



# Toward cleaner production: What drives farmers to adopt eco-friendly agricultural production?

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## ABSTRACT

Due to the indiscriminate use of chemical inputs like pesticides, serious agricultural diffused pollution is arising, not only with the ecological environment damaging, but also with the agriculture sustainable development restricted. It is imperative for China to reduce pesticides use. Under the decentralized production background, farmers' willingness to reduce pesticides is worth discussing. This paper aims to explore farmers' willingness to reduce pesticides use based on its determinants analysis. A structured questionnaire was administered to a random sample of 924 farmers in rural China. Binary logistic regression model was used to examine the determinants. The results showed that farmers' environmental concern, pesticides residues cognition, agro-products quality concern and input controls positively and significantly influence farmers' willingness to reduce pesticides, while non-agricultural income share influence negatively. Results also reveal that farmers' self-discipline is more effective than government regulations; enhancing farmers' self-discipline is important to guide farmers toward environmentally-friendly measures in agricultural production. This paper recommended that policy makers take measures to improve farmers' environmental awareness and strengthen input supervision. Improved effectiveness of pesticides usage is also needed.

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## 1. Introduction

Pesticide is an important agricultural input, playing a positive role in improving the output of agro-products and reducing work for the labor force (Soares and Porto, 2009). China uses 7% of the world's arable land to feed 22% of the world's population, and pesticides have significantly contributed to this. However, with climate and agricultural changes, diseases and pests are frequently increasing (Christensen et al., 2011), to better control pests, farmers tend to overuse pesticides. As can be seen in Fig. 1, the amount of pesticides used by Chinese farmers increased dramatically in recent years, from 1.28 Mt in 2000 to 1.84 Mt in 2014, making it the world's largest consumer of pesticides based on China Economic and Social Development Statistics Database. The unit area pesticides consumption is 2.5–5 times the world's average (Zhang and Li, 2016). The overuse of pesticides is a serious

problem in agricultural production, exposing farmers, consumers, and ecological systems to pollution and health hazard, and has led to problems that need to be addressed, it is imperative to reduce pesticides in China.

Faced with serious agricultural diffused pollution, the Chinese government has decided to reduce pesticides. In March 2015, the Chinese government undertook the "Pesticides Reduction and Efficiency Promotion" to reduce pesticides and improve efficiency. In May 2015, the Ministry of Agriculture and eight other ministries jointly issued the National Agricultural Sustainable Development Plan (2015–2030), which emphasized the prevention and control of pests and diseases through green prevention and control, with the objective of achieving zero growth in pesticides usage before 2020. Although Chinese agricultural development has made great progress, its development is still low, mainly with decentralized household production. The farmer is the main decision maker of pesticides use, and reducing pesticides depends on farmers' behavior. Planned behavior theory (Martin and Ajzen, 1975) suggests that farmers' pesticides reduction behaviors closely relate to their willingness to reduce pesticides. This study aims to determine their willingness and its determinants and incentives, so as to

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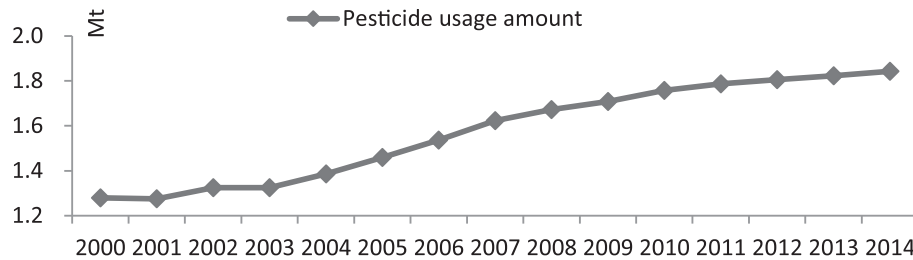


Fig. 1. 2000–2014 China pesticide usage.

achieve pesticides zero growth targets and guaranteeing agro-products quality safety.

This paper analyses problem in agricultural production under the decentralized production background, which conforms to the agricultural development situation of most developing countries; This paper investigates farmers' willingness to reduce pesticides and its influencing factors using survey data; third, the study is based on farmers' perspective rather than public; The paper provides an overview and information useful for agricultural activities which help farmers adopting cleaner production methods, and ensure agro-products quality safety. This study aims to fill this gap by providing information about factors significantly influencing farmers' willingness. The study also provides valuable information for related agricultural and ecological policy decisions.

The next section summarizes the relevant literature. Section 3 provides the background of this study. Section 4 presents the methods. Section 5 defines the variables and data collection. Section 6 presents the results and discussion. Section 7 provides conclusions and policy implications.

## 2. Literature review

Ever since Rachel Carson's book "Silent Spring" was published, environmentalists abroad have argued that the overuse of pesticides contaminates our water supplies, the air we breathe and the food we eat (Matthews et al., 2016). This has led to policy efforts to reduce pesticides ranging from moral suasion to regulations and economic instruments (Brethour and Weersink, 2001). Many countries (such as the European Union, Denmark, Japan, Korea, France, the United States) have taken measures to reduce pesticides and introduced programs to establish quantitative, time-based reduction targets. Since their implementation, this issue has attracted scholars. Many recent studies have focused on patterns of pesticides reduction, factors affecting farmers' pesticides reduction behavior and conditions of low-input or organic cultivations.

### 2.1. Studying on patterns of pesticides reduction

Since the 1970s, the intensive use of pesticides in agriculture has significantly damaged the environment. The on-farm benefits of pesticides use are off-set to some degree by the off-farm costs imposed by these pesticides on the environment (Brethour and Weersink, 2001). Since then, increasing attention is being paid to this issue, and governments in developed countries are setting objectives to reduce pesticides (Femenia and Letort, 2016). Concerns about the health and environmental effects associated with pesticides use have motivated the development of integrated pest management (IPM) programs in both developed and developing countries (Cuyno et al., 2001). These programs aim to improve both the economic well-being of adopters while also reducing environmental and health risks (Maupin and Norton, 2010). Different approaches based on IPM have been developed to reduce the use of

pesticides in crops cultivation, non-chemical techniques, such as cultural practices and biological control, and resistant cultivars (Côte et al., 2009), compulsory inspection of sprayers in fruit crops (Gil, 2007). Agro-ecological innovations aimed at reducing pesticides use have also been adopted, including intercropping, improved fallow and new pest-tolerant varieties, and systems involving intercropping or improved fallow seems to be the most promising, while the presence of new variety is not valued positively by potential adopters (Blazy et al., 2011). Some economics measures have been used to pesticides reduction practices, like pesticides tax, quota, bio-pesticides subsidies and price premiums et al., and in some developed countries, pesticides consumption decreased significantly. For the pesticides practices in some developing countries, like China, Philippine, Thailand, some new production technologies or standards proved to use less of pesticides, for example, growing genetically engineered (GE) crops in China (Huang et al., 2003), introducing public standards of good agricultural practices (GAP) aims to improve food safety and reduce pesticides (Schreinemachers et al., 2012).

### 2.2. Studying on factors affecting farmers' pesticides reduction behavior

Increasing consumer and policy concerns about food safety and environmental impacts has led innovation in agriculture to be associated with more environmental-friendly production technologies (Blazy et al., 2011). Technologies which aim to reduce pesticides were widely adopted, and agriculture practices were also modified. However, new challenges arise, for instance, a single innovation may not be able to replace all types of pesticides (herbicide, fungicide, etc.), and therefore farmers may have to adopt simultaneously several agro-ecological technologies in order to maintain their crop yields (Edmeades et al., 2008). As agro-ecological cropping systems are more sensitive to climate and soil conditions, their adoption is likely to differ according to farms' economic resources and farmer human capital. In order to maintain their crop yields, farmers may not adopt the agro-ecological technologies, affecting the pesticides reduction effect. Faced with this dilemma, some scholars began to think which factors affect farmers' pesticides reduction behavior. Scholars interviewed 71 farmers in France, the results showed that pesticides reduction practices were conducted by farmers' bearing social responsibilities and showing environmental awareness (Stéfanie et al., 2013). To effectively deal with crop output risks while taking environmentally-friendly production measures, crop insurance was used in agriculture production, some countries even encouraging farmers' participation in crop insurance by giving insurance subsidy. Some research was carried out to check whether crop insurance significantly affects pesticides reduction, results showed that insured farmers tend to use fewer pesticides (Smith and Goodwin, 1996; Zhong et al., 2007). Education and training programs are needed to guide farmers adopt pesticides reduction technologies,

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