Effect of Contour Hedgerow-Intercropping System on Slope Land and Some Problems of Application in TGR

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Abstract: The contour hedgerow was considered as an effective alternative measure of stone dike in the utilization and management of slope land. However, there are still some doubts in the applications. Based on the results of experimental plots and field trial in the Three Gorges Area, the objective of this study was to discuss the structure and function of contour hedgerow-intercropping system in order to offer some practice references for applying it. The system was consisted of two main parts, the hedge and intercrops. After contour hedgerows implemented three years, the available soil depth rang from 50 to 60cm that is much deeper than slope land, while slope become gentler. With the result that the soil water capacity was extended and that soil fertility was promoted. The hedgerows may also produce many kinds of agricultural products, such as medicinal plants materials, forage for cattle, forage for silkworm, tea and other food when you selected suitable species. The contour hedgerow-intercropping system can spread in the region where is difficult to construct stonewall terrace. It is a suitable way to reform and use slope land, control slope soil erosion, and ensure agriculture sustainable development in mountainous and hilly area.
Keywords: contour hedgerow, slope land, sustainable agriculture development, soil and water conservation

China is a long history agricultural country with 1.2 billion population and 0.1 billion ha arable land. Given the size of population and the limitation of land, a farmer has less than 0.13 ha land for himself, which availability shrinks further to less than 0.03 ha in densely populated areas. The easily exploited and fertile land, such as plain, upland and intervale， were opened out and cultivated frequently in most part of South China. It is terribly necessary to empolder the hilly and mountainous slope land resource and promote its sustainable productivity where the cultivable land resource is serious lock, so as to meet the needs of citizen for being rising living standard. However, soil erosion and water loss were easily occurred on the slope land, which reduce the sustainable productivity and result in soil degradation, land lose and environment deteriorations. It is the key concerned issues to achieve the high output of farming utilization and diversify the productions on the basis of improving the environmental conditions, enhance the ecological stability (Kuchelmeister, 1989; Wenhua *et al*.,1994; Chongfa *et al*.,1996). This is especially true in the Three Gorges Area (TGR)of Changjiang River in west Hubei and east Chongqin, where cultivated steep slope land reaches 0.2 million ha, which is up to 22% of agricultural land. Being considered the major origin of erosion, the cultivated land covers more than 60% of the total erosion region (Zitong *et al*., 1993). With increasing demand of social economics development, the potential land will mainly come from the exploitation of slope land in mountain and hilly areas of TGR. Soil erosion is not only one of main obstacles to agricultural development of steep land area, but also contributes huge amount of sediment in the river and the constructing TGR's reservoir. Most of the farmers and agricultural managers used to make stonewall dike terrace to avoid the crises. It is considered an efficient measure in some parts of China. However, shale rock, covered 80% land in TGR, is easy to be weathered and not strong enough to make wall. Hence, stones, the main construction materials, are not easy to prepare in purple sandy shale area. Moreover, to make stone dike terraces requires high capital investment and the dike of terrace normally need repair every year after implementation (Xiubing, 1996). One possible solution to these problems is the introduction of agroforestry system to the slope area. Contour hedgerow-intercropping system is one of good agroforestry model as alternative biological measure. It is reported that they offer both economic and ecological advantages (Wenhua *et al*., 1994). Because systemic evaluation is not well-

conducted assessment and the contribution of hedgerows to soil fertility is not clear in subtropical area of China, the farmers doubt to accept the technology. The objective of this study is to discuss the structure, function and benefit of the contour hedgerow-intercropping system systemically with the results of experimental plot and field trial in the TGR.

1 System structure

Contour hedgerow-intercropping system is farming system that generally composed of two parts: contour hedgerows and the agricultural enterprises between them. Contour hedgerow known as active hedge, is to plant trees or shrubs closely and horizontally along contour line on the slope land. Spacing between the rows is design to accommodate the mature size of the hedgerows as well as for annual crops, perennial fruit trees or cash trees, which makes a special way of land use. This design has a high potential to conserve soil and water compared with the pure plantation and shifting cultivation. The practices show the various microclimatic conditions have occurred. As a pattern of agroforestry, it is a multiple purpose, highly productive and ecologically stable farming system.

According to the relations between the crops and the hedgerows, the hedgerow-intercropping system is commonly classified as system, sub-system and structure. For agroforestry, based on feature of its products, which is classified as agriculture-forestry, agriculture-fruit, agriculture-livestock, forestry-fruit and forestry- livestock etc. Based on the type of system, system can be sub-classified as sub-system. For instance, the agriculture-forestry can sub-classified as grain-forestry, fodder-forestry etc. Classification may open out the affiliation of the parts in the system and let farmers understand and apply the agricultural management practices. In fact, it is very difficult to clearly classify the system vertically since the components of system interact complex.

2 System function

The function, which integrates the hedgerows and intercropping of the slope, is to reduce the soil erosion, improve soil fertility and diversify the agricultural products.

Reduce soil erosion

In contour hedgerow—intercropping system, trees are commonly planted with no regard for slope or contour. This practice helps slow surface water and reduce soil erosion.

In the slope land, surface runoff has higher velocity than normal land due to a certain slope. The soil is easily eroded after destruction of the plant cover. The contour hedge is usually made up of the shrub trees and grasses, when planted; the densely tufted hedgerows block the erosive force of runoff, slow down runoff, retain sediment, held up water to infiltrate into soil, and result in reducing runoff and increasing water retention.

The results of the field experiment, at soil and water conservation station of Zigui County, give some facts, where *Vetiveria Zizanioides*, *Vitex negund*o, *Leucaena leucocephala* (lam) and *corianrisa Sinica* were selected as hedge and planted on purple soil (Inceptisols) derived from shale.

The research results show that the hedgerows can filter out silt, which could slowly build into a natural terrace, anchored by dense spongy hedgerows' roots over the years. After three years of field trials, compared to the slope land, it reduces 22%—24% of runoff and 94%—98% sediment yield (Chongfa *et al*., 1999). The effect of controlling the soil erosion is equal to the stable stonewall dike terrace. The profit of the water and soil retained by hedgerows is reflected by the height of the fence dike, depth of soil-retained and reduce of the gradient. Augment of the active soil depth can increase soil water capacity, boost up the resisted-drought of soil and offer crop a better condition (Table 1). If the hedgerows are implemented for large scale in agricultural fields, it generally seems to enhance the suitability of the microclimate for agricultural crops, including reducing wind speed evaporation rate, increasing the moisture content of upper layer of soil and going up air temperature in winter and down in summer in the day time.

Table 1 Soil retained by hedgerow

Hedge	years of plant(a)	height of fence dike(cm)	depth of soil-retained(cm)	reduce of gradient(degree)
Vitex negundo	3.5	55	30	5—6
Leucaena leucocephala	2.5	40—60	15—25	2—6
Coriaria sinica	3	20—45	10—25	2—4

Improve soil fertility

The system may improve soil fertility in two ways. One is that the sediment held by the hedgerows is almost fine grain, which contains most of sediment and sediment-borne nutrients; the other is that fast growing hedgerows should be pruned 3—4 times every year, and the rapid decomposition of its foliage makes hedgerows an excellent mulch or green manure for crops. Foliage and pruned shoots can supply the N (nitrogen) and other nutrients required by an intercrop. In the case of most legumes, fixing nitrogen can also improve soil fertility. Comparison of nutrient content in slope land, hedgerow and stone dike terrace is showed at Table 2. As can be see from Table 2, the content of organic matter, available N and K (potassium) were higher in hedgerow- intercropping then in stone terrace and slope land. After 5 years of hedgerow planted, the content of organic matter was higher then in slope land, available N, K and P were also higher (Table 3).

Table 2 Comparison of nutrient content in different type of land in purple soil(Same crop)

Type of dike	N		P		Available. K mg/kg	Organic mater(Or.M) g/kg
	Available. mg/kg	Total. g/kg	Available mg/kg	Total g/kg		
Stone	46.4	0.48	11.0	19.9	99.5	8.6
No(Slope)	34.6	0.32	1.6	16.8	45	6.9
Hedge(3y)						
Leucaena l	104.0	0.42	4.6	23.4	153	9.6
Coriaria s	62.6	0.43	5.1	22.3	158	9.1
Vitex n	81.4	0.50	7.4	22.2	173.5	9.9

Table 3 Changes of purple soil nutrient contents under different hedges(start from 1992)

Hedge	Year	Or.M g/kg	Avail.N mg/kg	Tot. P g/kg	Avail.P mg/kg	Tot.K g/kg	Avail.K mg/kg	pH
Leucaena	1998	12.4	50.0	0.42	6.01	—	172.5	8.01
Leucocephala	1996	9.6	104.7	0.42	4.60	23.4	153.3	7.87
	1993	9.0	49.5	0.40	4.18	22.7	130.7	7.86
Coriaria	1998	12.6	65.9	0.44	7.71	—	159.8	8.06
Sinica	1996	9.1	62.6	0.43	5.10	22.3	158.7	8.09
	1993	8.9	34.1	0.38	3.65	23.1	137.5	8.03
Vitex	1998	13.5	60.5	0.48	10.59	—	174.6	8.14
Negundo	1996	9.9	81.4	0.50	7.40	22.2	173.5	7.86
	1993	9.7	35.1	0.47	5.36	23.3	134.4	7.81
No(slope)	1998	10.5	52.2	0.40	5.82	—	122.1	8.07
	1996	9.1	75.6	0.43	5.00	22.9	136.9	8.03
	1993	8.8	41.5	0.41	3.84	23.4	131.9	7.98

Diversify agricultural products

The hedgerows-intercropping system, integrated hedgerows (trees, shrubs and grass) with other farm enterprises, can provide much more additional products then simple agriculture or forestry. Hedgerows might provide products such as firewood, biomass feedstocks, fodder for gazing animals, and other traditional forestry products like raw material for industry. And the farmers can also harvest from intercrop such as the foodstuff, for example maize and wheat etc, other cash crop or fruit like oranges, Chinese medical plant etc. So, according to the marketing option, there are many choices to apply hedgerows practice. The food crops, oil plants, mushroom, plants for silkworm, medicinal plants, plants for berries honey, industry stuff plants, tea, vegetable, firewood and green manure plants are all considered. It also can apply the alley cropping rotation.

The system can supply many other economic benefits, such as additional sources of income, spreading farm labor throughout the year, and improved habitat for both wildlife and humans.

3 Implementation of contour hedgerow-intercropping system

Choice of hedgerow plants

One main partly benefit of the system is related to the hedgerows species. It involves three aspects.

Firstly, adaptability to the conditions of local region: it is necessary to take into account soil type, terrain, climate and the understanding of local farmers.

Secondly, upstanding ecological profits: the optional plants should have the strong ability to restrain silt and reduce water runoff downhill and improve soil structure. For year around use, some of the species selected should be evergreen, fast-growing, deep-rooted, the strong ability of stump sprouts, strong tolerance for pruning, fixing- nitrogen, no or weak competitive species with intercrop.

Thirdly, economical profits: the farmers want to increase their economic stability and improve their management of the natural resources. If there only exists the ecological benefits, the farmers are unwilling to accept and apply it. So the combination of the both must be considered.

Based on former research and practice (Chongfa, 1996; Feng, 1999), following plant could be recommended to TGR and similar region. It mainly includes *Acacacla Dealbat, Acacla Mcarasu, Amorpha Fruticosa, Grojalarla Juncca, Leucaena Leucocephala* (lam) De wit CV. Salvado, *Pennisetum Purpureum, Pobinia Pseudoacacia, Vitex Negundo, Eulaliopsis Binata, Camellia Sinensis* Var. assamica Kit, *Morus Alba* L., *Eucommia Ulmoides* div, *Miscanthus Sinensis, Tephrosia Candida etc.*

Establishment of hedgerow

It is necessary to concern the rationalization of the width of hedgerows and the space between rows strips. Broader or narrower are all unfavorable. Generally hedgerows were set closely and horizontally along contour line. This practice helps slow surface water and reduce soil erosion. Single or multiple rows hedgerows are planted below the original line. Subsequent rows are planted below the original ling according to the slope of the land. The final row of the hedgerow in the first block is planted so that it is parallel to the contour line on which the next block of hedgerow will begin. The proper planting density lengthened the intercropping period and increased the commercial value of wood, productivity of land and economic benefits. And the width should be large enough, determining space of the hedgerow strips according to the gradient, soil characteristics, rain intensity, confirming grow density and type by the biological hedgerow traits. Some designs include sun-loving crops such as corn or some herbs, so that, even when the hedgerows reach maturity, the rows must be wide, accommodate the amount of light available for the crops.

Suitable region for the system

It is a commonly way to adopt stonewall dike terrace to manage the slope land in mountain and hilly area in most part of south China. The government officials and soil conservation manager of county and township appraise the outcome and their contribution with the statistic amount of stonewall dike terrace, so the stonewall dike terrace is the main practice of the soil and water conservation. However, many

evidence of former researches and practices testify the disadvantages when applying in some regions, where it is not feasible to use stone dike terrace or needs especial skill management and technique to build and maintain with high investment. In the following cases, it is preferable to apply contour hedgerow- intercropping system.

Ancient landside site or shallow accumulation: If larger scale of stone dike is constructed in the accumulation of landslide, the slide body will be disturbed and its weight will be added. Moreover surface water will infiltrate into soil and keep on the impermeable layer where may be the old side of slip. Since no strong deep root to fix accumulation of landslide, construction may be result in the re-movement of the slide body.

Granite and purple shale region: Shale and granite are easy to be weathered with weak structures and soils derived from them are fragile to be eroded. Moreover, it's not convenient to prepare the solid stone, and the farmers construct the terrace by sub-weather instead of it, which is easy to be damaged.

Some clayey soil area. In this kind of slope, earth dike terraces are normally built, on which some native plants grow. The native plants are poor in economic benefit and shoveled yearly, which may cause earth ridge terrace collapse. But if use some creeping or drooping plants, earthy ridge terrace can be protected.

4 Some problems in application

(1) The system is original designed to control soil erosion, so it should be integrated with channel and farmland drainage system.

(2) For the contour hedgerows occupy some space, contour hedgerows should be chosen carefully and considered both economical benefits and soil conservation benefit in land-limited area.

(3) Before extension, experiment and field trial should be well conducted so as to understand both the advantage and disadvantage of special model, and find the suitable way to avoid disadvantage. The education should also be carried out in undergoing area.

(4) It is also important to explore new sources through plant breeding and other improvement programmers. For this purpose, the researcher also should begin to discover more hedgerows symbioses with the other crops.

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