Deterioration of bench terrace and its rehabilitation technique with weed buffer strips

ベンチテラスの崩壊と草生帯設置による補修技術

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1. INTRODUCTION

Terracing is an effective soil and water conservation technology. Bench terrace is a relatively high-cost system and it requires high level of supervision, maintenance and on-going extension. Sometimes, its effectiveness is questioned as loss of surface soil and depletion of soil suitability such as organic matter occurred on bench terraces and decreasing of crop yields. Finally, deformation of bench terraces happened (Barber and Eijinsbergen, 1981).

The objective of this study is to investigate the effectiveness of bench terraces under bare condition, which was practiced by farmers in Chiang Rai, Thailand and to test the effectiveness of weed buffer strips and residues in reducing terraces erosion.

2. METHODOLOGY

A model bench terraces was constructed in the Farm Museum Tama Hills of Tokyo University of Agriculture and Technology. The model bench terraces was constructed based on relation of soil properties and structure of bench terraces found in Pang Prarachatan village of Chiang Rai, Thailand. The dimension of the plot was 5 m across and 10 m along on 33 degree of slope. The model bench terrace was kept bare during June to November 2002, and weeds were allowed to grow on the slope of bench terrace during June to November 2003. Surface runoff and soil loss from the model bench terraces were weekly measured. A natural forest was set up as a control plot.

Revised Universal Soil Loss equation (RUSLE) (Renard et al, 1996; Yang et al, 2003) was applied for evaluating the effectiveness of bench terraces and weed buffer strips by means of the CP factor. R and K factor were calculated as follows:

$$R = \Sigma[1099(1-0.72\exp(-1.27ir))][\Delta Vr][I_{30}] \times 0.1702 \quad [\mathrm{MJ\ mm\ ha^{-1}\ h^{-1}\ yr^{-1}}]$$

ir is rainfall intensity (in hr^{-1}), Vr is depth of rainfall (in), and I_{30} is maximum 30-min rainfall intensity (in hr^{-1})

$$K = 0.0293\,(0.65-D_G+0.24D_G^2)\exp[-0.0021(OM/f_{clay}) -0.00037(OM/f_{clay})^2-4.02f_{clay}+1.72\,f_{clay}^2] \quad [\mathrm{ton\ ha\ h\ ha^{-1}\ MJ^{-1}\ mm^{-1}}]$$

$$D_G = -3.5f_{sand} - 2.0f_{silt} - 0.5f_{clay} \text{ (USDA classification)}$$

3. RESULTS AND DISCUSSION

Rainfall during June to November of 2002 was 1119 mm and of 2003 was 1369 mm. R factor during experiment in 2002 was 3030 MJ mm ha^{-1} h^{-1} yr^{-1} and in 2003 was 3334 MJ mm ha^{-1} h^{-1} yr^{-1}. Peak of monthly rainfall, R factor, and surface runoff occurred in August 2003, but peak soil loss occurred in October 2002 (Figs. 1 and 2). Soil loss in October 2002 was 24.74 ton ha^{-1}; it was 88.7% of the total soil loss in 2002. There was no soil loss in November 2002. Total soil loss from the natural forest plot during the experiment in 2002 and in 2003 was far lower than that of the terraced plot; it was only 0.004 ton ha^{-1} in average.

Soil erodibility factor (K factor) of the model bench terraces were 0.017 ton ha h ha^{-1} MJ^{-1} mm^{-1} in 2002 and 0.018 ton ha h ha^{-1} MJ^{-1} mm^{-1} in 2003. The model bench terraces was deforested and kept bare for erosion research since 1998, thus the K factor of the model bench terraces was much higher than that of the natural forest plot. K factor of the natural forest plot was only 0.007 ton ha h ha^{-1} MJ^{-1} mm^{-1} in average.

As the forest is the best land use system, its C factor was only 0.00005. Some roots existed in the model bench terraces and it affected to P factor of the model bench terraces, thus the CP factor is discussed as a component. The CP factor of the model bench terrace was 0.02 in average during June 2002 to September 2002, and it increased to 0.32 in October 2002 due to a heavy storm.

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Native weeds were allowed to grow on the slope of bench terraces since June 2003, however their growth rate and density were too low to perform as a conservation measure due to low intensity of light and severe erosion. Its CP factor in June 2003 was 0.30. In late August 2003, weeds were trimmed and the residues were left on the slope of bench terraces. The CP factor was obviously decreased from 0.48 in July 2003 to 0.11 in August 2003. In November 2003, fallen leaves enhanced effectiveness of weed buffer strips in reducing soil erosion from the model bench terraces.

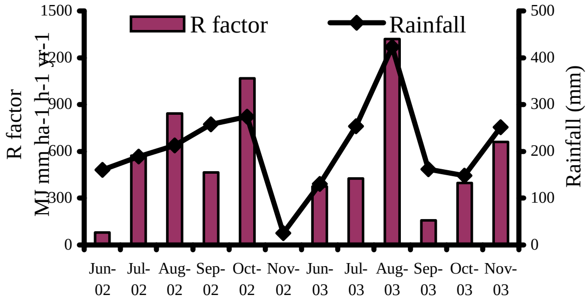

Fig. 1 Rainfall and R factor in FM Tama Hills

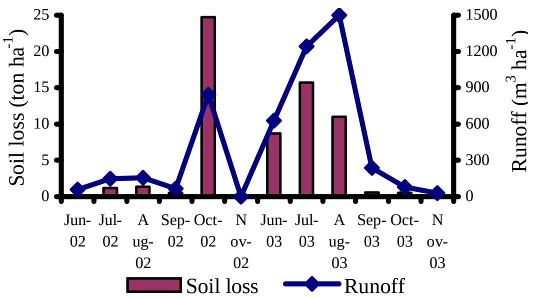

Fig. 2 Runoff and soil loss from the model bench terraces in FM Tama Hills

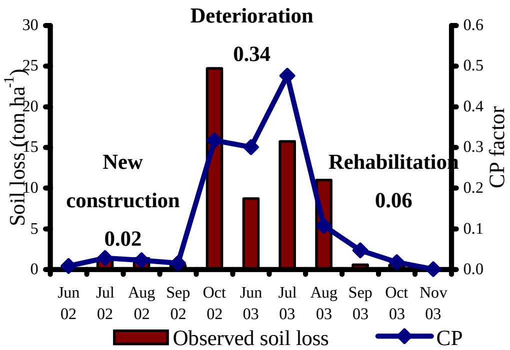

Fig. 3 The CP factor of bench terraces in various stages in FM Tama Hills

As shown in Fig. 3, the model bench terraces can be divided into 3 stages; those are new construction, deterioration, and rehabilitation. Effectiveness of bench terraces under bare condition was very high after new construction. However, its effectiveness decreased rapidly where it was kept bare to heavy rainfall. Finally, it resulted in deformation of bench terraces, the structure of terraces changed from backward type to level or outward types.

Weed buffer strips including residues and fallen leaves effectively reduced soil erosion from the deteriorated model bench terraces. However, due to low percentage of ground cover on the model bench terraces, effectiveness of the deteriorated terraces with rehabilitation technique by application of weed buffer strips was lower than that of the new construction of backward bench terraces,.

4. CONCLUSIONS

The bench terrace under bare condition is easy to be eroded, thus it is not appropriate to install as a conservation technique. Its effectiveness greatly reduced after some storms. Native weed buffer strips and residues is effectively reduced soil erosion from the deteriorated bench terraces. The farmers should allow native weed to grow on the bench terraces. The amounts of soil and nutrient losses from the model bench terraces would much decrease if the percentage of ground cover increases.

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