Experimental Research and Evaluation on Different Mulching Treatment Effect on Soil Quality

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Abstract：Straw mulching, one of the core technologies of conservation tillage, can reduce the environmental pollution and field evaporation effectively and increase crop yield. However, there are different effects on the soil conditions in different amount of straw mulch. This paper tested on the different mulching treatment effect on soil quality, and sampled during the winter wheat's sowing to overwinter time. Then analyzed the soil quality changes under different treatments during this period and did the fuzzy comprehensive evaluation. It can be concluded that it is more reasonable to choose the scheme of 50% straw coverage during the winter wheat's sowing to overwinter time.
Keywords: Straw mulching, different treatments, soil quality, evaluation

1. Introduction

The crop straw were used in China early, but because of historical conditions and technical constraints, they were used to feed livestock, washers, etc. and most of them were dealed in the form of burning or burned for fuel, which made waste and pollution extremely serious. Thus, the straw mulching farming gradually emerged in an environmental way, but the real systematic research began in 1990s. In recent years, various types of conservation tillage techniques gradually form, such as straw mulching farming, mulching tillage, minimum tillage and straw mulching method, the entire straw mulch tillage method, etc. The promotion and application of these measures have already received some benefits, solved dry farming land "dry" and "thin" issue to some extent and also made a remarkable difference on soil moisture conservation, increasing soil organic matter and crop yields.

With the gradual promotion and popularity of conservation tillage, the requirements of related technologies are more stringent and the rules are more detailed. As the most critical technique in conservation tillage, straw-covered research is particularly important。The study is based on practical situation in Zibo, Shandong, referring to existing research in related technologies and index and drawing on previous experience to conduct experiment on soil changes and regulations after the straw mulch so as to obtain a more accurate data and provide a reliable basis for the further promotion of conservation tillage.

2. Materials and Methods

2.1 Test sites and conditions

The test area is located in Fanjia village, Fangzhen town, Zibo. It is a wide and flat area with good cinnamon soil quality.

The wheat sowing time is in early October. Before sowing treatments, we collected the soil samples to test the basic soil quality, and then carried on the experiment. The results are shown in Table 2.2.1.

Table 2.2.1 Basic soil quality of the experimental land

Soil layer/cm	vailable N / $mg \cdot kg^{-1}$	available P / $mg \cdot kg^{-1}$	available potassium / $mg \cdot kg^{-1}$	Organic matter / $g \cdot kg^{-1}$	pH

0-10	52.62	10.95	141.25	12.72	7.86
10-20	50.12	8.81	133.08	10.96	7.95

2.2 Test materials and equipment

Autumn mature corn stalks； equipment needed： hay cutter，electronic scale ，sampling bottles and so on.

2.3 Experimental design

After harvesting mature corn stalks, we need to shred stalks and the length of each is not more than 5cm. Do three levels of straw mulch treatment: 0 mulching quantity, 50% mulch quantity, 100% mulch quantity. Decomposition accelerator are set two levels, that is, decomposition accelerator and no decomposition accelerator , then we do completely random combination of the two experimental factors （0 mulch is only combined with the no decomposition accelerator, namely as a reference test）a total of five treatments and repeated twice for each treatment. The test area was divided into 15 experimental treatment plots with each for 2m × 2m. Each treatment was arranged randomly to 15 small areas.

This study only discusses the different mulching treatment effect on soil quality, and the impacts of microorganisms are not considered temporarily. It is left to follow-up study.

2.4 Determination method and data processing

2.4.1 Determination projects

Select soil organic matter, nitrogen, phosphorus, potassium and pH as indicators of soil quality measurement.

2.4.2 Detection method and data processing

Soil quality was measured by TYP-6 soil nutrient determinator. Use Excel to process data and fuzzy comprehensive evaluation to analyze data.

3. Results and Analysis

3.1 Straw mulch impacts on soil organic matter

Soil organic matter, one of the important indicators to measure soil conditions, is the main sources of plant nutrients. It can promote crop growth, soil structure; improve water and fertilizer retaining capacity of soil. The soil with more organic matter has better soil fertility. We detected the organic matter under different mulching amount in middles of December, 2009 (during this period, we didn't fertilizer, and the following experimental data is average). As figure3.1.1:

It can be seen from the figure 3.1.1 that organic matter content of three treatments in 0-10 cm and 10-20 cm layer has declined. And the organic matter consumption of 0 mulch quantity is the largest, decreased obviously by about 35.93%; 100% mulch quantity is the second, about 23.35%; the changes in organic matter of 50% mulch quantity are relatively small, 2.12% lower than baseline. From wheat sowing to overwinter time, we didn't use any fertilizer, it can be thought that the organic matter used to meet the wheat growth was provided by the soil. Thus, soil organic matter content declined. The experiment showed three results. The first one is that straw mulch can reduce the consumption rate as well as consumption quantity of organic matter. The second is that the organic matter content of 50% mulching treatment is 52.76% higher than those without straw mulch. The last one is that total mulch (100% mulch) is 19.63% higher than those without straw mulch. Therefore, according to the change of organic matter content, we can conclude that in the course of straw returning, 50% straw mulch is more suitable.

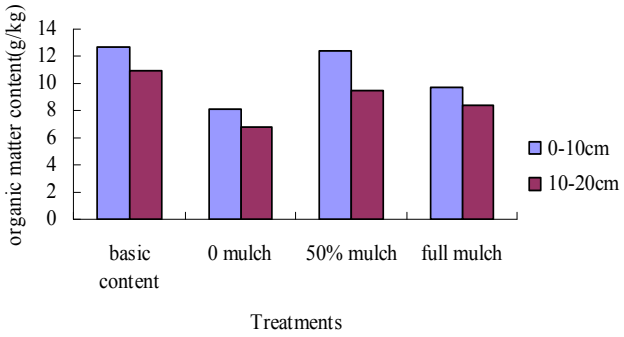

Figure 3.1.1 Organic matter content of different treatments

3.2 Straw mulch impacts on the soil of available nitrogen

From figure 3.2.1, we can know that the in 10-20 cm soil layers is lower than that in 0-10 cm. In 0-10 cm soil layer, compared with the basic content, the available nitrogen content in 50% mulch and full mulch (100% mulch) decreased by 3.90% and 18.02% respectively. Full mulch is nearly 5-fold lower than 50% mulch, while the 0 mulch increased 20.07% compared with the basic content; in 10-20 cm soil layer, three kinds of treatment all decreased in comparison with basic content, while the trend of 50% mulch treatment is the most obvious, 31.86%. Full mulch followed it, 22.01%. The least obvious one is 12.31% for the 0 mulch.

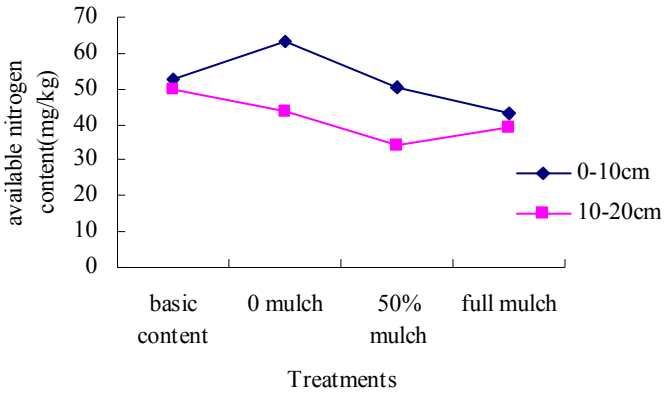

Figure 3.2.1 Soil available nitrogen of different treatments

3.3 Straw mulch impacts on soil available phosphorus

The results show that the available phosphorus content change among three kinds of treatment is quite different. Among them, the available P amount of full mulch treatment decreased lowest compared with the basic content: 0-10 cm soil layer and is about 19.18% ,10-20 cm soil layer is about 43.59%; the two layers of 50% mulch decreased by 28.40% and 49.60% respectively, While the changes in available phosphorus content of 0 mulch is the most obvious(0-10cm soil layer decreased by 73.52% and 10-20 cm layer decreased by 86.38%), that is, far greater than those of the total mulch and 50% mulch. Apparently, the straw cover plays a role in reducing phosphorus loss and consumption.

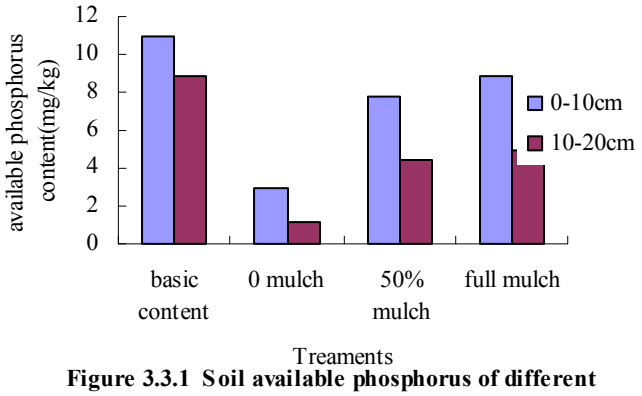

Figure 3.3.1 Soil available phosphorus of different treatments

3.4 Straw mulch impacts on soil available potassium

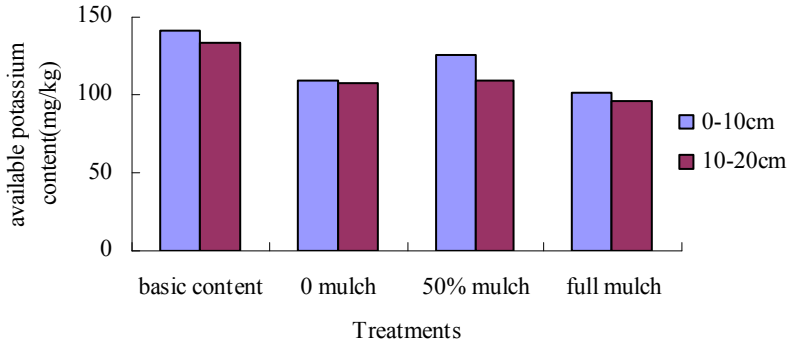

Figure 3.4.1 Soil available potassium in different treatments

Obviously, the available potassium declining contents of full much and 0 mulch are relatively larger than 50% mulch, but the difference between the former two is not obvious. The specific reduction rates are as following table 3.4.1:

Table 3.4.1 Soil available potassium reduction rate of different treatments

Soil layer/cm	no mulch	50% mulch	full mulch
0-10cm	22.69%	11.46%	27.96%
10-20cm	19.21%	17.97%	27.31%

The above figures show that from wheat planting to overwinter period, 50% straw mulch is effective in reducing the consumption or loss of soil available potassium. But full mulch shows side effects, under these circumstances, the potassium consumption is higher than no mulch. In 0-10 cm soil layer, the former is 6.81% more than the latter. In 10-20 cm, the former is 10.04% more than the latter. It also shows that from the change of soil available potassium, the effect of 50% mulch is better than the others.

3.5 Straw mulch impacts on soil pH

In wheat sowing time, the soil pH in 10-20 cm soil layer is slightly larger than that in 0-10 cm soil layer,

between 7.5 and 8.5, that is, the soil is alkaline. To overwinter time, the pH of three treatments all changed, but the range did not show obvious fluctuations. As the following table 3.5.1:

Table 3.5.1 Soil pH value of different treatments

Soil layer	Basic content	0 mulch	50% mulch	full mulch
0-10cm	7.86	7.86	7.94	7.83
10-20cm	7.95	7.81	7.94	7.79

3.6 Analysis and Assessment

Fuzzy comprehensive evaluation on the experimental results

1. No mulch, 50% mulch and full mulch are three treatment programs (called 1,2,3 program), the factor set as follows: (organic matter, nitrogen, phosphorus, potassium, pH), according to practical information and experience, one by one contrast method was used to determine the weight of each factor :

$$a = (0.378 \;\; 0.220 \;\; 0.220 \;\; 0.127 \;\; 0.055)$$

2. Determine the rating set R and Grade V = (good middle bad)

$$R_1 = \begin{pmatrix} \frac{3}{15} & \frac{3}{15} & \frac{9}{15} \\ \frac{8}{15} & \frac{1}{15} & \frac{6}{15} \\ \frac{3}{15} & \frac{6}{15} & \frac{6}{15} \\ \frac{10}{15} & \frac{2}{15} & \frac{3}{15} \\ \frac{1}{15} & \frac{6}{15} & \frac{8}{15} \end{pmatrix} \quad R_2 = \begin{pmatrix} \frac{10}{15} & \frac{2}{15} & \frac{3}{15} \\ \frac{6}{15} & \frac{2}{15} & \frac{7}{15} \\ \frac{9}{15} & \frac{2}{15} & \frac{4}{15} \\ \frac{10}{15} & \frac{2}{15} & \frac{3}{15} \\ \frac{3}{15} & \frac{1}{15} & \frac{11}{15} \end{pmatrix} \quad R_3 = \begin{pmatrix} \frac{8}{15} & \frac{2}{15} & \frac{5}{15} \\ \frac{6}{15} & \frac{1}{15} & \frac{8}{15} \\ \frac{10}{15} & \frac{2}{15} & \frac{3}{15} \\ \frac{8}{15} & \frac{3}{15} & \frac{4}{15} \\ \frac{3}{15} & \frac{2}{15} & \frac{10}{15} \end{pmatrix}$$

3. For fuzzy comprehensive evaluation $b = a \bullet R$

$$b_1 = a \bullet R_1 = (0.325 \quad 0.217 \quad 0.458)$$
$$b_2 = a \bullet R_2 = (0.568 \quad 0.130 \quad 0.303)$$
$$b_3 = a \bullet R_3 = (0.515 \quad 0.127 \quad 0.358)$$

It can be obtained, the final evaluation of the program 1 is a poor assessment, 2 good, 3 program is well received, and scores from the final evaluation can also show 2nd is greater than the 3rd program. Therefore, we do a final ranking of the three programs, it is: 2, 3, 1.

4. Conclusion

Through the analysis of soil quality of wheat from sowing period to overwinter time, we can conclude:

1) According to the change of soil organic matter and available potassium, it can be concluded that choosing 50% straw coverage is a better way. From the change of available nitrogen, the effect of non-mulch is much better than the other two treatments; however, full mulch is more superior to the other two treatments in reducing the loss and consumption of available phosphorus.

2) By fuzzy comprehensive evaluation, it can be said that the scheme of 50% straw coverage is more reasonable.

5. Discussions

After the overwinter time, the wheat growth should experience jointing, blooming, milky stage and so on. From the aspect of soil quality change, we can know that the scheme of 50% straw coverage is more reasonable from sowing period to overwinter time. But during the subsequent periods, how the soil quality index changes, what the variation law is, whether the comprehensive evaluation result is the same as the result of this paper, and whether the superior or inferior degree of the three different mulching treatments remains, all of these are unknown. Therefore, the long-time effects of the three different straw mulch treatments on the soil quality change remains to be further researched and discussed.

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