Ju et al. 2009), and 900-1300 kg ha^{-1} in the south (Shi et al. 2009).

The objective of the study was to compare the N surplus in three systems in order to provide references for the development of high-yielding and sustainable cropping system.

A formula of N surplus which equals to N input minus N output was used in this paper. The N input includes N of fertilizer, transplants and irrigation while the N output comes from N of vegetable. And the leaching, denitrification, NH_3 volatilization and different forms of N in the soil were included in N surplus.

Material and methods

Experimental site and design

The long-term experiment was initiated in June 2002 on a salinized cinnamon soil at Quzhou Agricultural Experimental Station (36º52´N, 115º01´E) in Quzhou, Hebei province, North China. Precipitation averages 604 mm year^{-1}.

This experiment was conducted in three side-by-side greenhouses with three cropping systems: 1) conventional system (CON): use a small amount of animal dung (water content was 33.40 %) and chemical fertilizer; 2) low-input system (LOW): animal dung (water content was 33.40 %) and lower amount of chemical fertilizer; 3) organic system (ORG): only use animal dung (water content was 33.40 %). The total irrigation rate during this periods was 5275 m^3 ha^{-1} in each system.
At each greenhouse there were 3 subplots and all data were taken from individual subplot separately. During this research, seedlings of eggplant were transplanted into each greenhouse on March 12, 2011 and harvested on July 15, 2011.

[1] Hui Han-China Agricultural University, China, www.cau.edu.cn, eMail: hh071@163.com
[2] Ruihua Guo-China Agricultural University, China, www.cau.edu.cn, eMail: b461400@qq.com
[3] Yubao Yang-China Agricultural University, China, www.cau.edu.cn, eMail: 304466yuxiao@163.com
[4] Ji Li-China Agricultural University, China, www.cau.edu.cn, eMail: liji@cau.edu.cn

Sampling and data collection

Three transplants were taken before transplanting and one plant sample was taken from each plot of each greenhouse on April 30, May 12, May 23, June 1, June 11 and July 15. Two lines of eggplants were chosen in each plot of each greenhouse for biomass weighting. Samples of irrigation water were collected from a well near the greenhouses.

The selected plants were separated into stems, leaves and fruits (without consideration of residues below the ground), oven-dried at 80 ℃ for about 24 h and ground to a 0.5-mm powder.

Total N in plants and manure samples was analysed by the Kjeldahl method (Bao 2000) and total N in irrigation water was measured by Alkaline potassium persulfate digestion - UV spectrophotometric method.

Soil nitrogen balance was calculated by following formula (van Eerdt and Fong 1998, Oenema et al. 2003):

N surplus = input components (fertilizer + manure + N from transplant + N from irrigation) - output components (N removed by aboveground plant parts).

The N surplus represented N that was lost by ammonia volatilization, denitrification or leaching, or stored in various soil fractions.

Results

Nitrogen input

Total N content of animal dung and irrigation water was 11.92 g kg^{-1} and 7.77 mg L^{-1}, respectively. Fig.1 showed the accumulated total N input in different periods. And total N input of ORG, LOW and CON systems averaged 1150 kg ha^{-1}, 1182 kg ha^{-1} and 1433 kg ha^{-1}, respectively. Fertilizer and manure was the main source of N nutrient, contributing 96.32 %, 96.42 %, 97.05 %, respectively.

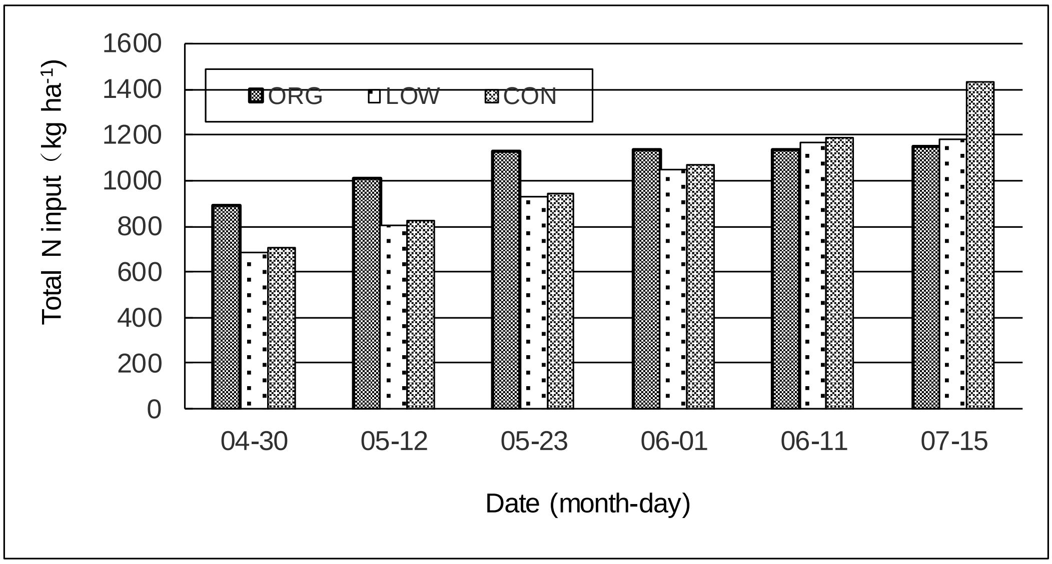

Figure 1. Changes of accumulated total N input in different periods under three cropping systems

Nitrogen output

Fig.2 summarized the N output of different growing periods of eggplant. It showed the N uptake and utilization of eggplant was lower during the vegetative stage and became higher during the reproductive stage, especially after the fruitage. The total N output of ORG, LOW and CON systems was 178 kg ha^{-1}, 135 kg ha^{-1} and 116 kg ha^{-1}, respectively, and the yield of them was 93458 kg ha^{-1}, 93320 kg ha^{-1} and 90209 kg ha^{-1}, but no significant differences were found.

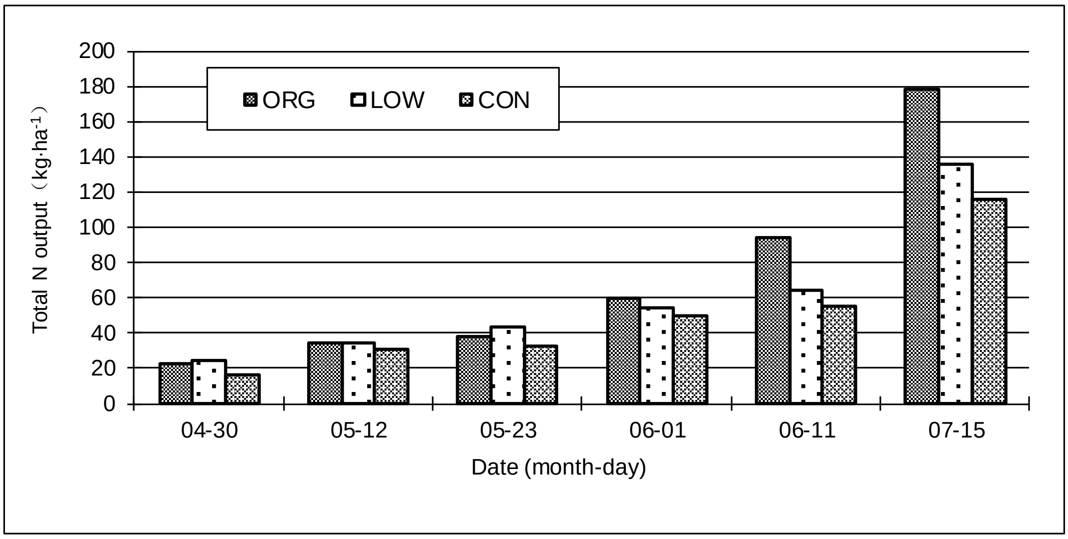

Figure 2. Changes of total N output in different periods under three cropping systems

Nitrogen balance

The net N surplus in ORG, LOW systems increased at beginning stages, and then decreased, but it increased at all stages in CON system (Fig.3). This may be led by two reasons: on the one hand, fertilizer application frequency under ORG, LOW and CON systems was four, six and eight, respectively and the amount of fertilizer in CON system was the most. On the other hand, the N uptake of eggplant increased greatly at fruitage, which leaded to decline of N surplus in ORG and LOW systems. The net N surplus in ORG, LOW and CON systems was 971 kg ha^{-2}, 1046 kg ha^{-2} and 1317 kg ha^{-2}, respectively. ORG system showed the least total N input and net N surplus.

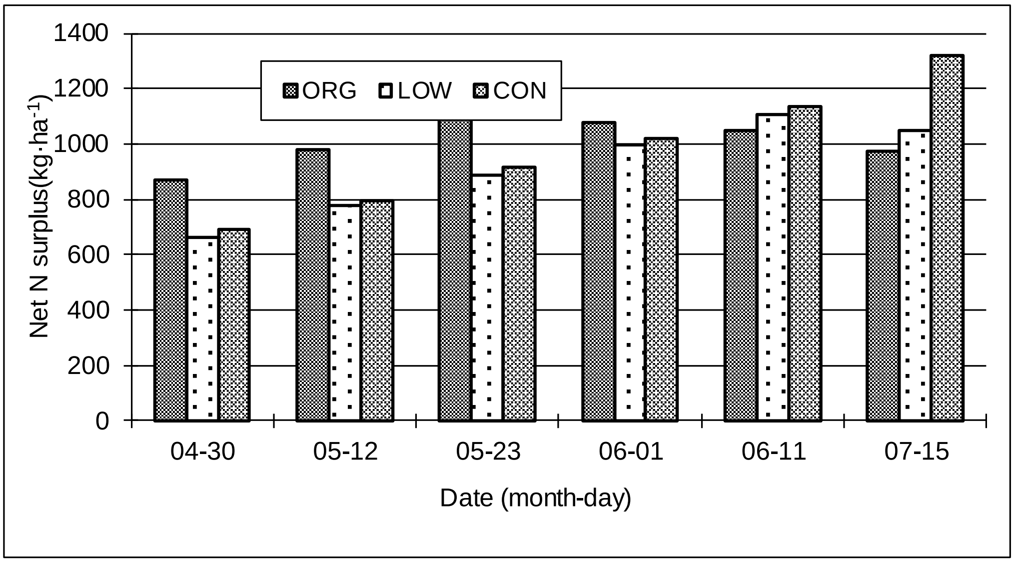

Figure 3. Changes of net N surplus in different periods under three cropping systems

Discussion

The total N input of ORG, LOW and CON systems averaged 1150 kg ha^{-1}, 1182 kg ha^{-1} and 1433 kg ha^{-1}, respectively. Total N output of ORG, LOW and CON systems was 178 kg ha^{-1}, 135 kg ha^{-1} and 116 kg ha^{-1}, respectively, and the yield of them was 93458 kg ha^{-1}, 93320 kg ha^{-1} and 90209 kg ha^{-1}. The net N surplus in ORG, LOW and CON systems was 971 kg ha^{-2}, 1046 kg ha^{-2} and 1317 kg ha^{-2}, respectively. Beside having very competent yield , ORG showed the lowest N input, highest N output and lowest N surplus compared with LOW and CON systems.

This result indicated that containing almost the same nitrogen content, manure had much more effects on decreasing N surplus than chemical fertilizers. This may be related to the higher organic nitrogen content, lower mineralization rate and lower proportion of leaching nitrate nitrogen in manure than chemical fertilizer. This research finding revealed the benifit of ORG in terms of reducing nitrogen loss over LOW and CON systems.

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