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Chinese land policies and farmers' adoption of organic fertilizer for saline soils

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ABSTRACT

Soil salinization has become a global concern and poses a great threat to food production and sustainable land use. Land use policies are the main driver of saline soil farmland use in ecosystems. This paper proposes a theoretical framework for analyzing how saline soil farmland use is affected by land use practices of individual farm households. An empirical study, using an ordered probit model, was conducted based on questionnaire responses from farm households in 8 towns and 14 villages in eco-fragile areas in Shandong, Jilin and Xinjiang provinces. The results suggest that land tenure, state systems agricultural support, characteristics of a field parcel and characteristics of the farm households have different influences on farmer's land use in three regions. The adoption of organic fertilizer by individual households is constrained by the lack of stability and integrity in land tenure. Furthermore, the parcel of a field is generally small, sparsely distributed and often fragmented, which increases costs. Even subsidizing organic fertilizer does not necessarily help in its adoption. Given these challenges, this study makes recommendations for different regions that may promote the adoption of improved saline soil farmland cultivation methods by farmers.

Introduction

Rapid economic development and population growth have resulted in a significant increase in the demand for food worldwide (Binns, 2007; Qiu et al., 2011). Saline soil is widely present in China, especially in the Yellow River delta, the western Songnen Plain and the Xinjiang region (Yang, 2008), and ecological, agronomic and engineering techniques have been integrated in the sustainable development of saline soil farmland use (Wen et al., 2012). Several studies have focused on issues related to land use and land cover change using GIS and remote sensing (Metternicht and Zinck, 2003) combined with projects related to saline soil reclamation technology (Rengasamy, 2002; Roberts et al., 2009; Wang et al., 2011b), while the human factors causing changes in saline soil farmland use at the regional scale have received less attention.

China no longer depends solely on technology for the sustainable use of saline soil farmland for agriculture (Wang et al., 2011a,b; Li et al., 2012). Long-term experimental studies related to the use of organic fertilizer for the improvement of saline soil farmland show that application of the appropriate amounts of organic fertilizers is cost effective in creating sustainable agricultural development on saline soils, and is useful in slowing the rate of desalinization. Mixing organic fertilizer with chemical fertilizer increases the availability of soil nutrients, increases water-use efficiency, helps farmers adjust soil moisture in the arid and semi-arid areas of China, and helps reduce soil bulk density (Lax et al., 1994; Du et al., 2005; Liang et al., 2005; Yang et al., 2008; Ahmad and Jabeen, 2009; Yu et al., 2009; Martin et al., 2010; Liu et al., 2010). For nearly half a century, the use of chemical fertilizers in China has been rising dramatically (Lai et al., 2009), while that of organic fertilizers has decreased creating an increased risk of secondary soil salinization. So the proper use of fertilizer is important for maintaining sustainable development of agriculture (Su et al., 2006). In this study, based on practices currently in use in China, organic fertilizers used with saline soil are defined as mainly including stalk burning, returning crop residue and crushed stalks to the ground, straw mulching, the use of biogas slurry, sheep and cattle manure, green manure, oil cake manure and other organic fertilizers.

Farmers' fertilizer choices directly affect the productivity of saline soil farmland. Because of its comparatively low effectiveness and the farms' basic conditions, the farmers' enthusiasm for an ecological manner of farming is dramatically undermined (Liu et al., 2013). The farm household's disposition-to-act tends to the choice of labor-saving input, not to sustainable land use practices (Chen

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et al., 2011), and interacts with internal resources of farm households, with external factors such as land use policies, state systems' agricultural support, technologies and markets, and with social and cultural values (Shucksmith, 1993; Bernet et al., 2001; Huang et al., 2009; Zhong et al., 2011; Lv et al., 2012). Land policy is a central question in many developing countries (Li et al., 1998; Clover and Eriksen, 2009). Rohde et al. (2006) report that privatization of communal land has resulted in the weakening or destruction of local, traditional land management institutions in southern Africa. In China, the current policies of land tenure and agricultural support still survive in traditional agriculture (Lin, 1992), but now many reports argue that these powerful policies have caused the very problems of land use and degradation which they were formulated to prevent (Yu et al., 2003; Ye et al., 2006). No empirical study has been conducted which considers land policy as a factor of organic fertilizer application on saline soil in China. Analyzing the driving factors of land policy in China, would enable policy makers to decide which types of land use policy tools to target for sustainable management of saline soil farmland resources, especially when considering policy recommendations for different regions.

The objective of this study, therefore, is to examine the factors of land policies that influence the choice of organic fertilizer adoption by smallholder farmers on saline soil as well as to determine the variation in different regions, which differs from previous research (e.g., He and Huang, 2001; Malá and Malý, 2013). In this paper, we define land policies as including the policies of land allocation, land use, land management and land conservation. Land tenure is defined as the institutionalization of land policy, which determines how access is granted to rights to use, control, and transfer land, as well as associated responsibilities and restraints (FAO, 2002, 2013). Based on the definition above, an approach with two components is developed: establishing the decision-making model of farm households for assessing the effect of land policy, and empirical analysis of the model in view of different regions. In order to get more detailed information related to organic fertilizer adoption from farm households, government and rural collective economic organizations, methods of simple random sampling, semi-structured interview and comparative analysis are applied.

The rest of the paper is organized as follows: the next section is study area and materials, which outlines the study area, sampling method, data collection procedure, empirical model and the independent variables choice. Empirical results and discussions are presented in Results and discussion section followed by conclusions and policy recommendations in the final section.

Study area and materials

Study area

Three typical study areas with saline soil were selected: the Huanghuaihai Plain in Shandong, the Songnen Plain of western Jilin, and the Ili River Basin in Xinjiang. A total of eight villages were selected located in Kenli (Jilin), Zhenlai (Shandong) and Chabuchaer (Xinjiang) counties, each representing different types and conditions of saline soil, and having different types of agricultural land use and different levels of socio-economic development as described later in the section (Fig. 1).

Kenli County is typical of coastal regions experiencing soil salinization mainly caused by salt water intrusion from the sea or when saline ground water rises to the soil surface. With the combined influence of natural conditions and human impacts, primary soil salinization and secondary saline-alkalization coexist in Kenli County where the main soil types are fluvio-aquatic, saline flavo-aquic and offshore saline soils. The natural factors influencing salinization mainly include a shortage of fresh water, the continental monsoon climate, salt water intrusion from the ocean, and topography, while anthropogenic factors include a simple cultivation structure with single cropping cotton and limited efforts to improve soil fertility.

In Zhenlai County, located in the western portion of the Songnen Plain, wind and sand erosion, drought and freeze–thaw are the main causes of soil salinization. Single crop rice is the main crop, but in the past arable land has been expanded without proper ecological considerations related to sustainability. Uncontrolled over-grazing has damaged the ecological balance and led to serious secondary saline-alkalization. Light chernozem soil is the main soil type; other types show a spotted and aggregated distribution pattern including light saline chernozem, saline meadow, saline land and meadow alkaline soil.

Chabuchaer County is a typical agricultural county in that it mainly relies on agriculture, combined with grazing and stock-breeding. The main crops are wheat, rice, corn, soybeans and cotton. Storms, frost, drought and dry-hot wind characterize the "south high-/north low-lying" topography; together with unsustainable human activity these are the main factors causing soil salinity in this area. The secondary saline-alkalization problem in Nadaqiniulu and Miliangquan counties is obvious, while the natural salinization does serious harm in Duiyiqiniulu and Butuo counties. The soil types along Ili River are mainly fluvio-aquatic and saline flavo-aquic. Duiyiqiniulu and Qinquan counties as well as Tuobu center have mainly gray calcium and saline gray calcium soils.

Low soil fertility, especially a deficiency in organic matter nutrients, is a common factor in all these areas which influences sustainable agricultural development of saline soil farmland in these eco-fragile areas.

Sampling and data collection

Farming on saline soil imposes unique constraints on agriculture. With knowledge of the regional characteristics of saline soil and the personal initiative of a farm household's choice of fertilizer application, each household's response to saline soil farmland use was classified into one of three types: no action, traditional action, and initiative action. The traditional actions include returning crop residue to the soil, burning old stalks and crops, and the application of sheep and cattle manure. The initiative actions include returning crop residue and burying it deeply, as well as the application of various types of organic products such as biogas slurry, green manure, oil cake manure and buying and applying other types of organic fertilizer.

In every county, 2–3 towns were selected based on methods farm households use to make decisions and characteristics of agricultural land use; also, 2–4 villages were selected in each town based on suggestions from local governments and research institutions which deal with farm-related issues. In every village, about 20–50 farm households were interviewed in 2011. The data related to farm households were obtained through structured interviews and informal discussions with village elders and local government leaders. A total of 476 questionnaires were completed, among from 458 were considered valid. The questionnaires included the following information: characteristics of farm households and their fields, land tenure of saline soil farmland, and the agricultural policy and social service system. Table 1 gives the descriptive statistics of farm households in each county.

Most crops are monocultured and farming is the main source of family income in these regions (Table 1). Most of the agricultural labor forces studied here comprise middle-aged, poorly educated people. Although the average family has fewer than three field workers, the average total arable land area per family is relatively large because of the large quantities of reserved land with saline-alkali conditions which restrict agricultural activities in these counties. The index of household annual income shows