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Techniques of Vetiver Propagation in 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 intensiveness in operating and maintenance, difficulty in transportation, and creating environmental problem in field planting. Using tillers as planting material, many other methods have been invented in Thailand. They can be grouped into two systems. 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 or raised bed). 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 culture 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 easy to transport.

Keywords: *Propagation, multiplication, tiller, bare-root tiller, biodegradable, strip planting, dibbling tube, tissue culture, plantlet, explant, transplanting, polybag.*

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 develops 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 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 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.

Propagation *vs* Multiplication

There are a few terms that are used to describe the mode of reproduction of vetiver. The two most common terms are *'propagation'* and *'multiplication'* that are sometimes 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 *any means of reproduction to increase the number of individuals, either for solely increasing the number of individuals or for planting out in the field,* while multiplication is *any means of asexual reproduction solely to increase the number of individuals.* It implies 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.

Vetiver Parts Used in Propagation

As mentioned earlier, vetiver in cultivation rarely produces seeds. Thus, only asexual reproduction will be treated in this paper. The parts of the vetiver plant that can be used in propagation, together with their definitions (written in *italics*), based on Webster's New World Dictionary (Third College Edition), are given below:

- ***Tiller:*** *A shoot growing from the base of the stem of a 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:*** *A stem, root, twig, etc. cut or broken off a plant and used for planting or grafting; cutting; scion.* Many authors used this term synonymously with tiller. Based on the definition of *'a stem cut or broken off a plant'*, the part that is referred to as *tiller* may also be called *slip*, although it does not give the true meaning of the term. To avoid further confusion, the present paper will not use this term as its meaning is not quite the same as *tiller*.
- ***Culm:*** *A stalk, stem; the jointed stem of various grasses, usually hollow.* The vetiver culm is strong, hard, and lignified, having prominent nodes that can form roots, which is one of the ways the plant uses to rise when it get buried. A mature culm normally has several well-developed lateral buds borne at the nodes. Such culms, which should be cut off to keep the vetiver clump in healthy condition, 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 (NAS 1993).
- ***Culm-branch:*** (There is no definition of such a term in Webster's Dictionary.) If the culm is mature and starts to produce flowers, lateral buds on the upper part of the culm will develop into shoots with many roots. Such structure is called *culm-branch* that can be detached for propagation. It produces good root systems under mist, and transplanting success into polybags is nearly 100%.
- ***Cutting:*** *A slip or shoot cut away from a plant for rooting or grafting.* This term is synonymous with 'cut culm' or 'culm-cutting'. Although commonly used as propagating material in horticultural crops, cutting is rarely used in vetiver. However, a case has been reported by NAS (1993) that a Chinese farmer used original culms which were cut in December, buried in the ground over the winter, and cuttings, which sprouted from buried culms, were obtained in early spring and planted in April.
- ***Ratoon:*** *A shoot growing from the root of a plant that has been cut down.* Like sugar cane, its close relative, vetiver can be cut to the ground and left to re-sprout. However, the operation is more laborious than obtaining tillers since it requires digging from deeper soil level than tillers, and the materials are not as vigorous as tillers.

- ***Tissue Culture Plantlet:*** *Differentiated tiny plant developed through tissue culture technique.* (This definition is not from Webster's Dictionary.) Unlimited number of plantlets can be produced in aseptic condition from the explants such as shoot tip, lateral bud, young inflorescence, etc. Upon attaining a good size, these plantlets can be planted in containers or fields similar to tillers.
- ***Clump:*** *A cluster, as of shrubs or trees.* In vetiver, a clump is formed when a plant produces numerous tillers in all directions. The whole clump can be transplanted in the field or separated out into individual tillers.

Propagation Techniques Commonly Employed in Thailand

Conventionally, vetiver in Thailand, as in any other countries, is propagated by growing tillers in a small polyethylene bags (commonly called polybags) for 45 days or more before field planting. The medium used is one part top soil 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 addition to the above, Thai vetiver scientists have also developed many other techniques of vetiver propagation, either through the use of tillers with diverse methods, or through the use of plantlets produced by tissue culture technique with diverse methods. The following sections summarize all the techniques of vetiver propagation developed and employed in Thailand.

Using Tillers

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. Several methods of using tillers to propagate the vetiver plant are employed in Thailand. These are:

♦ ***Planting in Polybags:*** Planting vetiver in polybags is both clean and easy to maintain; however, it requires proper tools for watering and caring. Depending on the size of the polybags and the objective, two types of polybag propagation are known, namely small polybags for field planting, and large polybags for multiplication.

Small polybags for field planting: This method is appropriate to use 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 polybags is about 5 cm wide and 15 cm long, with a diameter of 7 cm when filled with soil. Several larger sizes are also available. 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.

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.

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

- *Expensive:* This includes the costs of polybag, medium (top soil 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 every day requires labor input and good source of water.

- *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 vetiver plant out, but instead, leave them there in the field, thus creating environmental problem.

- *Demand-Supply Problem:* In many cases, the demand for vetiver planting material is not in line with the supply. Sometimes a large number of polybags with vetiver is available at the multiplication center but no one requests for them. 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).

- *Labor Intensiveness:* Starting from procurement of medium (top soil and compost), cutting the edges of the polybags, filling the medium into the polybag, preparing the tillers, planting the tillers in the polybags, placing 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.

♦ ***Planting in Cultivated Land for Multiplication:*** For multiplication purpose, vetiver can be planted not only in the large polybags, but also directly on the cultivated plots. In Thailand, this is normally employed in the government-owned vetiver multiplication centers, such as the Land Development 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.:

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 50x50 cm. However, to make it easier for caring and maintenance, six rows of a 50x50 cm spacing are planted alternating with the walking space of 1 to1.5 m. The 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.

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 gives 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 50x50 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.

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.

Caption for photo at right:

1: Planting vetiver tillers in small polybags. 2: General view of a vetiver propagation nursery. 3: Vetiver tillers planted in small polybags ready for transplanting. 4: A group of pupils earning income for school lunch program by propagating vetiver for sale. 5: A few weeks after transplanting, vetiver tillers grow well on raised beds. 6: A view of full-grown vetiver tillers planted for multiplication on raised beds. 7: The making of biodegradable nursery blocks made from vetiver biomass. 8: Vetiver tillers planted on biodegradable blocks.







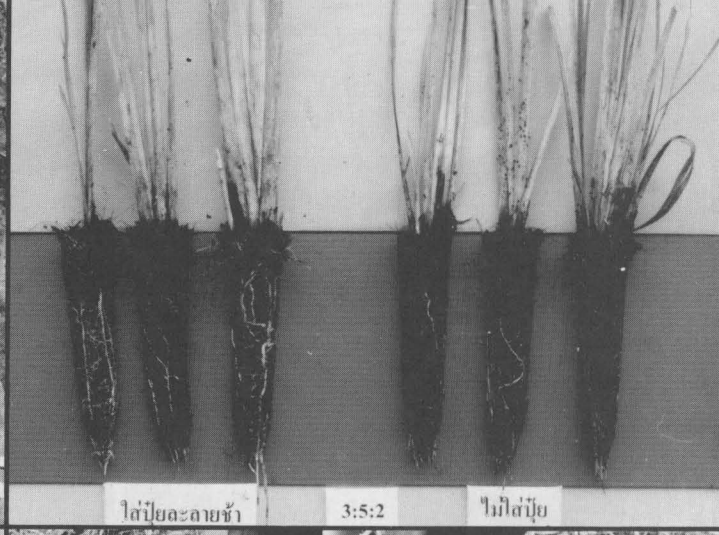



Photo caption

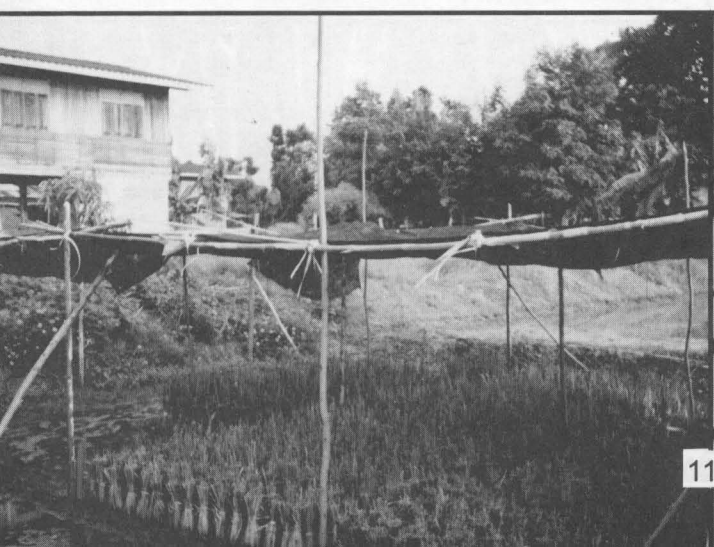
9: A view of propagating bed, consisting of trays, each with 8x10 (80) holes, placed with dibbling tubes containing vetiver tillers. 10: Tillers of vetiver planted in dibbling tubes (removed to show medium to compare the amount of roots provided with and without slow released fertilizer. 11: A tiller planted in dibbling tube showing root mass after medium has been washed away; note effect of air pruning on root growth at the bottom. 12: Making three holes in one operation. 13: Hole-making apparatus having three iron rods of the shape and size of the dibbling tubes. 14: Holes spaced at 5 cm apart made by hole-making apparatus. 15: Placing vetiver tiller root mass (removed from dibbling tube) in prepared holes.

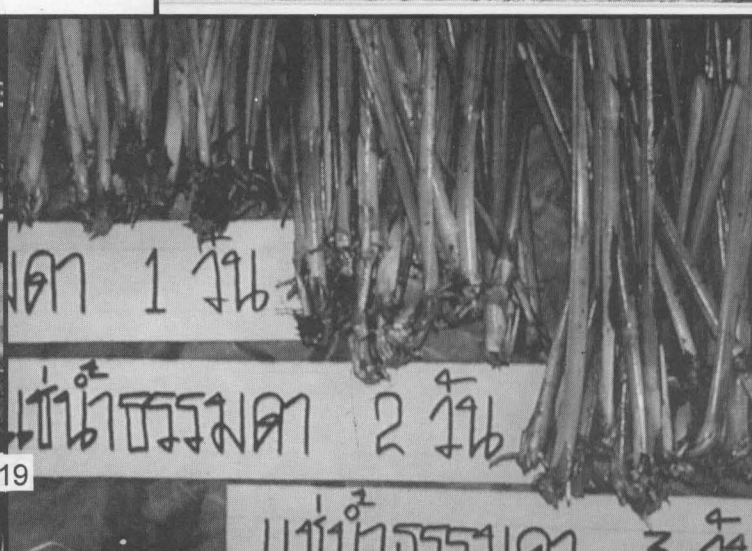
Photo caption

16: Vetiver plantlets grown in tissue-cultured bottles. 17: Close-up view of bottles containing vetiver plantlets ready to be transferred. 18: Her Royal Highness Princess Maha Chakri Sirindhorn is transferring vetiver plantlets from the tissue-cultured bottle to a small polybag.

Photo caption

19: Bare root tillers with roots trimmed, tied in bundle, ready for immersing in water for 3-4 days before transplanting. 20: A nursery for keeping bare-rooted vetiver tillers immersing in water to stimulate root formation. 21: Bare-root tillers kept in water for 1, 2 and 3 days; *note* root formation at 3 days.





♦ ***Using Bare-Root Tillers for Field Planting:*** A new techniques 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 as with using polybag technique. It is quite convenient and economic since it does not require polybags, medium, and maintenance. As compared to the polybag method, transportation cost to the site of planting is much less.

♦ ***Growing Tillers in Strips for Field Planting:*** The Khao Hin Son Royal Development Study Center (1998) recently 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 as the roots are not disturbed as in the case of using polybags. It is also environmental friendly since no waste material (used polybags) is left in the field.

The facility includes two rows of cement blocks (each is 20 cm high, 30 cm long and 4 cm thick) placed at a distance of 1.3 m apart and any length depending on the length of the area. 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 2 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.

♦ ***Growing Tillers in Dibbling Tubes for Field Planting:*** Scientists at the Thailand Institute of Scientific and Technological Research conducted an experiment of 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.* 1999). 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. 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.

Caption for photos at left

22: Steel rods placed crosswise (1 m wide) on nursery-bed ridges made of cement blocks. 23: Black plastic-sheet lining over steel rods being pushed down to hold planting medium made of 1:1 burnt rice husk and sand. 24: A view of the nursery filled with planting medium (in the background). 25: Planting tillers in the narrow strips between the two steel rods. 26: A nursery bed planted with vetiver tillers along the strips. 27: A view of the strip-propagating nursery equipped with sprinkle irrigation. 28: A 1-m strip of vetiver mass ready for transplanting in one piece. 29: A 1-m strip of vetiver mass after planting medium is washed off to show interconnecting root mass.

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 dibbling tube. This can be packed into a carton of corrugated paper with plastic sheet lining (to prevented spoilage of the carton) 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 exactly 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. No wonder that 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.

♦ ***Growing Tillers in Biodegradable Nursery Blocks:*** A number of used containers such as soft drink cups 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. 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 all kinds is left in the field as compared to polybag technique.

Using Tissue Culture Plantlets

As micro-propagation through tissue culture technique is quite well developed in Thailand, such a technique has now been implemented in a few laboratories such as the Doi Tung Development Project (Charanasri *et al.* 1996), Kasetsart University (Namwongseprom and Nanakorn 1992), and the Land Development Department (Sukkasem and Chinnapan 1996).

♦ ***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.

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 (Namwongseprom and Nanakorn 1992). The Department has been producing tissue culture 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).

Young inflorescence: The Doi Tung Development Project has succeeded in propagating vetiver plantlets using meristematic tissue of the inflorescence and culture it in aseptic condition. 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).

♦ ***Transplanting of Plantlets:*** Plantlets can be transplanted to various containers and fields:

Transplanting plantlets to the 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 of 7 cm during the dry season and 10 cm during the rainy season. Press the 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.

Transplanting plantlets into the 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 60-90 days (after transplanting), or 20 cm tall, they are ready to be transplanted in the field.

Transplanting plantlets 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.

Transplanting plantlets into other containers: Similarly, the 60-90 days old plantlets can also be transplanted in strips, dibbling tubes, or nursery blocks. In fact, plantlets obtained from tissue culture technique have an advantage over tillers as they are small in size which fit well in small structures of the dibbling tubes and nursery blocks.

Discussion

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. growing tillers in other types of containers, or using tissue culture 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 propagation of vetiver before the operation is started. The following goals are the guidelines for the manager of the project to make decision in the choice of techniques to be used in propagation:

Quality Planting Materials

One of the major goals in propagating vetiver is to produce only high quality planting material. High quality includes healthy and vigorous growing plant material. It is advisable to throw away any plant that does not look good rather than to give to other people because it can cause frustration, extra labor, and disappointment to the end user.

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 earlier. 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 themselves.

Input and material savings can be tremendous. However, being a living organism, 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.

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.

Easy to Transport

Containerized planting materials are considered most practical. However, it would be quite difficult during transportation if the containers are large, and planting medium is bulky and/or heavy. Trays to hold polybags or other containerized planting materials should also be light weighted, 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 material is to be collected and returned to the nursery for re-use or throwing away.

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