VETIVER SYSTEM TECHNOLOGY: APPLICATION AND DEVELOPMENT IN CHINA FROM 1998 TO 2015

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1. INTRODUCTION

Vetiver grass (*Chrysopogon zizanioides*) as early as the 1950s was planted in southern China, mainly used to extract its essential oil (Vetiver oil). Today, China's Zhejiang, Fujian, and Jiangxi provinces are still involved in harvesting vetiver to extract the fragrant oil. Vetiver technology, applied to soil and water conservation projects, was introduced by Richard g. Grimshaw to China in 1988. Since then, vetiver technologies in China have received large interest by plant community scholars as well as the environmental fields. During this time, officers in the international vetiver network (TVNI) (Richard g. Grimshaw, Paul Truong and late Diti Hengchaovanich) have offered essential guidance and assistance to vigorously promote and develop Vetiver use in China. Because vetiver is a tropical and subtropical type crop, vetiver technologies in China have mainly concentrated south of the Yangtze river basin for testing and application.

Throughout China's 25 year history of vetiver technology, applications have included: development of sliding slope resistance, vegetation restoration, artificial wetland conservation, water purification and wastewater treatment, as well as the management and development of a comprehensive ecological landscape. During this 25 year span, there have been many successes, failures, and surprises, such as positive government support. Today, the central government has a new directive for China's "ecological civilization and beautification", which should help usher in an era of greater development opportunities.

2. RETROSPECTIVE ON THE DIFFERENT STAGES OF VETIVER APPLICATION IN CHINA

2.1 Research Stage (1988 -1997)

In October 1988, Richard g. Grimshaw introduced 1000 strains of Vetiver from India into Jiangxi and Fujian provinces. Since 1989, 13 provinces and southern regions of China had begun large-scale professional research, mainly comprised of universities, agriculture research institutions and related government departments.

Research had focused primarily on vetiver in southern China, with different altitude and

climate adaptability and its growth and development characteristics. Dr. Xia Hanping of the South China Institute of Plants(Guangzhou) specialized in researching characteristics of vetiver growth, water resistance, adsorption of metals with repulsion, soil and water conservation functions, and applications for slope protection against sliding; Jiangxi scholars Mr. Cheng Hong and Lu Shengruan are specialists with vetiver grass breeding and its root system tensile strength; Guizhou province academy of agricultural sciences' Chen Xuhui and researcher Xiong Yuan focused on exploring the application of vetiver in agriculture; engineer Zhang Qing of the Soil and water conservation station in Fujian province, utilized vetiver wave sand-fixation and edible fungus cultivation; and Yunnan engineer Huang Po investigated water pollution control and bio-fuel.

In March 1996, Dr. Xia Han-ping and Mr. Feng Ziyuan were successful in becoming the first to apply vetiver in southern China for engineering purposes. During this time, they also studied concepts for the integrated application of vetiver irrigation. This series of research, exploration and tests were also designed to aid in China's popularization and application of vetiver for engineers to better understand and master the main techniques of its use.

2.2. The Promotion Stage (1998-2003)

In 1997 and 1999, TVNI under the support of China's formally established China vetiver network (CVN), held vetiver technology seminars in Fuzhou and Nanchang, where vetiver technology in southern China began to enter a formal application stage. An engineering group headed by Mr. Feng Ziyuan, began to introduce vetiver technology to markets in Guangzhou, Fujian, Zhejiang, Jiangxi, Hubei, Hunan and Guizhou with successful experimental applications for government infrastructure projects (roads, water conservancy and environmental protection).

Because vetiver technology is a multidisciplinary approach; engineers traditionally trained in hydraulics don't understand botany, as well as plant scientists not grasping the principles of engineering; the advancement of vetiver technology in China had been slow. Additionally, due to a lack of clear vetiver application standards, designers tended not to adopt the use of vetiver in initial construction stages and thus, was still an emerging technology. With this, Mr. Feng Ziyuan and Mr. Ke Chengchun, a water conservancy expert, set out to put forward vetiver technology principles, based on mechanics and engineering data. Focusing on a sliding slope protection initiative for construction projects, a calculation was formulated:

The Sliding Resistance Formula
$F = ARNM$

F = sliding resistance per meter wide ,
A = root area/one plexus,
R = shear strength of root,
N = number of plexus,
M= number of vetiver rows per meter.

Through Mr. Feng Ziyuan, more than 40 application papers were published in Chinese professional and technical journals, emphasizing four key aspects of vetiver technology; 1) design and seedling quality, 2) construction technology, 3) nutrition supply and 4) professional maintenance management. This provided the theoretical basis for designers to incorporate vetiver in construction applications and would help further development in China.

2.3 The Development Stage (2004- 2012)

In October 2003, the Third International Conference on Vetiver (ICV3) was held in Guangzhou, China, presenting international counterparts the status in China, along with introducing more chinese people to the roles and functions of vetiver technology. During this time, development in China had reached a peak stage, with more than 20 provinces in southern china involved in large numbers of breeding productions and promotion of its use. At the pinnacle, there were more than 20 professional companies engaged in vetiver activities, some attaining over 100 staff, and professional manufacturing bases reaching nearly 100 hectares. However, the application of vetiver technology had mainly focused on aspects of water resources and hydropower engineering, highway construction engineering, and vegetation restoration projects. This increased use of vetiver though, was a large divergence from the theme of ICV3, "vetiver with water." The main reason for this was the government's environmental protection awareness had not progressed enough, and was also associated with China's national infrastructure policies. Therefore, the popularization of application by engineers was stalled, by way of only being able to promote vetiver grass with engineering construction technology, as a cheap and practical solution to specific traditional engineering methods.

Due to the narrow application opportunities that existed, some experts and scholars engaged in the research and exploration of vetiver gradually withdrew their work. Additionally, with the lack of ecological established professionals combined with some disadvantages of vetiver itself, the momentum of vetiver development declined sharply. By 2012, the production base of vetiver fell from 100 hectares to less than 40 hectares, professional companies shrank to less than five, and associated professional engineers had reduced to less than 20. The three main aspects to this decline were 1) China's rapid economic development has brought more employment opportunities, a fall in building material cost, but coupled with an excess aging population, labor costs increased, making vetiver technology costs rise as well, 2) low development of vetiver technology application and a technical foundation within the engineering community, leading to application failures, and 3) small flaws with vetiver itself by lacking a strong landscaping effect, yellowing and withering of the leaves during winter, and easy to catch fire.

Overall, even though development has waned, China has created some remarkable achievements. According to incomplete statistics, the popularization and application of vetiver grass had reached nearly 10,000 total hectares. Along with this, the difficulty of vetiver technology application, application scope, and effect had been widely recognized.

2.4 The Status Quo (2013 - present)

At present, the only professional firm in China solely implementing vetiver technology and application is the The Guangzhou Vetiver Grass Industry Science and Technology Co. By 2013, professional enterprises involved in the vetiver business became stagnant, with most companies turning to landscaping, wasting a lot of vetiver nurseries in the process, falling to less than 20 hectares. Small projects using vetiver are still being installed, but are often completed by non-professional technology companies, and the quality of the application is poor. Also unfortunately, due to the multi-functional characteristics of vetiver, scientific research achievements have not been able to transform the field to a productive level. Therefore, according to China's economic development level and the national construction of "ecological civilization and the beautiful China," ideas targeted at a series of adjustments and improvements include:

1. Expand China's vetiver grass research, application, and foreign experience, to adjust and expand the scope of application

In the primary stages of vetiver's introduction into China and application, many universities and scientific research institutions obtained valuable results exploring vetiver characteristics. However, the research has been performed by experts and scholars in the botanical sciences, who appreciate its morphology, but users (engineers, designers) are mostly unaware. Construction project designers mostly study civil engineering and have no botany background, and vice versa for plant scientists, consequently there is very little exchange between these fields. Additionally, research results found in the laboratory, resource management officials have uncertainty regarding vetiver's use under field conditions and practical applications. For example, highway engineers must consider the ecological landscape, driver's visual impairments, and fire prevention, when designing slope protection; items that vetiver researchers don't take into account. Therefore, beginning in 2013, environmental protection management in water conservancy, hydropower and roads directed field experiments, in order to attain more applied data in preparation for the expansion of vetiver application.

2. Establish a vetiver production and application technical standard: improving the application of quality control of quantitative indicators

After nearly 20 years engaged in the popularization and application of vetiver, Mr. Feng Ziyuanm and his Director recognized the need to formulate standards for various vetiver technologies such as: 1) Regulations on the production management and quality of vetiver seedlings; 2) Regulations on the application of quality control; 3) Regulations on the application of construction procedure of engineering construction; and 4) Measures for the application of internal supervision and other quality control procedures.

There also needs to be a wider variety of available vegetative selections through breeding

of dwarf and evergreen species, making design configurations of ecological elements easier to incorporate. Other factors include more attention on auxiliary materials in construction applied to plant technical details; and providing a technical system on vetiver nutrition (including costs such as urea) as part of a professional maintenance management plan, to ensure a high success rate on vetiver applications.

3. Application crossover

Vetiver technology should be integrated into other specialized applications such as botanical designs for lawn, shrub, and leguminous vegetation; engineering hydraulic plans with water conservancy construction projects; sewage disposal by microbial anaerobic reactions and aquatic plant ecology; vegetative restoration with wave beam structures; geotechnical material skeleton for pump storage power stations; and as part of any comprehensive ecological applications.

4. Train capable professional engineers and organize seminars

Develop a training program that introduces professional engineers to vetiver technology application through a comprehensive approach (botany, engineering, hydraulics and ecology, etc.), especially at the site construction level. To achieve a higher level of acceptance, organize seminars where users and designers can share their successes and provide more technical counsel for interested organizations. With adjustments and improvement over time, the application scope of vetiver technology in China will have a greater effect. The Chinese government has also put forward an "construction of ecological civilization" plan last year, where more government agencies (such as the water conservancy, agriculture, environmental protection and construction departments) have recognized the importance of vetiver technology by its practicality and low cost. In 2015, the application of vetiver in China is expected to have a big change.

3. FUTURE DEVELOPMENT TRENDS

The development trend for vetiver applications in China will be diversified and comprehensive, crossing into other major disciplines, as single application has declined. The proportion of comprehensive ecological applications should also greatly increase.

4. CONCLUSION

After 25 years of history in China, although vetiver technology development has experienced a long process of ups and downs, overall the quantity and quality of applications are at the forefront of the world. Therefore, we believe extensive vetiver application still has a high potential.

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