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Editorial

An Effective Nutrient Management Strategy for the Emerging Large-Scale Rice Farming in China

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Editorial

With the development of off-farm labor markets, land rental has become more active in rural China [1]. Consequently, a new class of farmers has emerged in recent years who obtain land on lease for large-scale farming. Although these farmers have been taking up new production technologies and using more and more farm machinery, they still use a number of traditional agronomic practices for field management. Several previous studies have confirmed that some of these traditional management practices, such as N application, utilize resources ineffectively and have negative impacts on the environment [2,3]. In China, the average rate of N application for rice production was 180 kg ha-1, about 75% higher than the world average [4]. Because of the high rate of N application, only 20-30% of N is taken up by the rice plant and a large proportion of N is lost to the environment [2]. The losses of N through leaching and runoff have led to drinking water pollution which affects 30% of the population and results in the eutrophication of 61% of lakes in China [5]. Annual synthetic fertilizer N-induced N_2O emission from Chinese croplands has increased from 120 Gg N_2O yr-1 in the 1980s to 210 Gg N_2O yr-1 in the 1990s [6]. Another case study shows that soil pH in the major Chinese crop-production areas has declined significantly from the 1980s to the 2000s because of excessive N fertilizer inputs [3]. Thus, great attention should be paid to optimize the management practices for the emerging large-scale farming systems to obtain environmental and economic benefits. Here we try to deduce an effective nutrient management strategy for the large-scale rice farming in China.

Everyone with field experience, researchers and farmers included, knows that crop productivity varies over the landscape. The reasons for the difference are mainly due to spatial differences in stochastic important soil factors [7]. The task is not trivial but farmers can increase crop productivity and improve resource utilization efficiency if they know enough about their fields [8]. It has been shown that such knowledge can be obtained and mapped and then responded to via GPS and GIS technologies along with variable rate controllers in what is commonly called Precision Agriculture (PA) [9]. In the USA and other countries where the fields are very large there is a growing interest in the use of PA. One of the major goals of the PA research is to define small sections of fields that can be managed in a uniform fashion so as to increase crop yield and profit [8]. In essence PA is a crop management strategy which seeks to address with-in field variability and to optimize inputs on a point-by-point basis within fields [10]. This is in contrast to the situation one finds in China where one also finds that yield varies across the landscape, but rather than having a history of uniform management as in the USA, the landscape is made up of many separate and small fields that are managed by different farmers using different methods. An on-farm survey in 50 adjacent rice fields in Ningxiang, Hunan Province, China showed that significant differences in soil attributes such as pH, and contents of organic matter, alkali-hydrolysable N, Olsen P content and NH4OAc extractable K were found among fields ($P < 0.0001$), but not within fields ($P > 0.05$) (Table 1). These indicate that the large-scale rice farmers in China should look for ways to manage nutrients at field level.

Table 1: *F-values* of analysis of variance for soil attributes in 50 adjacent rice fields in Ningxiang, Hunan Province, China.

Source	pH	Organic matter content	Alkali-hydrolysable N content	Olsen P content	NH_4OAc extractable K content
Among-field	16.01^{****}	9.81^{****}	4.62^{****}	20.56^{****}	10.43^{****}
Within-field	0.20^{ns}	1.07^{ns}	2.62^{ns}	0.26^{ns}	0.28^{ns}

The soil test was based on samples taken from the upper 20 cm of the soil of 3 random sites in each field.
**** Significance at the 0.0001 level.
^{ns} Non-significance at the 0.05 level.

Table 2: Mean fertilizer rate and grain yield of rice grown under Farmers' Fertilizer Practice (FFP) and Site-Specific Nutrient Management (SSNM) in Ningxiang, Hunan Province, China.

Nutrient management	Fertilizer rate (kg ha^{-1})			Grain yield (t ha^{-1})
	N	P_2O_5	K_2O	
FFP	156	44.2	67.7	6.09
SSNM	126	36.5	60.0	6.41
Statistical significance (FFP *vs.* SSNM)[a]	0.001	0.035	0.254	0.037

Data were collected from 48 fields. Each field was divided into two parts with a levee, and FFP and SSNM treatments were randomly assigned to each half of the field.
[a] Based on Paired *t* test.

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There have been two principal approaches for satisfying crop demand for nutrient and minimizing nutrient losses: plant-based and soil and fertilizer-based [11]. Site-Specific Nutrient Management (SSNM) is a plant-based approach, which provides a field-specific approach for dynamically applying nutrients to rice as and when needed [12,13]. This approach advocates optimal use of indigenous nutrients originating from soil, plant residues, manures, and irrigation water. Fertilizers are then applied in a timely fashion to overcome the deficit in nutrients between the total demand by rice to achieve a yield target and the supply from indigenous sources. SSNM has been used successfully to improve nutrient use efficiency in rice [14,15]. We compared fertilizer rate and grain yield of rice grown under Farmers' Fertilizer Practice (FFP) and SSNM by using data from farmers' fields in Ningxiang, Hunan Province, China. Paired t test showed that SSNM produced significantly higher grain yield ($P < 0.05$) with significantly lower N ($P < 0.01$) and P_2O_5 ($P < 0.05$) rates and an equal K_2O rate ($P > 0.05$) as compared to FFP (Table 2). These results support that SSNM is an effective approach to improve nutrient use efficiency in rice at field level.

Taken together, we conclude that implementing SSNM at field level may be a feasible way to improve nutrient use efficiency for the large-scale rice farming in China.

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