Effects of Different Mulching Methods on Soil Agro-Physical Characteristics and Cotton Yield

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Abstract: In world cotton cultivation, in addition to fundamental practices for saving and improving soil fertility, improving water-physical characteristics (soil tillage, fertilization, and crop rotation and others), various mulching methods and technologies are being utilized to enhance soil characteristics. In Uzbekistan, the effectiveness of mulching with polyethylene film, coal dust, K-4 polymer, petroleum residues, and oil-impregnated black paper has been studied. These experiments are aimed at improving the soil layer, conserving water, improving the efficiency of applied fertilizers, and enhancing the water-physical state of soil, which are considered urgent issues of today.

1 INTRODUCTION

Among the most important water-physical characteristics of soil, especially for cotton germination, are soil moisture, soil temperature, porosity, bulk density, and water permeability.

According to S.N. Rijov, the lower limit of soil moisture during cotton sowing should be no less than 17.0% for clayey soils, 15.0% for heavy sandy soils, 13.0% for medium sandy soils, 11.0% for light sandy soils, and 9.0% for sandy soils. Excessive soil moisture at the time of sowing can lead to seed rot.

According to S.K.Isaev, mulching with polyethylene films increases soil moisture by 2.7-4.8%.

Soil temperature is a crucial factor in the growth of plants, significantly affecting seed germination, growth, and development. Low soil temperatures can cause seed rot due to excess moisture, while high temperatures can lead to dryness due to insufficient moisture.

Experiments conducted by B.I.Niyazaliev in typical sierozem soil conditions showed that using manure (2 t/ha) as mulch increased soil temperature by 0.5°C in the 0-5 cm layer (Akhmurzaev, 2018; Ryzhov, 1957; Isaev, 2002).

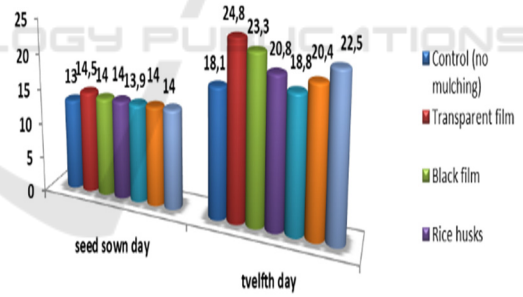

Figure 1: Effect of mulching methods on soil temperature.

2 MATERIALS AND METHODS

Field experiments were conducted in the conditions of typical sierozem soils of Tashkent province. In the experiment, depilated cotton seeds of the medium

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fiber Namangan-77 variety were sown in the 90x10-1 scheme.

The following norms and types of mineral fertilizers were used in the experiments. N-200 kg/ha, P_2O_5 – 140 kg/ha, K_2O – 100 kg/ha; ammonium nitrate (N-34%), ammophos (N-12, P_2O_5 – 46%), potassium chloride (K_2O-56%).

Mulch materials: transparent film 50,0 kg per hectare, black film 50,0 kg, rice husk 8-10 t/ha, wheat straw - 8-10 t/ha, SAG pereparation-1,0 and MT pereparation-20 kg/ha was used.

Calculations were carried out during phenological observations in June, July, August and early September. The methods written in the book "Methods of field and vegetation experiments with cotton under irrigation conditions", "Methods of conducting field experiments", agrochemical and agro-physical characteristics of the soil "Methods of agrochemical and agro-physical analysis of soils and plants of Central Asia" were used for conducting phenological observations.

In our conducted experiments, where has shown that mulching with different materials (black and white polyethylene films; wheat straw and rice husks; polymers like SAG and MT preparations) positively impacts soil moisture and temperature (Niyozaliev, 1987;Allanov et al., 2009).

3 RESULTS AND DISCUSSION

According to the data, on the day of cotton sowing, soil moisture and temperature in the 0-5, 5-10, and 10-20 cm layers were almost the same in all variants. After 6 days, when the cotton seeds were just beginning to germinate, it was found that in the control variant, soil moisture were 14.0%, 16.0%, and 17.0% in the respective layers, in contrast, when used transparent film in second variant, these indicators were determined 1.0%, 1.9%, and 1.0% higher.

The variant with black film utilized soil moisture was 0.9%, 0.6%, and 0.4% higher during this period. The increase in moisture with transparent film was closer to that of black film, indicating that the difference between them was minimal and had little significance for the development of the plant roots or above-ground parts.

In the variants where mulching was done with rice husks and wheat straw, soil moisture in the layers were 14.8% 14.7%, 16.2%-16.2%, and 17.4%-17.3%, respectively. These were 0.8%-0.7%, 0.2%-0.2%, and 0.4%-0.3% higher compared to the control. However, these indicators were 0.1%-0.2%, 1.7%-1.8%, and 0.6%-1.0% lower than those in the polyethylene film variants.

In the variant using the SAG polymer preparation, soil moisture was 15.2%, 16.4%, and 17.8%, with similar results observed with the MT polymer preparation.

12 days after sow, the moisture was 12.9%, 13.2%, and 14.0% in the 0-5, 5-10, and 10-20 cm layers (compared to dry soil), respectively. In mulched variants, the moisture levels were higher. Particularly, the variant mulched with transparent film showed 2.0% higher moisture compared to the control and 0.1%-1.1% higher compared to the experimental variants.

If we classify the mulching materials based on their effect on soil moisture, polyethylene films (both transparent and black) take the first position, followed by polymers (SAG and MT preparations), and finally plant residues like rice husks and wheat straw.

According to the observations, it was found that there is a significant difference in the temperature change of the soil temperature of the mulch materials. In the control option, the average soil temperature on the day of sowing the seeds in the 0-10 cm layer of the soil was 13.0°C, and in all options (2-7 var) where mulching methods were used, similar indicators were obtained. This situation indicates that the mulch material has no effect on the soil temperature. However, after 6 days, it was found that the soil temperature increased not only in the studied options, but also in the control. This is definitely related to the increase in air temperature.

On the 6th day of research, in the control variant, the temperature in the 0-10 cm layers of the soil was on average 15^0C, or it was observed that it increased by 2^0C from the day of sowing.

In option (2) where a transparent film was used, the average soil temperature was 21.2°C, which was 6.2°C higher than the control. When black film was used, these indicators were slightly lower and equaled 19.6°C. The temperature of the soil increased towards the research period, and after 12 days after sowing the seed, the temperature in the above variants was on average 24.8 and 23.3^0C.

Table 1: Effects of applied mulch materials on cotton growth and development.

Number of options	Experimental Variants	Main stem height, cm	Number of productive branches, pcs	Number of bolls, pcs		Including opened ones, %
		1.08	1.08	1.08	1.09	1.09
1	Control (no mulching)	90,7	10,4	8,1	8,4	22,5
2	Mulching with transparent film	103,5	13,0	9,4	10,9	45,4
3	Mulching with black film	101,2	12,1	9,3	9,5	43,2
4	Mulching with rice husks	95,7	11,0	8,4	8,6	30,5
5	Mulching with wheat straw	95,1	10,9	8,3	8,5	26,2
6	Mulching with SAG preparation	94,3	11,0	8,5	8,7	26,5
7	Mulching with MT preparation	97,4	11,3	8,7	9,1	34,9

In options (4-5) where rice husks and wheat straw were used as mulch, the average temperature was 20.8-18.8 ^{0}C 12 days after sowing. These indicators were 5.2-2.7^{0}C higher than those of the control variant, but 6.0-4.0^{0}C lower than those of the film variants.

On the 12th day, the soil temperature was 20.4 0C in the case of the SAG preparation, and 22.5 ^{0}C or 2.3 and 4.4 0C higher when the MT preparation was used. It was found that in the options using polymer preparations (SAG and MT), all indicators were slightly lower than those in the options using polyethylene films, and higher than those in plant residues.

First of all, it is worth saying that the rate of germination of cotton seedlings depends on soil temperature, moisture level and other physical properties. The earlier the seed is planted, the more positive the effect of our applied mulch materials will be.

In our observations, in the control variant, 6 days after sowing the seeds, the seedlings were 5.4 pieces or 28.3% sprouted per meter, when transparent and black films were used as mulch, this indicator was 7.4 and 6.7 pieces or 38.9 and 35.4%. These indicators are 2.0 and 1.7 units or 10.6 and 7.1% more than the control. In the options using rice husk and wheat straw, the germination of seedlings during this period was 6.5-6.1 units or 34.3-32.1%, compared to the control by 1.1-0.7 units or 6.0-3.8 % more, but due to the effect of polyethylene films; It was found to be 0.9; 0.2-1.3; 0.6 units i.e. 4.6; 1.1-6.8; 2.2% less. In the options where SAG and MT preparations from polymers were used, seed germination at 1 p/meter was 6.3 and 6.7 grains, 33.4 and 35.6%. These indicators are 1-3% higher than the effect of plant residues, but 3-4% less than polyethylene films.

On the 10th day of research, 12.4-65.4% sprouts sprouted per 1 p/meter in the control option, while in the options with transparent and black films, these indicators were happened 15.4-15.2 and 81.3-80.5%.

15.9 and 14.9% more germination of cotton seedlings was observed under the influence of polyethylene films compared to the control. It should be noted that the effects of transparent and black films on the germination rate of seedlings were found to be close to each other.

In variants using rice husk and wheat straw as mulch, these indicators were 15.0-14.8 units and 79.2-78.1%, compared to the control by 2.6-2.4 units or 13.8-12.7 % more, but compared to polyethylene films, they were 0.4-0.2 and 0.6; 0.4 pieces or 2.1; 1.1; 0.6; 0.4% less.

The variants using polymers (SAG and MT) obtained data slightly lower than the aforementioned polyethylene films, but higher than the effects of plant residues. After 12 days after sowing, 99.0% of seedlings emerged in control and 100.0% in all other variants.

So, it was determined that the effect of mulch materials on the germination of cotton seedlings depends primarily on weather (soil) temperature, soil

moisture and other physical properties, as well as on the timing of seeding.

All applied mulch materials generally had a positive effect on the water-physical properties of the soil, as a result of which it was observed that cotton growth was higher than the control.

According to the data of August 1 observations, the height of the cotton main stem in the control was 90.7 cm, 10.4 branches, the number of bolls on September 1 was 8.4, including 22.5% of the opened ones. In the case where a transparent film was used, these indicators were proportionally 103.5 cm, 13.0; 10.9 pieces and equal to 45.4%, compared to the control, 12.8 cm; 2.6 and 2.5 pieces and 22.9% more. In the variant where black film was used as mulch, the height of the main stem was 101.2 cm, the number of productive branches was 12.1, and the number of bolls was 9.5, and the opened ones were 43.2%. These indicators were proportionally 11.5 cm, 1.7 and 1.1 grains and 20.7% more, but 2.3 cm, 0.9 and 1.4 grains and 2.2% less than the indicators of transparent film.

It should be noted that because the transparent film transmitted light directly to the surface of the soil, the temperature of the soil was slightly higher under its influence than that of the black film. As a result, sprout germination was accelerated and it was found that it had a favorable effect on the development of cotton.

In the option (4) where rice husk was used from plant residues, the above indicators were proportionally 95.7 cm, 11.0 and 8.6 pieces and 30.5 %. These numbers are 5.0 cm, 0.6 and 0.2 and 8.0% higher than the control, and were lower than the indicators of the polyethylene films, especially the number of open bolls was 14.9% and 12.7%. The parameters of the variant using rice husk were 0.6 cm, 0.1 and 0.1 grains and 4.3% higher than those of wheat straw. In other words, the effect of plant residues on the growth and development of cotton was almost the same.

Among the used polymers, it was found that the effect of the MT preparation on the growth and development of cotton was better than that of the SAG preparation. In this case, in the variant where MT was used, the height of the main stem was 97.4 cm on August 1, the yield branches were 11.3, and the number of bolls (on September 1) was 9.1, including 34.9% of the opened ones, SAG preparation indicators are proportionally less than these by 3.1 cm, 0.3 and 0.4 units and 8.4%.

Therefore, regardless of the types of mulch materials used, it was found that cotton has a positive effect on growth and development. Better results were obtained when polyethylene films (transparent and black) were used, followed by polymers and finally when plant residues were used.

Thus, it is necessary to use mulching methods to grow cotton crop in early and higher periods than cotton. In order to increase their effectiveness, it is necessary to sow the seed earlier.

The effectiveness of any agronomic practice used in experiments is evaluated by its effect on cotton yield. In addition, the main goal of all scientific research is focused on early and high-quality cultivation of the cotton crop. Therefore, in our experiments, the effect of mulching methods on cotton yield was determined depending on the period of seed planting.

According to the results of the observations, the average cotton yield in the control option was 26.9 c/ha in 3 years. In the case of using a transparent film, this indicator was equal to 32.8 c/ha, and an average of 5.9 c/ha additional cotton yield was obtained compared to the control. Under the effect of the black film, the additional cotton yield was 4.0 c/ha, which was 1.9 c/ha less than the indicator of the transparent film. The average yield of cotton under the influence of rice husk was 28.8 c/ha and when wheat straw was applied, it was 28.7 c/ha. These indicators were certainly less than the effect of polyethylene films.

The average cotton yield was 28.9 c/ha in three years in which SAG preparation was used from polymers, and 2.0 c/ha additional yield was obtained from the control. Under the influence of the preparation MT, these indicators were equal to 29.9 and 3.0 c/ha. Therefore, 1.0 c/ha additional yield of polymers was obtained under the influence of MT preparation compared to SAG preparation.

Due to the increase in soil temperature and humidity due to the effect of polyethylene films, cotton sprouts were completely recovered and optimal conditions for their growth were created. 1.9 and 1.1 c/ha less cotton yield was obtained due to black film compared to transparent film. This condition can be attributed to the fact that soil moisture increases under the influence of a black film, but its temperature is lower than that of a transparent one. Similar data were obtained from plant residues (rice husk and wheat straw).

It was determined that the cotton yield obtained from these effects is economically preferable, even if it is less than others.

A relatively high yield of cotton was obtained from polymers under the influence of the MT preparation, and the additional yield was 3.0 c/ha. The next one is taken by the preparation SAG.

4 CONCLUSIONS

In conclusion, all the used mulching materials had an acceptable effect on increasing the cotton yield, besides, they are resource-saving factors in maintaining soil fertility and moisture.

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