The Technologies of Comprehensive Utilization of Terrace Ridges

Liu Zhanxin, Pan Wenlin and ***Bao Wenlin***

Water and Soil Conservation Research Institute of Henan Province, Zhengzhou 450008,
Tianshui Scientific Experiment Station on Water and Soil Conservation of
Yellow River Conservancy Committee
Tel: 0371—5715762 Fax: 13838175789
E-mail: JZ_xu205@sina.com

Abstract: Because of the lack of arable land in the mountain area in western Henan province, the level terrace, as the elementary cropland, is much valuable. For the ridges are made of soil and occupy certain space, unreasonable use of it can cause the new soil and water loss, even to damage terrace itself. Through more than 10 years' experiments and researches, a set of technologies of comprehensive utilization of terrace ridge has been concluded successfully. Practices indicated that the technologies were one effective way of developing the land resources with a little investment but quick return. It's popularization and application not only can protect the terrace itself but also can bring considerable economical benefits.
Keywords: soil and water conservation, level terrace, ridge, the slope of ridge, comprehensive utilization

1 Preface

The terrace, as the elementary cropland, is distributed extensively in the mountain area in the west of Henan Province where is full of hills and gullies. There the terrace whose ridge is made of soil is the majority, exactly there are 179,000 hm^2 of it, which is account for 93% of the total. For the brown earth such as lehm, white clay, red clay, which is loose in structure, is predominated in the area, the ridges made of it therefore are softer and not steep. The data surveyed in Hugou watershed in Songxian county shows that the average gradient of terrace ridge is 47.2 degree and generally takes 16.81% of land area. There should be about 30,000 hm^2 of ridge that is calculated from the above data. Most of them remain uncultivated, in fact less than 17% of them are planted with suitable crop and this part also needs to be refreshed. Meantime rainstorm domineers in the area hence the ridge was damaged companying with serious soil erosion and need a lot of labors to be rebuilt. For this reason, to work out a set of the technologies of comprehensive utilization of terrace ridge is not only the necessity for terrace protection but also the needs to control erosion and to promote the economy in mountain area.

After many years test, the vegetable species including arbor, bush and grass have been selected, which is good at control of soil erosion but low effect on main crop and valuable in economy, of cause, suitable to the ridge. The match method of vegetable species on different ridge has been concluded too. Practices indicated that the technology was one effective way of developing the land resources with a little investment but quick return. It's popularization and application not only can protect the terrace itself but also can bring considerable economical benefits.

2 Selection and test of vegetable species

2.1 Principle of selecting of ridge plant

According to the characteristic of the terrace and the need to enforce the ridge itself in west of Henan, we concluded the principles to select the vegetables suitable to growing on ridge, which are as follows, ① species that will be resistant to drought, broad in adaptability and no harm to main crops. ② that only the part above the ground can be harvested to keep ridge not disturbing and will be benefited for many

rears. ③ that can protect the ridge and be outstanding in water and soil conservation. ④ that will have high value in economy. ⑤ that will be easy to manage and to popularization.

2.2 The result of selection

After contrast test, field test and laboratory analysis of plants selected based on the principle the following species have been selected for ridge:

(1) Arbor: hawthorn, jujube, persimmon, paulownia, poplar etc.

(2) bush: false indigo, insect wax tree, prickly ash，Japanese honeysuckle etc.

(3) herbaceous: Astralus adsurgens, lucerne, goldenrod, legume crop (soybean, China bean and so on), melon crop (China squash and so on).

Of the above species, the goldenrod, legume crop and melon crop are suitable on the top of ridge and the others on the slope of ridge.

2.3 Test of soil control effectiveness at plot

From the observation data during 1991—1993, the ridges planting with Astralus adsurgens, false indigo, goldenrod respectively contrasted with blank ridge, the decrease ratio of runoff modulus are 93.13%，98.14%，90.15% accordingly and 95.75%，98.85%，92.14% of the erosion modulus. In 1992 and 1993, 100% of runoff and silt was stopped since the rainfall intensity in both years was not high enough. (See Table 1)

Table 1 Data of runoff and silt on ridge slope(1991—1993)

Term / Year		Rainfall to create runoff （mm）	Runoff （m^3 / km^2）				Silt eroded off （t / km^2）			
			The contrast	False indigo	Golde-nrod	Astralus adsurgens	The contrast	False indigo	Golden-rod	Astralus adsurgens
1991		367.9	34,524.6	732.7	3,889.4	2,693.8	2,319.0	28.2	192.6	104.2
1992		38.4	2,485.9				37.7			
1993		73.7	2,432.2				94.0			
Sum	Value	480.0	39,492.7	732.7	3,889.4	2,693.8	2,450.7	28.2	192.6	104.2
	%		100	1.86	9.85	6.87	100	1.15	7.86	4.25

The protection of terrace by the ridge plant under super rainstorm is notable too. In July 1992 there was a super rainstorm of 396mm of rainfall and 101mm/h of maximum intensity, it was found after it that the ridges without any plant had been eroded into gully even landslide, more badly on the lower terrace than the uppers. A typical case was a 3-step terrace on the northern slope of Hanlin mountain; on the top step there was 2.83 m^3 soil loss from the gully, on the second step was 7.13 m^3 and on the lowest step was 19.73 m^3 from not only gullies but also landslide which was cutting through the face of the terrace and there was 105 m^2 of silt deposit and 80 m^2 of crop was burred, on contrast, the ridges with plants had only tiny rills and rarely formed gully or landslide.

2.4 Improvement of soil

The plants on the ridge leaves roots, stems and leaves in soil which increases the humic substance in soil so that the soil is improved in both chemical and physical property. The branch and leaf litter on ground and the root under ground of some plants was surveyed. (See Table 2)

Table 2 Branch and leaf litter on ground and root underground of some plants

Plant		Goldenrod	False indigo	Astralus adsurgens	Wax tree	Average
Age		5	5	4	10	
Root	kg / m^2	0.8	2.69	1.45	2.41	1.85
	kg / hm^2	36.9	119.6	63.8	107.1	81.8
Litter	kg / m^2	0.62	0.47	0.26	0.50	0.46
	kg / hm^2	27.6	20.9	11.4	22.2	20.5

According to the lab analysis of soil from 0 cm to 60 cm depth on ridge, the soil nitrogen, hydrolysis nitrogen, organic material increased by 31.1%, 38.6% and 47.5% respectively after 3 years growing of goldenrod, false indigo and Astralus adsurgens，comparing with the soil without any pant and its volume weight decreased by 12.0% and its infiltration rate increased by 0.8 times. (See Table 3) The improvement of soil by the plants is Obvious.

Table 3 The changes of soil property of ridge

Ridge plant	Time	Nitrogen	Organic material	Hydrolysis nitrogen	Volume weight
		（%）	（%）	（mg / 100g）	（g / cm^3）
Goldenrod	Before	0.0367	0.2883	4.110	1.56
	After 3 years	0.0523	0.4125	5.910	1.31
	Change（%）	+42.5	+43.1	+43.8	–16.0
False indigo	Before	0.0306	0.5073	2.320	1.56
	After 3 years	0.0394	0.6830	3.610	1.34
	Change（%）	+28.8	+34.6	+55.8	–14.1
Astralus adsurgens	Before	0.0370	0.3678	3.94	1.56
	After 3 years	0.0451	0.6064	4.58	1.47
	Change（%）	+21.9	+47.5	+16.2	–5.8
Changes（%）		+31.1	+64.9	+38.6	–12.0

2.5 Economical benefit

The popularized area of the technologies in western Henan reaches 4 700 hm^2 and the extra annual income is 7.8×10^6 RMB YUAN. The 6-year plot observation shows that the ridge planting with pasture （Astralus adsurgens）can get 0.56RMB YUAN/ m^2 annually in average within 4 years or 5 years and the maximum can be 0.85 RMB YUAN/ m^2 which occurs in the third year, that with bush can get 0.87 RMB YUAN/m^2 —1.53 RMB YUAN/ m^2 annually since the fifth year, the bushes such as prickly ash and goldenrod can get relatively high benefit, that with economical tree can get 0.19 RMB YUAN/m^2—2.48 RMB YUAN/ m^2 annually since the fifth year and the hawthorn have the more benefit relatively, that with arbor can produce timber since fifth year and the volume increased by 0.0037 m^3 / m^2 per year within 5 years, which is equal to 0.63 RMB YUAN. The economical benefit of each plant varies along with their age, the bush can benefit quickly but benefit less than arbor (especially the economical arbor) as they aged. Considering the time and accumulation of benefit, if 3 years given the grass (such as Astralus adsurgens) is the best choice, 5 years the bush (such as false indigo, goldenrod etc.), more than 10 years the economical arbor (such as hawthorn, jujube) or the economical bush (such as prickly ash, goldenrod) is the best.

Meanwhile the labor invest and the yield were surveyed during the 20 years' improvement of ridge plant. (See Table 4)

Table 4 Economic statistics of the ridge plant per meter Unit: RMB YUAN

Year / Species	5				10				15				20			
	1 year		Total		1 year		Total		1 year		Total		1 year		Total	
	Input	Yield	Input	Yield	Input	Yield	Input	Yield	Input	Yield	Input	Yield	Input	Yield	Input	Yield
Persimmon	0.01	0.20	0.07	0.20	0.02	0.61	0.14	2.14	0.03	1.16	0.28	6.28	0.05	2.08	0.50	14.1
Jujube	0.02	0.41	0.08	0.41	0.03	2.26	0.17	7.19	0.05	4.10	0.40	24.6	0.06	5.13	0.74	47.7
Hawthorn	0.02	2.50	2.13	2.50	0.03	7.56	0.26	27.5	0.05	7.60	0.49	65.0	0.07	7.80	0.79	102
False indigo	0.05	0.96	0.32	3.82	0.05	0.90	0.59	3.63	0.05	0.96	0.86	13.4	0.05	0.96	1.13	18.2
Wax tree	0.05	0.92	0.30	3.65	0.05	0.92	0.53	8.25	0.05	0.92	0.77	12.8	0.05	0.92	1.01	17.5
Prickly ash	0.26	1.79	0.99	3.19	0.30	2.19	2.39	13.9	0.34	2.60	3.99	26.2	0.34	2.60	5.69	39.1
Goldenrod	0.24	1.40	1.04	4.40	0.24	1.40	1.44	11.4	0.24	1.40	2.64	18.4	0.24	1.4	3.84	25.4

Note: The labor calculated with price of 1.2YUAN / day, the yield with national fixed price.

Based on the observed data above, the economic analysis of more than 10 ridge plants was made both statically and dynamically. The result is that, within 6 years, the net benefit from the ridge is 7.45 RMB YUAN/ hm^2, the ratio of benefit and investment is 6.38, and the recover time of investment on average is between 1.65 to 1.80 years. If the most of the ridges in western Henan were utilized rationally there would have been additional income nearly 100 million RMB YUAN. It is obvious that the use of ridge can bring large benefit quickly in a certain period with a little investment, so it is important and valuable in the development of mountain area in western Henan.

3 The type of ridge and their pattern

It is divided as follows by the height of ridge:

(1) Low ridge, the height of it is below 1.8 m, is suitable for bush or grass. If the grass is chosen it can be planted entire surface of the ridge, if bush is chosen it can be planted only on the part of ridge slope that 40 cm below of the ridge top in order to reduce the threat to the main crop.

(2) Middle ridge, the height of it is between 1.8 m and 4.4 m, besides bush and grass, it is allowed to plant one row of arbor tree but it should be 1 m apart from top of the ridge so that their root and crown can not effect on main crop.

(3) High ridge, the height of it is more than 4.4 m, besides bush and grass, it is allowed to plant more than two rows of arbor tree and their interval should not less than 2 m.

On the ridge the legume and melon should be planted normally. The others factor ought to think of are (1) the direction of the ridge. The ridge facing west or east is better than it facing south or north for arbor. Because the northwestern wind is dominant in the area, on the ridge facing east arbor should be avoided so that to prevent damage of ridge from shaking tree caused by wind. The special characteristic of chosen plant should be considered too. For example, the sun ray at 8 or 9 o'clock (the intensity is about 64,000 Lux) is help to increase the weight of persimmon fruit and therefore it should be planted on the ridge facing east or west, mean while the jujube should be planted on the ridge facing north or south because the sun shine at noon is helpful for it to bear fruit.(2) The species should be matched reasonably to avoid contending each other for light, water or fertilizer and being victims for common disease or insect. For instance, goldenrod and prickly ash are not suitable to mingle with arbor, under the crown of hawthorn is not suitable for grass for its' shallow root. (3) The match with main crop also needs to be deliberated. The typical case is that the ridge whose main crop is cotton must not be planted with prickly ash, because the aphid can damage both of them, after harvest of cotton the aphid migrate to prickly ash to lay eggs and live through the winter, in addition the ridge of the apple orchard should not grow the clove, for its' root can excrete harmful substance which can restrain growing of apple.

Besides the above the other factors such as density, character and depth of soil, the needs of " Three F " (fuel, fodder and fertilizer) and son on should be considered (See Table 5). In brief, after thoroughly analysis and research the use of ridge could be reasonable and benefit maximum.

Table 5 The brief of matching of ridge plant

Plant	Planting location	Interval (m)	Type of ridge	Direction of ridge	Direction face to	Matching and other requirements
Persimmon	1.0m from the top	4—5	M、H	N-S	Any	With grass, better on red clay
Jujube		4—5	High	E-W	South	Not with late-mature grass
Hawthorn		3—4	M、H	Any	Any	No grass under crown
Paulownia		5—6	M、H	Any	Any	with Astralus adsurgens on deep soil
Popular		4—5	M、H	Any	Any	with Astralus adsurgens , false indigo
Ailanthus altissima		4—5	M、H	Any	Any	Same to above
False indigo	About 0.4m from the top	0.5—1.0	All	Any	Any	No mix up
Wax Tree		0.6—1.0	All	Any	Any	Better on deep soil
Prickly ash		1.0—1.5	All	E-W	South	Not with arbor, main crop not cotton
Goldenrod		1.0	M、H	E-W	South	Not with arbor or bush
Grass	Slope of ridge	500—2,300 g/Mu	All	Any	Any	No requirement for arbor or bush
Aemerocallis flara	Top	0.5	All	Any	Any	No mix up
Legume	Top	Normal	All	Any	Any	Suit for new ridge
Melon	Top	3—5	All	Any	Any	Same to above

Reference

The Report of Study on Utilization of Terrace Ridge in West Henan, 1994, Water and Soil Conservation Research Department of Henan Province.