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Space-time statistical analysis and modelling of nitrogen use efficiency indicators at provincial scale in China

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ABSTRACT

Nitrogen use efficiency (NUE) is crucial to establish efficient fertilizer application guidelines that balance crop yield, economic return and environmental sustainability. Although there are quite a few researches about the spatial and temporal variation of NUE, little work has been done on modelling NUE through deriving empirical relationships with explanatory environmental variables and exploring their relative importance quantitatively. The space-time patterns of NUE indicators (i.e., the Partial Factor Productivity of nitrogen, PFP_N, and the Partial Nutrient Balance of nitrogen, PNB_N) at provincial scale in China were derived and related to environmental covariates using stepwise multiple linear regression. PFP_N was higher in east and south China than in central and west China and was smaller than 30 kg kg^{-1} yr^{-1} in most provinces, while PNB_N was moderate in most provinces (0.41–0.50 kg kg^{-1} yr^{-1}) and low (< 0.40 kg kg^{-1} yr^{-1}) in south China. The national PFP_N declined slightly from 32 kg kg^{-1} in 1978 to 27 kg kg^{-1} in 1995 and went up gradually to reach 38 kg kg^{-1} in 2015. The national PNB_N decreased from 0.53 to 0.36 kg kg^{-1} from 1978 to 2003, thereafter stabilizing at around 0.40 kg kg^{-1} yr^{-1} between 2004 and 2015. The multiple linear regression models explained 74 % of the variance of PFP_N and PNB_N. The main explanatory variables of PFP_N were planting area index of sugar crop (32 % of the R-square), followed by Arenosols (12 %), planting area index of oil crop (8 %), planting area index of vegetables (5 %), silt content (5 %) and total potassium (5 %). For PNB_N, the variation was mainly attributed to mean annual daytime surface temperature (28 % of the R-square), planting area index of crops (beans 20 %, orchards 10 % and vegetables 9 %) and wet day frequency (5 %). The results of this study indicate that crop types, temperature and soil properties are important variables that determine NUE. These should be considered by policy makers when agricultural land development decisions are made in order to balance NUE and productivity (i.e., agronomy and environment).

1. Introduction

Cereal crop yields in China increased substantially from 1961 (1200 kg ha^{-1}) to 2017 (6000 kg ha^{-1}), mainly driven by the increasing use of chemical fertilizers, improved crop varieties and agronomic management (Mueller et al., 2012; Chen et al., 2014; FAO, 2018). Nitrogen (N), as a major constituent of chemical fertilizer, is applied to agricultural fields to improve the growth and yield of crop (Sharma and Bali, 2017). For

Abbreviations: ALI, Alisols; AMP, agricultural management practice; AND, Andosols; ARE, Arenosols; BEAN, planting area index of beans; CHE, Chernozems; COA, coarse fragments volumetric; DIE, agricultural diesel engines; DTR, diurnal temperature range; EXH, exchangeable acidity; INC, per capita annual net income of rural households (farmer income); INF, inorganic fertilizer output; KAS, Kastanozems; MEL, planting area index of melons; NUE, nitrogen use efficiency; OIL, planting area index of oil crop; ORC, planting area index of orchards; PFP_N, Partial Factor Productivity of nitrogen; PNB_N, Partial Nutrient Balance of nitrogen; POP, rural population; REG, Regosols; ROC, absolute depth to bedrock; SILT, silt content; STA, Stagnosols; SUG, planting area index of sugar crop; TC, total carbon; THR, motorized threshing machines; TK, total potassium; TMP, mean annual surface temperature at daytime; TOB, planting area index of tobacco; TS, total sulfur; VEG, planting area index of vegetables; VIF, variance inflation factor; WET, wet day frequency

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