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STUDIES ON UP-CUT ROTARY CULTIVATION

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ABSTRACT

With the developement of modern agriculture, a new cultivating method with high efficiency, good quality and low energy consumption should be developed to satisfy agricultural requirements. After comparing various cultivating patterns and summerizing research results, the submerged up-cut rotary cultivation is predicted to have bright futures and still some problems nee d to be solved.

Keywords: up-cut method; rotary cultivation

INTRODUCTION

In agriculture, the objective of tillage are to develope a desirable soil structure for a seedbed or a rootbed, to control weeds or to remove unwanted crop plants, to manage plant residues, to minimize soil erosion, to establish specific surface configurations for planting, irrigating, drainage, harvesting operations, to incorporate and mix fertilizers, pesticides, or soil amendments into the soil and to accomplish segregation.

The moldboard plow is one of the oldest of all agricultural implements and is generally considered to be the most important tillage implement in the traditional multicultivating methods. Its main shortages may conclude as great energy cost, low efficiency, little soil breakup,uneven soil surface and poor soil preparation after cultivation.

Although the cost of till-less method is the lowest, the weeds after cultivation are overgrown, the fertilizer are not easy to keep in the tillage layer and the soil erosion could not be prevented successfully. It is quite unnecessary to put into application and dissemination.

From the developing trend, it is certain that the minimum-tillage method will take the most part in the futural cultivating systems. To put the method into practice, it is essential to adopt a simplified working process which takes the rotary cultivating as the primary step to im-

prove harmful and unnecessary processes. It was clear that the rotary cultivation will be of more and more importance in soil tillage.

Currently, the down-cut rotary cultivating is most widely used. It could pass the power directly to the soil and fulfill double tasks of cultivating and harrowing. After cultivation, fine effects of soil pulverization and surface level could be obtained. Alao the fertilizer could be well distributed in the tillage layer and agricultural requirements of fertilizer's spreading in layers would be well satisfied. However, the following problems are still needed to be solved.

1. Mostly, rotary cultivating depth stays between 12 cm and 14 cm. There is one till-less layer between rotary cultivating layer and original plow bottom. In the first year, this layer is helpful for ventilation and water permeability of the soil. But with time goes on, the bottom will be in much less tillage. This conclude in the reduction of production after rotary cultivating for three years.
2. The coverage of rotary cultivating is relatively worse. This makes the weeds germinate more and earlier.
3. The rotary cultivation accounts for more energy consumption than others for its high speed cutting.
4. With the cultivating depth increasing, the thrust and lifting force acting on the tiller will increase a lot. The groundtouch load of front wheel will increase and that of the rear wheel will decrease. This lead certainly great difficulty in manipulating and make the tilling width shaking.
5. When the acting force of soil to blades is greater than the driving force, the tractor will be put forward by the tiller and parasitic powers will be produced. This will result in power waste and life loss of transmission parts. Meanwhile the tilling depth will fluctuate and remain unsteady. So the purpose to increase tilling depth is very difficult.

In view of the above problems, studies on the up-cut rotary cultivation are carried out by some researchers. Preliminary research results show that the up-cut method is advantageous than the down-cut method for steady tilling depth, low energy cost and well adaptability to deeper tillage. Also after cultivation, a proper soil layer distribution could be formed which is necessary for seeding.

PRESENT SITUATIONS

KINEMATIC ANALYSIS

The rotor of the up-cut method rolls in the reverse direction as the driving direction. Blades cut the soil from bottom to top and so show some advantages on working properties.

In same cultivating conditions, the blade will cut relatively thinner soil slices than that of the down-cut method. With the cultivating course goes on, the thickness of the slice is getting increased. This will certainly result in the acting force to the rotor stable and the tiller's bearing smaller punching.

In the cultivating course, the cutting angle of blade varies from large to small and variation

of cutting angle is smaller than the down-cut method. Similarly, the cutting speed is higher than that of the down-cut method which will be benefit for soil cracking. All these are of great help to soil cutting.

After cultivation, the ridginess of uncut bottom is smaller than the down-cut method. This allows the up-cut rotary tiller to work on larger tilling pitch which could well satisfy agricultural requirements too.

LOAD AND ENERGY

Logically thinking, blade in up-cut method move toward the soil surface. Compared with the down-cut method, more soil will break for the action of tensile force.

Grinchuk and Matyashin summerized research results of four Russian researchers. The cutting force in up-cut method was reported to reduce by one-third. While cultivating, fine stability of tilling depth could be obtained and damages of blades in soil with sandstone will be greatly reduced. However, when the tilling depth is smaller than the rolling radius, more energy consumptions were needed.

Matsuo used Japanese bend blade to compare the up-cut method with the down-cut method in many aspects of cultivating. The energy consumption of the up-cut method was indicated to be smaller than that of the down-cut method with the same tilling pitch.

Matyashin reported that the up-cut method need 10～15% more energy than the down-cut method in shallower cultivation and the down-cut method need 20～30% more energy than the up-cut method in deeper tillage.

Dalin, Pavlov and Furlong studied on the contrast test of the up-cut and down-cut method in various cultivating parameters with different blades. The down-cut method cost more energy than that of the up-cut method. Also, there are interrelations between the rotation direction and blade shapes.

PULVERIZATION AND COVERAGE

On the same ratio of peripheral velocity to forward velocity, from kinematic analysis, thinner soil slices will be produced in the up-cut method. However, besides kinematic conditions, there are still many other factors affecting the soil's pulverization.

Matyashin, Matsuo and Furlong found through experiment that the soil slices in the up-cut method is larger and more irregular. Kunio Morimoto designed a circular pulverizing grid between the rotor and the cover which has the same center as the rotor and this proved to be well effective. While cultivating, the bigger thrown slices and surplus straw are blocked by the grid and fall along the inner surface of the grid. The smaller slices will pass through the grid and fall from the cover's inner surface, then covers on the top of the bigger slices. So the tilling layer distribution is well qualified for seeding.Test result show that the soil pulverizing degree of this kind of rotary tiller is 20～30% higher than that of the ordinary down-cut tiller. The coverage ratio of surplus straw increases by 20%. The improvement is notable.

DEEPER TILLAGE

For a long time, the problem that ordinary down-cut rotary tiller could not solve is how to cultivate deeper.

Sakae Shibusawa and Noboru Kawamura did a lot of research work on deeper tillage from model test to field test. The up-cut method with small rolling radius is found to be in low energy cost and well adaptability to deeper tillage. Meanwhile, the blade used for this purpose was developed to avoid recultivating soils.

DISCUSSIONS AND SUGGESTIONS

To sum up, with proper values of tilling parameters, the submerged up-cut rotary cultivation proved to have bright futures which could replace the moldplough method to be the main manner of the minimum-tillage system.

However, there are still two existing problems need to be solved. One is to suit the transmission system to the submerged structure of cultivating parts. Another may be to prevent the tillin g soil slices to be thrown forward.

Here are some suggestions for further studies,

1. to study on the working process of up-cut rotary cultivation and analyse the principles of soil deformation and destruction; to make the soil ruin from tensile or shearing forces, not from presures.
2. to study on the fundamental characters of load and energy consumption of submerged rotary cultivation on various parameters.
3. to develope blades for submerged cultivation and avoid soil slice's being thrown forward to reuce energy consumption.
4. to design proper rotary tiller structures to realize submerged cultivation.

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