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The Possibility to Adapt the Shaft Tillage Cultivation Method to Arid Land Farming

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Abstract: Desert is said to be the product of human agriculture, mainly of monoculture practices. Monoculture is considered to be a method of sweeping away all natural vegetation on the land surface and producing uniform crop. It is based on soil fertility which was created by the previous natural forestry decomposition in the soil. Therefore, thoughtlessly the repeating of monoculture causes deterioration of soil which at the same time increases the risk of desertification. Most of the recent studies on sustainable agriculture have focused on maintaining the biodiversity of farmland. Nowadays, agro-forestry in which agriculture coexists with forest has been introduced and is being carried out in arid land.

In this study we propose the shaft tillage cultivation method which is under developing as a new cultivation system for full automatic solar powered farming system, and as a sustainable cultivation method for arid land agriculture. Shaft Tillage Cultivation was designed to minimize power requirements and to reduce damage on soil structure when tilling. It has also big merits on keeping the natural cycle in the farm land. This paper explains the possibility to adapt Shaft Tillage Cultivation to arid land farming.

Key words: Arid land farming, Shaft Tillage Cultivation, Shaft Tillage tool

1. Introduction

Desert is said to be the product of human agriculture, mainly of monoculture practices. Monoculture is considered a practice of sweeping away all natural vegetation on the land surface and producing one single crop. It is based on soil fertility which was created by the previous natural forestry decomposition in the soil. Average depth of topsoil covering the earth is said to be 30 cm (Encyclopedia Nipponica). Therefore, thoughtlessly repeating monoculture practices causes deterioration of soil which at the same time increases the risk of desertification (Gebhardt *et al*., 1985).

Most of the recent studies on sustainable agriculture have focused on how maintaining the biodiversity of farmland. Nowadays, the introduction of agro-forestry in which agriculture coexists with forest is being carried out in arid land (Jama *et al*. 2005).

The authors propose Shaft Tillage Cultivation which is under developing as a new cultivation system for fully automatic solar powered farming system and cultivation experiments have been repeated (Tajima *et al*., 2000). Shaft Tillage Cultivation was developed as a method to reduce power requirements by minimizing tillage area and soil stirring. At the same time, Shaft Tillage Cultivation has been characterized as a futuristic farming method aimed to maintain the natural cycle of farmland.

This feature is considered to have potential as a farming method while maintaining the biodiversity needed in arid land farms.

This paper explains the possibility to adapt Shaft Tillage Cultivation to arid land farming.

2. Shaft Tillage Cultivation Features

Currently, large-scale agriculture in the United States and other advanced countries, cover crops or living mulch has been introduced for the redeeming of monoculture farming method.

Such farming method is a way to continue growing without barring land and apply of allelopathy, as a result it is expected water retention, prevention of erosion, saving farmland biodiversity, and maintain nitrogen fixation.

Shaft Tillage Cultivation is a farming method promoting crop coexistent with weeds. These were mowed at 3~5 cm while the aim of maintaining biodiversity in vegetation as close as possible to nature.

Figure 1 shows the utilization of sunlight under Shaft Tillage Cultivation. Efficiency is high in the use of sunlight because the sunlight is fixed into the whole farmland by the

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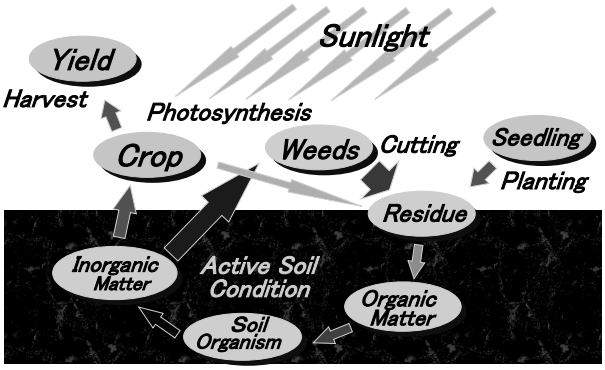

Fig. 1. Utilization of sunlight under Shaft Tillage Cultivation.

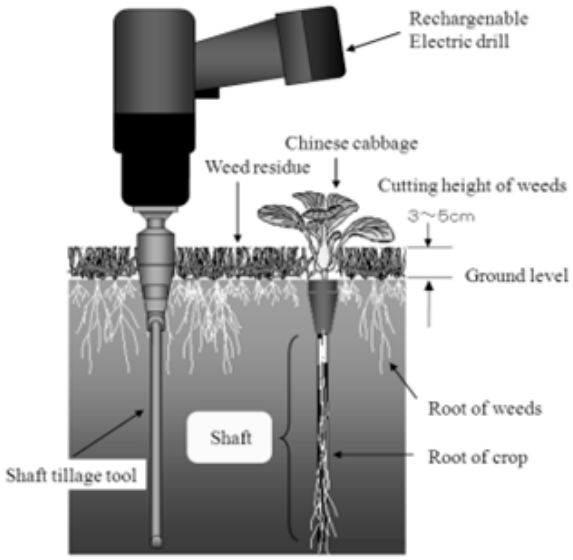

Fig. 2. The image of Shaft tillage cultivation.

photosynthesis of the weed in Shaft Tillage Cultivation and can inflect as organic matter.

3. Tillage and Planting by Shaft Tillage Cultivation

Figure 2 shows the image of Shaft Tillage Cultivation. Weeds are mowed certain height around non-growing season and stabilize coating with vegetation of the perennial weeds. The Shaft Tillage Cultivation is carried out by transplanting. Planting is performed by inserting the seedling into the molded planting hole, which is molded while tilling, for preventing the hole from covering with soil.

Figure 3 shows the Shaft Tillage tool. This tool mold a deep vertical shaft by roating the tillage tool, at the same time mold the planting hole which have the same shape as seedlings. Furthermore, this tool has no direction of rotating, which allows repeating alternative reverse when planting. These prevent accumulation of weeds residues and roots on the tool.

Figure 4 shows the image of the mechanism of root taking when planting. Transplanting has improved plants survival

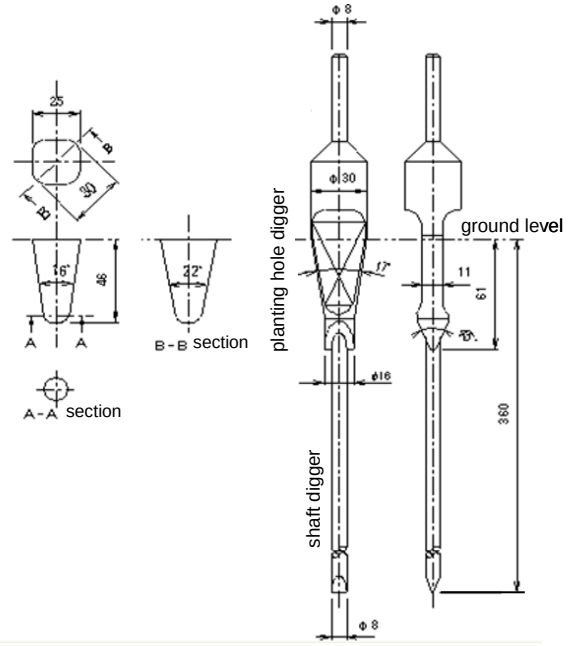

Fig. 3. The Shaft Tillage tool and the shape of seedling.

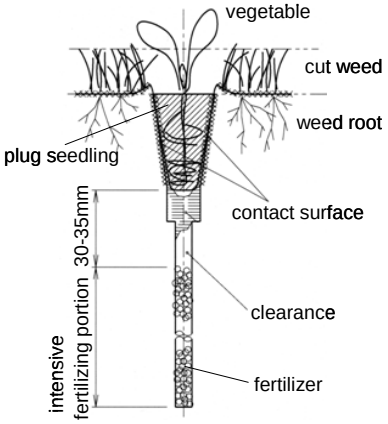

Fig. 4. The image of mechanism of root taking.

Fig. 5. The state of seedling after planting.

rates compared with direct sowing. Also, crops differentiate themselves with the surrounding weeds by adding water and fertilizer directly under the deep vertical shaft before planting.

Figure 5 shows the state of seedling after planting seedling takes root. Due to the sidewall of the seedling adheres with the inner wall of the planting hole. The surrounding of the

Fig. 6. The state of the cultivation.

Fig. 7. The state of cultivation in dry conditioned greenhouse.

planting hole is covered with cut weeds and residues. Shaft Tillage Cultivation is a farming method where roots are left in the field after harvesting, and crop residues on the field are not tilled but only the position of planting is changed.

The shaft which has strong walls was molded by a cylindrical tool with a smooth surface under the planting hole, which allows obtaining tillage effect. Therefore, the power requirement is the minimum and the soil is not mixed. In addition, the air permeability in the field is maintained by repeating cultivation.

4. Notable Points Obtained from the Result of the Cultivation Experiments

The obtained experiment results of Shaft Tillage Cultivation adapted to the cultivation of Chinese cabbage (*Brassica rapa* var. *chinensis*) are as follows.

(1) Soil erosion is low due to the surface is covered with weeds.
(2) Weeds cover surface prevent soil from splashing upward by rainfall, help to avoid disease's infections from wounds of the crops.
(3) It is possible to prevent a conflict between weeds and crops since weeds vegetation are stabilized by regular pruning.
(4) There is the effect to reduce a single type of pest outbreaks since it is possible to maintain biodiversity by weed cover.
(5) It is possible to differentiate between weeds and crops by watering and fertilizing before planting.
(6) Cultivation is possible even if the surface is arid due to the shaft can induce roots to deep parts.

Figure 6 shows the state of the experimental plots in the Shaft Tillage Cultivation field. **Figure 7** shows the state of cultivation experiment in a dry conditioned greenhouse.

5. Possibility to Adapt Shaft Tillage Cultivation to Arid Land Farming

Considering the possibility to adapt Shaft Tillage Cultivation to arid land farming from the notable points acquired by cultivation experiment.

(1) Ensuring erosion resistance
In conventional farming method is necessary to remove the covering of soil surface such as vegetation and rocks when tilling, therefore soil after tillage is easily eroded by wind and rain. However in Shaft Tillage Cultivation is less likely to be impaired in soil erosion resistance because most of the topsoil is maintained.
(2) Ensuring biodiversity
Shaft Tillage Cultivation can maintain biodiversity because it does not destroy the plow layer as well as ground surface. Advantages of the Shaft Tillage Cultivation are the accumulation of organic matter and maintain soil structure. As a result, Shaft Tillage Cultivation leads to prevention of soil degradation.
(3) Because a root is induced in the deep part of the shaft, it can absorb deeper water after planting in a short term, this allows for cultivation in the land where soil is hard.
(4) It is possible to avoid conflicts between crops and surface vegetation since irrigation and fertilization are carried out before planting.
(5) The possibility of cultivation in land which is hard to cultivate increases by putting water-retentive material and soil conditioning preparations into the shaft.
(6) Because it is thought that use efficiency of the sunlight is high as much as a weed fixes it by photosynthesis in Shaft Tillage Cultivation, it is thought that the effectiveness is high in the arid land of the region in a low latitude area that there is the sun light abundantly.
(7) Because the organic increase in the soil is effective in water-holding improvement of the soil, we can expect the effectiveness of Shaft Tillage Cultivation from the viewpoint of harvesting of the surface water.

6. Conclusion

Cultivation experiment has been conducted for 15 years so far, comparing growth and yield of Shaft Tillage Cultivation field with full-scale tilling field (Tajima *et al*. 2001). Although growth of plants in full-scale tilling field is generally superior to in Shaft Tillage Cultivation field, in the case severe environment condition, more individuals survive in the Shaft Tillage Cultivation field.

In the future, we want to verify the adequacy of Shaft Tillage Cultivation in arid land farming by the experimenting there.

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