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Research article

Cutting environmental footprints of maize systems in China through Nutrient Expert management

Shaohui Huang [a,b], Wencheng Ding [a], Liangliang Jia [b], Yunpeng Hou [c], Jiajia Zhang [a], Xinpeng Xu [a], Rui Xu [a], Sami Ullah [a,d], Yingxia Liu [a], Ping He [a,*]

[a] *Ministry of Agriculture Key Laboratory of Plant Nutrition and Fertilizer, Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences (CAAS), Beijing, 100081, PR China*

[b] *Hebei Fertilizer Technology Innovation Centre, Institute of Agricultural Resources and Environment, Hebei Academy of Agriculture and Forestry Sciences, Shijiazhuang, 050051, PR China*

[c] *Jilin Academy of Agricultural Sciences, Changchun, Jilin, 130124, PR China*

[d] *Department of Biology, University of Okara, Okara, 56130, Pakistan*

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ABSTRACT

Excessive fertilizer consumption, poor management, and intense pollution currently restrict sustainable agriculture in China. To address these problems, two 9-year experiments involving typical maize production systems in Northcentral China (summer maize) and Northeast China (spring maize) were conducted to evaluate the effectiveness of Nutrient Expert (NE) management, a Nutrient Decision Support System which combines 4 R nutrient management with improved varieties and optimized plant density, on reducing carbon (C) and nitrogen (N) footprints. The mean grain yields under NE were 7.4 and 11.5 tons ha^{-1}, which were 3.9% and 6.9% higher than those of local farmers' practices (FP) in the summer and spring maize systems, respectively; the N-derived (affected by N fertilization) yield accounted for 21.7% and 73.5% of the total yield under NE, respectively. Compared with FP, NE achieved 21.8% and 16.0% lower reactive nitrogen (Nr) losses, 18.4% and 20.9% lower greenhouse gas (GHG) emissions, 24.8% and 21.4% smaller N footprints (9.1 and 2.3 kg N ton^{-1} grain), and 21.5% and 26.0% smaller C footprints (436 and 206 kg CO_2 eq ton^{-1} grain) in summer and spring maize, respectively. NE reduced the N-derived N and C footprints by 30.3% and 27.2% in summer maize and 22.9% and 28.0% in spring maize, respectively, as a result of greater yields and optimal N management. Moreover, compared with summer maize, spring maize showed significantly smaller N-derived N (12.6-fold) and C (7.2-fold) footprints. The results demonstrated the ability of long-term NE management to sustain maize yields, reduce Nr losses and GHG emissions, and cut C and N footprints, indicating its potential suitability as an alternative management for sustainable agriculture. Moreover, the summer maize system still had considerable potential for environmental footprints reduction even when current NE management practices were adopted.

1. Introduction

The intensification of agriculture has mitigated the pressure of food demand in most developing countries (Fischer and Connor, 2018; Hashemi et al., 2019). However, intensified agriculture depends on the use of large amounts of synthetic fertilizer, especially nitrogen (N) fertilizer (Chen et al., 2014). This fertilizer usage has caused many environmental impacts, such as increased reactive N (nitrous oxide emissions, ammonia volatilization, and N leaching) loss, greenhouse gas (GHG) emissions, soil acidification, and loss of biodiversity (Rockstrom et al., 2009; Cui et al., 2013; Xia et al., 2016). Sustainable agriculture, which maintains grain yields while minimizing environmental costs, is therefore needed (Cassman, 1999; Fischer and Connor, 2018; Solangi et al., 2019).

Reactive nitrogen (Nr) losses and GHG emissions, which reflect environmental impacts, have received increasing attention (Knudsen et al., 2014; Zhou et al., 2019). Moreover, the N and carbon (C) footprints (the quantity of Nr losses and GHG emissions per unit of grain yield) are increasingly being used as environmental indicators in agricultural management research (Wang et al., 2020b). These parameters

* Corresponding author.
E-mail address: heping02@caas.cn (P. He).

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