APPLICATION OF THE CONTOUR VETIVER HEDGE TECHNIQUE TO THE PROTECTION OF HIGHWAY EMBANKMENT IN JIANGXI PROVINCE IN CHINA

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Abstract

An application of the contour vetiver hedge technique to highway embankment protection was conducted on a section of the Shangrao-Fen Shuiguan highway of Jiangxi province in China, where elevation varies from 280 m to 750 m and soils are derived from granite, with a sandy and gravel texture, a pH value 4.0-4.5 and organic matter content of 0.2%. The survival rate of vetiver grass planted on roadside slopes with gradients of 32-49^{o} was up to 98%. At the end of May, each vetiver slip produced 3 to 9.7 tillers on average, and the height of the grass increased up to 36.7-70.7 cm in two months after transplanting. On 23 August, when the grass reached a height of 160 cm, pruning was implemented 20 cm above ground surface. Six months (one growing season) after planting, in October, the grass was 115-143 cm tall again and each slip produced 6.4 to 29 tillers on average. Contour vetiver hedges were quickly formed, functioning in erosion control and stabilizing roadside slopes. The local *Bamao* grass had only eight tillers of an average height of 100 cm.

Introduction

In most developing countries, highway construction is one of the major infrastructure projects. At present, highway construction is in full swing in China. In Jiangxi province alone, Yuan 4-5 billion is invested each year and the length of newly built or rebuilt highways is about 1 000 km per year. However, because most of the highways were built in mountainous and hilly areas and because of the shortage of road protection due to limited funds, severe gully washing and collapse occurred frequently, which affected not only transportation but also agricultural production along the roads and in the area of the lower basin. Therefore, it was very important to develop and apply cheap and effective highway embankment protection techniques. Compared with “hard” engineering projects in which huge investment and complicated technology are needed to construct concrete elements, “soft” bio-engineering techniques in which slopes are fixed by plant root systems and rain splash impact is stopped by the luxuriant plants are simpler, more convenient, cheaper and good for the environment (Ao et al. 1997).

Findings in the experiments of slope stabilization with vetiver by Hengchaovanich (1998) in Malaysia showed that the mean tensile strength was about 75 MPa at 0.7-0.8 mm root diameter, which is the most common diameter class for vetiver roots. It was approximately equivalent to one sixth of the ultimate tensile strength of mild steel.

Vetiver grass usually grows well in Jiangxi, with adequate soil and climatic conditions. However, will it grow normally in adverse environments with granite weathered residues and coarse sands containing very small amounts of N, P, K and organic matter? Will it function well in protecting slopes? Shall we continue to extend this soft technology in roadside slope protection? Our application aimed at giving answers to these questions.

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Location, Material and Method of the Experiment

Location

The application sites were located in several sections of a highway under construction from Shangrao in Jiangxi province to Fenshuiguan in Fujian province. The main sites were concentrated in sections A, B, C and D distributed in the mountainous areas between Zixi and Fenshuiguan. Each section had several slope sites where erosion was severe. For example Section A had four sites stretching 10 to 70 m along the highway (Table 2). More than 10 000 m^2 of vetiver were planted in the application. Located in the north-central part of the Wuyishan Mountain, application sites were distributed on rough terrain with a relatively vertical relief difference of more than 50 m and transverse slope gradient of about 60°. There were well-developed gullies on hill slopes due to heavy rainfall. The highway was built across mountains and hills. The highest peak in East China, called Huang Gang Shan, with an elevation of 2400 m, was south-west of the application location.

Geologic-geomorphology conditions: The hills where the application sites were located were formed by the granite invasion mass of the Yanshan phase. With thin mantles, these coarse-medium granule granite masses were strongly weathered, forming the prevailing sandy residue soils. In addition, clayey, gravel sandy soil and gravel were also found on Quaternary alluvium, diluvium and residuum deposits.

Climatic conditions: Located in the East Asia monsoon area, application sites have humid climatic conditions with an annual average temperature of 17.8°C and yearly rainfall of 1 900 mm, mostly concentrated in the period from March to June. The extremely low temperature was -11°C, the maximum temperature 40°C. The four seasons were characterized by sharply different temperatures and rainfall.

Soil condition: Soil samples were collected on 26 May 1999 at random from 16 vetiver planting spots at A, B, C and D sections. They came from three kinds of soil, i.e. strongly weathered granite, gravel sand, and clayey soil. The properties are listed in Table 1.

Experiment Material and Methods

Two hundred thousand slips of vetiver bought from the Institute of Red Soil of Jiangxi province on 28 March 1999 were planted along the contour at A, B, C and D sections of the highway between 28 March and 7 April 1999. The planting methods were as follows: earthy platform contours with a width of 30-40 cm were constructed with vertical spacing of 1 m at the filled road slopes; vetiver seedlings (2-3 slips per clump) were planted on the earthy platforms with clump spacing of 10-15 cm after application of organic manure on platforms or small amounts of Ca-Mg-P fertilizer; periodic observations were practised for data on re-greening status, survival rate, growth height and tiller numbers. The local grass *Bamao* was planted in C section as control.

Experimental Results

Analysis of Data of Soil Samples

Samples were collected on 20 May 1999 when small amounts of farm manure were applied on the platforms (Table 1).

Table 1. Results of analysis of soil samples

Type of soil	pH	Total N (%)	Available P (ppm)	Available K (ppm)	O.M. (%)
Strongly weathered granite masses	4.5	0.0037	2.26	34	0.2882
Sandy soil	4.2	0.0044	2.39	61	0.2087
Red soil (clayey)	4.0	0.0068	1.83	25	0.2340

Survival Rates and Vetiver Growth

According to the observations on A, B, C and D sections, re-greening of seedlings was found 20 days after planting and a survival rate of 98% was recorded on May 26. It was obvious that vetiver grew much better than local grass *Bamao* (Table 2).

Table 2. Growth of vetiver and *Bamao* grass

Treatment	Height 6 months after planting (cm)	Tillers 6 months after planting	Depth of root system (cm)	Number of roots
Vetiver*	133 - 140	25.7	82	many
Bamao	100	8.0	28	few

** On 23 August when the grass reached a height of 160 cm, pruning was implemented 20 cm above ground surface*

Embankment Conditions, Vetiver Growth and Tillering Status

Table 3 shows the embankment condition details in A, B, C and D sections and the growth behaviour observed on 28 May 1999, just two months later.

Table 3. Embankment conditions and vetiver growth behaviour

Location	Slope gradient	Exposure	Slope length (m)	Planted slope width (m)	Average growth height (cm)	Tillering number slip/clump	Plants observed clumps/time
A-1	49°	N	15	30	41.8	3.0	6-17
A-2	45°	N	10	70	53.6	3..3	6-17
A-3	39°	N	12	40	44.7	3..5	6-17
A-4	32°	N	20	10	54.8	4.4	6-17
B-5	34°	NE	10	40	45.3	4.0	6-17
B-6	34°	W	20	35	36.7	4..3	6-17
B-7	38°	N	20	35	58.5	3..5	6-17
B-8	39°	NE	15	25	39	3.0	6-17
C-9	38°	N	6	25	40	3..2	6-17
C-10	35°	W	4	200	51.6	9.0	6-17
D-11	27°	SW	15	20	60.5	4..4	6-17
D-12	47°	N	8	120	70.7	4..3	6-17
D-13	42°	SW	10	100	38.3	3.0	6-17
D-14	32°	NW	7	150	55.3	9.7	6-17
D-15	36°	N	6	100			6-17
D-16	35°	SW	4	150	60.8	3..2	6-17

Relationship Between Vetiver Growth and Tillering Status

The relationship between the altitude of the experiment spots, vetiver growth and tillering status is shown in Table 4.

Table 4. Relation between altitude and vetiver growing status

Location	Altitude (m)	Aver. tillering no. (slips/clump)	Average height (cm)
A	729.18	3.3	42.7
B	638.49	3.7	44.9
C	318.04-367.81	6.1	45.8
D	284.79	4.9	57.0

Slope Erosion Status after Planting

Table 5 shows the slope washing status about two and seven months after planting.

Table 5. Slope washing status after vetiver planting

Treatment	Location	Observed on 26 May	Observed on 23 Oct.
Vetiver	A	Washed gullies, 2.5 m wide, 1.2 m deep	Slope almost fixed. Vetiver grew weakly because of high altitude and P shortage
	B	Washed gullies, 0.15-0.2 m wide, 0.2-0.3 m deep	Slope fixed, vetiver grew well, hedges almost formed
	C	No gullies, no surface erosion, a few weeds	Slope completely fixed, root system 82 cm deep
	D	Washed gullies, 2 m and 4 m wide, 0.5-1.5 m deep	Slope completely fixed, root system 85 cm deep

***NB:** In May and June some vetiver grass was washed out by heavy rain because there was no drainage system established, i.e. drainage is necessary before planting vetiver grass*

Analysis and Discussion

High Adaptability of Vetiver

The very high survival rate (98%) of vetiver planted at spots with extremely infertile soils containing very little organic matter indicates the high adaptability and re-growth ability of vetiver grass. If planted during the warm (20-25°C) and rainy springtime, vetiver will grow well and get a high survival rate. Compared with local *Bamao* grass, vetiver had a more developed deep-root system.

Contour Terracing

Key vetiver planting technique rules were formulated from this experiment: (1) vetiver should be planted in contour lines on roadside slopes; (2) contour platforms as well as organic manure and Ca-Mg-P fertilizer are needed for vetiver planting on roadside slopes to ensure a high survival rate in adverse conditions. In an environment with plenty of sunshine and rainfall in Jiangxi, a high survival rate may be expected with these two techniques. Steep slope gradients could be gentled down, runoff washing decreased and runoff water held by the establishment of platforms to accelerate plant growth on slope surfaces.

Elevation

Growth and tillering of vetiver were delayed by the high elevation and low temperature. For example, the growth and tillering of vetiver planted at Section A where the elevation is above 700 m and the climate is characterized by thicker fog, less sunshine and a lower temperature were worse than those at sections C and D where the elevation is much less (Table 3). However, vetiver grass grew well at the elevation of 1 800 m on the Yun Nan plateau, which indicated that its growth was affected mainly by relative rather than absolute elevation.

Slope Drainage

At the early stage of the application, erosion and washing took place on slope surfaces and sometimes vetiver seedlings planted were washed away by runoff water. This was because of the lack of a drainage system needed for slope protection due to engineering construction reasons. Better results may be expected if a drainage system is arranged on the catchment surface before vetiver is planted. Besides, replanting will be needed during the first few months after planting.

Bibliography

Ao, H.X.; Xia, H.P.; and Liu, S.Z. 1997. Studies on the application of vetiver hedges to landslide control for highways in Guangdong. Vetiver Newsl. 3(1) (in Chinese).

Hengchaovanich, D. 1998. Application of vetiver technology to engineering – slope stabilization and erosion minimization. Vetiver Research and Development, China Agriculture S & T Press, pp. 118-130 (in Chinese).