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RESEARCH ARTICLE

The status and distribution characteristics of residual mulching film in Xinjiang, China

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Abstract

Pollution of residual plastic film in arable lands is a severe problem in China. In this study, the status of residual film and influential factors were investigated using the methods of farm survey in combination with questionnaires and quadrat sampling at a large number of field sites in Xinjiang Uygur Autonomous Region, China. The results showed that the amount of film utilization increased largely and reached to 1.8×10^5 t in 2013. Similarly, the mulching area also substantially increased in recent decades, and reached to 2.7×10^5 ha in the same year. According to the current survey, 60.7% of the sites presented a greater mulch residue than the national film residue standard (75 kg ha^{-1}), and the maximum residual amount reached 502.2 kg ha^{-1} in Turpan, Xinjiang. The film thickness, the mulching time and the crop type all influenced mulch residue. The thickness of the film had significantly negative correlation with the amount of residual film (P<0.05), while the mulching years had significantly positive correlation with it (P<0.05). The total amount of residual film in Xinjiang was 3.43×10^5 t in 2011, which accounted for 15.3% of the cumulative dosage of mulching. Among all the crops, the cotton fields had the largest residual amount of mulch film (158.4 kg ha^{-1}), and also the largest contribution (2.6×10^5 tons) to the total amount of residual film in Xinjiang.

Keywords: Xinjiang, residual mulching film, influential factor, agricultural resources, agricultural pollution

1. Introduction

Plastic films have been used extensively as mulching for crops in the modern agriculture. Worldwide, the annual consumption of mulching plastic film has reached as high as 0.5–1.5 million t (Yang *et al.* 2015). China is the largest consumption country of the mulching film, accounting for 60% of the world agricultural film demand (Yang *et al.* 2015).

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Film mulching technology has been reported to remarkably improve crop yields and economic benefits by effectively maintaining soil moisture and thus conserving water resource (Lamont 2005; Li *et al.* 2005; Anikwe *et al.* 2007; Yang *et al.* 2011; Zhang *et al.* 2011; Briassoulis *et al.* 2013). This technology is of particular importance and of wide use in the arid and semi-arid regions of China (Schimel 2010; Yan *et al.* 2014). Without rational management measures, however, a large amount of plastic mulching film can reside and accumulate in the field and cause a series of agronomic and environmental problems due to its nature of resistance to degradation (Briassoulis *et al.* 2015; Makhijani *et al.* 2015). It has been observed that residual mulching film can block water, nutrient and heat transfer in the soil, disrupt soil environment, and thus decline soil quality and reduce crop production (Huang 2012; Shen *et al.* 2012; Makhijani *et al.* 2015; Yang *et al.* 2015).

In China, the wide use and high residual ratio of mulching film has made its associated problems more serious than any other country of the world. In the past decades, recovery rate of the plastic film in China was very low, because of high demand for labor, inefficiency of recovery machinery, and especially lack of mandatory recycle policy. In the beginning of year 2015, the Ministry of Agriculture, China set the environmental goals of "one control, two reductions, and three basics" by 2020. One major goal is to realize pollution-free disposal of agricultural film and to achieve more than 80% recovery of the plastic film. To achieve the goal of improved film recovery rate, the first necessary step is to find out the present situation of residual film in the major film mulching areas.

Most of the previous investigations on the residual film have been conducted at a small number of field sites within a relatively small region. Moreover, there was a general lack of consideration of various factors such as climate characteristics, crop types, film thickness, mulching years, film utilization amount, covering ratio and etc., which all influence film residue (Mi *et al.* 1998; Chen 2008; Ma 2008; He *et al.* 2009; Hu *et al.* 2013; Picuno 2014). As a result, significant different results have been reported in the previous studies. For example, the regional mulch residual amount (301 kg ha^{-1}) of Yan *et al.* (2008) was obviously higher than the value (209 kg ha^{-1}) reported by He *et al.* (2009), even though both studies were conducted in Shihezi, Xinjiang. In both studies, only 3 or 4 field sites were investigated, which is probably the reason for the great difference of the results. There is an urgent need to more accurately assess mulching film use based on a large number of datasets, with consideration of different categories such as crop types.

This study aims to assess the status and distribution characteristics of residual mulching film in Xinjiang Uygur Autonomous Region, Northwest China, where use of mulching film has been reported (Yan *et al.* 2008; Wang *et al.* 2012) to be several times higher than in South China (Cai *et al.* 2013; Kang *et al.* 2013; Zeng *et al.* 2014). To our best knowledge, this study is the first to investigate the mulch residue status and analyze its influential factors by combining the farm survey method with the quadrat sampling method. To obtain a fair assessment, a large set of questionnaires and quadrat samples were collected. This study will eventually contribute to promoting effective control and management of residual mulch pollution in China.

2. Materials and methods

2.1. Study site

This study was conducted in Xinjiang (73°40′–96°18′E, 34°25′–48°10′N, Fig. 1), Northwest China. Xinjiang is the largest land area in China's provinces and regions, spanning over 1.6 million km^2, and it is an important Chinese agricultural production base for several crops including cotton, maize, fruits and vegetables. For example, in 2013, the planting area of cotton in Xinjiang was 1.7×10^6 ha, which accounted for 39.5% of the nationwide area (Rural Social and Economic Investigation Department, National Bureau of Statistics 2014). This region has a typical arid continental climate with a mean annual precipitation of 150 mm. Mulching is an extremely important farming practice to maintain soil moisture content. Thus, most of the crops are covered with film during growth, and particularly almost all cottons are film-mulched (Liu *et al.* 2010).

2.2. Farm survey method

To obtain a thorough picture of mulching plastic film using, a total number of >700 copies of the questionnaires were sent out to the farmers covering all the main agricultural production regions across Xinjiang. By the end of the survey, 672 copies of the questionnaires were returned by farmers, and 593 copies of them were valid. The questionnaire was designed (Appendix A) to include as much information related to mulching film use and site-specific factors as possible, such as the information on the survey location, soil type, crop type, irrigation type, film thickness, mulching years, film mulching dosage, recycling methods, amount and etc. Since the distribution of arable land is scattered in Xinjiang, the field sampling sites located quite unevenly (Fig. 1). What's more, the survey was conducted comprehensively as possible. The survey covered a wide range of major crops in this region, including cotton, maize, wheat, vegetables, potato, as well as minor crops such as sunflower, soybean, flowers, melon, etc. The minor crops were grouped in one category in the survey due to their