Journal of Integrative Agriculture 2015, 14(6): 1212–1221

ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

RESEARCH ARTICLE

Carbon and nitrogen allocations in corn grown in Central and Northeast China: different responses to fertilization treatments

MIAO Hui-tian[1,2], LÜ Jia-long[1], XU Ming-gang[2], ZHANG Wen-ju[2], HUANG Shao-min[3], PENG Chang[4], CHEN Li-ming[5]

[1] *College of Natural Resources and Environment, Northwest A&F University, Yangling 712100, P.R.China*

[2] *Key Laboratory of Crop Nutrition and Fertilization, Ministry of Agriculture/Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing 100081, P.R.China*

[3] *Institute of Plant Nutrition and Environmental Resources Science, Henan Academy of Agricultural Sciences, Zhengzhou 450002, P.R.China*

[4] *Agricultural Resources and Environment Research Center, Jilin Academy of Agricultural Sciences, Changchun 130124, P.R.China*

[5] *School of Environment and Natural Resources, The Ohio State University/The Ohio Agricultural Research and Development Center, Wooster, OH 44691, USA*

Abstract

In order to reveal the impact of various fertilization strategies on carbon (C) and nitrogen (N) accumulation and allocation in corn (*Zea mays* L.), corn was grown in the fields where continuous fertilization management had been lasted about 18 years at two sites located in Central and Northeast China (Zhengzhou and Gongzhuling), and biomass C and N contents in different organs of corn at harvest were analyzed. The fertilization treatments included non-fertilizer (control), chemical fertilizers of either nitrogen (N), or nitrogen and phosphorus (NP), or phosphorus and potassium (PK), or nitrogen, phosphorus and potassium (NPK), NPK plus manure (NPKM), 150% of the NPKM (1.5NPKM), and NPK plus straw (NPKS). The results showed that accumulated C in aboveground ranged from 2 550–5 630 kg ha^{-1} in the control treatment to 9 300–9 610 kg ha^{-1} in the NPKM treatment, of which 57–67% and 43–50% were allocated in the non-grain organs, respectively. Accumulated N in aboveground ranged from 44.8–55.2 kg ha^{-1} in the control treatment to 211–222 kg ha^{-1} in the NPKM treatment, of which 35–48% and 33–44% were allocated in the non-grain parts, respectively. C allocated to stem and leaf for the PK treatment was 65 and 49% higher than that for the NPKM treatment at the both sites, respectively, while N allocated to the organs for the PK treatment was 18 and 6% higher than that for the NPKM treatment, respectively. This study demonstrated that responses of C and N allocation in corn to fertilization strategies were different, and C allocation was more sensitive to fertilization treatments than N allocation in the area.

Keywords: long-term fertilization, corn, carbon allocation, nitrogen allocation

1. Introduction

Nitrogen (N), phosphorus (P) and potassium (K) are primary macronutrients for high plants. They are required in large amounts for plant growth. When soils cannot provide sufficient amount of these elements for a crop, its yield will

Received 4 March, 2014 Accepted 21 April, 2014
MIAO Hui-tian, Mobile: +86-18429043029, E-mail: huitian_miao@aliyun.com; Correspondence XU Ming-gang, Tel: +86-10-82105636, E-mail: xuminggang@caas.cn; LÜ Jia-long, E-mail: ljlll@nwsuaf.edu.cn

doi: 10.1016/S2095-3119(14)60790-5

decrease greatly. Jenkinson (1991) reported that long-term use of mineral fertilizers at the Rothamsted long-term classic experiments could sustain crop yields for more than 100 years. N deficiency in soils and crops is more common than other nutrients. In the US, 97% of the corn-planted area requires N fertilizer applied (Economic Research Service 1996). Chen *et al.* (2008) reported that optimal N fertilizer rate was 133–233 kg ha^{-1} for corn in Ohio, US. In China, excessive N fertilizer application is very common (Li *et al.* 2005, 2008), which not only increases costs but also potentially pollutes groundwater, rivers and lakes with nitrate (Zhu and Chen 2002; Ju *et al.* 2009).

In the past two decades, sustainable agriculture has received great attention worldwide and manure has been used increasingly in the US and China. Applying organic matter can improve soil physical and chemical properties, increase soil organic carbon (SOC) and provide nutrients for crops (Huang *et al.* 2014; Xu *et al.* 2014). SOC is a fundamental indicator for soil fertility and plays a key role in soil nutrient cycles (Ingram *et al.* 2005; Rasool *et al.* 2008; Yang *et al.* 2012) and is also an important factor for maintaining agricultural productivity (Lal 1991; Zha *et al.* 2014). Additionally, SOC sequestration can act as CO_2 sink and mitigate global climate change (Christopher *et al.* 2009).

Manure application and straw incorporation were efficient ways to increase C input into soils (Izaurralde *et al.* 2001), which might enhance SOC accumulation, thereby affect crop yield (Mohammad *et al.* 2012). A number of studies indicated that SOC content under the treatment with farmyard manure combined with chemical fertilizers continuously applied for over 20 years was significantly higher compared to the treatment of chemical nitrogen, phosphorus and potassium (NPK) (Manna *et al.* 2006; Zhang *et al.* 2010, 2012; Yang *et al.* 2014). It was concluded that the practice to apply both chemical fertilizers and farmyard manure is an efficient way to enhance crop yield (Manna *et al.* 2006). Similarly, Lou *et al.* (2011) reported that a high rate of straw incorporation could lead to a significant increase in SOC.

Fertilizer practices might affect C and N accumulation and allocation in different organs of a crop, which could determine terrestrial C and N cycling. To date, there are a few literatures to investigate the relationships between the practices and C and N allocation in corn. He *et al.* (2001) reported that higher rates of inorganic N application increased the percentage of C and N allocation in aboveground of corn. A recent study also showed that there was a positive N effect on aboveground C accumulation (Gentilesca *et al.* 2013). However, there is a lack of systematic analyses on the effect of various long-term fertilization practices on C and N accumulation and allocation in different corn organs in North China.

In this study, we tried to assess the impacts of fertilization management on C and N accumulation and allocation in various corn organs in long-term fertilization experiments at two sites in Central and Northeast China with different soils and climates.

2. Results

2.1. Dry weight of corn organs and harvest index under various fertilizations at Zhengzhou site

Dry weight of each organ for the NPK plus manure and 70% of nitrogen from manure (NPKM) treatment was significantly higher than that for the other treatments (Table 1). Grain weight for the PK treatment (2 500 kg ha^{-1}) was significantly lower than that for the NPKM treatment (11 500 kg ha^{-1}). Weight of stem and leaf for the NPKM treatment (7 910 kg ha^{-1}) was 196% higher than that for the control treatment (2 680 kg ha^{-1}). Cob weight for the NPKM treatment was two times of that for the control and chemical phosphorus and potassium (PK) treatments. As a consequence, dry weight of aboveground for the NPKM treatment was significantly higher than that for the NPK, 1.5NPKM and NPK plus straw and 70% of nitrogen from corn straw (NPKS) treatments.

Table 1 Dry weight of different corn organs and harvest indexes under various fertilization treatments at the Zhengzhou site in 2008

Treatments[1)]	Grain (kg ha^{-1})	Stem and leaf (kg ha^{-1})	Cob (kg ha^{-1})	Aboveground (kg ha^{-1})	Harvest index
Control	2 310 f	2 680 f	597 e	5 580 e	0.414 f
N	3 730 e	3 340 e	883 d	7 950 d	0.469 e
NP	9 600 c	5 750 c	1 020 c	16 400 c	0.587 a
PK	2 500 f	5 130 d	565 e	8 200 d	0.305 g
NPK	10 200 b	7 220 b	1 100 b	18 600 b	0.552 b
NPKM	11 500 a	7 910 a	1 210 a	20 600 a	0.558 b
1.5NPKM	8 550 d	7 340 b	1 010 c	16 900 c	0.506 d
NPKS	8 810 d	6 870 b	984 c	16 700 c	0.529 c

[1)] Control, non-fertilizer; N, chemical nitrogen; NP, chemical nitrogen and phosphorus; PK, chemical phosphorus and potassium; NPK, chemical nitrogen, phosphorus and potassium; NPKM, chemical NPK fertilizers plus manure and 70% of nitrogen from manure; 1.5NPKM, 150% of NPKM; NPKS, chemical NPK fertilizers plus straw and 70% of nitrogen from corn straw.
Different letters in the same column are significantly different at $P \leq 0.05$.
The same as below.