TAPPSC: An Effective Method of Soil and Water Conservation during the Process of Reforestation?*

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Abstract: It is extremely urgent to promptly and effectively restore the seriously destroyed and degraded forests and environment in mountainous regions. However,the suitable technique for forest restoration is one of the key factors which control the effect of restoration and rehabilitation of degraded forest and environment.The method of clearcutting for site preparation of silviculture,i.e.,trees are planted after all brush and herb on the site have been completely cut and removed,even burned and killed by phytocide, have inevitably resulted bad effects such as serious water runoff losses and soil erosion. TAPPSC,i.e.the technique of Alternative Pattern with Preservation Belts (Belt zone of the present vegetation) and Silviculture Belts (Belt zone of clearcutting the present vegetation for planting seedlings or sapling) along Contour line, has assumptively been put forward to satisfy with practices of soil and water erosion control in forest restoration. The hypothesis has been tested in the paper. It showed that TAPPSC reduced 30,732 t/(km^2 • a)—62,589 t/(km^2 • a) water runoff losses and 1,068 t/(km^2 •a)—1,408 t/(km^2 •a) soil losses on the slopes with 25.8° and 35.0°. Finally,effects of factors including brush as well as rainfall and slope characters on soil and water conservation of TAPPSC have been discussed. The authors advocated that TAPPSC was more efficient in reducing soil erosion and water runoff losses than traditional clearcutting method be during the process of forest restoration practices,especially on steep terrain in watershed area.
Keywords: soil and water conservation, preservation belt,silviculture belts,reforestation soil nutrients, soil erosion

1 Introduction

Forest vegetation has been destroyed and replaced by secondary brushes in lots of mountainous regions in the world such as regions on the eastern Qinghai-Tibetan Plateau.Consequently,ecological environment degraded seriously and regional social and economic sustainable development were limited. Thus, it is extremely urgent to promptly and effectively restore the seriously destroyed and degraded forests and environment (Zhaoguang Liu,1991). However, suitable technique for reforestation is one of the key factors which will influence on effective restoration and rehabilitation of degraded forest and environment.

Obviously, the goals and methods of forest restoration and rehabilitation are closely related to natural conditions and human demands and original vegetation characters. Natural disasters including landslips and collapses and terrible floods and droughts have frequently occurred and soil and water run off gravely because of typical topography of higher mountain and deep gorge in mountainous regions. And so the main goals of reforestation focuses on satisfying the following objectives: (1) soil and water conservation and provision for decreasing emergence frequency of mountainous natural disasters, (2) provisions for maintaining and improving site quality, (3) biodiversity conservation and control of damaging agents such as insects and diseases, and (4) benefit for tree growth and increasing economic incomes from timbers and non-timber products.Clearcutting is one traditionally and commonly seen method of site preparatory for reforestation in those mountainous regions where original forest vegetation

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has been destroyed or cut.However,clearcutting for site preparation of silviculture, i.e.,trees are planted after all brush and herb on the site completely are cut and removed,even burned and killed by phytocide, have inevitably resulted in bad effects including: (1) surface soil coverage lowering quickly in very short period, (2) soil and water running off gravely, (3) forestland degrading and biodiversity decreasing, and (4) lower survival reserve rates for trees planted,especially for shade-tolerant tree species selected.Those effects go against the goals of forest restoration in those regions.

Contour cultivations such as terracing,strip cropping,bench terracing etc are the effective soil erosion control measures that has been applied in agriculture to promote sustainable land use on steep terrain in watershed area.Strip clearcutting in forestry that previously existing forest cut along narrow strip is one of site preparation measures for reforestation.Those provide us a cue to establish TAPPSC,i.e. the technique of Alternative Pattern with Preservation(Pr.) Belts(Belt zone of the present vegetation) and Silviculture Belts (Belt zone of cutting the present vegetation for planting seedlings) along Contour line, according to relevant principles of ecological engineering and soil and water erosion control(Kaiwen Pan *et al*.,1998).

A hypothesis that TAPPSC is effective to reduce soil erosion and water runoff losses has been tested in this paper.

2 Materials and methods

2.1 Selected region

Selected region,with an elevation of 1,554m—4,199m and east longitude of 103°54′04″—103°56′52″ and north latitude of 31°37′20″—31°44′53″,and typical topography of higher mountain and deep gorge on the fringe transition area from Sichuan basin to eastern Qinghai-Tibetan Plateau, locates at Dagou valley, Maoxian county in Sichuan province on the upper reaches of Minjiang River which is one of main branches of Yangtze River. Distributions of vegetation types with progressively increasing elevation are shrub in semi-arid valley, mountain shrub, secondary deciduous forest, subalpine and meadow, and corresponding soil types are cinnamon soil, brown soil, dark brown soil and subalpine meadow soil (Kaiwen Pan,1998).

Experimental observation locates area with 1,826m—2,200m of elevation and 900mm—1,100mm of annual precipitation.Secondary brush is dominated by some deciduous broad-leaved species such as *Quercus liaotungensis*, *Ostriopsis spp.*, *Ostryopsis davidiana*,*Corylus heterophylla*, *Corylus yunnanensis* and *Rosa cymosa*.Trees for selection of reforestation mainly include needle tree species such as *Pinus tabulaeformis, P. armandii, Larix kaempferi, L. principis rupprechtii*, and some broad-leaved trees as *Crataegus wilsonii*,*Cercidiphyllum japonicum* and *Betula albo-chinese*. Soil are cinnamon and brown soils.

2.2 Experimental design

TAPPSC was applied to reforestation during the area with 1,826m—2,200m of elevation on the same semi-shade and semi-sunny face of slope. Brushwood with mean 1.5m high was dominatingly composed of *Quercus liaotungensis* and *Ostriopsis spp.* in preservation belts with 2.5m wide. Sapling trees for plantation with 1.5m in row and 1.0m in column were *Pinus tabulaeformis*,*P. armandii*,*Cercidiphyllum japonicum* and *Betula albo-chinese*,which were mean respectively 40cm,50cm,70cm and 60cm high and 4,4,1,2 years old in silviculture belts with 2.5m wide. The horizontal width of experimental plot were 100m and the CK,i.e. was the same as above except that all shrub and herb species were clear cut and then removed, was adjacent to the area where the TAPPSC were used.

2.3 Study method

3 runoff losses observation plots with each plot of $(4\times4)m^2$ were respectively built in TAPPSC and CK area on the 28.2° and on the 35.0° slopes. Amount of soil surface runoff and content of mud and sand in runoff were measured during the process of rainfall per time. Meantime,rainfall volume was collected

and measured accord to 6 rainfall cylinders set outside of forest. The experimental observation has last two years.

Surface soil(0cm—20cm depth) were respectively collected from TAPPCCC and CK by isometry(60cm interval) sampling after the experimental was end. Surface soil nutrients including organic matter,available N(nitrogen) and P(phosphorus) and K(potassium) were determined by methods of scatter-assimilation,colorimetric analysis and flame photometry, respectively(Nanjin Institute of Soil,CAS,1993).

3 Result

3.1 Effect of TAPPSC on soil and water conservation

The TAPPSC decreased 62,589 t/(km^2 • a) and 30,732 t/(km^2 • a) surface runoff losses on the slope with 28.2° and 35.0°, respectively.Meanwhile, the TAPPSC reduced forestland soil erosion amount with 1,068 t/(km^2 • a) and 1,408 t/(km^2 • a) in the correlative slopes of given two gradients.Above results indicated that TAPPSC could efficaciously lower water runoff losses and soil erosion (Table 1).

Table 1 Effect of TAPPSC on soil and water conservation

Gradient	28.2°		35.0°	
Modulus	Water runoff (t/(km^2 • a))	Soil erosion (t/(km^2 • a))	Water runoff (t/(km^2 • a))	Soil erosion (t/(km^2 • a))
TAPPSC	110,213	1,118	162,433	1,467
CK	172,802	2,186	193,165	2,875
Difference	62,589	1,068	30,732	1,408

3.2 Effect of TAPPSC on soil nutrient conservation

Before the TAPPSC did not be used to establish forests in the area, previous conditions of soil of TAPPSC and CK were basically parallel. It was obviously different in soil nutrient status between TAPPSC and CK in two years after TAPPSC were applied. Content of tested nutrients including organic matter, available N and P and K of surface soil of TAPPSC were higher than that of CK (Table 2). Thus, it provided us evidence that TAPPSC was very effective to conserve soil nutrients.

Table 2 Effect of TAPPSC on soil nutrient conservation

Treatment	TAPPSC	CK	Difference
Organic matter,g/10kg	4.83	3.97	0.86
Available N,10^2 mg/kg	1.77	1.53	0.24
Available P,10^2 mg/kg	2.45	1.87	0.58
Available K,10^2 mg/kg	1.67	1.07	0.60

4 Discuss

4.1 Effects of rainfall on soil and water conservation of TAPPSC

Rainfall had significant effects on reducing soil erosion of TAPPSC (Data from Table 3 were tested by SPSS software,SAS institute,1985,$F(10,4)=121.105$,Significance = 0.000),while it had no significant influence on controlling water losses of TAPPSC. It had obvious tendency that amounts of soil and water losses reduced by TAPPSC have been increasing when rainfall volume enlarged (Table 3).

4.2 Effect of slope gradient on soil and water conservation of TAPPSC

There was no significant effect of slope gradient on soil and water conservation of TAPPSC in the given two gradients. But it differed between effects of TAPPSCC on water and soil conservation along different slopes gradients. Effect of TAPPSC on water conservation increased along rising slope gradient when amount of rainfall per time was less than 1mm,and decreased along rising slope gradients when amount of rainfall per time was larger than 1mm.However,effect of TAPPSC on soil conservation has always raised along the enhancing slope gradient (Table 3).

4.3 Effect of brush character on soil and water conservation of TAPPSC

It indicated that *Quercus liaotungensis+Ostriopsis spp* brush paid an effective role of reducing soil erosion and water runoff losses, especially in the regions with steep slopes in the paper (Table 3). Almost brush and herb had noticeable capacity to conserve soil and water (Kaiwen Pan *et al*., 1995).However, it should be possible that amount of effects of TAPPCCC on soil and water conservation has dramatical difference under different conditions such as different brush and climatic and soil and topography characters.

Table 3 Factors influencing on effects of TAPPSC on soil and water conservation

Rainfall/times		<1mm	1mm—5mm	5mm—10mm	10mm—25mm	>25mm
Slope 28.2°	TAPPSC	66/0*	601/3,837	1,211/7,373	1,765/17,673	7410/87,543
	CK	125/0	910/7,493	1,801/14,262	2,609/33,488	10,695/162,900
	Difference	59/0	309/3,656	590/6,889	844/15,815	3,285/75,357
Slope 35.0°	TAPPSC	132/0	821/5,983	1,594/12,931	2,619/26,395	10,562/100,766
	CK	250/0	1,113/11,610	1,972/24,865	3,118/49,497	11,307/185,967
	Difference	118/0	292/5,627	378/11,934	499/23,102	745/85,201

*:Water loss(t/km^2) / Soil loss(kg/km^2)

4.4 Significance of statistical analysis

Variance analyses of effects of TAPPSC on soil and water conservation were tested, but there were no significant effects. This was partial result from at least two reasons: (1) little sample number and (2) the sparse density of the brush and its weaker capacity of soil and water conservation. However, data from the paper clearly showed that TAPPSC had obvious effects on reducing soil erosion and water runoff losses. Brushes easily grew in the almost of mountainous regions with semi-moist or moist climates (Kaiwen Pan *et al*., 1995).And so the TAPPSC is worth and easily to be applied in the processes of reforestation practices.

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