Adequate Areas in China for the Application of Vetiver System

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Abstract: Vetiver System was introduced into China by Mr. Grimshaw from the World Bank in 1988. Beginning from the Fuzhou Symposium in 1997, the system was applied for infrastructure protection in China. Since the Nanchang Symposium in 1999, it was extended quickly countrywide, and in particular, it was extensively applied and extended in South China. On the basis of reviewing successful research cases all over China, this paper deals with adequate areas where vetiver grasses can be planted, and lists related issues that should be further studied in the future.
Key words: Vetiver system, Slope protection, Adequate planting area

Environment protection is one of the most urgent missions faced by the contemporary world and also one of the basic tasks faced by the Chinese people in their economical construction and social development. Therefore, it should be considered as a basic state policy to be adhered in a long historic period. In its broad sense, environment protection consists of two fields, i.e., soil and water conservation as well as pollution control. To practice environment protection, various measures may be adopted. However, among those measures, bioengineering technology has been becoming favorite one frequently adopted by more and more people in recent years.

Vetiver (*Vetiveria zizanioides*) is characterized by its strong stress tolerance, wide adoptability, quick growing vitality, huge biomass, highly developed root system with fantastic mechanical properties, and powerful soil bounding capacity as well as is to be easily planted and simply managed at very low cost. Consequently, it has been being applied in more and more sectors and countries since 1980'. At the Second International Conference on Vetiver held in Thailand in 2000, Vetiver System was specially defined as "a practical, low cost and easily managed vetiver bio-engineering technology to be applied in soil conservation, land stabilization and restoration". Nowadays, the System is being applied in over 100 countries and areas.

1. The actual statue of applications of Vetiver System in China

Vetiver System and formerly called as Vetiver Grass Technology (VGT) were introduced into China's South China Red Soils Development Project by Mr., Grimshow from the World Bank in 1988 (Liyu XU, et al, 2003). Then, the grass and related technology were extended from Jiangxi and Fujian Provinces to Hunan, Zhejiang and Guangxi Provinces and Regions. One year later, Seminar on Vetiver Planting Techniques was jointly held both by China's Ministry of Agriculture and Ministry of Water Conservancy in Shaowu, Fujian Province from October 20 to 23, 1989. The task of this meeting was to promote and coordinate developments of vetiver technology in Provinces above mentioned. However, in those days, vetiver technology was only applied in agricultural sector, especially in farmland erosion control in mountainous and hilly areas. In later days, duo to the joint effort of scientists and technicians in universities and research institutions, it was extended to other provinces and regions in South China. In the purpose of further promoting the research, application, and extension of vetiver system, China Vetiver Network, supported by international Vetiver Network, was set up in Nanjing Institute of Soil Science, the Chinese Academy of Sciences. Then, organized or jointly organized by China Vetiver Network, 3 international symposia or seminars were held at Fuzhou in 1997, at Nanchang in 1999, and at Guangzhou in 2003 respectively. These meetings resulted in continuous hot waves to the research, application, and extension of vetiver system in China. Experiences proved that vetiver system is indeed a highly effective bioengineering technology. Due to its strong adaptability to the environment and the development level in China, the technology is worth to be recommended and extended.

Biologically, vetiver grasses are characterized by their tolerance to waterlogging, drought, infertility, and fire-attack, and by their quick growing ability. And mechanically, they are characterized by high tensile strength, high sheering strength and strong perforating ability. Their powerful root systems may perforate into very deep soil layers, effectively fixing soils, stopping displacements of upper earth bodies on slopes. They are plants ease to be planted and managed at very low cost. Hedges formed by these grasses are capable of effectively controlling soil erosion, while protecting roadside slopes along highways and railways

and stabilizing construction projects, such as dykes, dams and mine facilities (Liyu Xu, 2002).

At the present time in China, vetiver system has been extended to all provinces and regions south of the north limit of the northern subtropical zone and applied in fields of agriculture, forestry, highway, railway, mines, dams, and reservoir for soil and water conservation, land stabilization, slope protection, soil amendment, eco-environment improvement, as well as pollution control for water bodies in lakes and rivers and for garbage field. However, among all these applications, the most extensively found one is highway embankmet protection, with a protected surface area amounting by far over 1 million square meters. Moreover, this technology is mostly applied at the most non-stable slopes.

Generally speaking, the ecologic environment along roadsides is quite bad due to numerous factors unfavorable, e.g. acid, alkali, drought, waterlogging, large quantity of stones and sands, compact soils, fogs, dusts, and all kinds of pollutants. Therefore, plants to be established along roadsides should be capable of tolerant to stress and bad conditions. Vetiver grasses have not only strong stress-tolerance but also excellent mechanical properties, hence being capable of quickly recovering the vegetation along roadsides (usually only 3 moths after planting) and stabilizing slopes. As a result, vetiver system becomes a favor of highway engineers because it may replace or partly replace hard construction projects.

2. Vetiver planting areas in China

Although vetiver grasses are widely planted in areas south of Yangtze River, they were applied the most in Fujian, Jiangxi, and Zhejiang provinces where large mountainous and hilly territories may potentially induce serious slope collapse. Originated in tropical areas, vetiver grows well in the South China's vast territories including Yunnan, Guizhou, Sichuan, Guangdong, Guangxi, Jiangxi, and Zhejang etc. However, scientists did their best and tried to extend vetiver to China's temperate areas, i.e. territories north of Yangtze River.

Early in late 1980's , vetiver grasses had been introduced to Tai'an city, Shandong Province_35°52_40˝N_(Hong CHENG, 1998), where they grew quite well with even a height of 70-80cm in the very year of planting, due to fairly good local climate in Summer. In Tai'an, the annual rainfall being 789mm_of which 65% falling in Summer_ 14% in Autumn; the mean temperature in July being 26.4 __and the extremely maximum temperature being 40.7_. However, these grasses could not survive in the following year due to local extremely low temperature in Winter, with an absolute minimum temperature -22.4_.

Later, vetiver grasses introduced to coastal area of Tianjin city in 1998 were found not safely survive again in winter. However, it is difficult to conclude that it is only the coldness that made grasses die, because in that area coldness and salinity are the two unfavorable factors limiting the growth of vetiver. Besides, vetiver grasses introduced to Lishi city_about 38ºN_, Luliang Prefecture, Shanxi Province could not also safely survive after cold Winter.

However, vetiver grasses introduced to Nanyang of Henan Province about 33°N. It had annual mean temperature 14.9_; mean temperature in the coldest month i.e. January, 0.9_; mean temperature in the warmest month i.e. July, 27.5_; absolute minimum temperature, -21.2_; absolute maximum temperature, 41.4_ (Table 1). Several years experience showed that the grass grew well there..

Besides, an experiment conducted in Kang County, Gansu Province in April 2000, showed that vetiver grasses survived through winter (Da FENG, 2001). The County is located at the edge of subtropical zone (33˚20_N), with an annual mean temperature 10.9__warmest days (from late July to Upper August) mean temperature 22.2 __Autumn mean temperature 11.0__a mean temperature in not very cold Winter 0.7__a mean temperature in coldest January -0.7_, an annual mean rainfall 807.5mm(of which 450mm in Summer and only 26mm in Winter), and an annual mean evaporation 1148.4mm. In this County, frozen soil layer would present for 7 days at the location of 1220.3m above sea level, with a maximum thickness of frozen soil for 20cm.

Experiments in areas above mentioned show that the north limit of vetiver planting area is about 33º N, and that this kind of grass cannot survive safety in winter when it is planted at about 36ºN. It is concluded that, as a plant originated from tropical area, vetiver cannot endure long-lasting low coldness, especially cannot endure long-lasting frozen-soil period, though it was reported that the grass survived safely at low temperature of -15.9_ in Jiangxi, 1991.

Table 1.Mean Temperature and Monthly Absolute Minimum Temperature in Nanyang, Henan Province

Month	Jan.	Feb.	Mar,	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Doc.	Year
Mean	0.9	3.4	8.8	15.1	20.5	26.0	27.5	26.7	21.6	16.0	9.0	3.0	14.9
Min.	-21.2	-13.7	-9.6	-2.4	5.6	9.2	16.4	12.8	6.6	-1.0	-8.0	-10.3	-21.2

Moreover, a premise of experiments above mentioned is that planting dates of experimented vetiver are in spring or early summer. Actually, the normal surviving ability of vetiver grasses involved is related to their planting dates. For example, vetiver grasses planted with row spacing of 20cm x (70-80cm) in November and December in Jiangxi mostly died in the following year, although they were normally managed after being planted. It is concluded that even in South China, vetiver grasses may not be planted too late in the year, and should be planted more and more earlier as the latitude increase. For example, in northern Fujian Province, they should be planted in times no later than September or so. Of course, determination of planting dates is also related to other factors, such as relief and altitude, etc.

3. Actual statue of vetiver planting in Jiangsu Province

Jiangsu Province is situated at 31-35ºN, a transition between subtropical and warm temperate zone, with an annual mean temperature 13-16__frost-free period about 200-240 days and a plentiful annual rainfall 800-1200mm. Although rainfall may not limit the growth of vetiver, the planting of this kind of grass in northern utmost territory of the Province at higher latitude may be limited by low temperature. Besides, most part of the Province's territory is below 50m above sea level, and only 14% of the territory is covered by low mountain and hills, hence the impacts of altitudes on vetiver growth may be ignored in experiments. As a result, we may largely infer the northern limit of the northward immigration of vetiver grasses in China by vetiver growth statue in Jiangsu province.

3.1 Experiments at Taixing, central Jiangsu

In the purpose of protecting railway base, 120 thousand shouts of vetiver grasses were introduced to Taixing, Jiangsu from The Dabie Mountains by China Vetiver Network. These grasses were planted in contour on railways' north and south slopes respectively, about 5 shoots in a hole, covering a total planted area of 4079$m^{2.}$ Before planting, vetiver seedlings were separated patch by patch evenly at the sequence from large to small. Then, they were planted vertically, with mud pulp wrapped around grass roots. After that, soils around the planted seedling patches in planting holes were compacted, and at last irrigation were practiced for root establishment.

Experiment site is located at a section of the newly constructed Xin- Chang Railway at Huangqiao town, Taixing city, Jiangsu Province. It is situated on a delta plain at mid-latitude zone, enjoying a subtropical monsoon and also an oceanic climate due to nearing a sea outside Yangtze River mouth. The climate here is therefore characterized by notable season differentiation, high humidity, plentiful rainfall and long frost-free period, with an annual mean temperature 15__an annual mean rainfall 1 042mm(of which 55.8% falling at the period from July to September)_an annual mean frost-free period 143 days_extremely maximum temperature 38__and an extremely minimum temperature -12.5_.

Located at an alluvial plain with flat relief and high ground water level, the experimented railway base consists of filled soils containing huge quantity of minor sands and silt sands and less clay, and as designed, needs enhancing treatment if its height is over 5.5m. Actually, the experimented embankment is a high (about 5m) and filled one with slope gradient of 1:1.5, consisting of loose filled materials taken from earth pits or farmlands along the railway. Therefore, the railway base is quite unstable and has many water pits and rills at the slope, resulting in frequent collapse and landslide. Experiment lasting for several years shows that vetiver grasses, no matter planted at north or south slope, grew well and began to effectively protect the railway base at the moment only several months after being planted and would protect it for long. It may conclude that vetiver grasses may grow normally in central Jiangsu Province.

3.2 Experiments at Mofu Hill, Nanjing City

After the experiment at Taixing, vetiver grasses were introduced to Mofu Hill, Nanjing City. The aim of the introduction is to control erosion and to promote vegetation recovering at mine tailings. Materials in the experimented area were found quite diversified and four types of deposits, namely, carbonized shale, Xiashu loess, dolomite ore slag, and laccustrine mud were identified. Experiments in the past years showed that vetiver grasses grew well on all types of deposits and survived in cold winter, no matter planted on sunshine slope or on shade slope.

3.3 Experiments at Nanjing- Qidong Railway

It seems that things are not all so simple as shown in cases above described. Vetiver grasses planted along the Nanjing-Qidong Railway in September 2003 grew not as well as expected. After winter, it was found that grasses planted on north slope totally died from coldness, although 65% of those planted on south slope survived. Besides, backup vetiver seedlings planted at a flat field located at north to and not far from the railway base were found almost totally died from coldness. The case shows that besides latitude, planting time is a more important factor limiting the planting of vetiver at north subtropical zone. Those vetiver grasses planted in too late season cannot survive in the cold winter of the very planting year or cannot grow normally in the following year due to lack of adequate time for establishment and development before the coming of cold Winter. Fortunately, some of grasses planted on south slope may survive due to more sunshine and higher temperature.

3.4 Experiments at Binghai County, northern Jiangsu Province

Similar results were found at Binghai County, northern Jiangsu Province, where vetiver grasses planted in July 2002 grew also not as well as expected. In this case, besides coldness, high soil salinity (pH8.7-9.6, salt content 1.36‰) resulted from seawater found not far from the experimented site, limited most the growth of vetiver. Moreover, waterlogging took place not long after the planting might be another important cause of low survive rate of the grasses. Therefore, it is not easy to determine which single factor that limits the normal growth of vetiver in northern Jiangsu Province, for diversified factors are found to be limiting at the same time. However, the case indicates that although vetiver grasses are so salt and alkali tolerant that farmers in Fujian Province plant them at the seashore to protect fish pools, they grow often badly in Binghai County because they also are limited by coldness there. Same results were also found in experiments conducted by Nanjing Institute of Soil Science, CAS. at Qidong County, northern Jiangsu Province, in 1998.

3.5 Experiments for different planting seasons at Nanjing City

For better understanding the adoptability of vetiver in Jiangsu province, China Vetiver Network conducted experiments of vetiver planting on highway embankments in Jiangpu, Nanjing, and on trial fields of Jiangsu Provincial Academy of Agriculture in the period October-December, 2003. Planting season experiments, mixed with others related to various planting measures, showed that survive rate of vetiver grasses planted on highway embankments in Jiangpu was lower perhaps due to coldness damage on the north facing slope, and that in trial fields of Jiangsu Provincial Academy of Agriculture was quite high perhaps due to constructions around the trial fields which prevent vetiver grasses from damages caused by

Fig 1 Vetivere planting at the critical area of China
Y = vetiver survived; N = vetiver did not survive from the cold winter.

4. Issues Needed to be Further Researched for Vetiver Planting Areas

When concerning the adequate areas for vetiver extension, China Vetiver Network generally recommended the areas along the Yangtze River Basin and south to the River. This means that it may usually fail to plant vetiver grasses in areas of Yellow River. As described above, vetiver grasses may grow normally at 33ºN, but may not safely survive in winter when they are introduced to locations at 36ºN. Issues concerning whether they grow well or not in vast areas between 33ºN and 36ºN remain to be made clear. Therefore, climate adoptability experiments, exclusive to other factors as salinity, alkali, watelogging, and inadequate planting times, may be conducted at some northern Jiangsu areas, such as Gaoyou, Huaiyin and Xuzhou, to verify the growth possibility of vetiver in so-called “high-latitude locations”.

Besides, experiments related to adequate planting season for vetiver are necessary, so as to make clear the optimum or inadequate planting time for various areas or various latitudes. On the basis of these experiments, scientists may search ways to prolong vetiver-planting season, so as to promote the application and extension of vetiver system in China.

5. Reference

Da FENG,, 2001. Gansu’s Success in Planting Vetiver Grasses, Vetiver Newsletters 5(2), China Vetiver Network Nanjing, p.6 (in Chinese)

Hong CHENG, 1998. Studies on the Growth Characteristics of Vetiver Grasses, *Vetiver Researches and Development* (Editor in Chief : Liyu XU) China Agricultural S & T Press, Beijing, p.153-158(in Chinese)

Liyu Xu, 2002. Vetiver Research and Development: A Decade Experience from China, *Proceedings: The Second International Conference on Vetiver*, ORDPB, Bangkok, 311-322.

Liyu XU, Changjiu FANG, Ming WAN, and Jinghui Qin, 2003. The Origin and Development of Vetiver System, *Vitiver System and Its Research and Application in China* (Editor in Chief : Liyu XU, Changjiu FANG, Ming WAN, and Jinghui Qin) Asia-Pacific International Publishing Co. Hong Kong, p2-4 (in Chinese)