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Managing pests after 15 years of Bt cotton: Farmers' practices, performance and opinions in northern China

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ABSTRACT

In China, a substantial amount of literature addresses pest control in Bt cotton, which is genetically engineered to resist some target pests but which had no direct effects on many other pests. The impact of this technology was positive a few years after the commercial release, but this impact was subsequently found to have reversed. The reversal was made known to the international community about ten years after the commercial release of Bt cotton in China, as a consequence of a pest complex shift phenomenon. Nevertheless, all the existing literature seldom took farmers' practices in spraying chemicals into account; farmers' opinions about using Bt cotton were not reported, nor were their opinions of their performance in growing cotton.

Our study compensates for this lack through a specific and holistic approach in appraising farmers' practices, performance and opinions 15 years after the commercial release of Bt cotton in northern China. It focused on the topic of pest control by combining a survey of farmers' characteristics and opinions about Bt cotton effectiveness and profitability, as well as on their cotton cropping characteristics, with participatory detailed record-keeping of insecticide spraying by farmers. It is a holistic approach as it took into account the farming context when analyzing the results.

Our results indicated that farmers used chemicals somewhat intensively, carrying out 11 insecticide sprayings on average, involving an average of 2 pest target-oriented insecticide controls. The pest complex shift phenomenon was confirmed as farmers aimed 60% of target-oriented insecticide controls at sucking pests, principally aphids even more than Lygus bugs. Three quarters of farmers were not content with Bt cotton profitability while providing a shorter protection time and most of them displayed a lack of proficiency in implementing chemical pest control. The remaining quarter of contented farmers carried out more pest target-oriented insecticide controls. Four spraying strategy factors were found and were associated notably with farmers' attitudes in controlling bollworms, aphids and Lygus bugs. The observed strategies were connected with distinct farming efficiency in a country where farming has lost its attractiveness. Sustainable use of Bt cotton calls for locally adapted actions to improve farmers' proficiency in pest control.

1. Introduction

In China, the impacts since 1997 of adopting Bt cotton –genetically engineered to resist some target pests among the whole complex of pests infesting cotton crops– have mainly been assessed positively. Based on data collected over the 1999–2001 period, a series of papers involving the same team in China, such as Pray et al. (2001), have popularized the success of Bt cotton in China. This vision is only challenged by a few studies, such as the one in Pemsl et al. (2008).

Most papers reporting the positive impacts of using Bt cotton have involved studies undertaken three to five years after the commercial release of Bt cotton, with a single but debatable exception. In addressing a long period up to 2012, Qiao (2015) claimed that Bt cotton has continued to decrease pesticide use, improve yield and reduce labor investment in cropping. He used three data sets which were little described, if at all, and which were not specifically collected to follow up the long-term impacts of Bt-cotton. The observed yield and labor outcomes were only attributed

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to Bt-cotton use, hence overlooking other research outputs or the rural sociological evolution in China, leading notably to a reduction in the time spent in fields, as demonstrated by de Brauw et al. (2013).

All the studies published so far in assessing the impacts of Bt cotton use in China have paid little attention to the ways in which the insecticide spraying carried out by farmers is quantitatively evaluated. Farmers were asked to provide the quantities of insecticides for various targeted pests, but without any indication of the data collation methods. Like all articles resulting from data provided by the Centre for Chinese Agricultural Policy, pesticide use was reported in kg/ha, namely the amount of commercial product (and not active ingredient) without specifying their concentration and dilution, so the interpretation of a decrease in quantity might be excessive while the commercial products have changed over time.

Farmers also used to be a missing factor in studies assessing Bt cotton use. They were not exactly overlooked but their opinions were seldom taken into account. In studies claiming that positive impacts have persisted such as Wang (2009), farmers' opinions were actually overlooked and their production behavior was not addressed in the assessment models. Even in the first paper reporting that Bt cotton success had been reversed (Wang et al., 2006), there was no indication of the frequency of farmers not content with profitability because of the need to spray much more against Lygus bugs, unlike Fok and Xu (2011) and Wang and Fok (2014).

This paper is based on a study conducted in Hebei province, where Bt-cotton was first released in China, to assess the management of Bt cotton fifteen years after its commercial release, taking into account cotton growers' opinions, their performance and their cultivation practices, particularly insecticide spraying. The study was conducted following a methodology focusing on chemical pest control to collect relevant data. The rural context of China was taken into account so as to identify the factors influencing the insecticide spraying and the opinion about Bt cotton use more holistically.

2. Materials and methods

Our study combined a survey and specific record-keeping of farmers' insecticide spraying practices in Hebei province, northern China, where the rate of Bt cotton was close to full area coverage a few years after its commercial release (Huang et al., 2002), but where cotton production has been declining in recent years.

2.1. Survey of farmers' characteristics, production costs and opinions

The survey used in this study was carried out in 2011 as a continuation of annual surveys of a research program under way since 2002 in Hebei province, traditionally a major location of cotton production in China, which has produced some original knowledge in the fields of variety market development (Wang and Fok, 2014) and women's efficiency in cotton production (Wang and Fok, 2016). Our research program was implemented without the involvement of the local extension services for fear of their influencing the farmers' answers in our surveys.

The annual survey was carried out by enumerators who were selected from among students at the Agricultural University of Hebei and whose families farmed in the cotton areas of Hebei province in the major six cotton production districts. Through their origins and their university training, the enumerators were familiar with agriculture. They were trained to conduct face-to-face interviews with farmers using the survey questionnaire during the Spring Festival (fluctuating between mid-January and mid-February) in their village of origin. This period coincided with the off-season in the fields when farmers have usually finished selling all their products from the previous calendar year.

Student-enumerators were instructed to interview around 25 farmers in their villages who were representative of the three classes of wealth (low, middle and upper) frequently used in rural research studies in China. The data they collected were expected to be reliable thanks to their relationship of confidence with the farmers in their villages of origin.

The way we established the study sample was adapted to the local context where there was no available list of cotton growers and where the number of these growers fluctuated a great deal from year to year because the farmers were very reactive to cotton prices and to the attractiveness of cotton relatively to other crops. In 2011, the survey sample was composed of 262 farmers in ten counties of six districts in Hebei province.

The survey was conducted with the aim of determining the possible influence of farmers' cultivation practices and of the characteristics of their farms in an interview taking 45 min on average. The survey included questions related to farms (land size, cotton area, and cotton production) and to farmers (age, education, family composition). On the basis of their memories, farmers were asked to indicate the number of cotton varieties they used and to provide production figures and costs for the whole cotton area.

Two performance indicators could then be derived from the above-mentioned data. Yield is a common indicator of technical performance obtained from cotton production and area. We opted for added-value as an indicator of economic performance, without considering family labor costs because we could not record the time that family labor spent in cotton plots, while indications by the farmers would have been too approximate.

The survey was specific to farmers' practices in using Bt cotton and in carrying out chemical management. Farmers were asked about their criteria in deciding when to carry out insecticide spraying. They had to give their feelings regarding changes in infestation (from the proposed answers: decrease, no change, or increase) by several major pests, namely bollworms (*Helicoverpa armigera* (Hübner) and *Pectinophoa gossypiella* (Sanders)), and various sucking insects (principally aphids, mirids, red spiders, and whiteflies). In addition, farmers had to indicate if they totally disagreed, disagreed, agreed or totally agreed with the claims that Bt-cotton was effective or profitable.

2.2. Record-keeping of each chemical spraying

Specific data collation was undertaken in addition to the survey, with a view to obtaining detailed information on farmers' practices in repeated spraying against cotton pests, in order to collect more reliable data than just depending on farmers' memories alone. The record-keeping of insecticide spraying was based on the participation of the surveyed farmers who had agreed to take part and who were all literate, along with their wives. Nevertheless, fewer than half of the 262 surveyed farmers accepted, probably because they were not accustomed to keeping records of their cultivation practices. To comply with local habits of financially compensating any task requested, we decided to give symbolic financial compensation for record-keeping, 100 Yuan (US$ 65) per farmer, corresponding to slightly more than the payment farmers received in off-farm activities for one day.

Record-keeping of insecticide spraying was carried out on a form provided to the farmers, on which they had to indicate the dates on which spraying was carried out, the names of the commercial chemicals they combined and the pests they wanted to

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