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Techniques of Vetiver Propagation

With Special Reference to Thailand

By

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Foreword

One of the immediate activities of the Pacific Rim Vetiver Network (PRVN) is to disseminate information on vetiver technologies, especially those that are adaptive to local conditions of developing countries in the Pacific Rim. In this connection, the PRVN Secretariat is publishing a series of technical bulletins which can provide useful information about Vetiver Systems (VS) to readers who are active members of the PRVN.

In 1998, two technical bulletins were published, namely "Vetiver Grass Technology for Environmental Protection" by Paul Truong and Dennis Baker, August 1998; "Vetiver Grass for Slope Stabilization and Erosion Control" by Diti Hengchaovanich, November 1998. In 1999, three technical bulletins were published, namely "Vetiver Handicrafts in Thailand" by the (Thai) Department of Industrial Promotion, October 1999; "Vetiver Grass Technology for Mine Rehabilitation" by Paul Truong, November 1999; and "The Use of Vetiver Grass System for Erosion Control and Slope Stabilization Along the Yadana Gas Pipeline Right-of-Way" by the Petroleum Authority of Thailand, December 1999. We are hoping that in 2000, the number of technical bulletins published by PRVN would be the same as in 1999, if not higher. This will not be possible without the unselfish contributions from those who have spent their years doing research and development on the vetiver to pass on their knowledge and experience to other scientists.

One of the problems in the transfer of technology on planting vetiver to farmers as well as the officials of the government and private agencies is the source of low-cost, high-quality planting materials which are available in large quantity at the place and time needed. Although several techniques have been developed and described in various publications, they are not readily available to users. Moreover, numerous confusing terms have been used to describe the parts and the techniques employed in propagation and multiplication. The author, who is one of the first Thai scientists who studied the vetiver since the 1970's, has done extensive investigations on its propagation techniques, including the innovative use of the dibbling tubes and their transplanting techniques in the field. The present paper, entitled "Techniques of Vetiver Propagation with Special Reference to Thailand", is a compilation of the various practical and innovative techniques of vetiver propagation employed in Thailand and abroad, based on the author's experience and his library research.

On behalf of the PRVN, we wish to express sincere thanks to the author/editor, Dr. Narong Chomchalow, and to Dr. Suyanee Vessabutr of the Queen Sirikit Botanic Garden, who helped to edit the manuscript on a voluntary basis.

It is hoped that this publication will be of some value to extension officers, engineers and others in the field of transfer of technology, to pass on this valuable information to the farmers and other vetiver users to encourage them to grow more vetiver for soil and water conservation, the ultimate objective of growing vetiver.

(Dr. Sumet Tantivejkul)
Executive Secretary, Pacific Rim Vetiver Network
and Secretary-General, Chaipattana Foundation

Contents

Techniques of Vetiver Propagation With Special Reference to Thailand

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Abstract

The most common method to propagate vetiver is through the use of tillers planted in small polybags. Problems of such a method include high cost and labor intensifies in operating and maintenance, difficulty in transportation, and creating environmental problem in field planting. Using tillers as planting material, many other modified methods have been developed in Thailand. They can be grouped into two main approaches. One is through the process of multiplication of the tillers in order to increase their number for use in subsequent field planting; multiplication can be done by growing tillers in large polybags or on cultivated land (upland, paddy fields or raised beds). The other is through the use of tillers directly in field planting without having to multiply them first; this can be accomplished by planting bare-root tillers directly in the field, or growing tillers in strips, dibbling tubes, or biodegradable blocks prior to field planting. Other planting material is tissue-cultured plantlets in which the explants are obtained from young shoot or young inflorescence; upon hardening, plantlets are taken out from the bottle, then grow them for further multiplication in the polybags, in the nursery beds, or in the field; or grow them in strips, dibbling tubes, or nursery blocks prior to field planting. This paper also discusses the main goals in vetiver propagation which are quality planting material, low cost, hardiness, and being easy to transport.

Keywords: *Propagation, multiplication, tiller, slip, culm, cutting, ratoon, clump, plantlet, explant, bare root, biodegradable, strip planting, dibbling tube, tissue culture, polybag.*

1. INTRODUCTION

One of the characteristics of all living things is their ability to reproduce themselves. Two main types of reproduction are known, sexual and asexual. The former involves exchange of male and female gametes through sexual process while the latter involves various forms of reproduction without the exchange of gametes, but the offspring is derived from maternal tissue. In the Plant Kingdom, asexual reproduction is quite common in contrast to the Animal Kingdom. This is particularly true of horticultural crops in which parts of plants can be separated out from the mother plant and develop into new individuals, having all genetic materials of the maternal parent.

Vetiver, like any other plants, can be reproduced both by sexual and asexual means. The former involves the formation of seeds whose genetic materials are derived from both the maternal and paternal sources. The latter involves several mechanisms that result in the formation of new individuals having the same genetic material as the mother plant. In natural habitat, vetiver plants can, and often do, reproduce by seeds. This is a mechanism whereby species or ecotypes can be distributed geographically. At the same time, it allows evolution to take place through the selection of natural variants arising from genetic recombination. In cultivation, however, the selected ecotypes, either rarely produce flowers, or even when flowers are produced, they rarely set seeds, or

even when seeds are produced, they rarely germinate and grow into new plants because the environment is not suitable for their germination and establishment.

The present paper is a revision of an earlier paper (Chomchalow 2000) distributed at the Second International Conference on Vetiver (ICV-2) held in Cha-am, Phetchaburi, Thailand during18-22 January 2000. In addition to re-arranging the entire manuscripts in the light of new information, it also incorporates many new techniques presented at ICV-2. The paper attempts to distinguish the two confusing terms (propagation and multiplication), describe the parts used in propagation, and the various techniques (conventional, common and innovative) used in vetiver propagation. It ends with the discussion on the guidelines to choose the techniques and goals in vetiver propagation.

1.1 Propagation *vs* Multiplication

There are a few terms commonly used to describe the mode of reproduction of vetiver. The two most common terms are 'propagation' and 'multiplication', which are used interchangeably by some authors. Others use the term 'propagation' to mean any means of reproduction of vetiver, irrespective of the ultimate goal, while the term 'multiplication' is used to solely increase the number of individuals of vetiver plants, without having the objective of planting them in the field. Some authors, however, use the term 'propagation' in place of 'multiplication', and *vice versa*.

In the present paper, 'propagation' is defined as *"any means of reproduction, either for increasing the number of individuals or for subsequent planting out in the field"*, while 'multiplication' is *"any means of reproduction solely to increase the number of individuals"*. It is implied that 'propagation' is used as a general term of reproduction of vetiver; it also includes 'multiplication' through various means to increase the number of individuals. The ultimate goal of 'propagation' is to grow individual vetiver planting materials in the field, either through the process of 'multiplication' first, or directly growing the propagated plants in the field.

1.2 Vetiver Parts Used in Propagation

As mentioned earlier, vetiver in cultivation rarely produces seeds. Thus, only asexual reproduction will be treated in this paper. In the vetiver literature, several terms have been used, sometimes indiscriminately, to designate the parts of the vetiver plant that can be used in propagation. In this paper, the author compiles all these terms, and, to avoid further confusion, provides their definitions (based on: (1) Webster's New World Dictionary, Third College Edition, 1993, written in italics; (2) www.dictionary.com, underlined; and (3) the author's own, specifically for vetiver, in italics and underlined), and their explanations. They are given below:

- ***Tiller:*** *(1) A shoot growing from the base of the stem of a plant;* (2) A shoot, especially one that sprouts from the base of a grass; (3) *A shoot sprouts from the base of the stem of a vetiver plant*. Tiller is the most popular part of the vetiver plant used in propagation since it is available in large quantity, employs simple technique, and gives good result.

- ***Slip:*** *(1) A stem, root, twig, etc. cut or broken off a plant and used for planting or grafting; cutting; scion;* (2) A part of a plant cut or broken off for planting; a cutting; *(3) A shoot cut off from a vetiver clump used for planting.* Many authors used this term synonymously with tiller. Some even erroneously called it a 'root division' (in vetiver, the structure from which the slip grows is the base of the stem, not the root). As it is a rather confusing term, and the fact that the term 'tiller'is more appropriate, the present paper will not use this term to avoid further confusion.

- ***Culm:*** *(1) A stalk, stem; the jointed stem of various grasses, usually hollow;* (2) The stem of a grass; (3) *The above-ground part of the stem of a vetiver plant.* The culm of the vetiver grass is strong, hard, and lignified, having prominent nodes with lateral buds that can form roots and shoots upon exposure to moist condition. Laying the cut pieces of culms on moist sand, or better under mist spray, results in the rapid formation of roots and shoots at each node.
- ***Cutting:*** *(1) A slip or shoot cut away from a plant for rooting or grafting;* (2) A part of stem removed from a plant to propagate new plants, as through rooting; (3) *Vetiver culm cut into sections with at least one node each used to propagate new plant.* Although commonly used as propagating material in horticultural crops, 'cutting' is rarely used in vetiver. This term is probably synonymous with *'cut culm'* or *'culm-cutting'* (as referred to by Yoon 1991).
- ***Culm-branch:*** *(1) There is no definition of such a term in Webster's Dictionary;* (2) There is also no definition from www.dictionary.com; (3) *A branch developed from the lateral bud of a culm.* It is a term derived from similar structure in bamboo and other ramified grasses. It was Yoon (1991) who used this term in vetiver literature for the first time to mean a branch developed from a lateral bud of a culm of more than three months old whose main culm has been repeatedly cut down to induce tillering.
- ***Clump:*** *(1) A cluster, as of shrubs or trees;* (2) A thick grouping, as of trees or bushes; (3) *A cluster of tillers developed originally from a mother plant of the vetiver in all directions.* In vetiver, a clump is formed when a plant has been grown for a certain period and produces numerous tillers in all directions.
- ***Ratoon:*** *(1) A shoot growing from the root of a plant (esp. the sugar cane) that has been cut down;* (2) A shoot sprouting from a plant base as in the banana, pineapple, or sugar cane; (3) *A shoot (tiller) sprouting from the base of the vetiver plant that has been cut down to induce sprouting.* As vetiver (or even the sugar cane!) does not seem to re-sprout from the *root* when the clump is cut down to the ground, but rather from the base of the stem, thus the re-sprouting structure is actually a 'tiller' which has been induced to sprout by cutting down the top part. This term will not be used in this paper to avoid further confusion.
- ***Tissue-cultured plantlet:*** *(1) There is no definition of such a term in Webster's Dictionary;* (2) There is also no definition from www.dictionary.com; (3) *Differentiated tiny plant developed from explant through tissue-cultured technique.* Unlimited number of plantlets can be produced in aseptic condition from the explants deriving from shoot tip, lateral bud, young inflorescence, etc. Upon attaining a good size, these 'plantlets' can be transplanted in the containers or in the fields similar to tillers, although much smaller in size. Tissue-cultured plantlets can be produced within a relatively short time with reasonable expenses. They also have certain advantages over other planting materials in that they are small in size, easy to transport, and free from pathogen (as they are grown, and still remain, in aseptic condition) which makes them safe for international movement, especially across the countries with strict plant quarantine system.

Of all these parts, only the first and the last are used extensively in most vetiver-growing countries to propagate the vetiver grass, simply because they are the convenient parts to be used in propagation. Besides, the cost of their production is relatively lower than that of the other parts while the success is higher. Of the remaining structures, culm (including cutting and culm-branch) and clump are also used in propagation to some extent while the rest are either not used for practical reason, or do not exist.

Vetiver Parts Used in Propagation

Clockwise from bottom right: A vetiver clump with numerous tillers; The base of a vetiver plant with all leaves removed, showing stout stem with short internodes and two lateral buds (to develop into tillers); A full-grown vetiver plant with four tillers growing from the base of its stem; A mature culm with a culm-branch; A lateral bud (to be used as explant in tissue culturing) on a culm with leaves removed); Tissue-cultured plantlets of vetiver grown on solid medium in a bottle.

2. CONVENTIONAL METHODS OF VETIVER PROPAGATION

Although vetiver has been cultivated in India and elsewhere for a long time, nothing has been done with respect to its propagation techniques until recently. Conventionally speaking, only two methods have been employed, namely: (i) a traditional method of planting bare-root tillers in the field, and (ii) a rather new method of planting tillers in polyethylene bag (commonly referred to as polybag) for a period of time and then transplant them in the field. They are described below:

2.1 Planting Bare-Root Tillers Directly in the Field

This traditional method of planting vetiver has been done since the old days when people started to grow vetiver for erosion control in India some 200 years ago. It was the most convenient method so far practiced in those days when no polybags were available and no other parts were used. This method is still in use even nowadays in many countries. Innovative technique of planting bare-root tillers has also been developed in Thailand (see Section 4.2).

2.2 Planting Tillers in Polybags and Transplanting Them in the Field

This is a technique that has only recently been developed when vetiver has been popularized to be grown for soil and water conservation as the result of promotional campaign of the World Bank in the late 1980s.

2.2.1 The Technique: Individual tillers are separated from the clump. The shoot is cut off to about 20 cm and the root to about 5 cm in length. Each tiller is inserted into a small polybag filled with planting medium, normally composed of burnt rice husk, manure, coir dust, and some topsoil. The techniques of propagation of vetiver employed in various countries differ somewhat. For example, in Thailand, the tillers are planted in polybags for 45 days or more before field planting. The medium used is one part topsoil and one part compost. The best time to transplant is at the beginning of the rainy season. Survival rate is expected to be more than 90%, especially if the rain falls normally (Chalothorn 1998). In Malaysia, Yoon (1991) planted tillers in polybags with sizes of 7" x 15" and 10" x 20". One nugget of Kokei (6 g) of slow release fertilizer (N, P, K, and Mg) was applied into each bag and a drip-dry irrigation system was used. Plants were divided as soon as they are bag-bound. At four months, the small bags had 17.1 $\pm$ 1.1 tillers/plant and the larger bags 25.5 $\pm$ 1.6 tillers/plant.

2.2.2 Problems in Polybag Propagation: Polybag propagation is by far the most popular technique in vetiver propagation. However, it has many drawbacks such as:

- *Expensive:* This includes the costs of polybag, medium (topsoil and compost), nursery, water, labor and transportation.
- *Problems in Maintenance:* A large area of the nursery is needed for keeping the vetiver in polybags for the period of 45 days or more. Watering the young plant everyday requires labor and installation inputs, and a good source of water supply.
- *Environmental Problem:* The disposal of a large number of polybags during field planting is always a problem since most laborers do not pay attention to collecting the polybags after removing the young vetiver plant out for planting. Instead, the polybags are left in the field, thus creating environmental pollution.
- *Demand-Supply Problem:* In many cases, the demand for vetiver planting material does not

multiplication center while the demand for them is much less. As a result, most of them are to be disposed of, since they are no longer good for planting a few months after their optimum period (of 45 days). In other occasion, there is not enough planting material at the time of need.

- *Labor Intensifies:* Starting from procurement of medium (topsoil, burnt rice husk, coir dust, and compost), cutting the corner edges of the polybags, filling the medium into the polybag, preparing the tillers, inserting the tillers in the polybags, laying the polybags in the nursery, watering and other maintenance, transporting the polybags to the field, removing the polybags, digging holes for planting, placing the vetiver plants in the hole, covering the holes with soil, collecting used polybags, etc., all are quite time- and labor-consuming.

Even with all the above drawbacks, planting tiller in polybag is still popularly employed in vetiver propagation in most vetiver-growing countries, as it is the most practical method of propagation.

Conventional Methods of Vetiver Propagation

A clump showing its numerous roots and tillers developed from the base of the stem

Vetiver tillers planted in the polybags ready to be transplanted in the field

Techniques Commonly Employed in Vetiver Propagation

Bare-root tillers ready to be planted directly in the field

Polybags filled with planting medium (foreground) and those planted with vetiver tillers ready to be transplanted

Acclimatization of vetiver tillers planted in small polybags before transplanting in the field

A nursery for polybag propagation

3. TECHNIQUES COMMONLY EMPLOYED IN VETIVER PROPAGATION

Tillers are by far the most commonly used part of the vetiver plant in propagation because they are the most convenient, economic, and large quantity can be obtained (simply by applying fertilizer and water). They can withstand relatively long period of transportation, and, in favorable condition, establish themselves quickly once the roots start to grow. Two approaches have been made in using tillers to propagate the vetiver plants: one by planting them in polybags first, the other by planting them directly in cultivated land.

3.1 Planting Tillers in Polybags

Planting vetiver in the polybags is both clean and easy to maintain; however, it requires proper tools for watering and caring. Depending on the objective, two sizes of polybags are used: small polybags for field planting, and large polybags for multiplication.

3.1.1 In Small Polybags for Field Planting: This method is appropriate to be used under various development projects in the initial stage of operation. It is very convenient in terms of distribution and providing services or support to various agencies and interested public for further multiplication or other purposes. It is easy to develop and keep a record of the number of bags and tillers needed to meet the demand.

The size of the polybags is about 5 cm wide and 15 cm long, with a diam. of 7 cm when filled with soil. Many other sizes have also been used in several countries. They are suitable for direct transplanting on land or specific areas for soil and water conservation purposes, such as in hedgerows on roadsides and road shoulders, at pond edges, and on paddy buns to hold the soil in dry, impoverished and saline conditions. Planting vetiver tillers propagated in small plastic bags ensures a better survival rate and faster establishment of the vetiver grass than conventional bare-root planting.

3.1.2 In Large Polybags for Multiplication: The large polybag is made of black polyethylene, about 10 cm wide and 25 cm long, with folding at the bottom. When filled with planting soil, the bag will have a diameter of 15-20 cm. Propagation of vetiver tillers in large polybags can produce a large number of new shoots. These shoots are collectively called clump and can be kept in the polybags for an extended period of time. Hence, these vetiver clumps are suitable for further multiplication or for separating into individual tillers (bare root) for large-scale transplanting.

3.2 Planting Tillers on Cultivated Land for Multiplication

For multiplication purpose, tiller can also be planted directly on cultivated land. In Thailand, this is normally employed in the government-owned vetiver multiplication centers, such as the Land Development Department's stations, or multiplication plots of other agencies. These are normally located near the area where vetiver will be transplanted. Depending on the kind of cultivated land used in multiplication, this type of planting can be separated into three categories, viz.:

3.2.1 On Upland Fields: Large-scale vetiver multiplication requires a large number of tillers well suited to government agencies, or large-scale plantations or companies. The system is suitable for non-irrigated areas. After land preparation, tillers whose shoots are trimmed to 20 cm and roots to 5 cm are planted when soil is moistened. Two or three tillers are used in each hole at a spacing of 50 x 50 cm. However, to make it easier for caring and best time for the operation is mid-rainy season (between mid-June and mid-August). In this method, each 4-5 month-old tiller

can generate an average of 50 new shoots per clump during the period of multiplication of about six months.

3.2.2 On Raised Beds: This method should be applied in area where there is a good watering system. Under proper cultivation practice, this system is highly productive. Moreover, tillers can be produced on a year-round basis. The tillers used in planting are obtained from the selected clump, and then trim the top to 20 cm and the roots to 5 cm. After that, the shoots are separated and bound together in bunches. The roots are soaked in water for four days, after which they start to grow. This will give more than 90% survival rate. Tillers are then planted on prepared raised beds of 1 m width with a walk path of 1 m. On each bed, the tillers are planted in double rows at a spacing of 50 x 50 cm. Watering after planting to maintain soil moisture is necessary. At one month, each tiller should receive approximately one teaspoonful of 15-15-15 fertilizer. Each clump will generate 40-50 new shoots after 4-5 months, and one ha of land can yield 750,000-975,000 new shoots.

3.2.3 In Paddy Fields: This practice is done in the paddy fields with good drainage or other areas having good watering and draining system. The same procedure of the above methods can be applied in this method. In such areas, vetiver can be propagated all year round.

Techniques Commonly Employed in Vetiver Propagation

Vetiver tillers planted in large polybags for multiplication

Used fertilizer bags can also be used

Planting bare-root tillers directly in the field for multiplication

Bare-root tillers planted on the upland fields for multiplication

4. INNOVATIVE TECHNIQUES IN VETIVER PROPAGATION

In order to improve the efficiency of vetiver propagation, many new techniques have been invented in recent years. The most significant one is the employment of the tissue-cultured technique that results in rapid multiplication at reasonable cost and with a lot of other beneficial features, so it is now becoming quite popular in many countries. There are, however, several other innovative techniques which have been attempted, and appeared to be quite efficient. The following paragraphs give the details of all these innovative techniques:

4.1 Tissue-Cultured Technique

As micropropagation through tissue-cultured technique is quite well developed in many vetiver-growing countries, such technique has now been adopted in these countries to mass produce vetiver planting material. This method is appropriate because it does not promote mutation; besides, vetiver plantlets, which are relatively small as compared to conventional tiller in polybags, make it easy for transporting large quantities to other areas (Charanasri *et al.* 1996).

In Thailand, a number of laboratories such as at the Doi Tung Development Project (Charanasri *et al.* 1996), Kasetsart University (Namwongprom and Nanakorn 1992), and the Land Development Department (Sukkasem and Chinnapan 1996) have been involved in such techniques. These are discussed below:

4.1.1 Plant Materials (Explants) Used in Tissue Culturing: In principle, any meristematic tissues of the plant can be used as starting material in tissue culturing. As for vetiver, those from young shoot and young inflorescence are preferred.

4.1.1.1 Young Shoot: The Botany Department, Kasetsart University has experimented with tissue culturing of young shoot derived from lateral or terminal buds and found that 70% of the plantlets survive which renders the method effective (Namwongprom and Nanakorn 1992). The Department has been producing tissue-cultured plantlets as a service to other government agencies as well as for their own experiments, e.g. to select for salt or toxic substance resistant clones (Nanakorn *et al.* 1996).

4.1.1.2 Young Inflorescence: The Doi Tung Development Project was successful in propagating vetiver plantlets using meristematic tissue of the inflorescence and culturing it under aseptic condition (Charanasri *et al.* 1996).

4.1.2 Transplanting Plantlets: Plantlets can be transplanted to various containers and fields:

4.1.2.1 On Nursery Beds: After the plantlets have been fully developed in the culture medium, they are removed from the bottle and transferred to the nursery beds. Raised beds of 1 m wide and 5-10 cm high should be prepared in the nursery with proper shading using saran (70%) or any other materials available in the locality such as banana or coconut leaves. Watering facility should be available to provide sufficient amount of water for the growing young plants. The nursery should receive full sunlight at least 6-7 hours per day.

Immediately after removing from the bottle, the plantlets should be planted in the nursery bed to avoid desiccation. The bed should be watered just before transplanting. Place the plantlets into the holes of the nursery bed at 1 cm depth, and at the spacing between plants of 1-2 cm, and between rows

moist soil firmly around the plantlets and water again. During the entire period of growth in the nursery beds, keep the soil moist by watering twice a day. Weeding should be done regularly. Fifteen days after transplanting, replace any dead plants and remove the shade to allow the plantlets to be exposed to sunlight; this will promote hardening of the young plantlets. Fertilizer (manure or chemical fertilizer) should also be applied to the young plantlets at this time. When the plantlets are 20-30 cm tall, they are ready to be transplanted in the field.

4.1.2.2 In Polybags: **The plantlets can also be transplanted into the polybags, using the same technique of polybag propagation described earlier. These are to be kept in the nursery during the first 15 days, after which the shade is to be removed to allow the plants to expose to full sunlight and fertilizer be applied to promote growth and development of the plantlets. When they are 20 cm tall or 60-90 days old (after transplanting from the bottle), they are ready to be transplanted in the field.**

4.1.2.3 In the Field for Multiplication: The 60-90 days old plantlets grown in the nursery beds or in the polybags are ready for field planting for further multiplication, using the same techniques described earlier.

4.1.2.4 In Other Containers: Similarly, the 60-90 days old plantlets can also be transplanted in strips, dibbling tubes, or nursery blocks (see later). In fact, plantlets obtained from tissue culture technique have an advantage over tillers as they are small in size that fit well in small structures of the dibbling tubes and nursery blocks

4.2 Planting Specially-Treated Bare-Root Tillers Directly in the Field

A new technique in vetiver propagation has been developed by Chalothorn (1998) at the Huai Sai Development Study Center by using bare-root tillers planted directly in the field. The procedure includes digging up the well-developed vetiver clump, chopping the shoot to 20 cm and the roots to 5 cm, then split the clump into individual tillers, tie them together into bundle, and keep them in shallow water for four days (to induce new root formation) before planting. This method is quite efficient, especially if operation is done in the rainy season after the soil has been sufficiently moistened. The survival rate is promising with this method. It is quite convenient and economic since it does not require polybag, medium, nor maintenance, and also save a lot of labor. As compared to the polybag method, transportation cost to the site of planting is much less.

A further improvement has been invented by Jirasathaworn and Sutharuk (1995, cited by Inthapan and Boonchee 2000) who submerged bare-root tillers in humic acid solution for three days until they produced new roots. They were found to grow faster after transplanting in the field (in the middle of May to the end of June) than tillers grown in polybags.

4.3 Planting Tillers in Strips for Field Planting

The Khao Hin Son Royal Development Study Center (1998) has developed a new propagating technique by making a long strip which would facilitate transportation and planting. It is a labor-saving practice with high survival rate since the roots are not disturbed as in the case of using polybags. It is also environmental friendly because no waste material (used polybags) is left in the field.

The materials employed include two rows of cement blocks (each is 20 cm high, 30 cm long and 4

Steel rods or bamboo stakes are placed 5-6 cm apart across the width of the cement blocks to support plastic sheet. With a piece of stick, push the sheet down and fill the cavity with planting medium (soil mixed with compost). Plant vetiver tillers along the length of the cavity at the spacing of 5 cm. After two months, the roots will form a closely tight net such that the whole strip can be lifted up without damaging the root system. Normal nursery practices such as watering and shading are given.

No watering is given to the young vetiver plants seven days prior to field planting to reduce the weight of the strips in order to facilitate transportation. In field planting, a grove is made in the soil along the contour of the slope to place the strip in it. Press the soil along the strip tightly. Since the whole strip (of 1 m length) is planted together in one operation, no damage is caused to the root mass; thus every plant starts to grow immediately after planting.

4.4 Planting Tillers in Dibbling Tubes

During the 1970's the author introduced the use of dibbling tubes to grow fast growing nitrogen-fixing trees with considerable success. He recently advised the scientists at the Thailand Institute of Scientific and Technological Research to conduct an experiment on propagating vetiver in a dibbling tube, which is a cylindrical plastic tube of the size of 12 cm long and 3 cm diameter, with a 1 cm diameter opening at the lower end to allow excess water to pass through (Anusonpormperm *et al.* 2000). The tube is made of durable black polyethylene with three groves along its length to prevent coiling of the roots. The tube is filled with nutrient-enriched medium (compost mixed with slow-released fertilizer) and placed on aluminum tray with 80 holes to hold the tubes vertically. Each tray has four legs of 15 cm long at the corners. Thus the lower end of the tube is 3 cm above ground. This 'air pruning' effect makes it difficult for the roots of the young vetiver plant to reach the soil below, but remain stagnant until they actually reach the soil after field planting.

Vetiver tillers of the size of around 20-30 cm high are preferable since they are still small enough to be inserted in the opening end of the tube but large enough to produce roots from accumulated nutrient in the plant tissues. Tissue-cultured plantlets can also be used, especially after being established in a nursery for a few weeks. Normal nursery practices, such as shading, watering, and liquid fertilizer spray, are given to the vetiver tillers for about 8-12 weeks at which time the root mass will fully occupy the medium in the tube. When they are ready for transplanting in the field, sprinkle water to add moisture to the medium; this will also facilitate the separation of the root mass from the tube. When pulling it up, the whole mass (consisting of the medium and the root mass) comes up as a single, tightly-held piece in the shape of the tube. This can be packed in a carton of corrugated paper with plastic sheet lining and transported to the field site for transplanting.

Field planting is done by inserting a hole-maker into the ground. The apparatus is made of steel with three iron rods of the shape and size of the tube, spaced at 5 cm apart. When the hole-maker is pressed by foot into the soil, it makes three holes in one operation. Each hole is 12 cm deep. Such a depth is a perfect fit for the root mass of the tiller grown in the 12 cm-long tube to be in touch with the soil. In practice, one person makes the holes along the line while another person simply inserts root mass of the tiller into the hole. Once the root mass touches the soil in all direction, each root quickly grows in the soil. Survival rate is close to 100%, especially if grown in the wet season.

This method is highly recommended for areas which are difficult to reach such as on steep slopes since materials to be carried up there are light-weight cartons of vetiver root-mass (about 80 per carton) and the hole-making apparatus. After planting, there is no used polybags to collect and bring back. Corrugated cartons are reusable for several times; they can be folded flat to save space.

4.5 Planting Tillers in Other Containers and Biodegradable Nursery Blocks

A number of used containers such as soft drink cups, cans, etc. have been tried to hold medium for vetiver growth. It was found that although the growth of the vetiver planted in such containers was good and the cost of the containers is negligible, but there was a problem in transport of vetiver plants still in the containers as well as in pulling the whole mass in the containers up before planting in prepared hole; such operation is likely to damage the root system, causing death or poor growth of the newly planted vetiver tillers. This has led the Doi Tung Development Project in Chiang Rai and the Highland Land Development Office in Chiang Mai to try an alternative approach by producing biodegradable blocks from vetiver biomass (mainly leaves and culms). The blocks are made by a simple machine using manual labor or a small engine. They come in various shapes and sizes; the most common ones are cylindrical and cube. Important features include solid nature of the block with small hole at the top to facilitate insertion of the tiller in place. Once the vetiver plant is ready for planting, the whole block with vetiver plant is then placed in the prepared hole without having to pull the vetiver plant out from the block. The block, which contains considerable amount of nutrient and moisture, nourishes the vetiver plant both in the nursery and in the field. This approach is very adaptive to planting in critical areas such as on side slope of the highway or rail road, along the newly compressed ridged of the farm ponds or reservoirs, since the block slowly disintegrates while releasing plant nutrient to the growing vetiver plant. Such biodegradable block is also ecological friendly since it is made mainly of organic matter; and no 'garbage' of any kinds is left in the field as compared to polybag technique**.**

4.6 Planting Tillers in Pots made from Vetiver Leaves

Thiramongkol and Baebprasert (2000) experimentally produced pots from clay, dry vetiver leaves and binder (polyvinyl alcohol or 'Poval'). In one of their trials, they planted vetiver tillers in such 'vetiver' pots after the latter had been hardened for a while. These tillers in the 'vetiver' pots were placed across the slope of the plantation area of the Doi Tung Development Project, Chiang Rai, Thailand. All vetiver planted in this way has grown successfully. This work has demonstrated that it is possible to recycle the vetiver grass through the 'vertiver' pot to the vetiver grass again.

4.7 Using Growth Promoters in Tiller Propagation

Ho *et al.* (2000) tested three commercial brands of growth hormones and two levels of auxin plus minerals in shortening the growing period of vetiver. By soaking the tillers for 15-20 min in growth hormone solutions and immediately planted in the polybags, the growth rate of the vetiver tillers was found to have increased considerably and can potentially reduce the growing period by as much as 50%. The gain in shoot and root length in just three weeks was almost double that of the control (water). An auxin level of around 0.34 ppm was preferred since this amount did not appreciably inhibit root growth and yet produced a good enough shoot growth.

Bernal (2000) used bencil adenine purine (BAP) and naphthalene acetic acid (NAA) to induce adventitious bud development of vetiver cuttings. It was found that BAP at 500 and 1,500 ppm gave better result than the control treatment, while 10 cm cuttings with 500 ppm NAA and 20 cm cutting without NAA were the two best combinations. When different concentrations of NAA were combined with applied time, it was found that 500 ppm for 60 min gave the best result.

Techniques Commonly Employed in Vetiver Propagation

Planting bare-root tillers on raised beds for multiplication

Planting bare-root tillers in paddy field

Innovative Techniques in Vetiver Propagation

Explant (young inflorescence) held in fingers and tissue-cultured planlets grown in the bottle

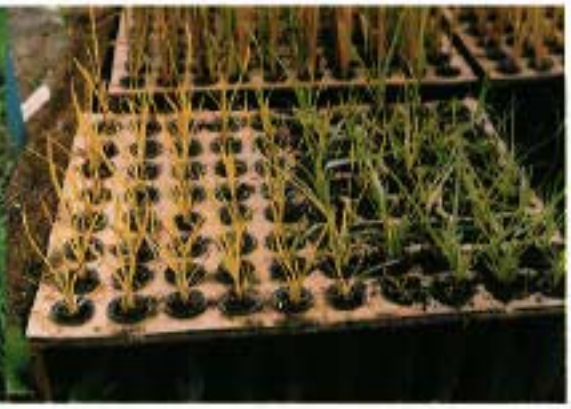
Tissue-Cultured Technique

Fully-grown plantlets in bottles ready to be taken out

Vetiver plantlets transplanted in a plastic tray

Tissue-Cultured Technique (Con't.)

Vetiver plantlets transplanted into small polybags



Vetiver plantlets transplanted into dibbling tubes

Planting with Specially-Treated Bare-Root Tillers

Preparing tillers for propagation/multiplication by trimming the roots to 5 cm and shoot to 40 cm

Bare-root tillers kept in moist medium for 3-4 days to induce root formation prior to field transplanting

Planting specially-treated bare-root tillers directly in the field for multiplication

5. USING OTHER PARTS OF VETIVER FOR PROPAGATION

In addition to the two most popular parts, the tillers and the tissue-cultured plantlets, vetiver can also be propagated from various other parts. Although not commonly employed in certain countries, e.g. Thailand, these parts are being used or experimented in some other countries. They provide alternative methods to propagate the vetiver plants. Brief information about these parts is presented below to complete the information on the general techniques of vetiver propagation.

5.1 Culm

A mature culm normally has several well-developed lateral buds borne at the nodes. Such culms can be used for propagation. Laying the culms on moist sand and keeping them under mist results in the rapid formation of shoots at each node. This is an effective way to propagate new plants from hedge trimmings (National Research Council 1993).

5.2 Cutting

As pointed out earlier, this term is probably the same as culm, and is referred to as cut culm or culm-cutting by Yoon (1991). National Research Council (1993) reported a case of a Chinese farmer who used cuttings with two nodes and planted them at 60° angle and then treated with indole acetic acid (IAA), a hormone, to induce root formation. Survival rate was up to 70%. An interesting fact was that the original stems were cut in December, buried in the ground over winter, then stem cuttings were taken from these in early spring and planted in April. In Malaysia, Yoon (1991) reported a case when vetiver clumps were cut back to 30-50 cm to encourage tillering, the cut-top included many culms; each culm had varying numbers of internodal buds which could be induced to sprout and produce new plantlets under mist. He was successful in inducing vetiver culm cuttings to sprout and produce new plants under mist spray by using three methods, namely: (i) burying in sand-bed for five weeks, (ii) rooting of individual node with leaf-sheath intact, and (iii) rooting of individual node with leaf-sheath slit. The first method with leaf sheath intact, removed, and slit, gave 23.2, 28.4, and 35.7% rooted, respectively. The second method at five and nine weeks gave 5.1 and 14.6% rooted, respectively. The third method at five, six, and eight weeks gave 31.4, 52.7, and 76.3% rooted, respectively.

5.3 Culm-Branch

To encourage tillering, vetiver clumps are repeatedly cut back (normally at the height of 30 to 50 cm from the ground). If the top part of the culm is more than 3 months old, the lateral buds will sprout to form shoots, the structure of which is called 'culm-branch'. It can be detached for multiplication. It produces good root systems under mist, and transplanting success into polybags is nearly 100% (Yoon 1991). When the vetiver plant is allowed to grow without topping it down, it will start to flower. Lateral buds on surface of flowering culm can be used to propagate vetiver, especially when large amount of planting material is needed and no other planting material is available nearby. The procedure includes the collection of flowering culms having numerous buds

on them and ripping off the buds and growing them in a nursery bed until they are about 15 cm in height. Then they can be used to grow in polybags or other containers before field planting.

5.4 Clump

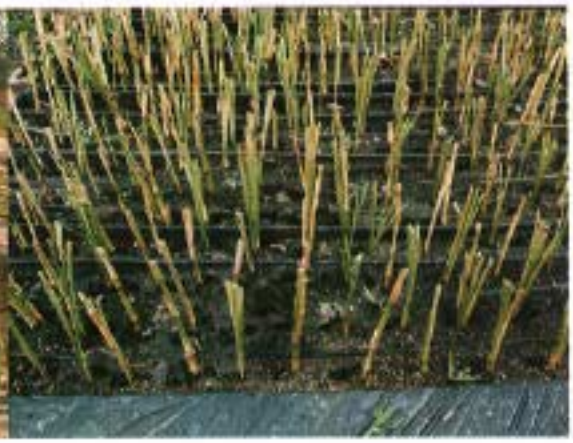
When a vetiver plant is mature enough, it will produce numerous tillers in all directions, forming a ‘clump’ consisting of culms growing close together. The whole clump can be transplanted in the field, or, to increase the number first, separated out into individual tillers. As it is rather luxury to use the whole clump instead of separating it into individual tillers, and also consumes more labor, it is not advisable to use this method.

Strip-planting Technique

Preparing beds for strip planting using bamboo poles placed 10 cm apart and lined with plastic sheet

Planting bare-root tillers in prepared beds

A view of vetiver propagating plot with sprinkle irrigation



A close-up of tillers planted in strip

A 1-m strip of vetiver tillers uplifted for transplanting

Strip with medium removed to show root development

Dibbling-Tube Technique

Aluminum tray to hold 80 dibbling tubes Tillers planted in dibbling tubes Hole-maker apparatus

Vetiver grown for 8 weeks in dibbling tubes; removed from dibbling tubes to show medium held by root mass
Above - with medium, Below - medium removed; Left - bare-root tillers, Right - tissue-cultured plantlets

Using Containers for Propagation

Soft drink cups can be used as containers for vetiver propagation (as used by a school project)

Biodegradable nursery blocks made of vetiver biomass. Vetiver tillers planted in biodegradable nursery blocks

Pots made from vetiver biomass can be used as containers to grow vetiver tillers

6. DISCUSSION

The present document provides up-to-date information of the various techniques of vetiver propagation employed in Thailand as well as in some other countries. It is up to the manager of the project to select which one he wants to employ in his project, and how it is accomplished to obtain the best result. The following paragraphs provide the guidelines in choosing the techniques to be used in propagating vetiver and also the ultimate goals in vetiver propagation.

6.1 Guidelines to Choose the Techniques of Vetiver Propagation

The various techniques of vetiver propagation presented above are an asset for those who are working on the transfer of technology of planting the vetiver grass to the farmers or other users. The followings are the guidelines for the users to choose which one they want to employ:

- **Availability of the mother plants**
- **Availability of the facility**
- **Availability of the techniques**
- **The demand of vetiver planting material**
- **The distance to transport**
- **The terrain in which the transplanting is to take place.**

6.2 Goals in Vetiver Propagation

Vetiver is easy to propagate at a relatively low cost. Under normal conditions, propagation by using tillers grown in small polybags will give satisfactory results. However, it has certain disadvantages such as being labor intensive, high weight per plant ratio, and may create environmental problem if polybags are not collected after field planting. Thus other alternative techniques of propagation, e.g. using bare-root tillers, growing tillers in other types of containers, or using tissue-cultured plantlets, may be of some advantages. Non-conventional parts may also be used in propagation in certain special conditions. These methods are by far much cheaper than if they were to be multiplied by tissue culture method. However, once the principal source for multiplication is established, the normal method of tiller planting should suffice. It is therefore very important to set the goals in propagating vetiver before the operation is started. The following goals are the criteria for the manager of the project to choose appropriate techniques for vetiver propagation.

6.2.1 Quality Planting Materials: One of the major goals in propagating vetiver is to produce only high-quality planting material. Remember that only high-quality planting material should be used in transplanting in the field. High quality includes healthy and vigorous growth. Poor-quality planting materials will result in slow growth or even death of the transplanted tillers. Even re-planting may be possible at a later date, this will not be as good as when every tiller survives and performs its function the moment it was transplanted.

6.2.2 Low Cost: Efficient nursery management will reduce extra cost of propagating vetiver. However, from a planning perspective, high input approach should be aimed at, especially to produce good quality planting material mentioned above. Nevertheless, especially in large-scale propagation, economic consideration should be of prime importance. The economies of scale and inputs will help to solve the problem considerably since the bigger the operation the cheaper the unit cost of production. The returns to production for a given input will often more than pay for

vetiver needs some inputs like water, nutrient, light, etc. It will not grow if no water is provided. Similarly it cannot grow well if it has no nutrient upon which to draw. It cannot compete with weeds or animal grazing. It also needs subdue sunlight for its early growth in the nursery, and brighter sunlight at a later stage, especially during the hardening period (see later).

6.2.3 Hardiness: **By its nature, vetiver is a tough plant. However, during its early stage of growth as propagating material grown in any form of containers, it is rather weak, especially when subject to long transportation through rugged terrain in the hot sun before being transplanted. Thus planting material should be durable in the sense that it will withstand such conditions without severe setting back. Since such material is aimed at planting in the field exposing to strong sunlight, a young propagating plant kept in shady nursery for a long time, for example, will not be able to withstand exposure to strong sunlight immediately after transplanting. A period of hardening or acclimatization, i.e. exposure to sunlight, prior to field planting is needed.**

6.2.4 Being Easy to Transport: **Containerized-planting material is considered most practical. However, it would be quite difficult during transportation if the container is large, and planting medium is bulky and/or heavy. Trays to hold polybags or other containerized planting materials should also be lightweight, small volume and easy to handle. A one-way transport, like the use of strip planting, biodegradable nursery blocks, dibbling tubes (tubes removed and retained), etc. has the advantage in that no containers and other materials are to be collected and returned to the nursery for re-use or throwing away.**

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