Environmental Pollution 263 (2020) 114408

Contents lists available at ScienceDirect

Environmental Pollution

journal homepage: www.elsevier.com/locate/envpol

Estimating regional N application rates for rice in China based on target yield, indigenous N supply, and N loss☆

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ARTICLE INFO

Article history:
Received 16 December 2019
Received in revised form
3 March 2020
Accepted 17 March 2020
Available online 28 March 2020

Keywords:
N loss
Soil N depletion
Straw return
Slow-release N
Manure cycling

ABSTRACT

Decision-making related to nitrogen (N) applications based solely on historic experience is still widespread in China, the country with the largest rice production and N fertilizer use. By connecting N application rates with target N uptake, indigenous N supply, and N loss estimates collected from 1078 on-farm experiments, we determined regional N application rates for five rice-based agroecosystems, including a quantification of the reduction potential of application rates when using low-loss N sources, such as organic N and slow-release N. Based on our results, the moderate regional N application rates were 165, 180, 160, 153, and 173 kg N ha^{-1} for single, middle-CE (Central and Eastern China), middle-SW (Southwestern China), early, and late rice, respectively; lower (99–148 kg N ha^{-1}) and upper (195–217 kg N ha^{-1}) limits of N application rates were developed for situations with sufficient and insufficient indigenous N supplies, respectively. The depletion of soil N mineralization was quantified as 46.8–67.3 kg ha^{-1}, and straw return is determined to be a robust measure to maintain soil N balance. Substituting manure or slow-release N for conventional N fertilizer significantly decreased N losses via NH_3 volatilization, leaching, runoff, and N_2O emissions. Overall, we observed 7.2–11.3 percent point reductions of N loss rate for low-loss N sources when compared to conventional N applications. On average, total N application rates could be theoretically reduced by 27 kg N ha^{-1} by using a slow-release N fertilizer, or by 30 kg N ha^{-1} when using manure due to their effectiveness at decreasing system N losses. Greater productivity, sustainable soil fertility, and a lower risk of N pollution would result from the ideal N application rate coupled with appropriate management practices. Widespread adoption of using low-loss N sources could become a key solution for future reduction in environmental N pollution and agricultural N inputs.

1. Introduction

Nutrient management is a key measure for achieving target crop production yields, and ideally matches the nutrient supply with the crop requirements in order to minimize nutrient losses from the fields. Therefore, crop nutrient requirements must be properly quantified, as fertilizer inputs that are lower than the crop requirement can result in low yields and yield quality, and the overuse of fertilizer may result in stagnation or a decrease in yield with considerable potential nutrient loss to the environment (Ju and Gu, 2014). Currently, most farmers in China still use historical experiences to determine their fertilization rate. Consequently, the overuse of N fertilizers to guarantee high crop yields in intensive cropping systems, like that for rice, has become a widespread phenomenon (Cui et al., 2018). As the world's largest rice producer, China consumed 3.9 million tons of N fertilizer, which accounted for 25% of the N fertilizer used in global rice production (FAOSTAT, 2017; IFA and IPNI, 2017). The seasonal N application rate adopted in Chinese rice paddies averaged 209 kg N ha^{-1}, which was 90% higher than the mean level worldwide (Chen et al., 2014). The continuous and excessive N application practice has caused soil degradation (Guo et al., 2010), nitrate pollution to the hydrosphere

☆ This paper has been recommended for acceptance by Dr. Yong Sik Ok.
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https://doi.org/10.1016/j.envpol.2020.114408
0269-7491/