Soil Conservation and Sustainable Management of Sloping Agricultural Lands in China

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Abstract: In the past decades China has been faced with two problems of increasing population and continuous loss of croplands, which have led to considerable decrease in per capita croplands and have made production of sufficient food more difficult than ever before. Sloping agricultural lands play an important role in production of food grains, animal products or fruits. However, the conventional methods of sloping croplands farming cause serious soil erosion and finally lead to abandonment of sloping lands. Soil erosion of the sloping agricultural lands contribute 60%—78% of the sediments of the Yangtze and other rivers. Effective control of soil erosion of the sloping agricultural lands hence is a prerequisite for reconstruction of ecological environment in West China Region. Terracing has been advocated and promoted intensively and extensively in China but its limitations have made it difficult to apply to all the sloping agricultural lands. Another option is converting the sloping lands to permanent fallow to foster revegetation. But increasing population pressure makes it difficult to operate. Results of research, demonstration and extension of more than ten years in Sichuan Province of China indicate that contour hedgerow intercropping technology can facilitate permanent cultivation of sloping land. The on-farm research has demonstrated that this technology is very effective in reducing soil erosion to a extremely low level, effectively maintaining or improving soil fertility, considerably enhancing land productivity, and increase farm income. The results indicate that surface runoff is reduced by 50%—70%; soil loss is reduced by 97%—99%; soil nitrogen has increased by 180%—280%; soil organic matter content has increased by 130%—150%; maize yield is enhanced by 70%. In addition, application of this technology can also help mitigate problems of shortage of fodder and fuelwood. This technology can be applied to gentle slope and to steep slopes of 40 degree. It has been extended to an area of around 2,500 ha in Sichuan and has great potential in most of the sloping agricultural lands in China. Governmental support is greatly needed to expand this technology to all the suitable region of China.

Keywords: contour hedgerow intercropping technology, sloping agricultural lands, food security, soil conservation, soil fertility improvement, sustainable cultivation of sloping agricultural lands

1 Introduction

In the past five decades, two striking changes in agriculture in China have been the rapid population growth and the continuous loss of croplands, which has led to decrease in per capita cropland. The per capita croplands is 0.106 ha only (MLR, 2002). Since the increase in population and decrease in croplands will continue in the next decades, the challenge to produce sufficient food supply not only has been a major task of the government but also has drawn international attention.

Croplands in China are 130 million ha and only 40% of them are irrigated (MLR 2002). Therefore, the remaining croplands including sloping croplands play a very important role in food production. However, cultivation of sloping land has caused many devastating environmental problems. In order to control soil erosion and to improve environment a national program of “stopping farming to reforest sloping croplands over 25 degree” has been implemented in the Western China since 2000. There are around 28 million ha of sloping land below 25 degree. These sloping lands are also faced with problems

of soil erosion and declined soil fertility. How to use them in a sustainable way remains a big challenge. This paper offers an option for sustainable management of the sloping land.

2 Role of sloping croplands in food security and environmental conservation

Due to declining per capita croplands and food insecurity, many steep slopes that are not suitable for agriculture have been exclaimed in the past decades. Sloping croplands in China account for 26% of the total croplands. Sloping lands in most areas are treated as supplemental land sources only. Due to their inappropriate and poor management soil erosion is severe, which has caused problems both in mountains and lowland regions. In addition, soil fertility management measures are hardly applied in sloping land. Farmers cultivate as wide as possible to produce food grains. It has been recognized that what obtained has been much less than the loss in sloping land farming. Therefore, management of sloping croplands in the context of sustainable food production and environmental conservation, especially soil conservation, is crucial for both food security and environmental conservation in China.

Soil erosion is the major problem of sloping land farming. Research indicates that 60%—78% of the sediments in the Yangtze River originated from cultivation of sloping agricultural land (Li 1999). Soil erosion was among the major contributing factors of the devastating floods in 1998. Therefore, appropriate management of sloping land is also important for mitigating floods. Many methods have been proposed for sustainable management of sloping croplands but terracing is the only one that has been widely used by farmers and promoted by governments. It has been advocated and promoted almost as the panacea for soil and water conservation in China and governments have invested substantially in terracing. The terraced area up to date is around 13.3 million ha. The areas that are terraced have been taken by governments as an important indicator of soil and water conservation progress. However, due to various reasons, soil erosion in China has been worsening though it has been controlled in some specific areas. It is therefore necessary to seek other options.

3 Contour hedgerow intercropping technology for sustainable management of sloping croplands

Sustainable management of sloping croplands in China, especially in West China has specially significance in environmental conservation and soil and water conservation. This is particularly important for river basin management, especially the Yangtze, Yellow, Pearl and Salween river basins. To achieve this goal, many programs, including integrated watershed management, river basin soil and water conservation, reforestation and natural forest protection, have been implemented. Contour hedgerow intercropping technology can play an important role in all these programs.

3.1 Contour hedgerow intercropping technology

The contour hedgerow intercropping technology is a farming system in which hedgerows of perennial nitrogen fixing trees or shrubs are planted very thickly with an inter-hedgerow distance of 4 m — 6 m cross slopes. The hedgerows consist of fast growing and good coppicing plants. Food crops and/or cash plants are planted in the alleys between hedgerows. When the hedgerows grow to around 1 m tall, they are pruned back to 30 cm — 50 cm to avoid shading on companion crops. Prunings are used mainly as mulch or green manure, but also as fodder when necessary. The hedgerows can also be managed to produce fuelwood. Economic trees can be planted within hedgerows to yield additional income and other benefits. The thickly planted hedgerows can conserve soil and water, minimize nutrient loss, and improve soil fertility. Compared to terracing, it can provide more benefits, require less investment, and is more effective.

3.2 Summery of on-farm demonstration and on-farm research

Based on the on-farm demonstration, on-farm research and extension to farmers' land in the past 11 years, this technology has shown the following striking advantages and great potential for sustainable cultivation of the sloping agricultural land.

3.2.1 Soil conservation

Demonstration and research indicate that properly established hedgerows on the sloping croplands can control very effectively soil erosion from the second year of hedgerow establishment and the effect increases with time. With establishment of hedgerows, soil loss is reduced to only 0.5%—1% and surface runoff to 26%—50% of the control (Sun Hui *et al.*, 2001a, 2001b). The substantial reduction in soil loss and runoff is attributed mainly to the very thickly planted hedgerows and interception of runoff velocity by the hedgerows. Additional factors include shortened slope length, prolonged infiltration of runoff and improved soil infiltration rate thought continuous addition of prunings. The reduced runoff means that around 50%—74% of the surface runoff is infiltrated into soil, which not only help reduce risks of floods but also help mitigate drought. Soil moisture regime is also improved.

3.2.2 Soil fertility improvement

Soil fertility management is important in agricultural production. Because of quick response and relatively easy availability, chemical fertilizers have been used very widely. However, problems of unselected and excessive use have also resulted in many problems. Due to their supplementary role, however, sloping croplands do not receive little chemical fertilizers in many areas. Management of soil fertility is physically more difficult in sloping cropland than in flat or plain land. For sloping croplands, apart from nutrient loss through crop residues and other ways, soil nutrients are lost through soil erosion. Declining soil fertility is a very obvious problem. Declined soil fertility has caused abandonment of sloping cropland, which has resulted in large-scale and widespread waste and baren land.

Though terracing can reduce substantially soil loss, it can not improve soil fertility. In contrast, contour hedgerows of nitrogen fixing plants can improve soil fertility through continuous addition of hedgerow prunings and decayed roots, reduced soil loss with soil erosion and increased crop residues. Based on the results from two sites, contents of organic matter, total nitrogen and available potassium increased considerably. In general, contents of most nutrient elements declined in the control but increased in the treatments with hedgerows. After 10 and 7 years of hedgerow establishment, content of organic matter, total nitrogen and available potassium increased by 133%, 283%, 124 % at site 1 and 155%, 181% and 63% at site 2, respectively (He Yonghua *et al*., 2001). Addition of hedgerow prunings is the key contributing factor to soil fertility improvement because around 8 t/ha—15 t/ha of fresh biomass is applied to soil annually. Application of hedgerow prunings improves not only chemical but also physical properties of soil.

3.2.3 Enhancing crop yield

From a farmer's point of view, outputs in terms of crop yield or cash income other than reduced soil erosion and improved soil fertility are his concern. Due to improved soil fertility and reduced soil erosion, crop yield was enhanced considerably. The 5 years' crop yield data indicated that maize and peanut yield was 11%—90% (70% on average) and 15%—42% respectively higher in hedgerow treatment than in the control (Sun Hui *et al*., 2001b).

3.2.4 Additional benefits of nitrogen fixing hedgerows

The system is simple but it provides multiple benefits. Apart from its great contribution to soil conservation and soil fertility improvement, contour hedgerow intercropping technology can also diversify cropping patterns so as to ensure and increase income of farmers. One way is to incorporate economic trees within hedgerows.

Establishment of hedgerows of nitrogen fixing plants along the contour lines on the sloping croplands to reduce soil erosion and to improve soil fertility has been promoted in many tropical areas in the past 30 years and a lot of resources have been invested. However, its adoption by farmers has not been satisfactory. Lack of direct and visible income from the system might be a major one (Tang Ya 1999). In addition, land lost to hedgerows has been also a big concern of local farmers. In view of this, potential ways of effective use of resources of the system have been explored. Incorporation of economic trees within hedgerows is among these ways. Research revealed the highest soil nutrient status under hedgerows (Sun Hui *et al*. 2002). However, appropriate use of land resources under hedgerows has been ignored and no studies of using this important resource have been reported from other regions. Among a

number of tested economic trees incorporated within hedgerows, mulberry has shown the best performance. Mulberry incorporated within hedgerows produces more fresh leaves than those in conventional cultivation (Zhang Yanzhou *et al*., 2001). Through incorporation of mulberry trees within hedgerows, the problem of land lost to hedgerows has been also solved. No land is lost in the system. Mulberry can provide addition income for farmers.

3.2.5 Increased cropping options

Many economic trees/cash crops require fertile soil with good drainage to yield marketable and profitable products. In conventional management, sloping croplands are usually not suitable for cultivation of many economic trees/cash crops due to their poor soil fertility and poor soil water regime. Often sloping lands have to be terraced before cultivation of economic trees. Contour hedgerow intercropping technology can conserve soil, improve and maintain soil fertility and soil water regime, which provides options for cultivation of economic trees/cash crops. Demonstration has indicated that a number of economic trees, such as sweet oranges that can be cultivated in the terraced land only can also be cultivated in the alleys between hedgerows. Other cash crops cultivated in the system include vegetables. Research indicates that orange cultivated in such a way is more profitable than oranges cultivated in conventional ways (Yuan Yongliang *et al*., 2001).

3.2.6 Fuelwood, fodder and pest control

Apart from the above comparative advantages, farmers have also reported some other benefits, including control of weeds and pests due to vigorous crop growth and possibly increased natural enemies. In addition, hedgerows can also provide excellent fodder, especially during dry season when most other plants could not grow. Many hedgerow plants are also excellent fodder trees and their young leaves have high nutrient value. Demonstration has revealed that young hedgerow leaves can be fed to pigs, goats, cattle and fish.

In addition, hedgerows can be managed to produce fuelwood through reduced pruning frequency. Around 3 t/ha of fuelwood can be produced if one pruning is reduced. Further more, economic trees planted within hedgerows can produce also fuelwood. Mulberry trees in the hedgerows are pruned once a year, which yield around 4.5 kg/tree (Zhang Yanzhou *et al*. 2001) or around 5 t/ha of dry fuelwood. The total fuelwood produced from system would be around 8 t/ha.

4 Development of different models

Since food production in China is no longer a problem for many farmers efforts have been made in collaboration with local government and farmers to development cash plant based models. Around six models have been adopted by local farmers. Cash plants include annual and perennial ones. The annual ones include vegetables, water melon and tobaccos. The perennial ones include mango, sweet orange, medicinal yam, sugarcane, mulberry, huajiao (*Zanthoxyllum bungeanum*) and fodder plants. In addition, development of livestock based models are going on. Among these models, hedgerow-mulberry-food crop, hedgerow-sweet orange, hedgerow-sugarcane, hedgerow-mango, hedgerow-mulberry, and hedgerow-mulberry-sweet orange models have been adopted widely by farmers. Efforts are being made to test and select suitable models in other regions.

5 Areas of application and needs for wide extension

From the proceeding section it is very clear that contour hedgerow intercropping technology can reduce soil erosion to a very low level, improve soil fertility and provide many additional benefits. Though this technology. Has been designed and developed mainly for sustainable management of sloping cropland, it can also be applied in national program on “stopping farming to reforest sloping cropland”, integrated watershed management, reforestation of waste and baren lands, livestock development, and terracing program.

Though this technology has shown a number of advantages over terracing and has potential for permanent cultivation of sloping cropland, farmers’ adoption of this technology has been poor in many

countries. The contributing factors identified include lack of visible and direct benefits, inadequate demonstration of benefits and potential risks, lack of commitments of project staff, lack of governmental policy, etc (Tang Ya 1999). The adoption in China is so far quite satisfactory. By the end of 2001, this technology has been applied in around 2,500 ha of land. An analysis indicates that incorporation of economic trees within hedgerows has been the key contributing factor for this satisfactory adoption.

However, there are also problems in promoting farmers' adoption in China. It is known that policy and governmental support is very important for extension of improved technologies in China. Unfortunately, no any policy and government supports have been extended to promoting extension of this technology. It has been well known that terracing has played an important role in soil conservation in China, for which governmental support and policy has been the key factor for its extension. Though subsides vary from regions to regions, governments have provided financial support for terracing of sloping croplands. The research and demonstration of hedgerow technology so far have clearly indicated that this technology is much more effective than and have many other comparatively advantages over terracing and can replace terracing technology. Government supports are needed to extend this technology to the suitable regions.

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