

# **Prospects and Present Situation of Conservation Tillage in Shandong Province**

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## **ABSTRACT**

This paper presents the situation of conservation tillage (CT) in Shandong province, analyses the various techniques including straw mulching, no-tillage seeding, raking tillage on the stubble, rotary tillage on the stubble, deep loosening, and control of weeds and insect pests. The paper also presents the ecological and social benefits of CT. It further analyzes questions related to CT such as seeding quality, use of agricultural machinery and agronomy, crop planting technologies, weed control, and fertilizer use. Measures to develop CT in Shandong province are also presented which include strengthening the organization with corresponding policy; reinforcing training interventions to increase the understanding of CT; combining agricultural machinery and agronomy; and enhancing the study on the theory behind CT.

**Keywords:** Conservation tillage, status, question, and countermeasure

Conservation tillage (CT) is a new tillage mode relative to traditional tillage. Due to its merits in improving the soil structure, controlling soil and water loss, reducing wind and water erosion, mitigating sand and dust harm, etc., it is now an important trend in international agriculture<sup>[1]</sup>.

In developed countries, CT is used to protect and restore ecology. Due to the high population and declining resources in China, CT is applied to increase unit yields. Thus, the study on the characteristics and countermeasures of CT in different regions is important.

## **1. STATUS OF CT IN SHANDONG PROVINCE**

Studies on CT were started in developed countries decades ago. With increasing population, worsening environmental conditions, droughts, soil and water losses, the study on CT was started in some provinces of China during 1970s<sup>[2-3]</sup>.

The study conducted by the Shandong Agricultural University (SAU) begun in 1978. This study was on minimum tillage with straw returned to the field and machines used in the operation. From 1989 to 1992, studies on rotation tillage were also carried

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out by the same university <sup>[4-5]</sup>.

After the start up of CT projects by the Ministry of Agriculture in 2002 and with the aim of increasing production and income, and protecting the environment, CT technology started to develop quickly in Shandong province. Today, the total area covered by CT technology is over 6 hm<sup>2</sup>, contributing to total sustainable development of the province.

## **2. TECHNOLOGICAL CHARACTERISTICS OF CT IN SHANDONG PROVINCE**

Shandong is an important agricultural production base of China. An abundant or poor harvest would affect the whole country's agriculture and economic development. The main cropping modes in Shandong province are relay intercropping and multiple cropping of wheat and maize. The technological characteristics of CT in Shandong province are as follow:

### **2.1 Straw covering technology**

#### **2.1.1 Straw breaking and mulching**

After harvesting wheat and maize mechanically using a combine harvester, or harvesting maize manually, the crop straw is crushed and returned to the soil. If the straw is too long with many weeds, a disintegrator or rotary tiller can be added to facilitate the operation.

#### **2.1.2 Covering with stubble**

In the region which uses straw widely, the CT modes were applied to the harvested crop using a machine with high stubble + seeding with no-till or with shallow rotary tillage. The suitable height of maize for this mode is 15 cm, and that of wheat was above 20 cm.

### **2.2 No-till seeding**

No-tillage technology is a kind of seeding technique which utilizes no-tillage planter to complete multi-procedures including cutting the stubble, ditching, fertilizing, seeding, and rolling at one time. In a double cropping system of wheat and maize, the no-till seeding technologies included wheat no-till seeding and maize no-till seeding <sup>[6]</sup>.

At present, there were less no-till seeding machines for wheat and seed quality was poor. Thus, a selection of wheat no-till seeding machines was carried out by the Agricultural Machinery Experiment Appraisal Popularization Station of China. As a result, 10 machines were selected for extension.

While there were many machines suitable for use in double cropping system of wheat and maize, 18 maize no-till seeding machines were chosen and recommended in September 2004.

### **2.3 Raking tillage on the stubble**

Raking tillage on the stubble, a practice popularized by the SAU, was a minimum tillage operation which can improve the fertility of the soil and increase crop yield <sup>[2-3]</sup>.

The key points of this technology are as follow: the utilization of whole maize straw which is returned to the soil instead of traditional tillage in autumn, and sowing the wheat after raking tillage by heavy cutaway disk harrow; the utilization of the whole wheat straw which is returned to the field after being crushed during wheat harvesting using a combine harvester, and then sowing the maize with no-till seeding.

In some regions, the maize can be relay-planted before the wheat harvest. Raking till is carried out once using a heavy cutaway disk harrow in diagonal and parallel methods, at a depth of 10-15 cm and burying 85 per cent of the stubble into the soil. Then, parallel raking is done once using a light cutaway disk harrow at a depth of 8-10cm, which results in an "upper loose and lower tight" arable layer for seeds.

According to the results of studies done by the SAU, two years was enough for raking tillage in a loamy soil after furrowing for one year. For sandy loam soils, three years was appropriate for raking tillage after furrowing for one year.

### **2.4 Rotary tillage on the stubble**

Rotary tillage on the stubble was also a minimum tillage practice.

According to the studies at the SAU, using rotary tillage based on the normal tillage in a double cropping system of wheat and maize results in yield and economic benefits <sup>[4]</sup>. This technology follows the following process: using whole maize straw and returning it to the soil instead of employing traditional tillage in autumn; sowing wheat after rotary tillage with the whole wheat straw also returned to the field after crushed when wheat was harvested by combine harvester; and sowing the maize with no-till seeding or relay-planted maize before wheat harvest. Since rotary tillage is a kind of surface tillage, it can be used for two to three years between normal tillage.

### **2.5 Deep loosen technology**

The main effects of deep loosen technology were loosening the soil, breaking the plough pan, increasing the infiltration of precipitation, and decreasing soil water evaporation loss, without disturbing the soil layers. There are two modes for the deep

loosen technology, which were partly deep loosening and whole deep loosen. The research results at the SAU showed that deep loosen after four-year raking tillage can partly break the plough pan, a condition which is beneficial for the root growth of wheat. By deep loosening, the water-holding capacity of the soil was better compared with continuous plowing, resulting in a 2.10-17.18 per cent higher wheat yield and 6.87 per cent higher maize yield than in continuous plowing, respectively <sup>[7]</sup>.

Considering the results of the field tests, it is beneficial to employ the tillage of raking + deep loosen and rotary + deep loosen.

## **2.6 Weeds, disease, and pest control**

The control of weeds, diseases, and pests is one of the key steps of CT. Agents are often used to control them. To control weeds, herbicides of adapted types and quantities should be used. Herbicides would be more effective if used either just before sowing, after sowing but before seedling, or during the early growth stage of the seedling. When herbicides are used before sowing, it is often interfused with soil by the combined process of sprinkling herbicide and soil loosening at the same time. The use of herbicides before seedling growth was generally incorporated with sowing.

Herbicides are usually applied using a device attached behind the seeding machine, spraying the agent into the soil surface. During the growth of crops, the herbicide can be used considering the situation of the weeds in the field.

The control of diseases and pests should be carried out according to their occurrence in past and current years. Agents for seed coating or dressing can be used to control diseases and pests. Forecasts for diseases and pests should also be considered in applying control agents.

## **3. ECOLOGICAL AND SOCIO-ECONOMIC BENEFITS**

The study, demonstration, and popularization of CT in Shandong province has resulted in benefits enhanced by support from national funds. The results showed that CT has ecological and socio-economic benefits for agriculture in Shandong province, which further builds a better environment, improves soil fertility, and increases crop yield and income <sup>[4-8]</sup>.

### **3.1 Ecological benefits**

CT can increase the benefits of straw return, and improve water and nutrient situation of the soil. In a double cropping system of wheat and maize, the water use efficiency of rotary tillage, raking tillage, and no tillage were 15.68 per cent, 10.53 per cent, and 19.52 per cent, respectively than normal tillage. At the same levels of fertilizer application and irrigation, the water preservation of soil under tillage and

raking tillage were higher than normal tillage. CT can still increase the nitrate accumulation in 0-60 cm soil layer, but decrease the nitrate accumulation in 60-100 cm soil layer. At 60-100 cm soil layer, the nitrogen absorbed by crops increases while nitrogen loss decreases.

### **3.2 Social and economic benefits**

Increasing the incomes of farmers is a main consideration in agricultural development. Increased production costs affect the competitiveness of agricultural products and farmers' income. Due to its complex process, the cost of normal tillage was higher, covering about 30 per cent of the total cost. As CT can shorten by half the whole process, costs are drastically reduced.

Studies at the SAU showed that fuel consumption for raking tillage and rotary tillage were decreased by 39.71 per cent and 5.88 per cent, respectively, compared with normal tillage. Considering the whole yield of wheat and maize, yields resulting from rotary tillage, raking tillage, and no tillage ranged from 11.93 to 12.6 per cent, 11.38-12.27 per cent, and 1.26-7.97 per cent respectively, higher than normal tillage.

## **4. MAIN PROBLEMS**

### **4.1 Seeding quality control was difficult**

Due to the rugged soil surface, uneven hardness of soil, and the higher quantity of straw in the field, seeding quality was difficult to control. The depth of seeds varied and seed distribution was uneven.

To reduce the disadvantages of CT, it is important to improve the performance of seeding machines. The conditions of the soil should be considered, and suitable quantities of seeds should be used.

Employing raking tillage or rotary tillage can increase and improve the uniformity of the soil surface and at the same time, decrease the straw above the soil surface. Both are better compared to no tillage.

### **4.2 Combining agricultural machinery and agronomy was difficult**

The choices for planting modes and machines were the necessary premises for the wide application of CT in China. At present, the maize no-till seeding machine basically satisfied the need of maize seeding. However, there were questions on the wheat no-till seeding machine. Due to the narrow row space, which was generally 20 cm, the anti-blocking equipment did not work well, which resulted in poor quality of seeding. The problems related to machinery prevented the wide acceptance of CT in Shandong province.

### **4.3 Crop planting technologies did not match CT**

At present, the technology of CT did not match the crop planting technologies which influenced the changes in soil quality; use of water and fertilizer; and control of weeds, diseases and pests. The technologies used in normal tillage were not suitable for CT due to the different situations. Thus, it is necessary to develop and build the corresponding technologies for CT.

### **4.4 Weed control was difficult**

Firstly, CT loses the weeds' overturning effects of normal tillage. Secondly, some weeds were covered by straw, making it difficult for the weeds to be in contact with the herbicide. Such situation reduced the effect of herbicide sprinkling. It is therefore important that weed growth be closely observed in CT and suitable methods for its control in time we used. Usually, weeds can be controlled with herbicide and hoeing by machine.

### **4.5 Fertilizer application technologies need reform**

With CT, fertilizer distribution in the soil is uneven. Changes in the soil's physical and chemical properties would affect the decomposition of nutrients in the soil. Therefore, fertilizer application technologies under CT should be modified. For example, fertilizer, preferably the slow release type, should be used at the same time during sowing. The use of organic fertilizer was difficult under no tillage. It is important to find out the fertilizer application methods under different tillage systems to increase fertilizer efficiency to attain the full benefits of CT.

## **5. COUNTERMEASURES**

The full application of CT in China would require a long time, and needs policy support and funds from the government. Studies should be expanded to determine the effects of CT and the suitable technologies with the corresponding machinery needed for its application.

### **5.1 Strengthen leadership and develop relevant policy**

Governments at all levels should give importance to CT and put in place programmes for sustainable agricultural development with strategies and feasible implementation schemes. Special management agencies for agricultural machinery, agricultural technology, finance, and education should also be in place. Relevant policies to support CT, e.g., soil protection policy, compound use of straw policy, etc., should be developed. Programmes for different regions should be put in place with targets and measures for success. Further, costs and taxes for agricultural machinery should be reduced and policies which support CT with low-interest loans should be

promoted by the government. Studies related to machinery performance should be promoted.

## **5.2 Strengthen the promotion of and training on CT, and enhance public understanding of the technology**

The news media should promote CT and its benefits through various forms. Through training, the farmers can be encouraged to apply CT appropriately.

## **5.3 Combining agricultural machinery and agronomy, and building and applying the CT innovation and its related systems**

Considering the experiences from abroad, it is important to build any technical innovation according to local conditions of different types of regions. Technologies should be developed according to the farming system and conditions, and economic levels of each region. Some of these technologies include CT modes, control on weeds, disease and pest control, and the matching implements. With these accompanying technologies, questions related to CT would be clarified and the integration, adoption, matching, and demonstration of CT technologies would be facilitated.

## **5.4 Strengthen theoretical studies with practical experiments**

Studies related to the long-term effects of CT are needed to guarantee the wide use of the technology showing ecological and economic effects. These studies could be on the double cropping systems of wheat and maize, and the effects and mechanism of CT on other crops or other cropping systems. For example, it would be useful to find out the physicochemical changes of the soil and the regulatory mechanism under CT on other crops or cropping system; the effects of CT on use efficiency of water and fertilizer; the suitability of straw covering mode and return rate, and the decay rule of straw and affected factors; the matter circle in soil and crop system and the regulatory mechanism; and a better cropping system with higher yield, higher quality and higher efficiency.

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