One Method of Ridged-Furrow Design

Yongsheng Ma, Tianyu Wei

School of Water Conservancy and Civil Engineering, Northeast Agricultural University, Harbin, Heilongjiang 150030, China

Abstract: As a soil conservation tillage method, ridged-furrow has been extended to apply in sloping field. Since the ridge can stop erosion of soil, the effect of soil conservation is obviously. Based on ridged-furrow can form soil reservoirs and increase soil moisture to save and increase water, the article has developed a new design method as a reference for tillage in semi-arid sloping field. [The Journal of American Science. 2005;1(1):75-77].

Key words: ridged-furrow; design method; soil reservoir

1. Introduction

Ridged-furrow has been widely applied in hilly area of Heilongjiang province as a soil conservation tillage method. It can efficiently remain surface flow and erosion of soil. The effect of soil and water conservation is obviously. The ridged-furrow tillage is furrows along the land slope and plus lateral ridges forming holes to remain soil erosion and runoff. Owing to soil and water erosion is very serious in hilly area of Heilongjiang province, soil conservation is very important. Before, ridged-furrow tillage was mainly used for protecting sloping farmland and conserving soil erosion, literature researches more concentrated to the effect of soil erosion, but less

research the effect of saving water. Based on the tillage method not only prevent soil erosion but also remain precipitation runoff to keep soil moisture, the field test for saving water has been carried out in Gannan county located in western semi-arid region of Heilongjiang province. Through the field test, the saving water effect of ridged-furrows and the adaptability for sloping land saving-water agriculture in semi-arid region have been tested and numerical analysis and design results have been obtained. The article propounded a new design method of ridged-furrow, which is applicable for the local conditions as the basic study on the technology of ridged-furrow application.
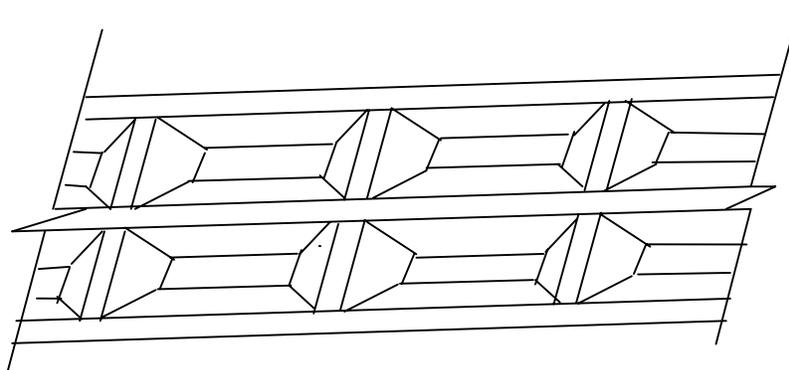

Figure 1. The sketch map of ridged-furrow

2. The hydrological features in semi-arid region

The western semi-arid region of Heilongjiang province is located in the middle of Nenjiang River, between the passage area from south hilly land of Daxing'an-ling Mountain to Song Nen Plain, and belongs to half hilly and half plain area. The general land elevation in the region tents to depress from high in northwest to low in southeast. The morphology in the region is divided into three sub-regions: low hilly mountain, high land of mountain front and uneven land with the elevation range between 160 and 380 m above sea level. In the region, mainly is the plant agriculture. The average annual precipitation in many years is 450mm or so, the evaporation is 1499.8mm. Therefore, the evaporation is three times more than precipitation. The average annual accumulation heat is 2400℃, the sun shine is 2791.7 hours, and non-frost period is more than 130 days. The wind usually is northwest wind and average wind speed is about 3.5 m/s.

Gannan County is one of important heavy arid county in west of Heilongjiang, nine out of ten years draught, the half land in the county is sandy soil and water capacity is very low. Every year, draught hazard

caused food reduction can reach to 0.1 million tons. Agricultural production has been seriously restricted by precipitation. Therefore, saving water to increase productivity is a key factor for developing sustainable agriculture in the region.

3. The design methods of ridged-furrow

3.1 Design the distance of ridges

Ridged-furrows remain runoff soil and water by forming holes with furrows and ridges. The distance of ridges design should take consideration of remains runoff as much as possible, and reduce or avoid surface water cut through the ridges. The ridged-furrow design mainly for selecting the reasonable ridge distance. If the distance is too large, it will catch too much water in each hole, the hole has not enough room to carry water, the resulting overload on the lower hole could cause it to overtop and begin a chain reaction that would likely produce a gully; otherwise, will increase the earth work and farm costs. Based on the principle of water balance, this article propounded the design method that the rain catching area must equal the water body in the hole and soil infiltration.
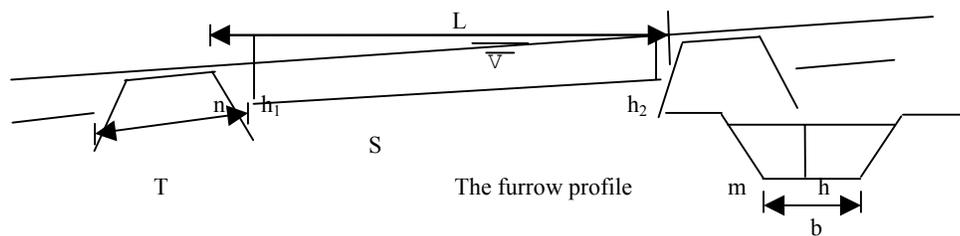

Figure 2. The profile of Ridged-furrow   The furrow section

3.1.1 The water storage in a hole

As show in figure 2, can establish the formula of whole storage with geometric method, as following:

$$V_s = (A_b + A_B) \times \bar{h}/2 \qquad (1)$$

which: V_s -- the volume of stored water body, m;

A_b -- the area of water body bottom , m^2;

A_B -- the area of water surface, m^2;

$\bar{h}$ -- the average depth of water body, m,

$\bar{h}$ = $(h_1 + h_2)$ /2.

$$A_b = b \times S \qquad (2)$$

$$A_B = [(b + 2mh_1) + (b + 2mh_2)]L/2 \qquad (3)$$

$$V = (A_b + A_B) \times (h_1 + h_2)/4 \qquad (4)$$

which: L— the length of water surface:

$L = D + nh_1 + nh_2$,   and take $m = n$。

D — the level distance of ridge bottom:

$D = S\sqrt{1-i^2}$,   D can take the approximate value of S, that is: $D \approx S$。

Therefore: $L = S + nh_1 + nh_2$;

And $h_2 = h_1 - Si$

The volume of water body as the formulae (5):

$$V = 0.25 \times [2bS(2h_1 - Si) + n(S + b)(2h_1 - Si)^2 + n^2(2h_1 - Si)^3] \qquad (5)$$

which： $(2h_1 - Si) = 2\bar{h}$

That equals 2 times of average depth.

3.1.2 *W* - caught rain water:

To suppose catching rain water equals the catching area times rainfall depth, as following:

$W = RB_f(S + T) = RB_f S + RB_f T$ （6）

Which： R – the net rain in one storm：

$R = P - I_0 - \bar{f}t_c - P'$ （7）

S — the distance of ridges，m；

T — the width of ridge section bottom，m；

B_f — the furrow space，m；

P — the rainfall depth in one storm，mm；

I_0 — soil infiltration，mm；

P' — the rainfall without runoff at the end of storm，mm；

f — The average stable infiltration rate，mm/h；

t_c — runoff period，h。

3.1.3 Calculate the distance of ridges

Based on the water balance conditions: $W = V$，with formula (5) and (6) can calculate the distance of ridges S.

3.2 Discussion: some problems in design

In practice, some problems should be taken consideration in the design of ridged-furrow：

(1). For the case of steeply slope, the hole can store little water, rain catching area must be small and the distance of ridges is very short. Therefore, the method is not suggested applicable with slope gradients steeper than 10%. For the case of steeply slope should change the method, such as contour furrow.

(2). When $h_2 = 0$, the distance of ridges is maximum value for that slope.

(3). In 2003, the ridged-furrow design method had been tested in the test site of Gannan county, Heilongjiang province. The soil in test field is black-earth, slope gradient is 2%, and the area of test field is 15 m×6 m, using artificial rainfall, and the design accords with the test results.

4. Conclusion

(1) In practice of farmland cultivation, ridged-furrow method is applicable with the slope gradients smaller than 10%, otherwise, for steeper slope should use other methods, such as contour furrow.

(2) Theoretically, ridged-furrow has increasing water effect; however, the project is still in researching and can not provide exact test results and extension beneficial results. The design method is just for a reference.

Correspondence to:

Yongsheng Ma
School of Water Conservancy and Civil Engineering
Northeast Agricultural University
59 Mucai Street, Xiang Fang
Harbin, Heilongjiang 150030, China
Telephone: 01186-451-55117878
Email: ysma66@yahoo.com.cn

Reference:

[1] Aimin Young. Study on soil and water conservation for sloping fields. Journal of Conservation 1994;2.

[2] Aimin Young. Study on the saving water and effect of increasing production with ridged-furrow in sloping field, Study on Agriculture in Arid Region 1997;4.

[3] Changpu Shen. The optimal distance of ridged-furrow and sloping land test, Soil and Water Conservation Notices 1997;17(3):6.

[4] Zhenguo Niu, Baoguo Li. A method of Determining Land-Use Patterns based on regional available soil water in semi-arid areas. Land and Water Management Vol. I - proceedings of the 7th inter regional conference on environment and water, pp. 613-9.