

# **The Expansion and Application of Conservation Tillage in Raised-Bed Planting Regions**

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## **ABSTRACT**

Aimed at the mode of raised-bed planting (RBP) and combining the technique of conservation tillage (CT), three modes were established - stubble residual mulch, fell stalk mulch, and smashed stalk mulch by applying it for six years. With the use of existing machines, moisture storage and manure storage were achieved while protecting the environment and increasing income by fully using existing machines. The purpose of adopting these measures is to spread the CT technology mode rapidly. In practice, two steps were adopted: firstly, as accepted by farmers; secondly, widening and expanding the coverage of CT.

**Key words:** Conservation tillage, mode, machinery, system

## **1. ADAPTABILITY OF CT MODE IN RAISED-BED REGIONS**

### **1.1 Fumeng County is typical dryland farming area**

Fumeng country lies in the northwest of Liaoning Province, located north latitude 41 ° 44'-42 ° 34 'east longitude 120 ° 01'-122 ° 25', at the Mongolian Plateau strip, the north of it near the southern margin of Dinghu Horqin desert, which is a hilly area. The county's land area is 6246.2 km<sup>2</sup>.

The county is in an area with semi-arid sub-temperate climate, four distinct seasons; abundant sunshine with a total sunshine of 2638.3h every year; 498mm average precipitation; and 1848mm of evaporation. The dry long cold winter and lack of snow; short and torrid summer from June to August account for 67.4 per cent of precipitation. Spring and autumn temperatures change faster while the difference in temperature is quite large. The average temperature of the whole country is 7.4° C; frost-free period reaches to 150 days; erosion is 3000-5000t/km<sup>2</sup>; the annual topsoil runoff is 2.5-4 mm. Soil is mainly brown and very barren. Organic compound content

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in the soil is only 0.7 to 1 per cent. The plowland area is 208,000 ha. The main crop is maize, with 80 per of the cropping area planted to it.

## **1.2 The problem in CT technique**

Fuxin County is a single-crop a year region of Liaoning province. From traditional agriculture, we can conclude some problem in traditional agriculture: cost of tillage is very high; soil nutrition lost due to long time of being barren; environment has worsened.

Drought has become a problem in the county that restricts the development of the economy. From some research, it was found that the soil in the raised-bed mode has greater water storing capability. However, in a dry situation, the soil has strong transpiration capability. Thus, effective measures should be taken to control the moisture transpiration. The advantage of raised-bed planting should be fully explored.

## **1.3 Importance of the relationship between raised-bed planting technique and CT technique**

Raised-bed planting results in a higher germination and seedling rate in spring. It is expected that raised-bed planting will have an important role in CT expansion. In the development of agricultural machinery, it is important that considerations be made both for agronomic factors as well as mechanical factors for the machine. This is an important link which should be considered.

Raised-bed planting enhances sunlight utilization by 10 to 15 per cent. The raised-bed is like a man-made baffle-board, which can delay seepage of rainwater and can be a good response to drought. Raised-bed planting can also prevent waterlogging and control weeds.

CT technique makes use of stubbles and straws in the field and adopts little or no-tillage technology. This technique is an effective method to solve the entropy problem in traditional agriculture. It can reduce work time, mitigate the disadvantages associated with raise-bed planting mode, increase income, and improve soil nutrition.

In conclusion, a combination of raised-bed planting and CT tillage technology is necessary.

Research conducted by Professor Jiang Yan, soil improvement specialist of the graduate school, Jilin Agricultural University, noted that based on the results of a ten-year research, it was found that maize has a strong adaptability to CT technology. The crop could be planted continuously but properly. Little or no tillage technology should be practiced.

## **1.4 Adaptability of the modes**

In the past six years, Fumeng County established three agricultural modes for CT tillage -- stubble residual mulch, fell stalk mulch, and smashed stalk mulch. The main crop is maize.

The technical process of stubble residual mulch mode is as follow:

Maize harvest---- dealing with stubble in the spring---- seeding accurately----getting rid of weed---- cultivation.

Due to the advantages of the traditional raised-bed planting mode, stubble residual mulch mode is promoted in the county. Many farmers practice straw burning. The government has discouraged this practice but there is no obvious effect. It is proposed that stubbles and crop residues be used in agricultural production. During the planting season, straw is being plowed back to the field and the seeds are sowed. This mode has achieved great success.

The technical process of the fell stalk mulch mode during the maize harvest with the whole straw remaining is as follow:

Maize harvest---- dealing with stubble and straw in the spring----no-tillage seeding accurately dealing with weeds----cultivation.

This mode is developed in some villages near Inner Mongolia. Farmers in the villages burn the crop straw. Using reconstructed seeders, the farmers were able to solve the problems in disposing excess straws.

The technical process of smashed stalk mulch mode is as follow:

Maize harvest----dealing with stubble and straw in autumn---- no-tillage seeding----dealing with weed----cultivation.

Some farmers are accustomed to clean their fields in autumn. The technology of mashed stalk mulch mode is practiced. This attitude of farmers to tidy their fields provides a good potential to extend this mode to be adopted in the region successfully.

Three modes are significant to raised-bed planting regions. These modes are not in conflict with current tillage practices of farmers. Farmers are willing to accept and practice these modes. With this attitude of the farmers, the government is optimistic that the mode will bring advantages such as improvement of soil entropy, enhancement of yield and control of weeds.

## **2. THE SELECTION OF CT MACHINE**

The key factor in CT is dealing with straw and seeding operations. The use of appropriate machines is another key to the adoption of CT. Based on local considerations, four factors would determine the adoption of the technology: (1) ability of the farmers to support it; (2) disposal of rice straw will not affect seeding in spring; (3) straw coverage should be above 30 per cent; and (4) soil overturn should be below 30 per cent.

## 2.1 Machine for stubble residual mulch mode

As shown in Figure 1, stubble residual mulch is a common mode of CT in this region. Traditional stubble height is 10 to 15 cm; crop experimental height is 25 to 30 cm; the desired height. Usually, stubbles should be handled in spring, using three kinds of machines.



A double-entry machine can perform various operations at one time: dealing with stubble, seeding and fertilizing. Applying this mode, working time is reduced. Seeding circumstances are shown in Figures 2 and 3.



After pressing the disc-harrows, seeds are accurately place as shown in Figure 4. Germination circumstances are shown in Figure 5.



Fig.4



Fig5

An accurate seeding machine is shown in Figure 6. This machine does not need stubble-broken sets, but uses a sharp knife opener.

By adjusting the opener's position, results of seeding on both sides of the past year's maize roots would appear at 60 cm width lines and 40 cm width narrow lines. Since farmers are used to tillage at 50 cm width line, aeration can be improved. Results of germination are shown in Figure 7.



Fig.6



Fig.7

## 2.2 Machine for fell stalk mulch mode

As shown in Figure 8, the practice of covering the field surface with straw and using it in the next spring is being done in many towns.

First, disc harrows press the straw as shown in Figure 9, after that, seeding is performed using a no-tillage seeder or ordinary seeder as shown in Figure 10. After being pressed by disc-harrows, straws fall to the ground. Germination results are shown

in Figure 11.



A residue covering machine and a combine coordinating machine would be used to spread and incorporate the straw into the soil (Figs. 12 and 13). This mode can keep the straw from being blown away or accumulating. The germination results are shown in Figure 14.

Then, a stubble-cutting and accurate seeding machine would be used as shown in Figure 15. After seeding, there are no straws beside plants (Figure 16). Germination results are shown in Figure 17.





Fig.14



Fig.15



Fig.16



Fig.17

This working mode is applied during autumn. During this time, humidity is very high. Surface situation after working is shown in Figure 18. Germination results are shown in Figure 20.



Fig.18



Fig.20

After working the land with a combine harvester, straw is pressed using a combine coordinating machine or a disc-harrow (Figure 19).



After harvesting, straw is smashed and pressed into the field using a disc harrow to prevent the straw from being blown away. Then, disc harrows are passed through the field twice, with the second pass done in spring because moisture content is low during this time.

### 3. METHODS OF EXTENDING CT

Experience has been accumulated during the long period of extending CT. However, there are many factors affecting the expansion of CT. These include policy, foundation, technology mode, etc. However, if the technology is feasible and effective, it could be extended.

#### 3.1 Implementation of a two-step strategy

The practice of raised-bed planting and the burning of straw by farmers cannot be changed in a short time. To enable farmers to change their methods and perceptions, simple ways of making them accept CT technology should be promoted. For example, farmers need to understand that CT methods could improve quality of the soil and eventually, increase production.

The two-step strategy is simply done in these steps: (1) convince farmers to implement the technology; and (2) popularize the technology so that there would be wide acceptance among the farmers. One way of promoting CT is through a centre demonstration. From this, the technology could be extended and a whole village could carry out the technology.

The goal of Fumeng County is to expand areas under CT to cover 66,000 ha and build a 156 km long CT zone in the boundary of the county. The zone is shown in Figure 21.

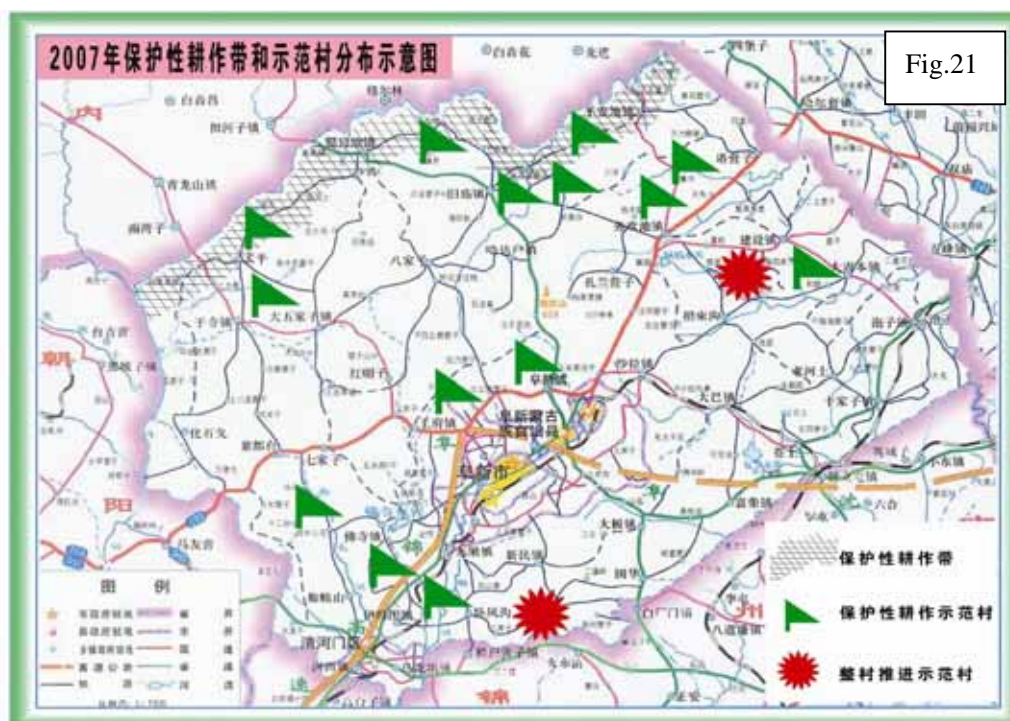


Fig.21



### **3.2 Set up effective development mechanism**

CT technology has been accepted by farmers with the help of agricultural machinery service stations. Through this mechanism, farmers found the effects and benefits of the CT technology. Service station buys the machines and manages their use. Farmers can use ordinary machinery for free. In the case of CT machinery, farmers pay a fee.

In some cases, farmers can use agricultural machinery from the service stations at discounted rates. For example, in Ping'an town, Wu Yaoguang rents disc-harrows for two years and uses the machinery for a 600 ha farm. The normal machinery usage fee is 12 Yuan per ha, but he was only charged 8 Yuan per ha. This scheme has helped him earn 72000 Yuan.

Wu's experience has enhanced other farmers' enthusiasm to practice CT and make use of agricultural machines from the service stations. Thus, CT technology is extended with the service stations taking a principal role hand in hand with the government.

As the technology of CT matures, farmers increase their use of agricultural machinery and their perceptions change. They later buy their own agricultural machinery for their use. Most of them fully use these machines without government allowance and carry out CT voluntarily. With this situation, the farmers take the principal role.

### **3.3 "Five turns" management**

In terms of management, five considerations are made called the "five turns management". The first is systemization. Here, some rules for CT are formulated such as "Technology Service Responsibility of CT", "Technology Drumbeating and Training Responsibility of CT", etc. The second is standardization. Here, rules are effectively implemented and respected. The third is modernization. Here, modern equipment such as soil temperature test instruments, sand collection instruments, soil moisture test instruments, and soil nutrient test instruments were bought and used. The fourth is normalization. The fifth is visualization. Here, proper recording of crop growth and use of machines are done.

### **3.4 "Four drives"**

There are four push factors for the expansion and popularization of CT technology. Firstly, drive by governments. Bring CT into the government's calendar. Here, effective measures are carried out.

Secondly, drive by policy. Here, capital is provided to farmers for machine allowance, work allowance and machine rental allowance. These measures have long-term effect. Although the capital quantity limited, it encourages reluctant farmers to join those in the CT practice.

Thirdly, start by department. It is important that the various modes of CT technology be studied. The appropriate ones should be determined, including the measures which are acceptable to the farmers. Then, propagating the technology follows, carrying out the “five turns”. The first turn is social publicity, enabling farmers to understand CT. The second turn is publicity of government leadership. A driving force should drive the government to expand CT. The third turn is to propagandize CT among machinery proprietors. Changes in tillage modes and practices, and machinery should be promoted. Fourth is giving attention to CT drumbeating effect. Change traditional tillage to conservation tillage. To make everyone aware of CT’s effects, the government organizes assistants and agriculture machine station members to understand the differences of maize grown in the CT mode and maize grown in the traditional tillage mode. For example, it is important for them to understand that with CT, maize grows 20 to 40 cm higher than traditional tillage maize. With this mode, the maize crop has fewer yellow leaves. Without rain for 40 days, moisture content of maize in the CT mode is 0.81 to 2.72 per cent higher than traditional mode. Maize grown through CT has thicker and denser roots and grows 3 to cm longer than traditional mode. In the CT mode, the soil is softer with more earthworms. Yields in the CT mode are 500 kg compared to the 350 to 400 kg in the traditional mode.

It can be concluded that the soil is enriched in the CT mode, keeping soil moisture and nutrition especially during the dry periods. The fifth turn is to propagandize CT among farmers from quantity to quality. In recent years, farmers Zhang Xingya, Wu Yaoguang, Jiang Haoming, Zhang Lei, and Ma Binghua have become large families. For example, Ma Binghua bought a maize combine harvester which attracted other factors to visit him and saw for themselves the effects and benefits of CT technology.

Lastly, pay more attention to training. One is specialized training for agriculture machine station members. Another is training for farmers. CT practices are explained and shown through videos, talking with and visiting farmers and machine operators instead of having meetings and lectures. Using this new system, hundreds of farmers were trained.

Self-motivation among farmers is also very important. Find a person who is credible and respected by other farmers. This person can extend CT and other farmers can truly benefit from the technology. Zhang Xingya, whose story was featured in the programme, “BlackSoil”, was the first one to carry out CT. When other farmers found that this tillage mode not only saved him labour cost but increased his yield and improved soil nutrition, they began to carry out the technology with him. Now, CT has become an acceptable mode by more farmers. Every year, the area for CT is increasing.

This is the result of farmers' motivation. At present, the county has formed a long-term system for CT. Every autumn, farmers conserve the straw and use these the next spring for CT.

#### 4. CONCLUSION

Our county is a typical raised-bed planting region. To improve soil nutrition and fight drought, it is necessary to combine traditional tillage and conservation tillage practices. Stubble residual mulch, fell stalk mulch and smashed stalk mulch are accepted easily and brings about beneficial effects for raised-bed planting regions.

In the Taoli village in Fuxin town, a test on the stubble residual mulch mode in the past four years was done. Results showed that after working, the earth's surface coverage rate was 33 per cent; the germination rate was 6.7 per cent higher; the soil moisture content was 1.54 per cent higher; the yield was 96 kg higher; and there were clear changes in soil nutrition. Table 1 shows the results.

Table 1. Results of maize stubble residual mulch in Taoli village Fuxin town, 2003-2007.

Unit: g/cm<sup>3</sup>, mgkg<sup>-1</sup>, kg

Kind	Seedling rate %		Moisture content %		Quality per vol.		Nutrition								Yield	
							Conservation tillage (CT)				Traditional tillage (TT)					
Year	CT	TT	CT	TT	CT	TT	Organism	N	P	K	Organism	N	P	K	CT	TT
03-04	90	81	9.46	7.23	1.25	1.24	0.9	58	13	70	0.8	57	14	72	500	440
04-05	92	89	13.29	12.34	1.29	1.25	1.1	79	19	108	0.7	55	16	75	670	600
05-06	93	80	13.27	1.8	1.33	1.26	1.2	98	21	119	0.7	62	17	74	560	400
06-07	90	82	8.7	7.2	1.22	1.25	1.2	118	22	122	0.6	61	17	76		

In Bajia village, Ping'an town, trials on CT as practiced for the past three years were conducted. Results showed that after dealing with straw by using disc-harrows, combine coordinating machine and straw-destroying machine, ordinary seeder or stubble-cutting and seeding machine, the earth's surface coverage rate was 65 per cent; the germination rate was 5 per cent higher; the soil moisture content was 1.06 higher; the yield was 120 kg higher; and there were clear changes in soil nutrition. Thus, it is clear that the technology is feasible and provides a breakthrough technique for CT machine selection and application (Table 2).

Table 2. Results of maize stubble residual mulch in Bajia village Ping'an town, 2004-2007.

Unit: g/cm<sup>3</sup>, mgkg<sup>-1</sup>, kg

Kind Year	Seedling rate %		Moisture content %		Quality per vol.		Nutrition								Yield	
							Conservation tillage (CT)				Traditional tillage (TT)					
	CT	TT	CT	TT	CT	TT	Organism	N	P	K	Organism	N	P	K	CT	TT
04-05	93	89	8.91	7.74	1.45	1.42	0.8	73	13	88	0.7	73	7	69	720	660
05-06	94	88	9.24	7.73	1.47	1.42	0.91	91	18	115	0.6	75	7.8	73	550	370
06-07	90	85	8.2	7.70	1.39	1.41	1.11	101	22	127	0.5	74	8.2	75		

Smashed stalk mulch mode is easily accepted by farmers. However, the cost is higher. In Ai Lin Gao village, Jianshe town, trials on smashed stalk mulch mode in the past four years was conducted. The results showed that after working, the earth's surface coverage rate was 73 per cent; germination rate was 6 per cent higher; soil moisture content was 2.96 per cent higher; the yield was 103 kg higher and the soil nutrition exhibited clear changes (Table 3).

Table 3. Results of maize stubble residual mulch in Ailingao village Jianshe town, 2003-2007.

Unit: g/cm<sup>3</sup>, mgkg<sup>-1</sup>, kg

Kind	Seedling rate	Moisture content	Quality per vol.	Nutrition								Yield	
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Year	%		%				Conservation tillage (CT)				Traditional tillage (TT)					
	CT	TT	CT	TT	CT	TT	Organism	N	P	K	Organism	N	P	K	CT	TT
03-04	90	80	8.7	8.22	1.31	1.28	0.9	52	8	85	0.8	53	8	85	530	460
04-05	94	90	15.14	11.42	1.29	1.32	1.1	71	13	94	0.7	55	9	83	640	560
05-06	95	90	16.58	12.34	1.25	1.28	1.15	89	19	107	0.7	54	7	86	540	380
06-07	90	86	11.3	7.9	1.23	1.27	1.3	101	22	115	0.65	58	8	84		

Fumeng County promotes CT proactively. Push factors for the expansion of the technology are administration, policy, technique, promotion and popularization, and motivation and enhancement of ego of farmers. Many parts of the county are practicing CT.

Presently, the area covered by CT is 27.9 thousand ha; production has increased by 21.37 million kg, and the increase in net income is 30.5 million yuan.

Trials in the past six years have shown that modes of CT are in accordance with farmers' tillage practices, machines selected for use are economical, system for expanding the technology is effective, and measures and methods are in response to the farmers' needs. CT technology practices have certainly a good direction in the county.

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