JEB
Journal of Environmental Biology

Journal Website : www.jeb.co.in
E-mail : editor@jeb.co.in
ISSN: 0254-8704 (Print)
ISSN: 2394-0379 (Online)
CODEN: JEBIDP

Determining time limits of continuous film mulching and examining residual effects on cotton yield and soil properties

Dong Hegan[1,2], **Liu Tong**[1]*, **Han Zhiquan**[3], **Sun Qinming**[1] **and Li Ru**[4]
[1]College of Life Science, Shihezi University, Shihezi, Xingjiang-832 003, China
[2]Rural energy and environment work station of Yili, Yining, Xingjiang-835 000, China
[3]College of Science, Shihezi University, Shihezi, Xingjiang-832 003, China
[4]College of Foreign Languages, Shihezi University, Shihezi, Xingjiang-832 003, China
*Corresponding Author's E-mail: betula@126.com

Publication Info

Paper received:
10 January 2014

Revised received:
30 October 2014

Accepted:
20 February 2015

Abstract

Film mulching of cotton could slow cotton maturation and increase yield, as well as reduce the impact of weeds. The present study, film residue was used in the main areas of cultivation of short-fiber cotton in northern Xinjiang. Six gradients of film residue density (0, 250, 500, 1000, 1500, 2000 kg hm^{-2}) with two major cotton varieties (Xinluzao 33 variety with a deep root system and Xinluzao 13 variety with a shallow root system) were studied to observe residues effect on cotton. To find the reason for decline in yield and calculate the length of time for which film mulching can be used without sacrificing cotton yield. Yield of Xinluzao 13 variety and Xinluzao 33 variety declined as the film residue density rose. Specifically, when the residue density was 2000 kg hm^{-2}, the yield of Xinluzao 33 variety and Xinluzao 13 variety decreased by 38.3% and 45.2%, respectively. Alkaline hydrolysis of nitrogen as well as available P dropped by 55.0% and 60.3%, respectively, at highest residue density. After film mulching had been used for 121 years and 157 years (for Xinluzao 33 variety and Xinluzao 13 variety, respectively), cumulative reduction in yield per surface area was greater than its cumulative increase in yield due to the use of film mulching. In other words, cumulative residue not only decreased cotton yield, but also negated the positive benefit of using film mulching, perhaps even permanently after mulching for many years.

Key words

Cotton yield, Film residue, Soil pollution, Time limits

Introduction

Film mulching can maintain and increase soil moisture in tillage because it prevents moisture from evaporating (Zhang *et al*., 2010; Zhang *et al*., 2013), and also reduces weeds (Anikwe *et al*., 2007; Mahajan *et al*., 2007). It is universally used in arid and semiarid areas in northern China (Yan *et al*., 2006; Du *et al*., 2005). Producers in China utilize film mulching for cotton and some other crops (Yan *et al*., 2006). Xinjiang is one of the three cotton producing regions of China (Yan *et al*., 2008). Xinjiang occupies about 1.53×10^{6} ha of cotton fields, with 50% areas covered by film of the whole cultivation area (Liu *et al*., 2010). Consequently, cotton yield increase largely depends on film mulching. However, the problem of film residue is a serious issue. There are 24% of the films still remain in fields in Xinjiang. In other words, there are 18 kg hm^{-2} of film residues left in farmlands every year (Yan *et al*., 2008). However, studies on the negative impact of film residue is meagre.

Film residue accumulation affects physico-chemical characteristics of soil in many ways. It may increase soil bulk density and slow down moisture movement (Xie, 2007), blocking water circulation in surface layers. It reduces moisture movement resulting in secondary salinization in surface layers (Lv, 2009). Film residue also decreases soil porosity, worsens air circulation, changes microbial communities and causes low soil fertility (Yan *et al*., 2008). Further, it makes ploughing difficult, causes pollution (Liu *et al*., 2003) and reduces crop yield by affecting seedling germination and growth (Xie *et al*., 2007; Sun, 2005). Several research demonstrated that the number of wheat seedlings were reduced by 25% when film residue was 37.5 kg hm^{-2} (Yan *et al.*, 2006). When film residue reached 58.5 kg hm^{-2}, crop yield was reduced 11-23% in corn, 9-16% in wheat, 5.5-9.9% in soybean and 14.6-59.2% in vegetables (Ma *et al.*, 2008). Till now most research on the effects of film residue on cotton yields focuses on how much residue remains in fields after mulching for 30 years and very few studies have focused on impact of film residue on farmlands and specifically for cotton.

Film residue reduces cotton yield by worsening physico-chemical characteristics of soil. It is crucial to research the effects of film mulching on cotton yield over time. This points towards the need to take measures to promote sustainable development of cotton production and farmlands.

Taking short-staple cotton production areas in Xinjiang as research sites, production experiments, in terms of different film residue density when filming mulching successively from 0 to 141 years, were artificially conducted after fully studying the characteristics of local cotton film residue. Two major varieties, having two different root systems comparatively, were chosen to explore the changes and causes of film residue on reduction in cotton yield and to calculate how long film mulching could be used before yield increase under film mulching use was negligible.

Materials and Methods

Study areas : Experiment was performed at the headquarters of the Shihezi farm in Nongbashi, which is located on an alluvial fan edge belt, with loamy soil in northern slope of Tianshan in areas of short-fibre cultivation. Annual precipitation was 125.0 to 207.7 mm and the main annual crops grown were cotton, wheat, sunflower and beets.

Study of film residue in reference fields : In cotton production area, continuous film mulching for 1, 5, 10, 15, 20 and 25 year oldcotton farms were sampled in each field using 5-point sampling (0.6 m ×0.6 m). Soil was sampled every 10 cm layer to a depth of 40 cm. Then film residue was removed from the soil, brought to the laboratory for calculating quantity and density of film residues in each layer of every sampled point, separating sizes of film residue into 0-25cm^2, 25-100cm^2 and 100-200cm^2.

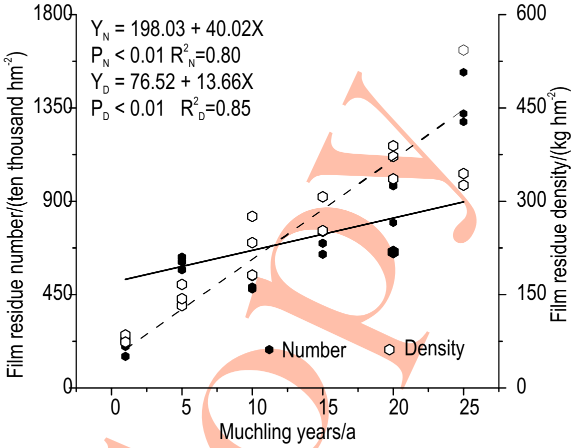


Fig. 1 : Variation of the quantity and density of cotton field's film residue of different mulching years

Manipulating film residue density : Based on the study in reference fields, six densities of film residue were chosen as treatments which represented varying years of film mulching: 0 (film mulching for 0 yr), 250 (film mulching for ~13 yr), 500 (film mulching for ~31 yr), 1000 (film mulching for ~68 yr), 1500 (film mulching for ~104 yr) and 2000 kg hm^{-2} (film mulching for ~141 yr). The reference study did not reveal any significant difference in density distribution among three size classes of film residue (0-25 cm^2 025-100cm^2 or 100-200cm^2) after mulching for 10 years or more. Additionally, the quantity and density of film residue was distributed evenly between soil layers from 0-40cm. Corresponding, three size classes of film residue and density rates 1:1:1 were mixed evenly into soil 0~40 cm for all residue treatments.

The varieties selected were the local varieties of Xinluzao 33 (with a deep root system) and Xinluzao 13 (with a shallow root system). An experimental area of 420 m^2 consisted of 7 treatments, and each treatment involved 2 varieties, 3 replicates and 10 m^2 area/replicate. Three drip tapes and six lines of cotton was used with aline spacing of (30 + 70 + 70 + 30) cm, and a row spacing of 10 cm. Irrigation quantity during growth period was 2980m^3 hm^{-2} and irrigation was repeated nine times. 700kg/hm^2 of urea and 550kg/hm^2 of potassium dihydrogen phosphate were fertilized throughout the experiment. Experiment lasted from April to October in 2011.

Determination of indices and methods

Physico-chemical characteristics of soil : In order to explore the effects of residue treatments on the physicochemical properties of soil during growth of cotton, 0-60-cm depth of soil were divided into three layers, and in each 20cm layer were sampled in October, to determine soil pH (using a Mettler-Toledo pH meter) were divided, conductivity rate (using a conductivity meter)ÿorganic matter (using the K_2CrO_7-H_2SO_4 external heating method), alkaline hydrolysis nitrogen (using the alkaline hydrolysis diffusion method), available P (using Mo-Sb colorimetry) and available K (using the ammonium acetate method) (Chinese society of soil agricultural chemical professional committee., 1983).

To investigate the effects of residue treatments on soil moisture and porosity, during the seedling stage (in February), flowering stage (in June), boll stage (in August and September) and boll opening stage (in October), 0-40 cm depth of soil, in all treatments, were divided into four layers and soil in each 10-cm layer were sampled to determine soil moisture content by drying method and porosity by using a cutting ring.

Cotton yield : During the seedling stage (in February), 100 plants were counted in each experimental plot to measure stand establishment rates of treatments. During the flowering stage (in June) as well as boll stage (in August and September), 100 cotton plants for number of flowers, number of bolls and subsampled 10 cotton plants for determination of biomass of bolls in each treatment were assessed.

During the boll opening stage, cotton yield in terms of cotton maturity were analyzed after picking cotton from each plot after 5 and 6 months.

Biomass, root/shoot ratio and root surface area : In the flowering stage (in June), the boll stage (in August) and the boll opening stage (in October), biomass of Xinluzao 33 variety and Xinluzao 13 variety was calculated using six plants in each plot, and root/shoot ratio and root surface area were sampled in all residue treatments.

Statistical analyses : Data for all the traits were analysed with SPSS Statistics 17.0

Cotton film residue : Linear regression analysis was used to examine change in the number and density of film residue in different film residue treatments.

Physico-chemical characteristics of soil : By applying least significant difference (LSD) multiple comparison, moisture content and porosity from different treatments, life stages and soil layers were differentiated (0-30 cm, 0-40 cm, and 30-40 cm). Through multiple comparison, soil pH, conductivity, organic matter, alkaline hydrolysis nitrogen, available P and available K were studied at 0-60 cm depth in six different residue treatments.

Physical properties of cotton and stand establishment rates, degree of maturity and root surface area : Linear regression was used to analyze number of cotton flowers, number of bolls, boll weight, changes in cotton yield, degree of maturity and stand establishment rates. LSD multiple comparison were used to explore treatment differences between biomass, root/shoot ratio and root surface area during flowering stage, boll stage and boll opening stage.

Stand establishment rate was calculated by the formula $S(\%) = nh/ (Ps \times g) \times 100\%$ (where nh is the number of healthy plants, *Ps* is the number of seeds planted and *g* is germination rate).

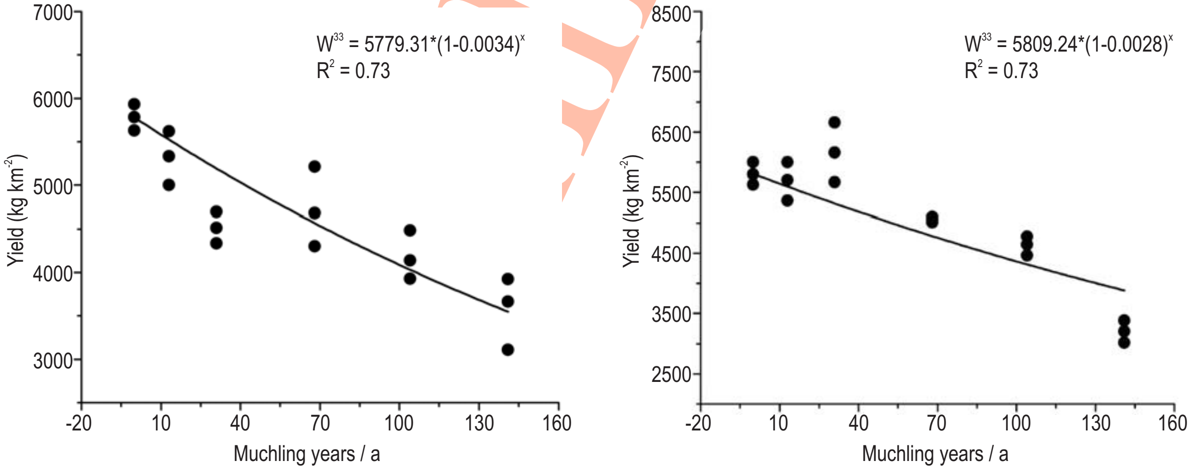
Total output was $P = F+S+T$, the degree of maturity $W = (F+S)/(F+S+T)$

(where *P* is the total output in kg, W is the degree of maturity in %, F is the quantity of cotton sampled for first time in kg; *S* is the quantity of cotton sampled for second time in kg; T is the quantity of cotton sampled for third time in kg (Dong *et al.*, 2009).

Calculation of effect of years of film mulching (and associated mulch residues) on cotton yield : The present study was based on the assumption that there were no more yield increases as technology developed.

Effect of years of mulching on yield increase : The yield decrease equation is given by the following formula:

$$W = P\ (1-A)^{x}$$



The label of 33 and 13 represent Xinluzao33 variety and Xinluzao13 variety

Fig. 2 : Regression simulation of two varieties yield and muchling years

(where W is cotton yield/per unit area after film mulching for years,; P is cotton yield/per unit area after film mulching for the first year; A is the reduction rate due to film residues remaining in field for 0 to 141 years; X is the years of film mulching). Fig. 2 illustrates that reduction rate of Xinluzao 33 variety was 0.0034 while that of Xinluzao 13 variety was 0.0028.

The equation of cotton yield/per unit area without film mulching is given by $Y=P(1-A)^m$ (where, m is the year between yield increase and its decrease due to film residue).

Cumulative yield after years of film mulching : After film mulching for years, IY, the cotton cumulative yield/per unit area, is given by the following equation :

$$IY = \sum_{i=1}^{m} [P \times (1-A)^i - Y]$$

Hypothetically, m years after film mulching can not be used, cotton yield decrease caused by film reside is given by $(1-A)^m$. Average cotton yields m years later is given by the following equation : $J = Y(1-A)^m$ (where J is annual cotton yield m years later).

In the equation DY=(n-m) (Y-J), n is the balance year between cumulative yield increase and its cumulative decrease due to film residue, and DY represents cumulative decrease yield caused by film residue without film mulching from the year m+1 to n year. The year n is when DY=IY.

Results and Discussion

Stand establishment rate, number of flower and bolls as well as boll weight for each plant decreased as film residue density increased (Figure 3a,b,c,d). At the film density of 2000 kg hm^{-2}, stand establishment rate, flower number, boll number, boll weight of Xinluzao 33 variety decreased by 19.0%, 21.4%, 23.4% and 55.8% respectively; while, stand establishment rates, flower number, boll number and boll weight of Xinluzao 13 variety declined by 24.4%, 28.2%, 31.5% and 44.9%, respectively. However, as the film density rose, degree of early maturation of both Xinluzao 33 variety as well as Xinluzao 13 variety increased by 69.1% and 78.2%, respectively.

The yield of Xinluzao 13 variety and Xinluzao 33 variety decreased as the film residue density rose (Table 3f). When film residue densities were 1000 kg hm^{-2} and 2000 kg hm^{-2} (around 141a), the yield of Xinluzao 33 variety dropped by 18.1% and 38.3%, respectively, while that of Xinluzao 13 variety decreased by 13.5% and 45.2%, respectively.

When the density of film residue increased, biomass of Xinluzao 33 variety during flowering varied little in different residue treatments but decreased during boll development and opening stages (Fig. 4a). In comparison, these measures for

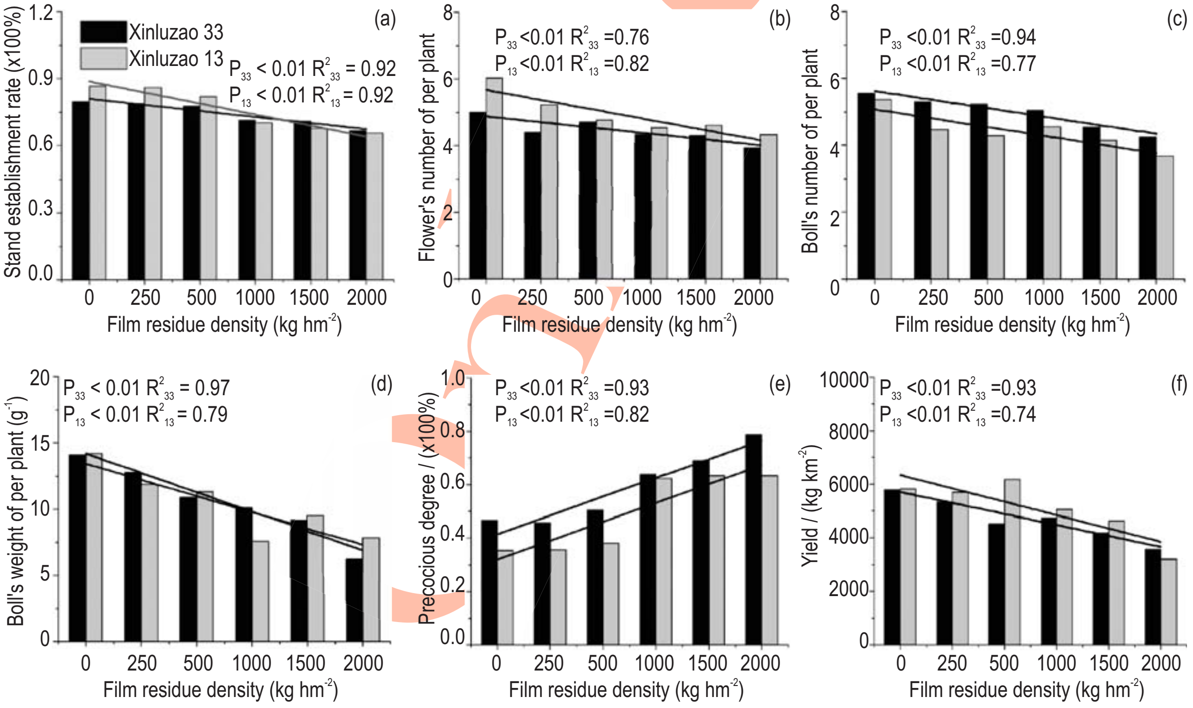


Fig. 3 : Effect of different film residue density on stand establishment rate, flower's number, boll's number, boll's weight of per plant, precocious degrees and yield of different cotton varieties

Xinluzao 13 variety decreased during flowering, even more during boll development and opening stages (Fig. 4b). Table 4c shows that during all stages, root/shoot ratio of Xinluzao 33 variety changed slightly. During flowering, root/shoot ratio changed slightly in Xinluzao 13 variety, but exhibited a drop during the boll stage and a rise during the boll opening stage (Fig. 4d). The root surface area of Xinluzao 33 variety didn't change much during flowering, decreased during the boll stage and increased during the boll opening stage (Fig. 4e). There was no significant change in root surface area of Xinluzao 13 variety during flowering as well as during the boll stage, but it increased during the boll opening stage (Fig. 4f).

With increasing film residue density, Xinluzao 33 variety and Xinluzao 13 variety's yield, stand establishment rate, number of flower and bolls, and boll weight per plant all declined but the degree of early maturity increased. Specifically, when residue density was 2000 kg hm^{-2} (when film mulching had been used 141

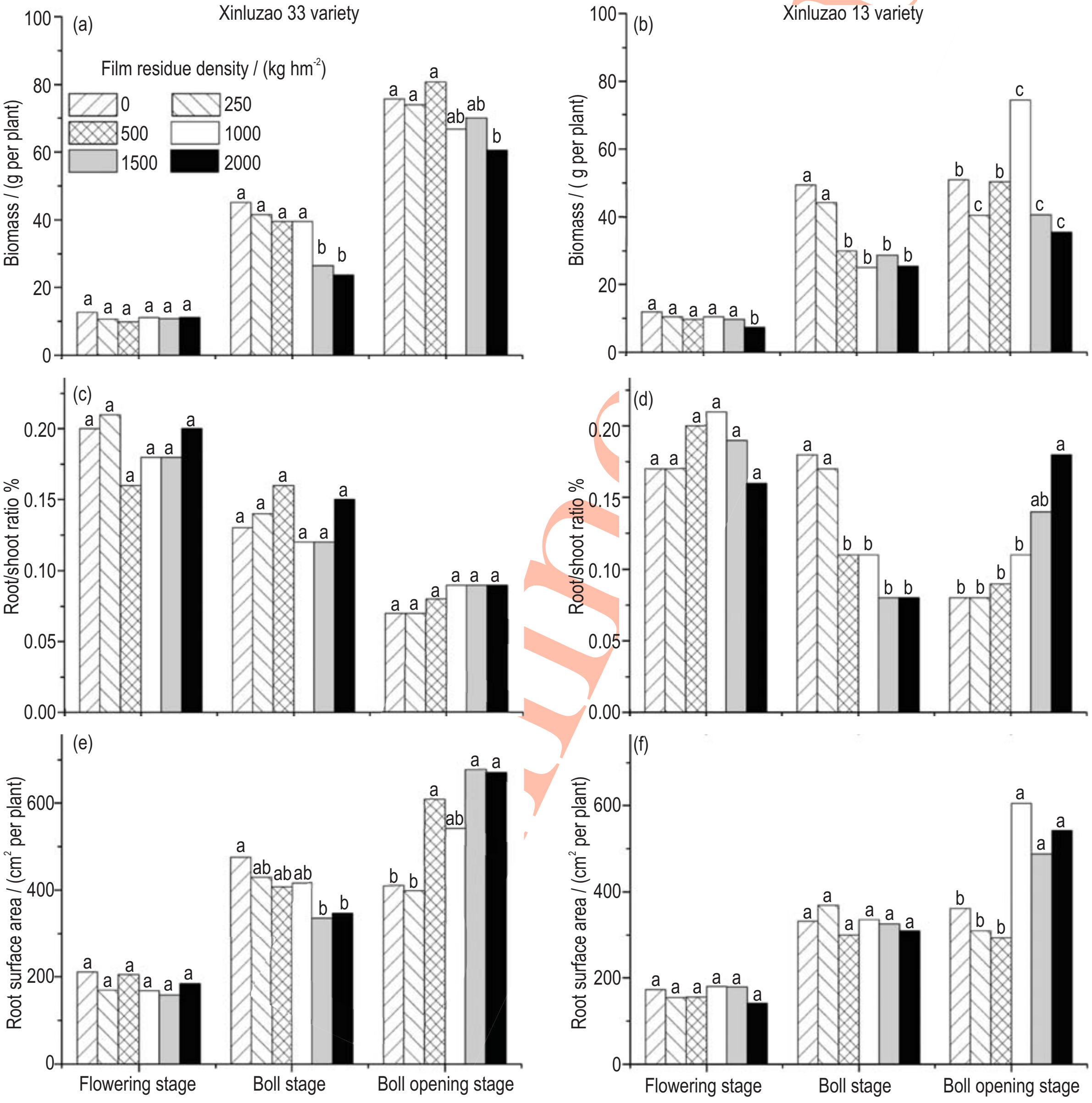


Fig. 4 : Effect of different film residue density on biomass, root/shoot ratio and root surface area of different cotton varieties; Different letters indicate significant differences at *p<0.05, using LSD's test.

years), respectively the yield of Xinluzao 33 variety and Xinluzao 13 variety decreased by 38.3% and 45.2%, stand establishment rate dropped by 16.3% and 24.3%, flower number fell by 21.4% and 28.2%, boll number reduced by 23.4% and 31.5%, boll weight of per plant decreased by 55.8% and 44.9% while degree of early maturity went up by 69.2% and 78.1%, respectively.

Film residue left on the surface may wrap up cotton seedlings, which prevents them from absorbing moisture and germinating; on the other hand, some seedlings may germinate well but may not establish correctly, leading to low stand establishment rate. Film residue prevents root growth, changes soil moisture, reduces nutrient surface area, and worsens soil nutrients, which all contribute to decreased flowers, bolls and boll weight/per plant. Plants flower early in adverse environments and Xinluzao 33 variety as well as Xinluzao 13 variety were no exceptions. Film residue increased cottons' degrees of early maturity, shortening the time for energy accumulation during the flowering and boll stages, decreasing flower number and boll weight/per plant as well (and thus decreasing cotton yields).

Film residue affected moisture content differently in the soil layers from 0 to 40cm during all growth periods. In seedling stage, high density film residues increased soil moisture content but decreased it during the flowering stage (Table 1). Soil moisture content in the 30-40 cm layer decreased with a high density of film residue. There was no great change in porosity between the 0-40 cm layers at all stages. In the boll opening stage, soil porosity in the 30-40 cm layer was reduced by high density film residue.

The present study, illustrated that increase in film residue density did impact soil nutrients (Table 2). For example, when film residue density was 1000 kg hm^{-2}, soil pH increased; At 500kg hm^{-2}, 1500 and 2000 kg hm^{-2}, organic matter was higher than other treatments. At 500 kg hm^{-2}, alkaline hydrolysis of nitrogen decreased. Available P as well as available K decreased when film residue density was 1000 kg hm^{-2}. As compared to soil without film mulching, pH rose by 10.2% while organic matter, alkaline hydrolysis of nitrogen, available P as well as available K decreased by 16.7%, 55.0%, 60.3%, 17.9%, respectively, at 2000 kg hm^{-2} residue density treatment. Film residue damage water and fertilizer infiltration, hinders air circulation, and may affect the growth of soil microorganisms. High film residue density significantly affected soil moisture, porosity, pH, organic matter, alkaline hydrolysis nitrogen, available P and K together with conductivity which worsened soil quality.

Salinity stress is a major limiting factor for plant germination. During seedling stage, high residue density increased moisture content below 40 cm while converse was true during flowering and boll stages. Film residue raised soil pH but lowered organic matter, alkaline hydrolysis nitrogen, available P and K. Alkaline hydrolysis nitrogen as well as available P decreased by 55.0% and 60.3%, respectively, when film residue density was 2000 kg hm^{-2}. Nitrogen is the main limit to cotton photosynthesis after film mulching and with drip irrigation, and it also limits cotton yield increase (Wang *et al*., 2007; Zhao *et al*., 2007; Mansouri-Far, 2010). Consequently, loss of alkaline hydrolysis nitrogen as well as available P jeopardizes cotton growth. Available P is difficult to supplement once it is lost because most phosphate fertilizers accumulate unusable in soil, with the available P absorbed by plants being only a small

Table 1 : Effect of different film residue density on soil moisture and porosity at different growth stages

Growth stage	Soil/cm	Film residue density / (kg hm^{-2})											
		0		250		500		1000		1500		2000	
		Moisture (%)	Porosity (%)	Moisture (%)	Porosity (%)	Moisture (%)	Porosity (%)	Moisture (%)	Porosity (%)	Moisture (%)	Porosity (%)	Moisture (%)	Porosity (%)
Seedling stage	0-40	0.173a	48.09a	0.172b	48.39a	0.198a	47.32a	0.189a	47.92a	0.186a	48.55a	0.190a	45.96a
	0-30	0.172a	47.61a	0.170b	48.26a	0.199a	48.01a	0.192a	47.88a	0.190a	49.28a	0.197a	45.99a
	30-40	0.177a	49.54a	0.180a	48.78a	0.197a	45.26b	0.180b	48.03a	0.173b	46.38b	0.170b	45.87a
Flowering stage	0-40	0.171a	47.95a	0.147a	48.86a	0.184a	50.40a	0.156a	52.17a	0.156a	49.27a	0.145a	54.45a
	0-30	0.173a	47.40a	0.149a	49.85a	0.183a	50.23a	0.161a	52.45a	0.150a	49.14a	0.151a	53.43a
	30-40	0.163a	49.61a	0.140a	45.88b	0.187a	50.89a	0.150a	51.33a	0.153a	49.64a	0.127b	57.52a
Boll development stage	0-40	0.178a	46.19a	0.179a	48.35a	0.160a	50.03a	0.171a	47.51a	0.167a	48.72a	0.157ab	47.16a
	0-30	0.176a	45.83a	0.177a	48.12a	0.160a	50.58a	0.171a	47.86a	0.169a	48.91a	0.166a	47.07a
	30-40	0.183a	47.27a	0.187a	49.04a	0.170a	48.39a	0.170a	46.46a	0.165a	48.16a	0.150b	47.41a
Boll opening stage	0-40	0.132b	51.81a	0.138b	51.30a	0.150b	50.75a	0.159a	52.44a	0.142a	52.00a	0.126a	51.90a
	0-30	0.129b	51.32a	0.136b	51.98a	0.148b	51.86a	0.162a	54.52a	0.142a	53.24a	0.129a	53.02a
	30-40	0.140a	53.26a	0.147a	49.26b	0.157a	47.42b	0.150b	46.21b	0.140a	48.26b	0.127a	48.54b

Different letters indicate significant differences at *$p<0.05$ using LSD's test

Table 2 : Effect of different film residue density on physical and chemical properties of soil in 60 cm layer

Film residue density/(kg hm^{-2})	pH	Conductivity rate/(ms cm^{-1})	Organic matter (g kg^{-1})	Alkali-hydrolyzable N/(mg kg^{-1})	Available P/(mg kg^{-1})	Available K/(mg kg^{-1})
0.00	8.07^{c}	1.17^{a}	8.02^{a}	38.41^{a}	13.26^{a}	291.89^{a}
250.00	8.20^{b}	1.08^{a}	7.61^{a}	33.25^{a}	12.40^{a}	284.99^{a}
500.00	8.18^{b}	1.04^{a}	6.71^{b}	20.91^{b}	10.25^{ab}	283.67^{a}
1000.00	8.60^{a}	1.06^{a}	7.92^{a}	20.53^{b}	9.55^{b}	264.72^{ab}
1500.00	8.98^{a}	1.18^{a}	6.73^{b}	13.49^{c}	6.61^{c}	233.85^{b}
2000.00	8.89^{a}	1.23^{a}	6.68^{b}	17.29^{bc}	5.26^{c}	239.51^{b}

Different letters indicate significant differences at $^{*}p<0.05$, using LSD's test.

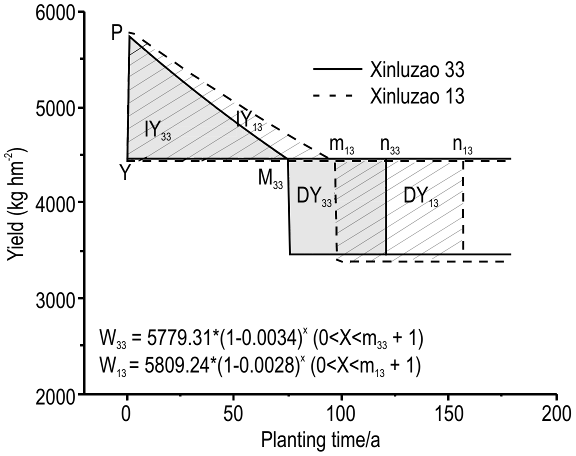


Fig. 5 : The schematic diagram of yield and time

proportion of the total P applied (Zhang *et al.*, 2011).

Based on experiments and equation 1.5.5, a time threshold for increase in cotton yield after years of film mulching (Fig. 5) was determined. From the first year to year m, the yield equation of Xinluzao 33 variety was W_{33} =5779.31*(1-0.0034)^{x} and for Xinluzao 13 variety, it was W_{13} =5809.24*(1-0.0028)^{x}.

The reduction rate of Xinluzao 33 variety (0.34%) was different from that of Xinluzao 13 variety (0.28%) with increasing years of using mulching films (Fig. 1). The yield of Xinluzao 33 variety without film mulching was 4495.2 kg hm^{-2}. It increased 29.3% for the first year with film mulching to an yield of 5779.3 kg hm^{-2}. However, the reduction rate would be much higher than its yield increase (4491.8 kg hm^{-2}) after mulching for 75 years. Within the first 75 years, yield increased 46030.0 kg hm^{-2} in total and by the 76th year, cotton yield without mulching would be 3493.6 kg hm^{-2}. From the 76th year and 121st year, the cumulative reduction would be 46069.4 kg hm^{-2}. In this case, DY_{33} becomes greater than IY_{33} and cumulative reduction would be greater than cumulative yield increase.

The yield of Xinluzao without film mulching was 4472.7 kg hm^{-2} and it increased by 30.63% to 5842.9 kg hm^{-2} during first year using film mulching. However, its yield increase would be less than reduction rate after mulching for 97 years. Within the first 97 years yield increased 63068.4 kg hm^{-2} in total and by the 98th year, cotton yield without mulching would be 3417.1kg hm^{-2}, a reduction of 1055.5 kg hm^{-2} as compared to cotton without film mulching. Between the 98th year and 157th year, cumulative reduction would be 63331.2 kg hm^{-2}. Hence DY_{13} would become higher than IY_{13} and its cumulative yield increase would be less than its cumulative reduction.

Most films are polyethylene which are stable and can stay in soil for 200-400 years. However, time thresholds for positive cotton yield of Xinluzao 33 variety and Xinluzao 13 variety were both less than 200 years. The average annual reduction of these two varieties were 0.34% and 0.28% respectively. The reduction rate caused by film residue was greater than its increase rate after film mulching for 75 years (film residue density was 1101.02 kg/hm^{2}) and 97 years(film residue density was 1401.54 kg hm^{-2}). If film mulching for 121 years(film residue density was 1101.02 kg/hm^{2}), Xinluzao 33's cumulative reduction/per surface area is greater than its cumulative increase. If film mulching for 157 years(film residue density) was 2221.14 kg hm^{-2}, Xinluzao 13's cumulative reduction/per surface area was greater than its cumulative increase. In other words, cotton yield decreased seriously owing to cumulative residue. Making matters worse is the cumulative cotton yield increasing would be zero because soil quality is degraded after mulching for years, these strongly influence soil sustainability utilization and cotton economic growth in Xinjiang.

There are ways to reduce film residue by using such materials as starch polymer composite plastic films, photodegradable plastic films and biodegradable plastic film (El-Kader and Hamied, 2002). All of these solutions can be crucial to avoid negative effects from film residue, although none of these works well in China due to high cost, inaccurate control of mulch degradation speed, poor wind and water resistance and difficulties during both hand and machine harvesting. The underlying negative impacts of film residue on cotton yield, time limits to its use and damages to soil quality are all reminders for the government and businesses to seek to study this issue in depth as well as use preventive technologies for film residues.

In the present study it was found that Xinluzao 33 variety's tolerance to film residues was greater than that of Xinluzao 13 variety. When film residue density was 2000 kg hm^{-2}, yield of Xinluzao 13 variety decreased by 6.9% more than that of Xinluzao 33 variety. Stand establishment rate of Xinluzao 13 variety dropped by 8.1% more than that of Xinluzao 33 variety. Meanwhile, the yield of Xinluao 13 variety was higher than that of Xinluzao 33 variety and time thresholds for favorable yields in Xinluzao 13 variety were longer as compared to Xinluzao 33 variety. Whether this is the characteristic of all shallow root systems needs more experimentation.

In conclusion, the present study, revealed that Xinjiang film residue had significant effects on cotton yield and soil. Greater attention to this problem and mitigation measures are needed, otherwise sustainability of cotton production and soil are in jeopardy. Cultivating and utilizing cotton cultivars with deep roots could lessen the impact of film residue on yield.

Acknowledgments

The research presented in this paper is supported by Joint Fund of NSFC-Xinjiang (Grant No. U1130304) and the Key Technology R & D Program (Grant No. 2014BAC14B02).

References

Anikwe, M.A.N., C.N. Mbah, P.I. Ezeaku and V.N. Onyia: Tillage and plastic mulch effects on soil properties and growth and yield of cocoyam (*Colocasia esculenta*) on an ultisol in south eastern Nigeria. *Soil Till. Res.*, **93**, 264-272 (2007).

Chinese society of soil agricultural chemical professional committee: Soil agricultural chemical routine analysis method. Beijing: Science Press, China (1983).

Du, X.M., G. Xv, R.P. Xv, T.K. Zhao and F.S. Li: Mulch film residue contamination in typical areas of North China and countermeasures. *Trans. CSAE.*, **21**, 225-227(2005).

Dong, H.Z., W.J. Li and W. Tang: Early plastic mulching increases stand establishment and lint yield of cotton in saline fields. *Field Crop Res.*, **111**, 269-275 (2009).

El-Kader, A. and A.. Hamied: Preparation of Poly (vinyl alcohol) films with promising physical properties in comparison with commercial polyethylene film. *J. Appl. Polym. Sci.*, **86**, 1219-1226 (2002).

Liu, J.G., Y.B. Li and W. Zhang: The distributing of the residue film and influce on cotton growth under continuous cropping in Oasis of Xinjiang. *J. Agro Environ. Sci.*, **29**, 246-250 (2010).

Liu, W.F., M.Q. Zhao and H.Q. Tiao: Analysis of environmental contamination caused by farm film and recovery technology. *Chi. Agr. Mechaniz.*, **5**, 34-36 (2003).

Lv, Z.Y., L.A. Niu and J.M. Hao: Problems faced by ecological environment of agriculture in China and their improving countermeasures. *Chinese Agr. Sci. Bull.*, **25**, 218-224 (2009).

Mansouri-Far, C., S.A.M. Modarres and S.F. Saberali: Maize yield response to deficit irrigation during low-sensitive growth stages and nitrogen rate under semi-arid climatic conditions. *Age Water Manage*, **97**, 12-22 (2010).

Mahajan, G., R. Sharda and A. Kumar: Effect of plastic mulch on economizing irrigation water and weed control in baby corn sown by different methods. *Afr. J. Agric. Res.*, **2**, 19-26 (2007).

Ma, H., X.R. Mei and C.R. Yan: The residue of mulching plastic film of cotton field in north china. *J. Agro Environ. Sci.*, **27**, 570-573 (2008).

Sun, X.G., W.J. Liu and R.W. Gan: Plastic film hazard of cotton fields and countermeasures in Xinjiang. *China Cotton*, **33**, 7-8 (2005).

Wang, X., G.B. Juan and Z.G. Ren: Effects of environment-friendly degradable films on corn growth and soil environment. *Chin. J. Eco-Agr.*, **15**, 78-81 (2007).

Xie, H.E., Y.S. Li and S.Q. Yang: Influence of residual plastic film on soil Structur, crop growth and development in fields. *J. Agro Environ. Sci.*, **26**, 153-156 (2007).

Yan, C.R., X.R. Mei and W.Q. He: Present situation of residue pollution of mulching plastic film and controlling measures. *Trans. CSAE.*, **22**, 269-272 (2006).

Yan, C.R., X.J. Wang and W.Q. He: The residue of plastic film in cotton fields in Shihezi, Xinjiang. *Acta Ecologica Sinica*, **28**, 3470-3474 (2008).

Zhang, J., X.L. Ren and S.F. Luo: Influences of different covering materials mulching on soil moisture and corn yield. *Trans. CSAE.*, **26**, 14-19 (2010).

Zhang, X.M., X.B. Sun and N.J. Wu: Investigation of photo-degradation controllability of degradable mulching film under different area climatic conditions. *J. Shihezi Univ.*, **31**, 90-94(2013).

Zhang, X.J., Z.J. Li and J.Y. He: Effects of soil moisture on phosphorus transformation in maize rhizosphere. *Southwest China J. Agr. Sci.*, **24**, 654-657 (2011).

Zhao, D., K.R. Reddy and V.G. Kakani: Canopy reflectance in cotton for growth assessment and lint yield prediction. *Europ. J. Agron.*, **26**, 335-344 (2007).