

Interactive comment on “Determining the optimal nitrogen rate for summer maize in China by integrating agronomic, economic, and environmental aspects” by G. L. Wang et al.

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We deeply appreciate the reviewers' time and effort to help improve the manuscript. And we have considered the suggestions seriously. Below are our replies to the detailed and constructive comments/suggestions.

Overview of Anonymous Referee #2

Experimental design and context: The study focusses on the application of synthetic N fertilizer in the form of urea solely and no mention of the application of other forms of N sources either in the form of manure and/or in the form of N provided by N fixing legumes as pre-crops. As this study has also the focus to improve smallholder-based cropping systems in China, it's hard to believe that the agricultural land under study is solely fertilized with synthetic N sources. Smallholder agriculture is typically characterized by a high degree of self-sufficiency meaning that livestock plays an essential role and their excrements deliver part of the required fertilizers and contribute to soil organic matter (SOM) reproduction.

Furthermore, the productivity of croplands will decrease over time due to SOM losses along with the decrease in soil structure and other soil quality aspects if organic inputs are not applied on croplands and/or a proper residue management is not considered. In this context carbon release from SOM mineralization might be further stimulated if only mineral N fertilizer is applied without substantial replenishment of SOM pools by organic inputs. This is state of the art knowledge. Therefore, improved cropping strategies, that's what the current manuscript is aiming at, in the 21st century should somehow consider the integrated use of synthetic and organic N inputs as has been postulated in various scientific reviews including the IPCC report of the year 2007.

Reply:

1) The application of synthetic N fertilizer in the form of urea is the main and typical fertilization method for maize in NCP (North China Plain) as well as in other regions in China. As developing fertilizer industry, more and more synthetic N fertilizer was used. A study indicated that, in China synthetic N fertilizer accounted for less than 5% of

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total N input in various forms before 1960, and increased to more than 70% after 2010, including 70% N fertilizer in the form of urea (Ma et al., 2014; Zhang et al., 2013). And more than 90% of cereal crop land area was fertilized with synthetic N fertilizer after 2000 (Ma et al., 2014). Generally, various factors affected farmers' willingness to use organic fertilizer. A survey of 200 farmers selected from Shandong Province in NCP was conducted in 2008 showed that the share of non-copping income in total income, awareness of organic fertilizer benefiting agricultural sustainability, confirming the quantity of organic fertilizer needed by the crops were significant factors (Liu et al., 2010). As mentioned in Discussion, NCP where our study was conducted is the major region with typical smallholder agriculture system in China. In this system, each farmer operates on <1 ha of land, and many educated young farmers have left the industry to other industry with higher profit, leaving the farming work to the older and less-educated individuals. And thus fertilizing organic N was always neglected, and smallholder agriculture with typical high degree of self-sufficiency was broken. Additionally, our experiments were conducted on the NCP with typical winter wheat-summer maize rotation systems. Thus, we focus on the application of synthetic N fertilizer in the form of urea without conditioning the application of N sources in the form of manure or in the form of N provide by N fixing legumes as pre-crops.

2) Yes, the productivity of croplands will decrease over time due to SOM losses if organic inputs are not applied on croplands and/or a proper residue management is not considered. In China, the concept of sustainable development of agriculture has been widely accepted. For defending the decrease in SOM because of the application of only mineral fertilizer, straw returning has been widely applied step by step since the late 90s, which has been an important part in policy and in practice (Shen and Chen, 2009). Many studies have indicated that straw returning could increase soil organic matter content and crop yield. For example, a study for ways of fertilizing soil in wheat-maize rotation system in North China Plain showed that, the integrated use of synthetic N and straw increased SOM and maize yield by an average 1.9 g/kg and 6.2%, respectively (Xing and Han, 2007). Other study indicated that because of the

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increase in crop yield and implementing straw returning, soil organic matter content has been increasing in recent decades in this region (Huang and Sun, 2006). Our study conducted in wheat-maize rotation system in North China Plain, where the straw returning has been widely applied in practice. Thus, there is substantial replenishment of SOM pools by straw returning, even without the application of manure. However, in the future, the pursuit of higher grain yields indeed need the application of manure for improving soil productivity with better soil structure and other soil quality aspects (Fan et al., 2011). In the next work, we might focus on the optimal N rate with high yield cultivation technique by integrating agronomic, economic and environmental aspects, and the application of manure should be considered.

3) On the other hand, there is a shortage of the methods for estimating various reactive N losses from organic N fertilizer at regional scale. Many empirical models and mechanism models were established based on synthetic N fertilizer to estimate reactive N losses at regional scale (Cui et al., 2014; Xia and Yan, 2012). However, Reactive N losses were significantly different between synthetic N fertilizer and organic N fertilizer. For example, with the same N rate application, N₂O-N emission for synthetic N fertilizer was only half of that for organic N (Meng et al., 2005). Thus, other models must be established based on organic N rate for estimating N losses from organic N fertilizer. Generally, the study about organic N fertilizer mostly focused on the effect on grain yield or soil quality, less attention was paid on its' N losses. And thus, the shortage of sufficient data about reactive N losses from organic N fertilizer made the difference for understanding various reactive N losses from organic N fertilizer at regional scale.

Methodological approach: The calculation of the ecologically optimal N rate lacks the consideration of CO₂ and N₂O emissions from N fertilizer production. This is an import source of agricultural greenhouse gases and their reduction/avoidance by technological means is actually an important part of carbon-offset activities in the agro-chemical industry sector. The impact on SOM degradation should also be addressed in the calculation of the ecologically optimal N rate. At least estimates of the loss of soil car-

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bon and the corresponding release of CO₂ should be considered in the climate impact calculation.

Reply:

1) Yes, CO₂ and N₂O emissions from N fertilizer production should be considered for the calculation of the ecologically optimal N rate. And we have included the environment cost associated with CO₂ and N₂O emissions from N fertilizer production and transportation in the update manuscript.

2) As mentioned above, our study conducted in wheat-maize rotation system in North China Plain, where the straw returning has been widely applied in practice, and there is substantial replenishment of SOM pools by straw returning, even without the application of manure. Thus, there is no condition of the impact on SOM degradation in the calculation of environmental cost.

3) In our study, there was no consideration of the effect of CO₂ released by soil respiration on atmospheric warming, the reason was that the contribution of net CO₂ released from soil to greenhouse effect produced by agricultural production systems was lower than 1% (Smith et al., 2007). Generally, CO₂ emission would increase because of N input, while CO₂ would be sequestered by crop production and soil because of the increase in yield (Zhang et al., 2012; Huang et al., 2013). Many studies also indicated that there was debate that crop land as a part of biogeochemical cycle of carbon whether would be a source of C or C-sink (Han et al., 2009, Yang et al., 2003). On the other hand, net CO₂ released from soil might be estimated by quantifying changes in SOC stocks. However, SOC stocks vary as a function of soil texture, landscape position, drainage, plant productivity and soil density, all of which vary spatially and contribute to the spatial variation in SOC stocks, making it difficult to quantify changes in SOC stocks in a short time experiment (Conant et al., 2010).

After all, we have revised the manuscript according to the comments from referee#2, and detailed correction is marked with red in the revised manuscript (including revised

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table 2 and 3, figure 1-4 and Supplementary table 1 and 2). Updated manuscript were showed in supplement as ZIP

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Please also note the supplement to this comment:

<http://www.biogeosciences-discuss.net/11/C559/2014/bgd-11-C559-2014-supplement.zip>

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