Vetiver in Thailand: General Aspects and Basic Studies

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Abstract

In Thailand, the study and research on vetiver began after His Majesty the King had expressed his impression on vetiver in 1992. From the study by the Department of Land and Development, the guideline for planting Thai vetiver, Faek Don (upland vetiver) and Faek Hom (lowland vetiver) in various soil types and regions was distributed nationwide, which was very useful for the promotion and extension of the vetiver technology. The basic research is an essential tool for utilizing vetiver efficiently and many projects were carried out during 1993-1994 according to the first master plan of the ORDPB. Some achievements in basic research in the area of genetics, plant development and breeding, vetiver and soil fertility as well as phytoremediation were obtained by Kasetsert University staff and have been described herein. The results of these studies show the importance of basic research and that we need to continually seek more information about the "Miracle of vetiver".

Introduction

Thailand's abundant natural resources have been used intensively for the development of the country. With the rapid growth of the population from 55.8 million in 1990 to 65.5 million in 2006 (National Statistics Offices, 2006), the demand on natural resources have dramatically increased. This has not only caused the depletion of such resources, but also created environmental pollution problems. Soil and water resources, the important factor in all living organisms, are significantly affected by economic and agricultural development. Soil deterioration is severe due to the inappropriate use of soil resources. Vetiver, the miracle grass, is a means to use nature to take care of itself. His Majesty King Bhumibol Adulyadej has promoted the initiative of conducting examinations of using vetiver for soil and water conservation since 1991. These experiments have showed that vetiver could prevent soil erosion because of its deep and widely spreading root system, penetrating deep into the soil. It also conserves soil water and nutrients which are favorable for all activities. His Majesty periodically added to these original initiatives by suggesting the use of vetiver for slope stabilization, erosion control, environmental improvement and protection, disaster prevention, etc., this has since then, brought about the studies on vetiver within various organizations.

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Vitiver in Thailand

Faek Don (upland vetiver) and Faek Hom (lowland vetiver)

Vetiver is generally known to be originated in India. It is also found widely distributed naturally in all regions of Thailand. From the botanical exploration, it could be concluded that there are two species of vetiver in Thailand, namely *Vetiveria nemoralis* A. Camus *and Vetiveria* zizanioides Nash.

Vetiveria nemoralis, the local vetiver, is distributed mainly in the South-east Asian region. In Thailand it is commonly found in the dry area with moderate to strong sunlight and well-drained soil, so it is called upland vetiver or **"Faek Don**" in Thai (Faek = vetiver and Don = upland). The leaf of Faek Don is 35-80 cm long and 0.4-0.8 cm wide and pale green in color. The color of the lower leaf surface is the same as that of the upper surface but somewhat paler. The septum can not be seen, whereas the midrib is hard and forms the prominent ridge. The leaf texture is coarsely rough and slightly waxy. Its roots have no fragrance and can be 80-100 cm long in one year old vetiver.

Vetiveria zizanioides or lowland vetiver, is called **"Faek Hom**" in Thai (Hom = fragrant) because of its fragrant root which can be used for volatile oil extraction. Faek Hom is able to adapt very well and grow well in various environmental conditions. Its leaf is 45-100 cm long, 0.6-1.2 cm wide, curved on the upper surface and flat near the apex with a smooth and waxy texture. The leaf color is dark green and the lower surface is paler than the upper surface. The septum can be seen clearly especially at the base and middle part of the blade, whereas the midrib is not clearly seen. The roots of Faek Hom are longer than those of Faek Don, the one year old vetiver can produce over 1 meter long roots.

Both Faek Don and Faek Hom pose distinct ecological variation which makes them adaptable to different habitats. Therefore, they are commonly found in all regions of Thailand and there are many ecotypes. Thai vetiver ecotype was named after the province where it was first found, e.g., Ratchaburi, Surat Thani, Roi Et, Loei, Kamphaeng Phet. The Department of Land Development has done a comparative study of 28 vetiver ecotypes, 11 ecotypes of Faek Don and 17 ecotypes of Faek Hom. As the result, 10 ecotypes have been proved suitable to grow in various soil types and regions (Tables 1 and 2) (ORDPB, 2000). This information is useful for research and development on vetiver in Thailand.

Table 1. Vetiver ecotypes suitably grow in various soil types

Soil type	Faek Don	Faek Hom
Sandy soil	Nakhon Sawan, Kamphaeng Phet 1, Roi Et, Ratchaburi	Kamphaeng Phet 2, Songkhla 3
Clay loam soil	Loei, Nakhon Sawan, Ratchaburi, Kamphaeng Phet 1, Prachuap Khiri Khan	Surat Thani, Songkhla 3
Leterite soil	Prachuap Khiri Khan, Loei	Kamphaeng Phet 2, Songkhla 3 Surat Thani, Sri Lanka

Table 2. Vetiver ecotypes suitably grow in the regions

Region	Faek Don	Faek Hom
North	Nakhon Sawan, Kamphaeng Phet 1	Sri Lanka
Northeast	Roi Et	Songkhla 3
Central region and East	Ratchaburi, Kamphaeng Phet 1, Prachuap Khiri Khan	Kamphaeng Phet 2, Songkhla 3, Surat Thani
South		Songkhla 3, Surat Thani

Research and Development

After His Majesty had delivered his initiative on vetiver, many agencies promptly responded to undertake researches and development on vetiver utilization. The Office of the Royal Development Projects Board (ORDPB) has been the central agency in coordinating and monitoring the projects to follow His Majesty's guidelines. At present, there are 41 agencies which are cooperating with the ORDPB in research and development. The theme of works has been done following the ORDPB's master plans. The first master plan which was active during 1993-1994, emphasized on basic and applied researches. The second master plan (1997-1999) aimed to continue the research responding to His Majesty's advices and the knowledge dissemination on utilization of vetiver to the target groups. The third master plan (2002-2006), was concerned with extension and promotion of using vetiver for soil and water conservation as well as natural resource and environmental rehabilitation with government organizations, private sectors, societies and farmers cooperation (ORDPB, 2005). The ORDPB also financially supported research and development on vetiver. During 1993-1999, there were 197 research projects under the ORDPB support in the areas of basic research, soil and water conservation and vetiver utilization (ORDPB, 2005). Many of them have been completed and have achieved their goals while many are ongoing. Many of the basic research works were done during 1993-1994 to follow the master plan of the ORDPB. However, it is still important to support the applied work on vetiver which is wildly expanded.

Role of Kasetsart University

Kasetsart University (KU) has the policy to serve the royal projects for improving the well-being of Thai people on the basis of self-sufficiency. The studies on vetiver began at KU in 1992. Up to the present time, there have been 79 research projects done by KU staff members in many areas including the basic research. The results from the applied research works could be transferred to the target groups while the knowledge and information obtained from the basic research works could reveal more on the nature of vetiver in which some results of these achievements are given as follows:

Genetic study

In general, the ecotype and phenotype characterizations were used to identify vetiver in Thailand. However, the minor nucleotide variations may also trigger morphological, physiological and biological differences. Srifah *et al.* (2002) have conducted an experiment for genome analysis of 42 Thai vetiver ecotypes. The result could show that both single-strand conformational polymorphism (SSCP) and random amplified polymorphic DNA (RAPD) analyses for DNA polymorphism are sufficient to distinguish each ecotype of Faek Don and Faek Hom.

For karyomorphological study, Kongpraphon *et al*. (2003) developed a cytological technique to display chromosome morphology in cells obtained from the root tip of 15 Thai vetiver ecotypes. It was found that all studied ecotypes had the same chromosome number of 2n = 2x = 20. The variation in satellite chromosomes in terms of number and morphology was evident in six ecotypes. The total chromosome length varied from 1.5-8.4 micrometers. The karyotype consisted of metacentric and submetacentric chromosomes, all of which were nearly symmetrical. Localization of the heterochromatic regions on the chromosome was achieved by modified C-band and N-band. All the pairs of chromosomes were identified by these banding patterns, along with their length and arm ratios. They can be used as the basis for reproducible karyotypes and for detecting chromosomal relationships among ecotypes. Each ecotype showed at least one chromosome with a whole dark band, indicating a constitutive heterochromatin. The remainder indicated variation patterns from ecotype to other ecotypes of the some faint and dark bands.

To understand the background of vetiver chromosome behavior, Kongpraphon *et al.* (2005) observed chromosome association in various stages of meiotic cell division and correlated them with the previous studies. The result showed that the meiotic division in five vetiver ecotypes studied seemed to be normal with only a few of them showing abnormality. Numerous micronuclei appeared to be related with the number of satellite chromosomes. The ecotypes with 1-2 satellite chromosomes had numerous micronuclei in meiotic cells while the ecotypes without satellite chromosome appeared to have no micronuclei.

Plant development and breeding study

The information on vetiver development is important for successful cultivation. Kaveeta *et al.* (2000) studied shoot apex development, rate of leaf primordial initiation and the rate of leaf appearance on main stem of four vetiver ecotypes namely; Surat Thani, Ratchaburi, Sri Lanka and Kamphaeng Phet 1. The results revealed that the four ecotypes had similar patterns of apex development, but differed substantially in the duration and rate of each development. All four ecotypes had similar linear relationships in the leaf primordial production and performed an exponential relationship with faster leaf production for the first 150 days; thereafter, the rate would slow down. They produced tillers that fitted to the quadratic relationship by which slow tillering was observed during the early stage of development.

Tissue culture technique has been used for veitver propagation as it can produce large quantity of plantlets and it is convenient for transportation for planting in other places. In order to promote rapid multiplication, the Department of Botany research team successfully developed this technique using lateral or terminal buds of vetiver with a 70 % survival rate of plantlets. Since 2002, they have propagated and distributed more than 100,000 vetiver seedlings each year to various governmental and non-governmental organizations for the promotion of vetiver technology.

With tissue culture technique, Na Nakorn *et al.* (2000) experimented to induce salt tolerance in nine vetiver ecotypes. From the results, the 50-gray gamma irradiated calli of Kamphaeng Phet 1 ecotype exhibited maximum degree of salt tolerance. The calli could tolerate up to 4% NaCl, higher than those of without radiation at 3% NaCl. The plantlet regeneration of salt tolerant calli is the next goal of this research team.

Plant cells resistant to herbicides have been produced by *in vitro* selection and successfully used in the study of herbicide resistant plant production. Prasertsongkun *et al.* (2002) performed an experiment to select vetiver cells suspension resistant to glufosinate and investigated the mechanisms of resistance. They could select vetiver cells which were 170-fold resistant to glufosinate, compared to the susceptible cells. The glutamine synthetase (GS) activity of the resistant cells was twice as high as that of the susceptible cells. These results showed that the resistance of the selected vetiver cell suspension to glufosinate is mainly due to increasing GS activity and its decrease in sensitivity to the herbicide.

Vetiver and soil fertility study

Soil fertility, which is an important factor for agricultural productivity, is influenced by parent material and inappropriate soil management practices. Many research works on soil fertility improvement by vetiver have been investigated. The experiment done by Roongtanakiat *et al*. (2000) revealed that vetiver mulching conserved topsoil moisture and increased available-N, available-P and extractable-K. The further experiment showed that one tonne of dry vetiver shoot buried at the depth of 10 cm would yield mineral N, available-K upto 4.4, 2.2 and 20.5 kg while that left on the soil surface would yield only 0.85, 0.74 and 7.20 kg, respectively (Chairoj and Roongtanakiat, 2004).

Vetiver cultivation could improve some chemical and physical properties of soil. Tantachasatid (2003) cultivated vetiver in laterite soil, Phon Phisai soil series. After nine months, a certain level of improvement of soil properties such as pH, organic matter, available-P, extractable-K, aggregate stability, bulk density, permeability and available water capacity, could be achieved by cultivation of vetiver as a sole crop and mixed cropping with cover crops.

Soil microorganisms associated with vetiver are important for vetiver growth and development especially in infertile soil. They produce nutrient sources and induce plant growth hormones for vetiver. Techapinyawat *et al.* (2000) reported that VA mycorrhiza inoculated to vetiver significantly increased plant biomass and the nutrient uptake. With isotope tracer technique, Techapinyawat *et al.* (2002) studied the effects of 3 species of arbuscular mycorrhizal fungi: *Acaulospora scrobiculata*, *Glomus* sp., *Glomus aggregatum* in combinations with phosphate fertilizer on P-uptake of vetiver.

They reported that arbuscular mycorrhizal fungi significantly increased P-concentration, P-uptake, %P derived from fertilizer and P-availability in vetiver. At 60 kg P_2O_5 ha^{-1} level of application, the highest % P P derived from fertilizer, P-availability, and total P-uptake obtained from *A. scrobiculata*, whereas *G. Aggregatum* treatments with no P-supplied gave the greatest P-concentration. Increasing phosphate fertilizer up to 90 kg P_2O_5 ha^{-1}, resulted in non-significant changes of P-uptake and P-availability in plants.

Phytoremediation study

Phytoremediation is well known for its environmentally friendly and inexpensive technology. Many researches showed that vetiver could be used as photoremidiation plant, especially for decontaminating heavy metal from soil and water. Roongtanakiat and Chairoj (2001a, 2001b) evaluated the uptake potential of three vetiver ecotypes for Mn, Zn, Cu, Cd, and Pb. The results showed that these heavy metals did not affect the growth of vetiver. At harvesting of 60 days after heavy metals application, Ratchaburi ecotype gave highest shoot dry weight and had significantly higher Mn, Zn, and Cd amounts in shoots than Surast Thani and Kamphaeng Phet ecotypes. However, Ratchaburi and Kamphaeng Phet showed similar Cu uptake. The concentration of heavy metals in shoot harvested at 120 days was lower than that harvested at 60 days due to dilution effect. This showed that vetiver is not a heavy metal hyperaccumulator plant. Therefore, the researchers suggested that when utilizing vetiver for the phytoremediation of heavy metals contaminated soil, the above ground biomass should be regularly cut to stimulate regrowth and the translocation of heavy metals to shoots.

Polluted soil from landfill leachate is an environmental problem of large cities. The landfill leachate usually has high content of pollutants, especially heavy metals and other harmful substances. Roongtanakiat and Chairoj (2001a, 2001b) showed that the leachate strength of landfill affected vetiver growth and heavy metals uptake. The vetiver treated with 100% leachate could not survive 80-85 days after planting. Vetiver uptook more heavy metals as the strength of leachate increase.

The results from an experiment using vetiver for wastewater treatment conducted by Sipen *et al*. (1997) indicated the possibility of vetiver as a biological wastewater treatment. Roongtanakiat and Tangruangkiat (2006) hydroponically cultivated three vetiver ecotypes in four types of industrial wastewater. The results showed that the concentration of heavy metal in waste water played an important role in vetiver growth. The vetiver absorbed Fe>Mn>Zn>Cu>Pb, respectively and they concentrated more in vetiver root than in shoot. Among the three vetiver ecotypes, Sri Lanka had best growth and the highest heavy metals removal efficiencies.

Conclusion

Following His Majesty's initiation, numerous research work and practical applications on vetiver were conducted by many organizations including Kasetsart University. The results showed useful information on the nature of vetiver, which helps us with the utilization of vetiver. However, there are still more questions to be answered, e.g. what makes vetiver work so well, how to enhance the potential for phytoremidiation, how to obtain shade tolerant vetiver and cold tolerant vetiver, how soil microorganism associate with vetiver. Basic research is still required to elucidate more on vetiver.

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