Study on Minimum Tillage with Water Saving Technology and Implement for Paddy Field

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ABSTRACT

In this paper, a brand-new method of tillage and soil preparation for paddy field is discussed. The method uses a special roto tiller for rotary hoeing field in strip, instead of the traditional moldboard plow or rotary tillage. The characteristics of this tillage method are as follow: first, it reduces the power consumption and the operation cost significantly compared to traditional tillage and soil preparation for paddy field. For the adoption of new strip minimum tillage, soil humifying and rice seedling transplanting, the four operations of harrowing, smashing, leveling and dragging paddy residues were canceled, power consumption was reduced, and savings of cost for soil preparation ranged from 50-60 per cent. Second, compared to traditional soil preparation, the wastage of water for dunking field was saved from 30-40 per cent. Thus, it is a new and highly effective technology in saving water. Third, it can curtail the period of tillage and soil preparation for paddy field from the primary 10-15 days to 1-2 days. Fourth, it realized conservation tillage by reduced tillage and putting rootstalk and part of straws back into the field. Fifth, the method increases outputs and income by 18 per cent. This technology is an innovation and has a great function for the development of paddy production.

Key words*:* Paddy conservation tillage, minimum tillage, water-savings, cost reduction, and income increment.

1. INTRODUCTION

For many years, paddy production in China has adopted the tillage system of traditional plowing or rotary hoe to till soil, and pouring water into field to dunk soil, then paddy harrowing, smashing, leveling and dragging. There are many problems in this tillage method, such as high expenses, too much water, long cycle in plowing and soil preparation, small quantity of straw back into the field, not good soil structure , etc. In recent years, along with the degradation of the natural environment, drought in some areas of the country, especially in the north area is becoming serious. To protect

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the ecological environment, savings in water resources and reduction in production costs should be realized through conservation tillage.

2. PRESENT STATUS

2.1 The international technical status

The mechanization of paddy production employs two tillage systems at present: one is paddy field direct seeding system as practiced in Europe and America which depends on advanced tillage implements to level up the field, and make the paddy field in strip. The varieties that are adapted to dryland direct seeding have been bred; herbicides used in eliminating weeds; and combines for harvesting the paddy. The United States is one of the countries that has mechanized paddy operations. In this method, production costs are low, operation efficiency is high, and outputs basically correspond to the rice transplanted. The second system is paddy transplant mechanization system which is popular in Japan. It uses the moldboard plow or rotary tiller, mechanically transplants rice, uses combines for harvesting, and basically has a uniform paddy planting method for the whole country. The implements for tillage, breeding, and transplanting have been standardized and degree of paddy production mechanization reaches 98 per cent.

2.2 The domestic technical status

The method of paddy planting in China is similar to Japan. In the 1980s, the Japanese technologies of dryland breeding and sparse planting, plate breeding in greenhouse, and factory seeding and breeding were introduced in China resulting in increases of paddy outputs. The whole set of traditional tillage system continued to be in use, including the use of moldboard plow or rotary tillage, harrowing, smashing, leveling, etc. As a result, soil structure was destroyed, air content in plough layer reduced, the speed of oxidation lowered which goes against the decomposition of organic matter and the release of nutrient in soil, and water wastage increases. Before transplanting rice seedlings, four operations must be done: harrowing, smashing, leveling， and dragging paddy residue. The whole process of soil preparation is long, and the costs are high.

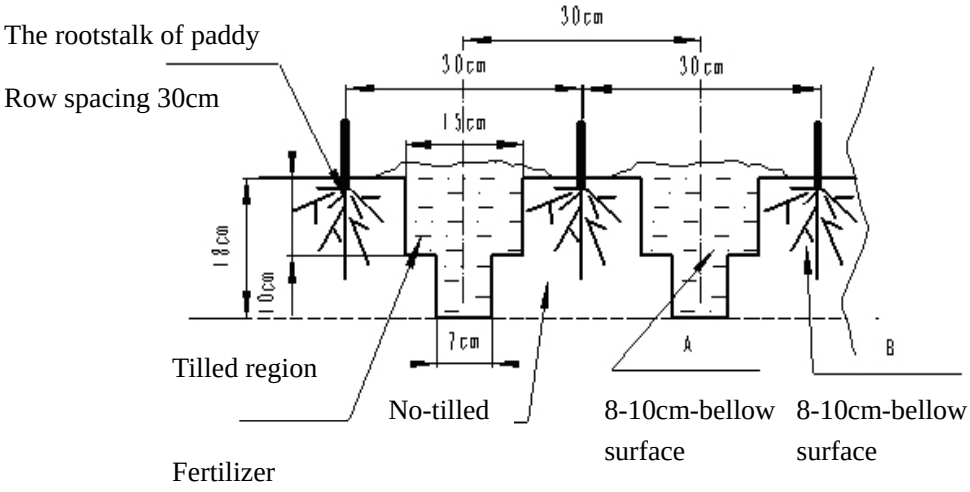
In China, water resources for agricultural production is lacking and the excessive plowing destroys the vegetation, resulting in barren soils, soil runoff, soil erosion, and the deterioration of the ecological environment. Thus, the exploitation of water saving and minimum tillage technology and implements for CT for paddy field will play an important function in the development of ecotype production for paddy.

3. THE MAIN CONTENT AND CHARACTERISTICS OF THE TECHNOLOGY

The soil in paddy fields is a special type of soil. It is different from the dryland soil. In the condition of traditional tillage and submerging the paddy field's soil particles after being drained and becoming dry in autumn, it will undergo the oxidation state. After repeating the cycle, it would make the paddy field soil different from the dryland soil.

3.1 The farming process and method of this technology

This technology adopts tailor-made zonal roto tiller with fertilizer drill unit to plow the paddy field in the shape of 'T' and do fertilization and compaction. The region and position of plowing is indicated in the diagram below. The work breadth of the roto tiller is 1.8 meters. The number of rows that the zonal roto tiller works at one time is six; the breadth of every row is 15 cm; the depth of plowing is 15-18 cm; row spacing is 30 cm; and it can be used with an ordinary transplanter. After performing these operations, irrigation can be applied to dunk the field. The water level should not be too high. Water 3 to 5 cm higher than the plowed soil is fine. After dunking the field for six hours, ordinary transplanter to transplant rice seedlings can be used. Other tillage applications are not required. On the second year, plowing will be done in the field which has not been plowed the previous year. After this time, the field can be plowed roundly on the basis of the above conditions.



3.2 Tillage characteristics of this technology

3.2.1 Minimum tillage and straw and rootstalk back into field

This 'T' shaped, zonal rotary and minimum tillage are adopted in this technology with all rootstalk and partial straw of paddy reserved and about 50 per cent of the plough layer structure is undisturbed, thus, satisfies the condition for soil preparation for transplanting or direct seeding. The confirmation of the 'T shape tillage is mainly based on the following: first, broad and flat top of the 'T' shape which can satisfy the

conditions for transplanting of rice seedlings. Second, the narrow and deep portion of the soil is propitious to root growth and gas exchange. Based on the results of the field tests in Fangzheng county, using this method of tillage after two months of transplanting rice seedlings would result into the soil compactness of A position and B position (as seen in the above figure) and are 3.11 and 7.20 kg/cm^2, respectively. It can be seen that narrow zonal deep-tillage played a favorable role for the paddy root expansion and the increase in soil conservation status.

3.2.2 The segments of tillage are predigested, and the workload and the production costs are reduced consumedly.

This method of tillage only plows the zonal part of the soil for transplanting rice seedlings. More than 50 per cent of the plough layer remained, reducing the power consumption of plowing and releasing the four operations of harrowing, smashing, leveling，dragging paddy residues， and overall, reducing the workload to about 60 to 70 per cent. It also reduced the total production costs. Another characteristic of this method of tillage is that there are parts of paddy field which are untilled. The soil porosity is increased, and the bulk density reduced; the air content in the soil increased; the soil moisture content is low, and the water and soil temperature of plough layer increases; the heat flux increases, and the daily dispersion of heat changes increases; it is propitious to the accumulation of dry matter. (The cost of the two methods of tillage is in Table 1.)

3.2.3 Reduce the wastage of water in the breeding paddy and shorten the periods of plowing and soil preparation.

Since there is 50 per cent of the soil remaining in the residues in mulch and no-till cultivation, many operations were released in the course of the tillage operations. Compared with traditional tillage, this method can save 30 to 40 per cent of water in dunking the field. Based on the diagram, it can be seen that the proportion of no-tilled region is deeper than the plough layer of 10 cm and is more than 75 per cent. This structure reduced the leakage of water in the paddy field effectively, and accordingly reduced water wastage. From the productive practice in Fangzheng county, it can be concluded that compared to traditional tillage, the water saving and minimum tillage technology of conservation tillage could save 30 to 35 per cent of water,

To a large extent, it alleviates the question of centralization of water usage for plowing and soil preparation and the shortage of water resources. It shortens the periods of plowing and soil preparation from 8 to 12 days to 1 to 2 days. This provides an advantage compared to a prolonged period of paddy growth.

3.2.4 Fertilizer utilization ratio is enhanced.

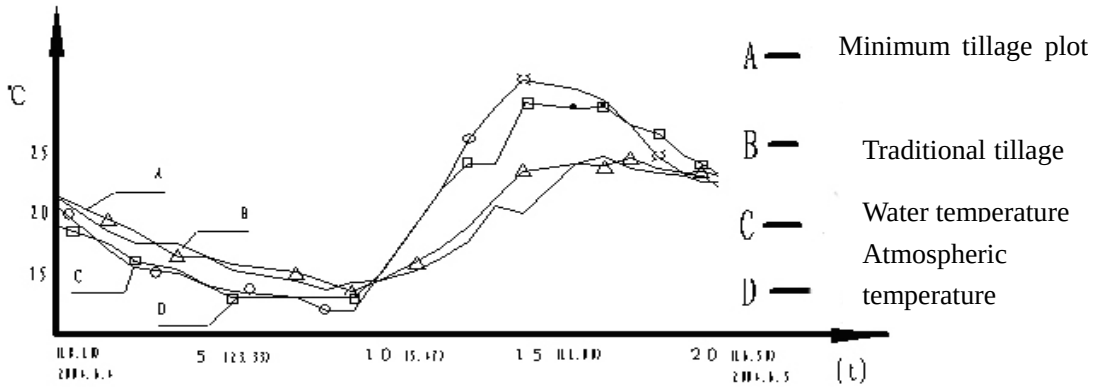
Fertilizer is put into the zonal tilled soil during minimum tillage, while there are no

fertilizers in no-tilled soil. By doing so, the fertilizer is concentrated relatively in the seedbed, so fertilizer utilization ratio is enhanced.

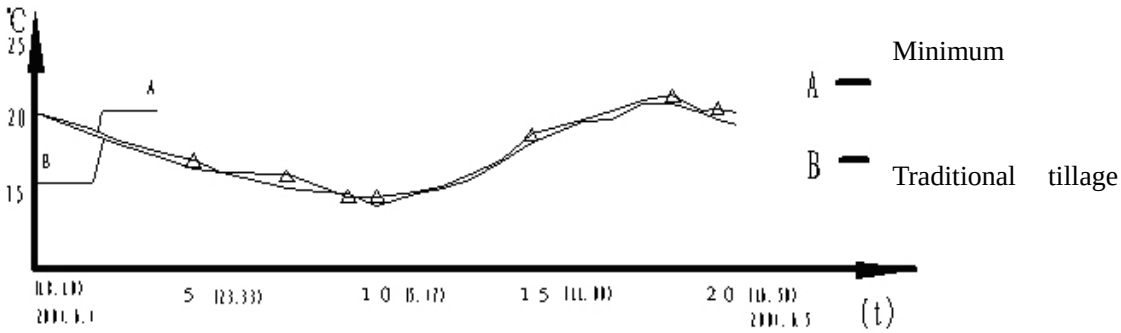
3.2.5 Increase in production is remarkable.

Based on the report on the measured output in the test field in Heilongjiang province Fangzheng County during autumn 2003-2005, the increment of output was 8-18 per cent. This output was complemented with a sturdy root system, a 0.5 to 1.5 ^{o}C higher temperature of the plough layer in contrast to the previous field and seedbed is elevated.

3.3 Varying soil temperature



Soil temperature curve of different tillage experiment locations in Fangzheng county Lianhua town



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While measuring the soil temperature of this tillage technology and traditional tillage, it was found that the soil temperature in the field adopting this tillage technology was higher than that adopting traditional tillage.

In a depth of 5cm plough layer, the result of minimum tillage is larger than traditional tillage by adopting the area comparison method which is the product of time and temperature. It can be confirmed that at present, the reason for the phenomenon has not been determined. The study group is doing a process research on the phenomenon.

Another phenomenon is that the variety of temperature is bent to consistent along with the depth of plough layer increasing. It can be seen in Charts 3 and 4 that the dispersion of area comparison is 20.629 ^{o}C in the depth of 10cm plough layer, while the dispersion is 15.265 ^{o}C in a depth of 15cm plough layer. The dispersion reduced gradually showing, that the dispersion of temperature also reduced gradually.

3.4 The application of farm machines and tools related to the technology.

Transplanter is an agricultural machine that has the closest relationship with this technology. If manpower is used to transplant rice seedlings, there is no distinct difference between the zonal tillage and traditional tillage. Zonal tillage has no particular requirement or clear influence on other field machines and tools. Since the tillage method of this technology is zonal rotary tillage, after plowing and dunking the field, it will emerge as distant zonal seedbeds. The soil will appear in a slashing state on the seedbed, while the no-tilled region will appear relatively with a hard ridge. This situation will induce the phenomenon that the transplanter driven by one wheel, such as the type of 935 produced by Yanji, would move on the hard ridge and the direction is difficult to control when working. The operating condition of other types of

transplanter such as two-wheel walking or four-wheel walking transplanter is superior to the one-wheel driving transplanter.

At present, the experiment is being doing on the 935 type of transplanter produced by Yanji, narrow two-wheel driving will be used instead of a one-wheel driving. The two wheels would walk on the row inside of the seedbed, so the track is easy to inoculate with the tillage region. In this aspect, further research and experiment will be done. Another important characteristic of this technology is its provision to install the seeding equipment on the base of zonal minimum tillage machine to do the operation of paddy dry direct seeding. Thus, the operations of zonal rotary tillage, fertilizer application, seeding, compaction, etc. would be completed in one time.

4. COST-EFFECTIVE ANALYSIS OF THE APPLICATION AND SPREAD OF THE TECHNOLOGY

Paddy is one of the important food crops that has the largest planting area, and highest total output.

In 1996, the area planted to paddy was 3140.6 ten thousands hm^2, and occupied 34 per cent of the crop cultivated area nationwide. Worldwide, paddy was grown in 21.0 per cent of the world's total cultivable area with a total output of 19510.2 ten thousand tones. It occupied 43 per cent of the total output of grains in the country, and 37.5 per cent of the total output of paddy in the world. The average single harvest of paddy is 6.212 ton/hm^2, which is double the average of the world.

These figures show that paddy occupies a prominent position in grain production in the country, and the country's production plays an important function on the paddy production worldwide. Thus, research and exploitation of tillage technology and implements is very important.

At present, traditional tillage is still being used for paddy production in China, and the water wastage of dunking field is very large. In the Fangzheng county Heilongjiang province, water wastage resulting from the practice of dunking fields is 150 m^3 per standard mu. During the whole growing period of paddy, it needs about 1200m^3 of water. With the adoption of this technology, the amount of water saved is about 300m^3 per standard mu. The effect of water savings is very clear.

Tillage technology is a new water-saving technology for paddy production which can alleviate the condition of water resource shortage. At the same time, tillage costs are curtailed from 50 to 60 per cent while paddy outputs are increased to about 18 per cent. Tillage technology is likely to become a breakthrough technology in paddy production; the application of conservation tillage technology in paddy production is another innovation. It is a new technology that fills a gap in the country. It is an innovative sense in the water saving technology of conservation tillage for paddy field.

5. CONCLUSION

From the productive practice in the growth periods of paddy in the year 2003-2006, researchers have formed a new cognition on the water saving and minimum tillage technology of conservation tillage. They accumulated some experiences on the no-tillage transplant technology. This research hopes that the development of water saving and conservation tillage technology for paddy would be accelerated and promoted through academic exchanges.

6. REFERENCES

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