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Residual Film Pollution in the Eighth Division of the Xinjiang Production and Construction Corps

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Abstract

This study investigated the residual film content and distribution at different soil depths in the Eighth Division of the Xinjiang Production and Construction Corps. Before spring plowing in 2019, representative fields in four areas (Anjihai, Shihezi suburbs, Mosuowan and Xiayedi) were selected for residual film collection. The average content of residual film in the Eighth Division was 104 kg/ha. The residual film content in the four areas decreased in the order Anjihai ＞ Shihezi suburbs ＞ Mosuowan ＞ Xiayedi. The average amount of residual film collected from cotton fields was greater than that from corn fields. Residual film content in the cotton field at soil depths of 0～10 and 10～30 cm was higher than that in the corn field, whereas the residual film content at a 30–50 cm soil depth in the corn field was higher than that in the cotton field. The results showed that farmers do not consider the long-term benefits, the high cost and short time of recycling, and the easy recycling of surface residual film. The shallow that the higher content of residual film, the less water in the soil of cotton. The same time, the results showed that the quantity of residual film in cotton field had greater influence on cotton quality.

Keywords: *Eighth Division ·Residual film ·Pollution ·Present situation ·Problems*

1 Introduction

The Chinese government has invested considerable manpower and material and financial resources in finding a solution to the major environmental pollution experienced across parts of the country; however, control of environmental pollution remains limited. Plastic film mulching has played an important role in Chinese agriculture because of its soil warming and moisture conservation effects (Liu et al., 2014). The application of plastic film in soil is a global agricultural practice aimed at achieving early harvests, increasing crop production, increasing water-use efficiency, and improving fruit quality. Consequently, water conservation and crop production enhancement measures in modern agriculture are becoming increasingly dependent on the use of plastic film. The quantities of residual mulch film in the soil are anticipated to further increase, and this persistent and poorly biodegradable pollution has already become a major limiting factor for sustainable agricultural development in China (Zou et al., 2017).

As plastic film use has enhanced year by year, the film itself is subject to becoming seriously damaged by machinery, light degradation, wind and trampling, and it also adheres to straw [1-3], soil and residual crops in the field, leading to poor residual film recovery. Residual film accumulates in farmland soil, damaging the soil ecosystem and causing deterioration of the soil environment (Gong et al., 2015; Wang et al., 2017; Zhang et al., 2017). Furthermore, residual film has been shown to affect biological flora, ion components in soil and soil moisture content, threaten growth and development of crops, and reduce the fertility of cotton fields, inhibiting the reduction of chemical fertilizer use (Ka et al., 2020). Moreover, white pollution, caused by the accumulation of a large amount of nondegradable polymers in the natural or agricultural environment, has become a major environmental problem (Gao et al., 2014).

Xinjiang, China, was the first region of the world to apply drip irrigation and mulch film for cotton planting and has the largest area of these measures worldwide (Quecholac-Piña et al., 2017). Xinjiang is a major cotton-producing region in China. The area is covered with plastic film and ranks first in the country in terms of

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the amount of plastic film use [4-6]. The problem of residual film pollution in cotton fields in Xinjiang is particularly serious, which has been compounded over the years by multiple factors, such as row planting, continuous cropping, poor film strength, insufficient recycling, and the absence of any residue standard (Liang et al., 2019). In recent years, the planting area of corn also has increased year by year under increased demand from aquaculture. The Eighth Division of Xinjiang Construction Corps is located in the middle section of the northern foot of Tianshan Mountain, the southern part of Junggar Basin. It contains 2 towns, 14 central agricultural and pastoral regiments and 5 sub-district offices. The 2 towns and 14 farms are located in the suburbs of Shihezi City, Anjihai District, Xianye District, and Mosuo Bay District. The Eighth Division of Xinjiang Construction Corps began to use plastic film in the early 1980s, and it is representative of the typical film use in Xinjiang (Ka et al., 2020).

This study investigated the content and distribution of residual film pollution in different depths of soil within the Eighth Division [7-11]. The problems and causes of residual film pollution in the Eighth Division were assessed and recommendations for tackling residual film pollution were given.

2 Sampling and Analysis Methods

2.1 Sampling Position

The suburbs of Shihezi, Anjihai, Mosuowan, and Xiayedi were selected as four representative regions of the Eighth Division. A total of 16 representative plots from the suburbs of Shihezi and the areas of Anjihai, Mosuowan and Xiayedi were selected before spring plowing of 2019 (Figure 1).

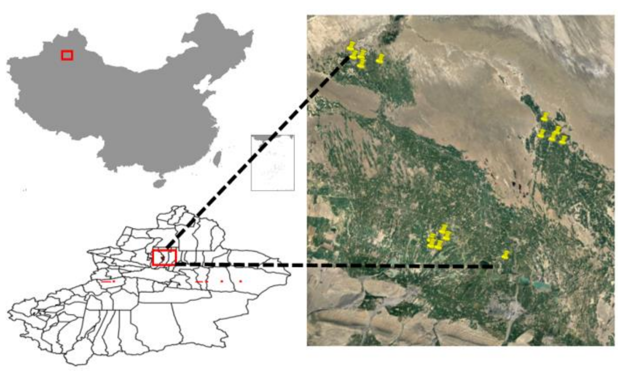

Figure 1 Location of the 16 sampling sites in the Eighth Division

2.2 Sampling Methods

Sampling was conducted by the five-point method, and included 14 cotton fields and 3 corn fields. Residual film at soil depths of 0–10, 10–30, and 30–50 cm from a 1.0 m × 1.0 m area was collected at each site.

2.3 Analysis Methods

After the samples were brought back to the laboratory, the dirt adhering to the surface of the residual film was removed and the film samples were then dried and weighed. The results were analyzed according to the collected area, crop type and sampling depth.

3 Results and Analyses

3.1 Content of Residual Film in Soil of Each Area

The average residual film content in farmland of the four areas of the Eighth Division is shown in Fig. 2. The residual film content was between 61.5 and 144.43 kg/ha. The residual film content was lowest in Xiayedi, at 61.5 kg/ha, whereas it was highest in Anjihai at 144.4 kg/ha. Across all four areas, average content of residual film was 104.0 kg/ha. The residual film content in the four areas decreased in the order Anjihai ＞ Shihezi suburbs ＞ Mosuowan ＞ Xiayedi.

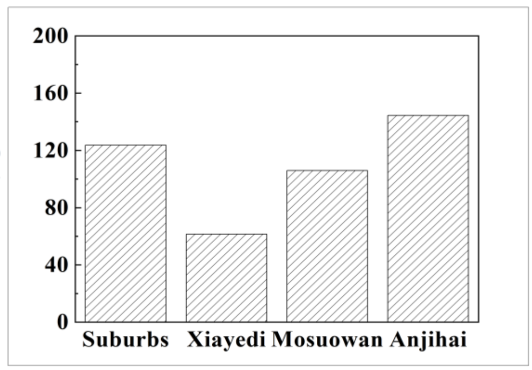

Figure 2 The residual film content of farmland in different areas

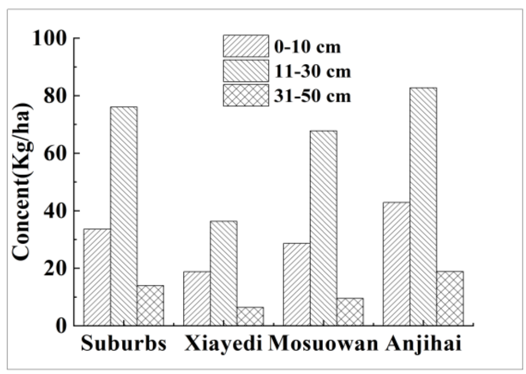

Figure 3 Residual film content in farmland with different sampling depth in different areas

3.2 Distribution of Residual Film at Different Sampling Depths in Each Region

The distribution of residual film at different soil depths are shown in Figure 3. The proportion of residual film was highest at a soil depth of 10～30 cm in the four regions of the Eighth Division. The content of residual film at a soil depth of 10–30 cm accounted for 60% of the residual membrane content in soil. In contrast, only 11% was found at a soil depth of 30～50 cm. The residual membrane content at 0～10, 10～30, and 30～50 cm soil depths was 18.80～42.85, 36.35～82.73, and 6.40～18.85 kg/ha, respectively.

3.3 Distribution of Residual Film by Size of Area at Different Sampling Depths in Each Region

The samples were classified and weighed according to the residual film area collected at different depths. After the residual film had been tilled, the approximate area of residual film was obtained by comparing it with the minimum area of 1-cm^2 grid. The weight of different areas of residual film in each area is shown in Table 1. The residual film content in the areas of ＜ 2 cm^2, 2～5 cm^2, 5～10 cm^2, and ＞ 10 cm^2 accounted for 33.8%, 21.9%, 18.4%, and 25.9% of the total mass, respectively. At 0～10 and 10～30-cm soil depths, the residual film area of ＜ 2 cm^2 and ＞ 10 cm^2 accounted for more than 30% of the total mass. At a soil depth of 30～50 cm, the residual film area accounted for about 40% mass in ＜ 2 cm^2, and the residual film area ＞ 10 cm^2 and the mass accounted for only about 10%. Therefore, in the Eighth Division, affected by the recovery mode of residual film, the residual film quality is mainly about ＜ 2 cm^2 and ＞ 10 cm^2 at a soil depth of 0～30 cm. However, in soil layers below 30 cm, residual film was mainly below 2 cm^2.

Table 1 Residual film content in different areas of farmland at different sampling depths (kg/ha)

Sampling depth	Sampling areas	＜ 2 cm^2	2–5 cm^2	5–10 cm^2	＞ 10 cm^2	Total mass
0～10 cm	Suburbs	9.82	6.76	5.68	11.36	33.62
	Xiayedi	6.09	3.42	3.57	5.71	18.80
	Mosuowan	8.91	4.73	5.01	10.00	28.65
	Anjihai	13.13	7.46	7.94	14.32	42.86
10～30 cm	Suburbs	22.96	20.07	8.59	24.41	76.04
	Xiayedi	11.09	9.01	4.40	11.85	36.35
	Mosuowan	19.24	17.68	7.32	23.51	67.74
	Anjihai	24.07	22.37	9.68	26.61	82.73
30～50 cm	Suburbs	5.55	2.82	3.46	2.19	14.01
	Xiayedi	2.70	1.27	1.52	0.92	6.41
	Mosuowan	4.19	2.11	2.52	0.70	9.53
	Anjihai	7.28	4.49	5.25	1.83	18.86

The manual or mechanical recovery of residual film in this region is usually undertaken in spring and autumn. Initially, the recovery of the larger plastic film takes place before the harvest of arable land. The mechanical recovery of film mainly occurs in spring and autumn. Since the depth of mechanized cultivated land is about 30 cm, it is difficult to collect the membrane from a soil depth below 30 cm. Moreover, due to the large tooth spacing of the recovery tools, residual film below 2 cm^2 was more difficult to be recovered from the soil. Due to the aging of residual film, further weathering damaged large-sized residual film, thereby increasing the proportion of residual film content below 2 cm^2 in the soil (Jiang et al., 2019; Li et al., 2017; Wang, 2013).

3.4 Amount of Residual Film by Size of Area at Different Sampling Depths in Each Region

The samples were classified and counted according to the size of the residual film area collected at different depths. After washing and drying, the quantities of residual film in different areas and at different depths were counted by pieces [12]. The number of areas with residual film in each studied part of the Eighth Division is shown in Table 2. Residual film was mainly concentrated in the area ＜ 2 cm^2 (＞ 80% of the residual film amount at the three different sampling depths in all regions). The amount of residual film with area ＜ 2 cm^2, 2～5 cm^2, 5～10 cm^2, and ＞ 10 cm^2 accounted for 84.5%, 11.6%, 3.0% and 0.9% of the total amount, respectively.

The results show that the amount of residual film area is mainly distributed at ＜ 2 cm^2 and 2～5 cm^2 in the farmland soil of the Eighth Division. The smaller residual film is more difficult to recover because of membrane recovery and with the long-term weathering and breakage and therefore the amount of ＜ 2 cm^2 residual film within the soil continues to increase.

Table 2 Quantities of residual film in different areas at different sampling depths (slice/m^2)

Sampling depth	Sampling area	＜ 2 cm^2	2～5 cm^2	5～10 cm^2	＞ 10 cm^2	Total
0～10 cm	Suburbs	418	36	13	4	471
	Xiayedi	281	25	9	2	317
	Mosuowan	378	31	11	3	423
	Anjihai	471	40	15	4	530
11～30 cm	Suburbs	361	66	11	6	444
	Xiayedi	256	38	5	4	303
	Mosuowan	310	45	8	5	368
	Anjihai	352	71	9	7	439
31～50 cm	Suburbs	237	63	14	2	316
	Xiayedi	165	18	9	1	193
	Mosuowan	217	23	11	1	252
	Anjihai	245	49	16	2	312

3.5 Effect of Soil Water Content on Residual Film

The 0-50 cm soil layer of the cotton field was collected, and it was found that the variation law of soil water content was different. Therefore, the soil was sampled according to the sampling depth of the residual film of the farmland, and the soil water was measured by drying method after collecting the soil. Fig. 4 to Fig 6. Shows the vertical variation of the average soil moisture content in the field after irrigation at the cotton flowering and boll stage. As can be seen from Figure 4, after irrigation, the increase of residual film amount will affect the uniform distribution of soil water in each layer of cotton field. In the soil layer of 0-10 cm, the soil water content of each treatment decreased with the increase of residual film amount In the soil layer of 10-30 cm and 30-50 cm, the soil water content changed irregularly with the increase of residual film amount, but overall, the smaller the residual film amount was, the higher the water content was, indicating that the increase of residual film amount would hinder the infiltration of soil water. Resulting in uneven distribution of soil moisture. The shallow soil of cotton field will have water accumulation, while the deep soil will have water deficit, because the residual film hinders the infiltration of soil water with the increase of residual film amount.

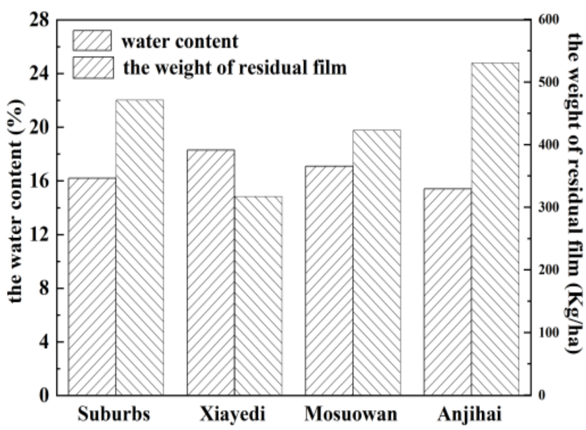

Figure 4 The water content and weight of residual film in soil 0~10 cm

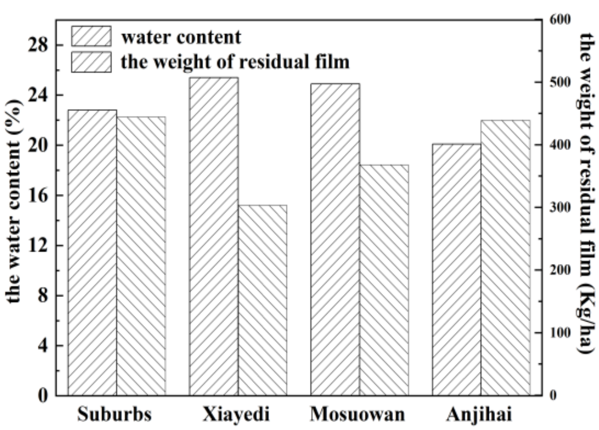

Figure 5 The water content and weight of residual film in soil 10～30cm

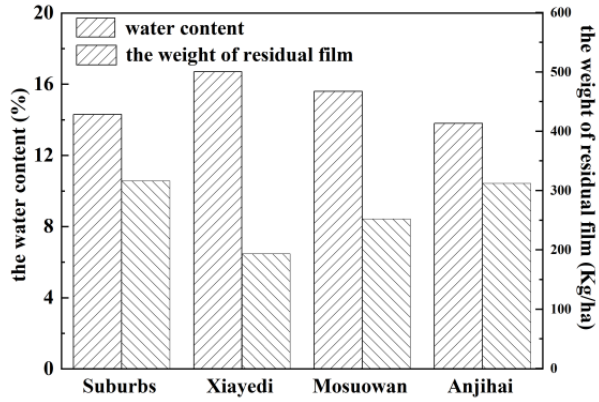

Figure 6 The water content and weight of residual film in soil30～50cm

3.6 Effect of Residual Film Content on Cotton Quality

It can be seen from the Table 3 that the quality of cotton in Xiayedi and Mosuowan area is better, while the quality of cotton in Suburbs area and Anjihai area is worse. The best area is he Xiayudi area, and the worst area is the Anjihai area. The results ndicated that the quantity of residual film in cotton field had greater influence on cotton quality.

Table 3 Effect of Residual Film Content on Cotton Quality

Sampling area	Boll Weight(g)	Lint percentage(%)	Color Grade	Light reflection	Yellow wishness
Suburbs	5.16	41.8	11	81.24	8.24
Xiayedi	6.32	45.1	21	83.63	8.05
Mosuowan	5.74	43.9	21	82.65	8.37
Anjihai	5.27	40.2	11	80.47	8.41
Suburbs	Micronaire	Upper half mean Length(mm)	Uniformity(%)	Fiber strength（cN/tex）	Micronaire
Xiayedi	3.39	28.94	82.83	28.31	3.39
Mosuowan	4.41	32.85	83.98	29.92	4.41
Anjihai	4.75	30.62	81.74	28.77	4.75
Suburbs	3.36	27.49	82.05	27.98	3.36

3.7 Recommendations for Prevention and Control of Residual Film Pollution

To reduce soil residual film content, it is necessary to upgrade and popularize agricultural technology, such as biodegradable biofilm (Semai et al., 2021). As new agricultural technology (Zhao et al., 2017) helps reduce residual film content, R&D needs to be vigorously promoted in this regard, and replacement products need to be brought in. It is important to promote the rational application of residual film cover technology and further reduce the dependence of residual film use.

Furthermore, actions to tackle film pollution should include continuing to strengthen the supervision of agricultural materials, strictly controlling residual film product standards, strictly complying with the requirements of the new national standard of agricultural residual film, supervising production and market circulation, combatting the illegal production and sale of non-standard residual film and cutting off non-national standard residual film production from the source [13-14].

Agricultural machinery subsidies and supporting facilities and mechanized residual film collection need to be strengthened alongside an increase in investment in research and development of residual film recovery and the targeted development of suitable local residual film recovery machinery. Strict management of statistical monitoring responsibilities is needed, along with promotion of the standardized use of agricultural film. It is also necessary to strengthen the research and development of recycling technology and popularization and application and establish a long-term effective agricultural film recycling system. At the national level, a corresponding financial subsidy program should be established to encourage workers to recover more film from the fields. The strengthening of organizational leadership, scientific and technological guidance, and publicity and education can together establish an organizational support system for residual film recovery and the reduction of associated pollution.

4 Conclusions

Residual film content in farmland of the three areas of the Eighth Division was between 61.5 and 144.43 kg/ha. Across the four areas, the average content of residual film was 104.0 kg/ha. The residual film content in the four areas decreased in the order Anjihai ＞ Shihezi suburbs ＞ Mosuowan ＞ Xiayedi. The proportion of residual film was highest at a depth of 10～30 cm, accounting for 60% of the residual membrane content in soil. The film at the three different sampling depths was mainly < 2 cm^2 and > 10 cm^2 in area, and film with an area < 2 cm^2 represented more than 80% of the total amount of residual film at the three different sampling depths in all regions.

The shallow that the higher content of residual film, the less water in the soil of cotton. The same time, the results showed that the quantity of residual film in cotton field had greater influence on cotton quality.

Declarations

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Conflicts of Interest The authors declare that no actual or potential competing financial interests exist that might compromise the content and the quality of the work presented in this article.

Availability of Data and Material Not applicable.

Ethics Approval Not applicable.

Consent to Participate Not applicable.

Consent for Publication All authors consent to the submission and publication in the journal.

Code Availability Not applicable.

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