Effect of Water Storage Pit Irrigation on Soil and Water Conservation

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Abstract: There are two major problems in the mountain and rolling area of North China. One is aridity, the other is water and soil losses. Based on this, the water storage pit irrigation method suitable for orchard irrigation was put forward in this paper. Compared to traditional surface irrigation method, the application of this method has the characteristics of saving irrigation and moisture-holding and drought resistance, and it can store local rainfall runoff. Therefore, it can prevent water and soil losses, and can make a good water hydrological cycle be formed. The principle and farm engineering of water storage pit irrigation and its effect on water and soil conservation were expounded in this paper.
Keywords: irrigation method, water and soil conservation, orchard, mountain and rolling area

There are two key problems in the mountain and rolling area of North of China, especially in loess plateau district. One is aridity, the other is soil and water losses. These problems have restricted the agricultural sustaining development and the construction of ecological environment in the area. The former have reported a large number of studies and practices about these problems. So far, the taken measures always were aimed at one problem. The main method of solving drought problem was looking for appropriate water source to irrigate. And the comprehensive improvement of smaller basin by taking biological measure and engineering measure and agricultural tilled measure were the main method of solving soil erosion problem. But scarce measure was capable of solving both problems at the same time. Water storage pit irrigation is a new method in which problems of aridity and soil erosion are considered. It is suitable for orchard and arboretum in mountain and rolling area.

1 Irrigation method of water storage pit irrigation

In traditional surface irrigation, water infiltrates into rhizosphere soil from ground surface. Some defects are shown in the application of this method to fruit tree irrigation with deeper roots distributing. Firstly, larger evaporation loss occurs during irrigation. Secondly, the soil moisture content nearby earth surface is often bigger in condition of smaller available water supply so that roots distribute concentrative in soil top layer, thus the drought resistance of fruit tree is decreased. Thirdly, with sluggish characteristic of soil moisture redistribution, roots of middle-depth soil layer absorb water slowly and smaller. Therefore, it is necessary that finding a new method suitable for North of China area to hold water and resist drought and irrigate efficiently.

Water storage pit irrigation method is that water flows into small storage pits(depth of pits is about 60 cm—80 cm) which are dug under a tree canopy and infiltrates into rhizosphere soil through pit walls. This method is middle-depth stereoscopic irrigation in comparison with traditional surface irrigation. It not only can decrease sufficiently land evaporation during irrigation to save water, but also make rhizophere soil absorb water rapidly by middle-depth irrigation. Meanwhile, because the surface of storage pit walls is a air surface, the ventilation and air permeability of middle-depth soil is improved, and it is benefit to roots plunging into deeper soil by water inducing. Deeper roots not only can improve drought resistance of fruit tree, but also make water effective utilization factor increase. Water storage pit irrigation method has a better characteristic of water conservation, even if irrigation requirement is smaller, the humidity thickness of middle-depth soil is bigger. Therefore water storage pit irrigation is a method suitable for orchard and arboretum and having water saving, water conservation and drought resistance characteristic.

2 Effect of water storage pit irrigation on water conservation

There are two main causes for soil erosion of slope face in rolling area. One is corrosion-resistance rather poor due to underlying surface conditions, such as soil texture, soil structure and vegetal cover etc.. The other is raindrop impact, raindrop erosion and slope face runoff generated to give rise to further scouring and sediment movement. Precipitation and runoff are dynamic factors of soil erosion, therefore, if rainfall runoff can be controlled effectively, so soil erosion can be.

Effect of water storage pit irrigation on soil and water conservation is achieved by impounding rainfall runoff. On the one hand, storage pit can accept rainfall runoff, the net rainfall received in single tree pits is given by the formula

$$h = \frac{250\pi D^2 HN}{A}$$

where D is water storage pit diameter(m); H is water storage pit depth(m); N is the number of single tree's storage pits; A is appropriated area of single tree(m^2); h is net rainfall received in single tree's storage pits(mm).

In general, it is assumed that total volume of single tree's storage pits is 0.4 m^3, and appropriated area of single tree is 16 m^2 (spacing between trees and spacing between rows are all 4 m), then water storage pits can accept 25 mm net rainfall. On the other hand, field conveyance furrow dams connected to storage pits in which slope face is cut into many strip-areas along contour line can intercept rainfall runoff in strip-area. Therefore, the soil infiltration is increased and slope face affluence is prevented.

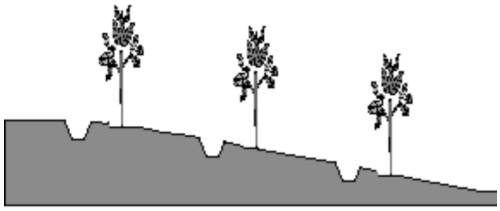


Fig. 1 field ridge schematic diagram

Soil erosion can be effectively controlled by water storage pit irrigation. In general, 40mm precipitation will be not form large area slope face runoff, thus soil will not be loss from slope. For the precipitation larger than 40mm, runoff will be reduced greatly to decrease soil erosion by using this method. Also, the utilization factor of rainfall runoff in the area with water storage pit irrigation will be improved. For mass rainfall, groundwater will be recharged to become sub-runoff by middle-depth infiltration in storage pits, and a better water cycle will be formed.

3 Field engineering of water storage pit irrigation

Field engineering of water storage pit irrigation includes storage pit, facilities fixing walls of storage pits, annular furrow, coverage of pit opening and field ridge etc..

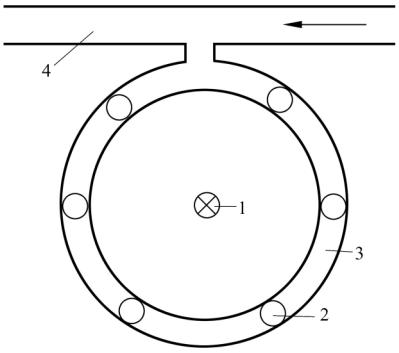
3.1 Water storage pit

Water storage pit is set at 1/2 of radium of a tree canopy. The total pit volume of single tree is determined by its irrigation requirement. The diameter of single pit is determined with the total pit volume of single tree, it is commonly 25 cm—30 cm. The depth of pits will be established according to effective rooting depth, it is often 60 cm—80 cm. The number of single tree's storage pits should be determined with the horizontal infiltration character of soil and irrigation requirement, this not only can ensure that soil mass between pits is all humid, but also can satisfy the volume demand of irrigation

requirement. The relation between the number of water storage pits and irrigation requirement is given by the equitation

$$N = \frac{4M}{\pi D^2 H}$$

where M is the irrigation requirement of single tree(m^3); N is the storage pit number of single tree; other symbols' mean are the same as former. The storage pit number of single tree should also be adjusted by experiment of infiltration characteristic and soil-water kinematic modeling to ensure middle layer soil wet uniformly.



1 fruit tree; 2 water storage pit;
3 annular furrow; 4 field ridge

Fig. 2 Field engineering schematic diagram of water storage pit irrigation

3.2 Facilities fixing walls of storage pit

Water storage pit is a fixed engineering, it needs to be protected by facilities fixing wall of storage pit in that the walls are easily destroyed by flow from irrigation or rainfall. The shape of the facilities fixing walls of storage pit is cylinder, and the facilities should be of well permeability. The facilities' material may be bamboo strip or tip strip to weave a cylinder, and cheaper renewable plastic or fine aggregate concrete may also be adopted to make into filter cylinder. The specifications of the facilities fixing walls of storage pits should be fitted with that of water storage pits.

3.3 Annular furrow

Annular furrow lies under tree canopy by which water storage pits around tree are linked up. In irrigating, water flows into circular furrow through field ridge then water is poured into pits from the annular furrow. The annular furrow is a shallow furrow with 20 cm-deep and 25 cm—30 cm wide. It can not only convey, but also storage runoff for greater rainfall.

3.4 Pit opening coverage

Pit opening should be cover by longer crop residue to prevent soil moisture from evaporating and avoid earth temperature lower to affect roots nearby pits.

3.5 Field ridge conveyance

Field ridge is a field fixed channel that connects irrigation main system to annular furrow. Field conveyance furrow is commonly set along contour line, lying in upper sides of tree rows in slope surface. It is advantageous that water flows into annular furrow by gravity and rainfall runoff is intercepted. The cross section scale of field ridge should be determined by irrigating delivery flow.

4 Summary

Water storage pit irrigation is a new method adaptable to orchard and arboretum in mountain and rolling area of North of China. This method has characteristic of water saving, water conservation and drought resistance, as well as taking advantage of local surface runoff and making a better water cycle. The application of this method is simple, easy and cheap and this method is understood easily for farmer and spread conveniently. But the many theory problems such as infiltration of varying head, complicated boundary in storage pit and its mathematical modeling etc. will be studied further to determine rationally technical parameters of water storage pit irrigation.

References

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