

**The Utilization of Vetiver
as Medicinal and Aromatic
Plants
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 systems, 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, and "Vetiver Grass for Slope Stabilization and Erosion Control" by Diti Hengchaovanich. In 1999, three technical bulletins were published, namely "Vetiver Handicrafts in Thailand" by the (Thai) Department of Industrial Promotion, "Vetiver Grass Technology for Mine Rehabilitation" by Paul Truong, "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. In 2000, one technical bulletin was published, namely "Techniques of Vetiver Propagation with Special Reference to Thailand" by Narong Chomchalow. The present bulletin, "The Utilization of Vetiver as Medicinal and Aromatic Plants with Special Reference to Thailand", is the first one for the year 2001.

One of the problems in promoting vetiver as a player in soil and water conservation is the lack of direct benefit that the farmers could obtain from growing vetiver hedgerows. As an ancient crop, vetiver has been utilized traditionally as medicinal and aromatic plants in many countries long before its use in soil and water conservation was realized in the late 1980s. The author, who is one of the first Thai scientists who studied the vetiver since the 1970's, has done extensive investigations on growing vetiver for essential oil production. With his interest in medicinal and aromatic plants as is evident from his role as the Executive Secretary of the Asian Network on Medicinal and Aromatic Plants as well as the Chairman of the Essential Oil Committee of the Thai Industrial Standards Institute, he places special interest in the utilization of vetiver as medicinal and aromatic plants while working in various capacities on vetiver networking. The present paper, entitled "The Utilization of Vetiver as Medicinal and Aromatic with Special Reference to Thailand", is a compilation of the information on the subject 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, Dr. Narong Chomchalow, and to Dr. Samran Sombatpanit who helped tidying up the manuscript voluntarily. It is hoped that this publication will be of some value to extension officers and others in the field of transfer of technology, to pass on this information to the farmers and other vetiver users to encourage them to grow vetiver as an income-generating crop in addition to growing it for soil and water conservation (which is the ultimate objective of growing vetiver), so that they are able to earn extra income. Social benefit in using vetiver as traditional medicine and as raw material for botanical pesticides, as well as in the production of flavor and fragrant materials for their household uses, or to earn extra income, is also envisaged.

Sumet Tantivejkul
Executive Secretary, Pacific Rim Vetiver Network

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The Utilization of Vetiver as Medicinal and Aromatic Plants With Special Reference to Thailand

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Abstract

Vetiver is a tall, tufted, perennial, scented grass with a straight stem, long narrow leaves and a lacework root system that is abundant, complex and extensive. Vetiver has versatile uses, particularly as an inexpensive yet effective and eco-friendly tool to combat soil erosion. Medicinal and aromatic plants (MAP) are two related groups of plants having in their part chemical constituents which are active in curing ailments (i.e. MP) or in providing flavors and/or fragrances (i.e. AP).

Vetiver has traditionally been utilized as MAP since ancient times, particularly in India, Indonesia, Pakistan, Senegal, Sri Lanka and a few other countries as well as in Thailand. This paper describes potential utilization of vetiver, both as MP and AP. It also highlights the utilization of vetiver as MAP in Thailand that includes the utilization of vetiver in traditional medicine, in pest control, and as fragrant materials. Research on production of vetiver oil and the R&D on industrial potential of vetiver as aromatic plants in Thailand are also described. It ends with the discussion on the main objective of planting vetiver, environmental implication, socio-economic aspects, and industrial potentials.

Keywords: *Vetiver, medicinal plant, aromatic plant, essential oil, vetiver oil, traditional medicine, aromatherapy, botanical pesticides, insecticides, acaricides, industrial potentials.*

2. INTRODUCTION

2.1 What is Vetiver?

Vetiver is a tall, tufted, perennial, scented grass, with a straight stem, long narrow leaves and a lacework root system that is abundant, complex, and extensive. It offers an inexpensive yet effective and eco-friendly tool to combat soil erosion. The roots have been used in Asia for centuries for their fragrance, and are woven into aromatic matting and screens. The roots of some cultivars and ecotypes possess essential oil that has been utilized as fragrant material since ancient times. The plant also contains active ingredients used in traditional medicine and as botanical pesticide.

2.2 What are Medicinal and Aromatic Plants?

Medicinal and aromatic plants (MAP) are two related plant groups that have in their chemical constituents that are either active in curing ailments (i.e. MP) or provide flavor and/or fragrances (i.e. AP) (Chomchalow 2000). Generally speaking, MAP are distinct enough to be classified into two different categories, if the main uses are taken into consideration, viz.

1.2.1 Medicinal Plants: These plants possess active ingredients used mainly in preventing or curing ailments. They may, and usually do, have other properties which permit them to be used as botanical pesticides, preservatives, incenses, herbal teas, herbal drinks, natural dyes, spices, etc. (Chomchalow 2000).

1.2.2 Aromatic Plants: These plants possess aromatic compounds used mainly as flavors (e.g. in spices and herbs) and fragrances (e.g. in perfumery, cosmetics, soaps) (Chomchalow 2000). However, from ancient times, these plants have also been used as raw materials for cosmetics, pharmaceuticals, botanical pesticides, disinfectants, insect repellents, herbal teas, herbal drinks, etc.

3. THE VETIVER OIL

2.1 Production of Vetiver Oil

Spongy root mass of certain cultivars of *Vetiveria zizanioides* contains trace amount of essential or volatile oil, known as vetiver oil or 'khus oil', which can be extracted by steam distillation. The dried roots, after washing and drying, can be distilled immediately, or are stored for 12-24 months so enzymatic process can increase oil yield (Dowthwaite and Rajani 2000). The process of distillation consists of soaking the root mass prior to packing in the distillation unit, and steam is allowed to pass through for a period of six hours or more. The steam distillation produces around 0.3-1.0% of oil although higher percentages can also be obtained. A resinoid is also produced by solvent extraction for perfumery work.

Commerce vetiver oil is mainly produced in China, India, Indonesia, Haiti and Reunion. The principal constituents include vetiverol, vetivone, khusimone, khusitone, terpenes (e.g. vetivenes), and sesquiterpenoids. Its chemical compounds were reviewed by Fuehrer (1970) and more extensively by Virmani and Datta (1975).

Indonesia, particularly Java, is the leading producers of vetiver oil in spite of the fact that people are convinced that vetiver actually causes soil erosion, if planted on the slope (Prayogo 1998). This is because harvesters often dig out the roots, leaving behind trenches that triggers severe soil losses. Such a problem results in the prohibition of vetiver cultivation in many parts of Java (National Research Council 1993). It is largely grown in the loose rich volcanic soils near Garut in West Java. Distillation is long and involves high pressure using water and steam distillation method. In Indonesia, oil from stainless steel vessels has a lighter color than oil from carbon steel tanks. In terms of volume, vetiver is the leading essential oil exported from Indonesia, with over 1,000 tons being exported in 1992, and is said to be competitive with the one produced in Haiti. However, the typical Indonesian product is sometimes discounted in the international market due to its having a 'smoky burnt' character (www/benzalco.com/vetiver/vetiver_page.html). The best type of vetiver oil is believed to come from Reunion Islands.

Planting vetiver grass and followed with a rigorous harvest of the roots could substantially affect soil erosion. Therefore, vetiver planting has been banned in some countries such as Indonesia. This has reduced the supply of vetiver oil such that its price has increased many folds during the past decade.

2.2 Properties of Vetiver Oil

Vetiver oil is a light to dark brown, olive, or amber viscous oil having a deep smoky, earthy-woody odor with a sweet persistent undertone. The color and scent can vary according to the source. For example, Angola produces very pale oil with a dry-woody odor. Poorer grades with darker color and have smoky backnotes are also produced in China and Java by subsistent farmers with primitive equipment (Dowthwaite and Rajani 2000).

Vetiver oil has a rather powerful smell but is very pleasant when diluted (Curtis 1996). It blends well with oils of sandalwood, rose, violet, jasmine, opopanax, patchouli, oakmoss, lavender, clary sage, mimosa, cassia, and ylang ylang (Lawless 1995). It is a high-priced oil as it is used extensively

1924). It is used exclusively in the preparation of compound perfumes, in which the oil, on account of its low volatility, is normally used as a base to fix other high-value volatile oils like rose oil, lavender oil, and jasmine oil.

Vetiver roots do not yield their oils easily because the essential oils are located inside hard-to-reach root tissues. To be extracted, these oils must diffuse (which is a relatively slow physical process) from inside fibrous root tissues outward to the surface. Furthermore, vetiver oil consists of a high percentage of sesquiterpenes (which have high molecule weights with low vapor pressures), which also contribute to the long extraction times needed. The most valuable fractions of vetive oil have the highest boiling points and constitute the high specific gravity oil portion, and characteristically pass through the condenser in greatest volume late in the distillation. These fractions are rich in vetivones and vetiverol (http://www.benzalco.com/vetiver/vetiver/_text.html).

Vetiver oil has been utilized as raw material for various fragrant products such as perfumes, deodorants, lotions, soaps, etc. In addition, vetiver oil plays an important role in aromatherapy.

In “Wilkes Priceless Recipes - a valuable collection of tried formulas and simple methods for people in every department of human endeavor:, under the heading “toilet articles”, there is the recipe for vetiver essence as follows: “Two pounds of the root of vetiver (cut small), moisten with a little water, macerate for 24 hours, then beat in a marble mortar, macerate in sufficient alcohol to cover for 8 or 10 days, and strain with pressure; filter through paper and in a fortnight repeat the filtration.” (Pease 2001).

Upon further separation, vetiverol, its main alcohol, can be acetylated to produce vetiveryl acetate having slightly stronger silky fruity-green-woody nuances. It is irreplaceable in the bottom notes of ‘Haute Couturier’ fragrances. Vetiver oil and its various derivatives are used in the following perfume brands: Guerlain’s ‘Vetiver’, Chanel’s ‘Coco’, Christian Dior’s ‘Miss Dior’, Yves St. Laurent’s ‘Opium’, Givenchy’s ‘Ysatis’, among others (Dowthwaite and Rajani 2000).

In addition to being used as a fixative in fine perfumery, vetiver oil is also used as a fragrance ingredient in soaps, cosmetics and perfumes, especially oriental types. In food, it is used to flavor sherbet and as food preservatives, especially for asparagus (National Research Council 1993).

2.3 Therapeutic Role of Vetiver Oil

The main action of vetiver oil is on the nervous system and it is both sedating and strengthening in effect. It is excellent in the treatment of depression, nervous tension, *debility**, *insomnia* and many stress-related diseases, and acts as an *aphrodisiac* where there is a clear connection between impotence or frigidity and stress. It may be used in massage blends and the bath; it has a rather powerful smell but is very pleasant when diluted. It stimulates the circulatory system and makes a useful massage oil for elderly or debilitated people with poor circulation. It also helps to stimulate the production of red blood cells and is thus beneficial for *anemia*. It makes a useful warming and pain-relieving rubbing oil, suitable for deep massage of muscular aches and pains, sprains, stiffness, rheumatism and arthritis. It may be added to sports oil blends and massaged into muscles before and after sports. In skin care, it helps to balance the secretion of sebum. It is also a useful antiseptic and is slightly stringent. It is used in lotions, compresses and baths for the treatment of oily skin, acne and weeping sores (Curtis 1996).

Vetiver oil revitalizes the body by fortifying the red blood corpuscles crucial in transporting oxygen to all parts of the system. Increased blood flow could alleviate muscular aches and pains and said to be useful in cases of *rheumatism* and *arthritis* (Sellar 1992).

Shealy (1998) advocates that vetiver oil is particularly useful for jet lag, and for grounding and clarity while traveling. His description on the use of vetiver oil for jet lag therapy is as follows: “Use as a base, 2fl oz (60 ml) apricot kernel oil. Add 5 drops of vetiver oil, 5 drops of geranium, and 2 drops of juniper or grapefruit oils. Apply this mixture liberally all over your skin before

may also carry a damp washcloth to which the oils have been added. If you are flying, the flight attendant may heat the washcloth in a microwave for you. Shower or bathe upon arrival and reapply the oils.” The fact that vetiver oil is good for jet lag, and for grounding and clarity while traveling has also been confirmed by Criss Juliard (pers. comm.) that he keeps a small vial of vetiver oil in

* *The meaning of this and other pharmacological terms, written in italics, is described in the “Glossary of Pharmacological Terms” given at the end of the text.*

his brief case, and applies it under his nose before, during and after long trips, and it works for him!

Vetiver oil is helpful during emotional stressful times, and has been used as a tonic for women suffering post-menstruation syndrome. In Sri Lanka and India, it is known as “the oil of tranquility”. The recipe for tranquility bath oil is to “add 2 drops of vetiver (oil), 2 drops of lavender (oil), 4 drops of rose (oil) to 2 teaspoons (10 ml) of sweet almond oil. Add to a running bath and disperse with your hands. Relax for at least 10 minutes” (Shealy 1998).

In Ayurveda, vetiver oil reduces ‘Vatha’ and increases ‘Pitta’ and ‘Kapha’ (Shealy 1998). It is valued most for its *sedative* properties. It is used in massage and in baths to relieve stress, anxiety, nervous tension and *insomnia*. It also helps to ground people who live too much in their head, or who need to feel stable after shock or a period of insecurity. It is a stimulant and *rubefacient*, so it can provide relief from *arthritis* or *rheumatism*, and general muscular aches and pains. It is useful in skin care as an *antiseptic*, *tonic*, and detoxifier.” Shealy (1998) continues to say that vetiver oil “helps to clear *acne*, and because it promotes skin regeneration and strengthens the connective tissue, it assists with wound healing and benefits aging skin.”

The many uses of vetiver oil in aromatherapy can be appreciated from the following statement quoted from http://tntn.essortment.com/whatisvetiver_rtco.htm: “In today’s aromatherapy vetiver has many uses. Vetiver is used to strengthen the red blood cells and promotes oxygen throughout the body. Vetiver is often used to alleviate the symptoms of *rheumatism*, *arthritis* and muscular aches such as muscle pain, sprains, and joint and muscle stiffness. It also aids the reproductive system; it is used to promote fertilization of the female egg. Vetiver is also useful for the skin, it can be used to alleviate the *inflammation* of *acne*, aids in healing of cuts, and it reduces oil in the skin. Vetiver is not toxic and nonirritant; it is great for the skin for sensitive and older skin.”

Vetiver oil is believed by Sellar (1992) to be a tonic to the reproductive system. Furthermore, its relaxing quality may have some effect on tension arising from sexual problems.

2.4 Pesticidal Role of Vetiver Oil

Vetiver oil is known to repel insects; people in India and elsewhere have placed vetiver root among their clothes to keep insects away (http://tntn.essortment.com/whatisvetiver_rtco.htm). It also repels flies and cockroaches and may make a useful ingredient in insect repellents (National Research Council 1993). It has been used to repel moths (Sealy 1998). The two tricyclic sesquiterpenoids – zizanal and epizizanal – isolated from vetiver oil show insect repelling activity (Jain *et al.* 1982). Maistrello and Henderson (2001) were of opinion that some of the components of vetiver oil, such as nootkatone – a sesquiterpene, which has been found to repel and even kill termites, may have important industrial applications, as insecticide or insect repellent, or eventually, other products may be developed.

It also has some anti-fungal properties (Dikshit and Hussain 1984).

AS MEDICINAL AND AROMATIC PLANTS IN DIFFERENT COUNTRIES

Vetiver is well known for its extensive fibrous root system. The larger its root volume, the better is the capacity to conserve soil and soil moisture. Besides, larger root volume will also ensure higher root yield that has multiple economic value including that related to aroma and essential oil. Vetiver's essential oil also plays a big role in traditional medicines as well as in pest control.

In traditional medicine, it has the following therapeutic actions: *diaphoretic*, *antiseptic*, *antispasmodic*, *depurative*, *rubefacient*, *sedative*, *stimulant* (circulatory, production of red corpuscles), *tonic*, and *vermifuge* (Lawless 1995).

The following paragraphs discuss traditional utilization of vetiver as medicinal and aromatic plants (MAP) in different countries including India, Indonesia, Pakistan, Senegal, Sri Lanka, and a few other countries. Traditional utilization of vetiver as MAP in Thailand will be discussed in detail in subsequent sections.

3.1 India

Being native to India, vetiver has found its utilization as MAP for several centuries.

4.1.1 As Medicinal Plant:

3.1.1.1 In Traditional Medicine: Various tribes use the different parts of vetiver for many of their ailments such as a mouth ulcer, boils, *epilepsy*, burns, snake bite, scorpion stings, *rheumatism*, fever, headache, etc. The Santhal tribe of Bihar and West Bengal use the paste of fresh roots for burns, snakebite and scorpion stings; *decoction* of the roots has been used as *tonic* for weakness. The Lodhas of West Bengal region use the root paste for headache, *rheumatism* and *sprain*; the stem *decoction* is used for urinary tract infection. The tribals of Mandla and Bastar of Madhya Pradesh use the leaf juice as *anthelmintic*. It is also used for boils, burns, *epilepsy*, fever, scorpion sting, snakebite and mouth sore. Root extract is used for headache and toothache. The tribals of Varanasi inhale the root vapor for malarial fever. The root ash is given to patients for acidity by the Oraon tribe. Likewise, there are many different applications of the plant for different ailments among different ethnic tribes in other parts of India (Jain 1991; Singh and Maheshwari 1983).

Local application of leaf paste for *rheumatism*, *lumbago* and *sprain* gives good relief. The dried roots are also used to provide fragrance to linen clothes (Rao and Suseela 2000).

Sastry (1998) mentioned about his father who used vetiver roots as one of the main ingredients of an ayurvedic medicine to successfully redress childlessness of women due to disorder of the uterus, while Rao and Suseela (2000) appraised vetiver oil as *stimulant*, *diaphoretic* and *refrigerant*.

3.1.1.2 In Pest Control: Singh *et al.* (1978) advocated that vetiver oil could be utilized as anti-bacterial and anti-fungal agents to combat agricultural pests. The powdered root, used in sachets, protected Indian muslin from moths and insects (Sellar 1992).

3.1.2 As Aromatic Plant: The bulk of the very sweetly-scent roots are used for cooling purposes and for the extraction of essential oil. A pleasant aroma is released from the vetiver root dug from the soil and hanged in the shade (Singh and Meheshwari 1983). In the hilly regions of Karnataka, people made use of the roots to prepare refreshing drinking water (Sastry 1998). Vetiver oil is utilized in perfumery, cosmetics and soaps, and for flavoring sherbets (Rao and Suseela 2000). The dried roots are also used to give fragrance to the linen clothes. The root mass of the vetiver plant is used as a blind to cool down the heat of the summer, a common practice in northern India. The blind is woven from the wiry, fibrous root of vetiver. The vetiver blind is continually doused with water throughout the day, turning the very wind that can dehydrate a person walking in the sun, into a scented cooling breeze, which passes through the soaked vetiver blind, releasing a bitter-sweet aroma. An

summer noon the scented chill of winter nights". This evidence indicated that vetiver is an ancient crop, but its utilization in those days has been limited only to its fragrance (Vetiverim 1998).

3.2 Indonesia:

Until recently, Indonesia used to be the world's largest producer of vetiver oil. The loose volcanic soils in the Garut area, West Java are ideal for easy harvesting vetiver roots used in extraction of its essential oil, In such cool moist elevations, vetiver grass flourishes. Annual yields of 5 t/ha of dried root with an average oil content of 1.5%, the range being 0.7-2.3% were reported. The annual yield range of vetiver oil production was between 40 and 100 kg/ha, with an average of 80kg/ha (http://www.benzalco.com/vetiver/vetiver/_text.html).

3.2.1 As Medicinal Plant:

3.2.1.1 *In Traditional Medicine:* Vetiver is used in the following recipes:

For body/sweat bad smell: Material: fresh or dried vetiver roots – 50 g, water – 2500 cc. Preparation: vetiver roots are cleaned and boiled until the water volume is half of its original; let it cool. Drink a glass every day (Wirakusumah and Setyowati 2000).

For rheumatism: Material: vetiver roots (1/4 handful). 10 leaves of betel pepper (*Piper betle*), 15 leaves of 'Gandarasa', 10 leaves of 'Glentang Warak', 10 cm of 'Canar Babi' root, 20 cm of 'Kelingtang' root. Preparation: clean all materials, ground to fine mix; add water and mix with calcium oxide (the same type used for chewing with betel pepper). Application: use the mixture for outside application while massaging the painful body twice daily (Lingga 2001).

3.2.1.2 *In Pest Control:* Vetiver roots are made into small ball and kept inside the cabinet or drawer to repel cockroaches (Suparan pers. Com.).

3.2.2 *As Aromatic Plant:* Traditionally (still practiced in many cities in Central Java), vetiver roots are made into a fan for use when the weather is hot to release sweet aroma. The same vetiver ball used to repel cockroaches makes the cabinet or drawer smell pleasant (Suparan pers. Com.).

3.3 Pakistan:

3.3.1 *As Medicinal Plant:* In Pakistan, vetiver, known in Urdu as Khas, Aseer, Daron, is extensively used in Indusynic medicine such as in *cardiac debility*, *palpitation*, fainting, and to drive away adverse effects of polluted air and atmosphere. It is prepared as syrup, or bruised and made in *infusion* (Usmanghani *et al.* 1997). It may be prepared as a refreshing drink to cure fever, *inflammation* and irritability of the stomach. Having the property of being *astringent refrigerant* and stomach *tonic* useful in quenching thirst, it is used as *febrifuge* in bilious and sanguinous fevers. The liquid prepared from half bruised root mixed with 2-3 lotus seeds in aqua 'keora' (*Pandanus odoratissimus*) and left for a few hours, can cure *polydipsia* in children. Vetiver oil is used to check vomiting in *cholera*. Vetiver leaf fumes over the fire with benzoin is effective in the treatment of headache due to *biliousness* (Khan *et al.* 1997).

3.3.2 *As Aromatic Plant:* With its aromatic property, vetiver roots have been made into scents and is useful *refrigerant* to individuals having warm temperament (Khan *et al.* 1997).

3.4 Senegal:

3.4.1 As Medicinal Plant:

3.4.1.1 *In traditional Medicine:* Criss Juliard (pers.comm.) reported that traditional practices confirm what the encyclopedia (Shealy 1998) identifies as the plant's use to calm emotional stress, as an *aphrodisiac*, and that it is regenerating. Juliard found a number of fascinating medicinal uses for *Vetiveria nigritana* in Senegal, and much of it revolves around both the *aphrodisiac*

however, is most widely known, used and sold as a water purifier (*antiseptic*) and because it gives drinking water a 'better scent', and for its anti-bacterial properties. He has recorded several dozen accounts of medicinal benefits many of them from women. When boiled with rice (a principal dish in Senegal), the *decoction* is drunk, as it "relaxes and relieves stress". A particular application is in the 'preparation' of the bride-to-be the week prior to her marriage. The family brings the rice/vetiver water daily to the young women as it "increases vaginal secretion". The groom is given the *decoction* one day prior to the wedding, supposedly as an *aphrodisiac*.

Young women use an *infusion* of vetiver roots to relieve menstrual cramps and treatment is recommended by practicing nurses. After childbirth, the water is used "to cleanse the reproductive

system" and recognized as an efficient *depurative* of female parts that have been under stress. Field research and usage in Senegal by Juliard (pers.comm) also confirm what is stated in the encyclopedia (Shealy1998) that vetiver is useful in skin care as an *antiseptic, tonic* and *detoxifier*. He found vetiver roots "ground into a powder" is sold in certain markets in the South (Moyenne Casamance) and used as an *astringent* "to speed up the healing of wounds and open sores." He adds that the drink made from the root boiled in water is used to disinfect and eliminate pathogenic bacteria. Water in which the root has seeped for a few hours is used for light cases of diarrhea for nursing mothers and for small infants.

3.4.1.2 In Pest Control: Juliard (2001) reported that vetiver is used in traditional grain storage as a way to preserve rice crops. The leaves of the native species, *Vetiveria nigriflora*, are soaked in seawater, placed on the ground with rock salt, then newly harvested rice is placed on the leaf bed. An additional layer of vetiver leaves, also soaked in salt water and sprinkled with sea salt, is then placed on top of the newly harvested rice. This method, developed by coastal farmers in the South, is claimed by practitioners to eliminate losses of stored rice due to invading pests and mold. In the Moyenne Casamance the vetiver root is placed in linen storage chests as a moth repellent, and the plant has been successfully tested and pictorially documented (Goudiaby and Malainy 2001) as a termite repellent. In the Niayes region, cabbage plants growing closest to vetiver hedges (used to outline vegetable fields) are recognized by the women planters as being less invaded by white flies and worms, and are more resistant to root disease.

3.4.2 As Aromatic Plant: Local finds also confirmed the statement that vetiver has grounding and relaxing properties. The Peulh, Djolas and Serer people of Senegal are the widest users of their native vetiver plant. Older women wear a 'belt' woven of vetiver root under their clothes as grounding "to increase their good scent and attract men".

3.5 Sri Lanka

3.5.1 As Medicinal Plant: The pulverized or powdered roots mixed with sandal wood powder or alone are applied to beautify the skin and impart a cooling effect. Roots are used in the preparation of *decoctions*, 'Arishta', 'Asava' (fermented products) powders, pastes and oils in Ayurveda along with other ingredients. It is believed that vetiver is effective in treating urinary tract infections, urinary calculi, etc. When used in oils and *decoctions*, it is believed to produce a cooling effect on the body (Arambewela pers. com.).

3.5.2 As Aromatic Plant: In Sri Lanka, vetiver oil is used in incense to impart sweet aroma (Arambewela pers. com.)

3.6 Other Countries:

3.6.1 As Medicinal Plant:

3.6.1.1 In Traditional Medicine: In Mauritius, vetiver is used as an *abortifacient* and as a medicinal tea in hispaniola (Watt and Breyer-Brandwijk 1962); and its root *decoctions* are used for *asthma influenza* and *pleurisy* (Gurib-Fakim *et al* 1993). In Nepal the roots are used in *infusion*:

When pulverized and paste in water, the roots are used as a cooling external application in fever (Anon. 1970).

3.65.1.2 In Pest Control: In Nigeria, Ibrahim (1996) reported the use of *Vetiveria nigritana* as a pest repellent. In South Africa, a researcher found that where vetiver was planted alongside maize, the maize stem borer preferred to lay its eggs on vetiver rather than on maize, and then when the stem borer larvae hatched on the vetiver, it promptly died (Grimshaw pers. com.). Over a century ago, farmers in Louisiana, USA used vetiver leaves and roots to mulch strawberry plants. They found that there were no white flies on the strawberries (Grimshaw pers. com.).

2.5.2 As Aromatic Plant: Vetiver's essence is used as a tonic in Nepal (Anon. 1970).

4. UTILIZATION OF VETIVER AS MEDICINAL PLANT IN THAILAND

Being a native plant found almost everywhere in Thailand, vetiver has traditionally been utilized in herbal medicine since ancient times. At present, there are two approaches in making medicinal uses of the vetiver plant, viz. as traditional medicine and as pesticides.

4.1 Vetiver in Thai Traditional Medicine

Rural Thai people have utilized vetiver roots to dissolve gallstones, to reduce fever and in treating diseases related to bile and the gall bladder, and healing stomach discomfort. In addition, various locations have their distinct ways of utilizing vetiver as medicinal plants. Among these are:

At Nong Chang District, Chachoengsao Province, a traditional healer described the curative properties of vetiver root as improving functioning of the heart, nourishing blood, treating nervous disorders. Mixing with other medicinal herbs, vetiver roots can be used in various preparations for treating fever and fainting (ORDPB 1996).

At Pho Prathap Chang District, Phichit Province, the herbal forum described the properties of vetiver that its roots can be utilized to treat stomach discomfort, reduce stomach gas, and stomach disorder while its leaves can be utilized to cure urination problem. In addition, vetiver roots mixed with other herbs in different recipes can be utilized for curing many disorders (ORDPB 1996).

4.2 Vetiver in Pest Control

In Thailand, vetiver has recently been found to have pesticidal effects on various pests. These include the utilization of vetiver as insecticides in vegetables and acaricides in cow.

4.2.1 Insecticides: Trials have been conducted by Babprasert and Karintanyakit (1996) on the utilization of vetiver root oil extract as insecticide in vegetable production. Using vetiver oil extracts of different concentrations (1:100, 1:250, and 1:500) and compared with a commercial insecticide (monochrotophos) and water in three kinds of vegetables - kale, cucumber and Chinese radish, it was found that during the first three weeks there was no significant difference among the percentage of damages to kale, while in the fourth week, there was a significant difference. For Chinese radish, during the first three weeks, the percentage of damage was significantly different, but was non-significant during the fourth until the sixth week. On the other hand, monochrotophos applied to kale and Chinese radish was more effective than essential oil when the number of insects was high, and there was no significant difference when the number of insects was low in cucumber where there was no significant difference among the percentage of damage from the first until the seventh week. In addition, there was no difference between vetiver oil and monochrotophos because of the presence of beneficial insects such as ladybird beetles and ants in the cucumber plots. There was also no significant difference between the yield. It was concluded that vetiver oil extract has potential to some extent in controlling and preventing insect pests from attacking vegetables, and its

attempted in order to obtain the maximum amount of vetiver oil extract from its root and also to arrive at appropriate concentration level of the oil for use as insecticide.

4.2.2 Acaricides: During milking operation, farmers have to clean the cow's breasts thoroughly to prevent the dropping of various dirty matters, particularly dairy cow ticks (*Boophilus microplus*) into the milk. This will deteriorate the milk quality drastically. As normally practiced, the farmers have to wipe the cow's breast with a piece of cloth dipped in chemical insecticide to eradicate the ticks before milking. Such a practice causes chemical contamination of the milk (ORDPB 1996).

Korpraditkul *et al.* (1996) conducted an experiment using vetiver extract to control cattle tick. Three ecotypes of vetiver grass were used, viz. 'Si Sa Ket', 'Uthai Thani', and 'Phetchabun'. Two methods of essential oil extraction were employed, viz. steam distillation and solvent extraction (using two solvents, ethanol and dichloromethane). It was found that the yield of oil was 0.93-1.00%. The oil, which was rarely separable from the condensate, was obtained through the use of ethanol as solvent contains polar substances, with darker color and stronger aroma than the one obtained through the use of dichloromethane that contained non-polar substances. When adjusting the oil's concentration at 10% and applying to treat dairy cow tick at larval and adult stages as well as egg-laying stage, the result indicated that chemical substance extracted from vetiver root of different ecotypes possessed different efficiency in controlling ticks. The extract by steam distillation of dried 'Uthai Thani' vetiver root killed ticks at both stages at the highest rates, with mortality rate of larval and adult of 50.7 and 20.0%, respectively. In addition, fragments and condition of the root also played a role in controlling ticks; extract from dry vetiver root was able to control larval-stage ticks better than adult stage, while extract from fresh root was able to control adult stage of ticks better than larval stage. It was also found that the oil extracted from vetiver root showed no significant difference in controlling ticks when compared with citronella extract and extract of both citronella and vetiver. The ethanol extract from dried roots of 'Phetchabun' ecotype showed very good result to give mortality rate of larvae at 99.4% and inhibited adults from laying egg at 46.7%. The result indicated that the extract from vetiver roots was able to control the growth of ticks during larval and adult stage, and including egg-laying stage of ticks. The ethanol extract has highest potential for controlling cow ticks. The authors were of opinion that if the extraction method is improved or its concentration is adjusted to the optimum level, the experiment may give better results.

4.2.3 Other Pesticides: Putiyanan and Nanthachit (2000) studied the biological activities of six ecotypes of *Vetiveria zizanioides*. Such activities have been ascribed to the chemical constituents of the six ecotypes, some of which were found to have antifungal action against *Trichophyton mentagrophyte*, while others have antibacterial action against *Staphylococcus aureus* ATCC 25923, *Escherichia coli* ATCC 25922 and *Pseudomonas aeruginosa* ATCC 27853. All four components from TLC separation demonstrated antifungal action against *T. mentagrophyte* that was determined by agar diffusion method. The minimum concentration of the purified chemical constituents against the growth of *T. mentagrophyte* was found to be 78 mcg/ml. The purified extract was found to have structural formula of 'vetiverin' (VZ1).

4.3 Vetiver as Herbal Drink

Chomchalow and Hicks (2001) described the method to make 'vetiver root drink' or 'Nam Ya Faek', a Thai traditional beverage, as follows: "A handful of vetiver roots and leaves in equal proportion are boiled with four glasses of water until the liquid is concentrated to a quarter of a glass". It is taken as a herbal drink.

5. UTILIZATION OF VETIVER AS AROMATIC PLANT IN THAILAND

5.1 Traditional Utilization of Vetiver as Fragrant Material

In the olden days, Thai people utilized vetiver root to provide fragrant to cloth cabinet, and its extract as an ingredient of *pot pourri*, perfume, hair pomade, traditional beverage, and rubbing oil. The process of extraction and of making such traditional products have been handed down from generation to generation without written record, many of which have now disappeared. The incidence that dealt a big blow to these traditional products is the public acceptance of new fragrant products derived from other fragrant plants or synthetic materials, resulting in the lack of interest in using vetiver as fragrant materials, probably due to its high price.

5.2 Researches on Production of Essential Oil of Vetiver

As the Head of the Thailand Institute of Scientific and Technological Research (TISTR)'s Essential Oil Project, the author introduced vetiver cultivars from Indonesia and Sri Lanka in 1968 to be grown on trial for essential oil production at TISTR's Highland Essential Oil Research Station at Chang Khian, Chiang Mai, Northern Thailand. It was found that they gave high yield of high quality vetiver oil. However, due to their erosion induction on steep-sloped land at the time of digging the roots off the ground, he discontinued the cultivation of vetiver on the sloping lands. His collection of vetiver cultivars and ecotypes are still existing to the present day. The cultivar from Indonesia has been used by the Royal Project Foundation staff in many trials (Pinthong, pers. comm.).

The author and his coworkers (Chomchalow *et al.* 1970) reported the results of their screening of essential-oil yielding crops in Thailand and found, on the basis of its potential for industrial production, that vetiver was one of the 14 plants selected for further study. It yielded 2.0-2.5% of oil by steam distillation, or 6.7% by solvent extraction.

In a multiplication plot at the Non Sung Agricultural Experiment Station, Nakhon Ratchasima Province, two of the author's staff members, Boonklinkajorn and Visuttipitakul (1968) reported that the root yield from a 9 month-old plot was 1,625 kg/ha containing 42.5 kg/ha of oil (2.6%). They also observed that there was a great loss of root caused by harvesting procedure. Lacking other possible means, the roots had to be dug up by the use of a hoe. Since the grass extends its fibrous roots in all directions, a certain portion of the roots was unavoidably cut off. The amount of roots left in the soil is believed to be considerable. It was therefore apparent that yield of roots of vetiver will be greatly affected by harvesting method. As a primary approach to reducing such a loss, they experimented with growing vetiver in pots (30 cm diam.) and polyethylene bags (38 x 50 cm size) compared with the one planted in the field (sandy soil). It was found that planting two tillers per pot or bag produced 32 culms at harvest against 24 culms by planting only one tiller; however, the difference is not significant. In terms of dry root yield, they found that growing two tillers per pot (200.89 g) or bag (164.55 g) gave significantly higher yield than growing only one tiller (111.23 g/pot and 134.97 g/bag). However, the number of bags that can be allocated to an area is much higher than the number of pots; consequently the yields of roots and oils are much higher in the former case. As much as 1,265 kg of oil is produced per hectare if bags are used with two tillers being planted for 9 months. This is almost 30 times as much as if they are grown in a hectare in the field.

However, the interest in extracting essential oil from the vetiver root was halted for quite some time after that, but resumed when vetiver was introduced for soil and water conservation in the early 1990s.

In 1993, Kasetsart University, in cooperation with TISTR, extracted vetiver oil from a 1 _ years old

(ORDPB 1996). It was found that air-dry root, with 9.17% moisture, yielded 1.91 g of oil from 800 g of the sample, or 0.24% based on half-dry weight. It was noted that the oil extracted had specific characteristic fragrance and is viscous which is of considerable advantage for industrial usage as it is able to fix fragrance for a longer period than the oil with lower viscosity.

The oil yield of 0.24% (half-dry basis) was considered very low as compared to the one produced industrially with 1.4-1.6% dry-weight basis. Furthermore, the result of chemical analysis of vetiver oil by TISTR revealed that the oil obtained from the 'Sri Lanka' cultivar possessed less chemical components than that from 'Chiang Mai' ecotype as well as from those exotic origins (Nanakorn 1993). The result of such studies indicated that vetiver oil varies considerable according to cultivars as well as ecotypes. It was concluded that systematic collection and selection of clones having high yield of oils and better quality of aromatic compounds, supplemented with the improvement in extraction method, can lead to the initiation of vetiver oil industry in Thailand.

Thubthimthed *et al.* (2000) investigated essential oils obtained by hydrodistillation from five ecotypes/cultivars of *Vetiveria zizanioides* Nash, namely 'Surat Thani', 'Songkhla', 'Sri Lanka', 'Indonesia' and 'Japan', cultivated in the same condition, for their chemical compositions by GC and GC/MS methods. It was found that the volatile oils of all ecotypes mainly contained sesquiterpenes; and khusimol, cedrenol and α -bisabolol were the main constituents, while some minor constituents such as α -terpene, eugenol, isoeugenol, etc. were also found. It was revealed that three 'foreign' cultivars, viz. 'Sri Lanka', 'Indonesia' and 'Japan' were similar, but were quite different in chemical composition from the two Thai ecotypes, 'Surat Thani' and 'Songkhla'.

Supatanakul (pers. comm.) conducted a trial on growing vetiver in black polybag of the dimension 43 x 66 cm, with 28 cm-wide base, filled with mixture of sand (59 kg/bag) and chicken manure (1 kg/bag). Ten g/bag of 15-15-15 chemical fertilizer were added. It was planted with a single tiller/bag of 8 foreign cultivars and 3 local ecotypes. The entire plots were watered by sprinkler every other days and the leaves cut down to 20 cm every three months. Harvestings were done at the ages of 12, 15, 18, 21 and 24 months by tearing the plastic bag off, cut through the whole root mass with big knife into quarters and remove the sand which adheres to the roots by shaking. It was concluded that 'Sri Lanka' cultivar gave the highest yield of dry root of 326.5, 456.7, 494.4, 543.8, and 527.9 g/bag at the ages of 12, 15, 18, 21 and 24 months, respectively. The increase in yield after 18 months was not significant. The yield of oil of the 'Sri Lanka' cultivar was also found to be the highest, which was 1.27% (dry weight, at the age of 12 months). The advantage of this system of growing vetiver in sand-based medium in large polybags is that harvesting is much more efficient than growing in the field, and can make efficient use of degraded land (e.g. acid sulfate soil, salty soil, toxic soil, mine quarry, etc.) since the land is only used to place polybags.

A more recent experiment has been carried out by the Department of Agricultural Extension to grow vetiver as an income-generating crop (Assawaprapa, pers.comm.). It was found that vetiver grown in large, black polybags with two tillers/bag and spaced at the amount of 8,000 bags/rai*, or 5 bags/m² gave the dry root yields of 4,000 to 6,000 kg/rai. At a contract price of Baht** 17/kg, an income of Baht 68,000 to 102,000/rai per crop (or US\$ 9,444 to 14,167/ha) of about one year is expected. This is an exceptionally high income on any standard. However, the cost of investment is also quite high. This includes the cost of the polybags (Baht 2.6/bag, or Baht 20,800 per rai), medium (burnt rice husk, compost, sand and soil), and wages to fill large amount of medium into the polybags, to transplant tillers, and to harvest. Thus only few rather rich farmers can invest in this venture. The Department of Agricultural Extension is now cooperating with the Royal Project Foundation and the Thai-China Flavours and Fragrance Industry Co. Ltd. to launch a commercial production of the vetiver oil by growing vetiver as an income-generating crop.

6. POTENTIAL UTILIZATION OF VETIVER

6.1 As Medicinal Plant

Most of the current demand for vetiver oil is from the fragrance industry, but some of the components of vetiver oil, such as nootkatone, the sesquiterpene compound in vetiver oil, have recently been found to repel and even kill termites. It may have important industrial applications, as insecticides or insect repellents, or eventually, other products may be developed.

6.2 As Aromatic Plant

Vetiver has been utilized as fragrant material from time immemorial by peoples of many Asian countries. Its root has been used as raw material for commercial essential oil production in Indonesia, Sri Lanka, China, Haiti, Reunion, and several other countries. In Asia, only one species of *Vetiveria*, i.e. *V. zizanioides*, possesses roots that are fragrant. Other species of *Vetiveria* are either not fragrant or possessing very mild fragrance. In fact, only a few cultivars of *V. zizanioides*

* 1 Rai = 1600 m² or 6.25 Rai = 1 ha; ** Baht 45 = US \$ 1 (September 2001)

are cultivated for their essential oil present in the roots while other cultivars or wild ecotypes, either contain no essential oil or contain in minute amount that makes them not profitable to be cultivated. In Africa, *Vetiveria nigritana* has also been utilized as aromatic plant, especially in aromatherapy.

A recently demonstrated works on vetiver for His Majesty the King of Thailand's viewing included the ones on essential oil production from vetiver roots and its potential utilization as household products, a collaborative efforts of the Royal Project Foundation and the Thai-China Flavours and Fragrances Industry Co. Ltd. The exhibition included: (i) the method of essential oil extraction from vetiver roots, (ii) the quality of vetiver oil produced in Thailand as compared to that of other producing countries, (iii) the application of vetiver oil in various industrial products such as cosmetics, soap, incense, and aromatherapy, (iv) demand of the world market and competitive potential.

In addition, the exhibition also covered proposed plan of action, including the following developments: (i) the portable still for use in the village to provide extra income to the villagers, (ii) the utilization of spent hay after oil extraction, such as in making powder incense, (iii) the extraction technology to have higher efficiency at industrial level, and (iv) the use of vetiver oil in various products.

7. DISCUSSION

7.1 Main Objective of Planting Vetiver

Vetiver has traditionally been used as medicinal and aromatic plants in many countries, especially in Asia. Recently it has received widespread recognition as being an ideal plant for soil and water conservation as well as environmental protection. This, however, has met with difficulty in promoting vetiver grown as hedgerows for soil and water conservation since the farmers complain that they do not obtain any direct benefit (i.e. cash return) from planting vetiver. However, it is argued that the indirect benefits the farmers could obtain are enormous. These are:

7.1.1 Using Leaves as By-Products: Vetiver leaves grown as hedgerows for soil and water conservation can be used as raw material for handicraft making, edible mushroom cultivation, roof thatching, industrial products such as garden pots, nursery blocks, household appliances, etc.

7.1.2 Impact of Insect Level on Adjacent Crops: There are a lot of evidence that vetiver actually repels insect pests of crop plants as discussed earlier. Thus vetiver would not only be good for the

7.2 Environmental Implication

Vetiver is one of the most suitable plants to be used in purifying pre-treated wastewater effluent in constructed wasteland. The lacework of root system of vetiver provides a large surface area for colonization by heterotrophic bacteria that degrade organic materials. At the same time, vetiver root system creates a hostile environment for other pathogenic organisms. The roots produced in the wetland can be harvested and used as a source of essential oil for non-fragrance applications, especially as pesticides. If the quantity and quality of oil produced by vetiver plants used in treating wastewater are comparable to conventionally produced oil, the revenues from vetiver production that could be recovered could offset the investment and operating costs of a wastewater treatment plant.

7.3 Socio-economic Aspects

Socio-economic factor has great influence in determining farmers' preference in doing their farming activities. In Indonesia where vetiver has been grown as a single crop for essential oil extraction, it is considered by the farmers as an unprofitable economic crop (Prayogo 1998). This is evident by the fact that farmers in the upland watershed area are more likely to choose other crops. He concluded that, as an integral part of an upland farming development, vetiver has the greatest role in soil and water conservation and not as erosion induction as previously believed. Thus the researchers and extension workers should reconsider the way to do their activities on the upland watershed areas.

A new concept, that of growing vetiver as an income generating plant, has recently been launched by the Royal Project Foundation of Thailand (see details in 6.4.2). This approach is interesting since vetiver provides a very good income to the farmers if grown specifically for its roots.

7.4 Industrial Potentials of Vetiver

7.4.1 As Medicinal Plant: As a campaign to go 'back to nature' is everywhere, the utilization of vetiver as a medicinal plant to produce pharmaceutical products on a commercial scale has great potential for development.

7.4.2 As Aromatic Plant: As the demand for vetiver oil is very high at the moment, the cultivation of vetiver for essential oil production is a reasonable proposal, especially if grown for other purpose, in which digging the roots does not interfere with environmental protection, like in constructed wastewater treatment area, or intentionally for essential oil production by growing in large polyethylene bags, as being attempted by the Highland Foundation Project in collaboration with the Thailand Institute of Scientific and Technological Research, Department of Agricultural Extension, and the Thai-China Flavours and Fragrances Industry Co. Ltd.

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9. GLOSARY OF PHARMACOLOGICAL TERMS

- abortifacient*: causing abortion; an agent that causes abortion or expulsion of the fetus from the womb
- acne*: a common chronic skin disease, esp. among adolescents and young adults, characterized by inflammation of the sebaceous apparatus, usually causing pimples on the face, back and chest
- anemia*: a condition in which there is a reduction of the number, or volume, or red blood corpuscles or of the total amount of hemoglobin in the bloodstream, resulting in paleness, generalized weakness, etc.

antiplasmodic: any substance which tends or has the power to prevent or relieve spasms or convulsions

antiseptic: any substance which prevents infection or decay by inhibiting action of microorganisms without necessarily killing them

aphrodisiac: stimulating sexual desire; a drug arousing the sexual instinct

arthritis: an inflammation of one or more joints due to infectious, metabolic, or constitutional causes

asthma: a chronic disorder of the bronchial tubes; a respiratory disorder in the body characterized by labored breathing, either continuous or accompanied by wheezing, a sense of constriction in the chest, and often by attacks of coughing or gasping caused by conditions that interfere with the inflow and outflow of air in the lungs

astringent: an agent which tends to shrink mucous membranes or raw or exposed tissues; a drug which arrests secretion or bleeding

biliousness: a symptom complex with nausea, abdominal discomfort, headache and constipation, formerly attributed to excessive secretion of bile

cardiac: of or relating to the heart; pertaining to the opening between the oesophagus and the stomach

cardiotonic: having a tonic effect on the heart; an agent that has a tonic effect on the heart

cholera: acute infectious inflammation of the intestine, caused by an enterotoxin elaborated by *Vibrio cholerae*, and characterized by severe watery *diarrhoea*

debility: weakness or feebleness of the body

decoction: a medicinal preparation or other substance made by boiling, especially in water.

depressant: diminishing functional activity; a drug which lowers functional activity and vital energy in general.

depurative: tending to purify or cleanse; blood purifier

detoxifier: agent used to remove a poison or poisonous effect from the body

diaphoretic: pertaining to, characterized by, or promoting (profuse) perspiration; a drug that induces sweating or copious perspiration or increases the amount of perspiration.

diarrhoea: a profuse, frequent, and loose discharge from the bowels

emmenagogue: an agent or measure that regulates and induces menstruation

epilepsy: a chronic nervous disorder marked by attacks of unconsciousness or convulsions

exhilarant: agent to make cheerful, merry, or lively

febrifuge: an agent that relieves or reduces fever

hyperaemia: an excess of blood

inflammation: a protective response of the body in response to injury, infection, irritation, etc., aimed at destroying or isolating the injurious agent and injured tissue, and characterized by redness, pain, heat, and swelling

influenza: an acute highly contagious virus disease characterized by sudden onset, fever, prostration, severe aches and pains, and progressive *inflammation* of the respiratory mucous membrane

infusion: a liquid extract obtained by steeping or soaking something in a liquid for the purpose of extracting its medicinal principles without boiling; medicinal fluid made by pouring boiling water on a plant or plant part, or adding a plant extract to boiled water; similar to a tea

insomnia: sleeplessness

lumbago: pain in the lumber region of the back (loins); lumbar *rheumatism*; *rheumatism* of the muscles of the small of the loins

palpitation: condition when the heart beats rapidly

pleurisy: *inflammation* of the membrane enclosing the lungs

polydipsia: abnormal thirst or having an excessive desire to drink

refrigerant: a drug which relieves feverishness or produces a feeling of coolness; an agent that relieves fever and thirst

rheumatism: any of various disorders, characterized by *inflammation*, degeneration, or metabolic derangement of the connective tissue structures of the body, especially the joints and related structures, and accompanied by pain, stiffness or limited mobility of these parts; an indefinite term used for pains in the muscle, joints and certain patches

rubefacient: a mild counter-irritant; reddening the skin by causing *hyperaemia*; an agent that reddens the skin

sedative: acting on the central nervous system to produce sleep; an agent that allays excitement

spasm: an abnormal muscle contraction that is often accompanied by pain and may signal an underlying disorder.

sprain: the resulting condition, characterized by swelling, pain, and disablement of the joint

stimulant: producing a temporary increase of the functional activity or efficiency of an organism or any of its parts; making a body organ or system work faster

stomachic: a drug that strengthens the stomach and promotes its action

tonic: an agent that restores or maintains health in the whole body or its individual organs.

ulcer: an open sore on the skin

vermifuge: an agent that expels intestinal worms; also called *anthelmintic*

Method of Growing Vetiver in Black Plastic Bags for Essential Oil Extraction



L. Full grown vetiver plant in black plastic bag. R. Overview of the experimental plot showing vetiver plants with leaf tops cut off



L. Close view of vetiver plants grown in black plastic bag.
R. Removing black plastic bags from vetiver plants.



L. Close up view of vetiver root mass after removal of black plastic bags.
R. Collecting vetiver root mass after black plastic bags being removed.



L. Close up view of vetiver root mass, with plastic bag removed, showing root formation within the confinement.
 R. Cutting vetiver root mass in half by using sharp knife



L. Close up view of vetiver root mass, split in half. Note dense roots at the top and bottom of the container.
 R. Spitting root mass further for ease in removing soil particles.



L. Removing adhering soil particles from the root mass



R. Washing the root mass with water to remove hard soil particles still adhering to the root mass.



L. Washing the spit root mass in water tank.



R. Washed root mass, showing part attached to the clump.



A worker shows section of root mass after washing.



Hanging the root mass in the shade for 10 days to dry.



Vetiver oil: Left from Thailand, Right from China. Note Difference in color of the oil - the lighter color the better.



Distillation unit for vetiver oil extraction of the Thai-China Flavours & Fragrance Industry Co.Ltd.

Vetiver Oil Production in Indonesia



Harvesting vetiver root in Garut, West Java, Indonesia Root of vetiver plant A vetiver oil extraction factory.

Utilization of Vetiver in Senegal



Enclosure with no vetiver has significant evidence of termite infestation - mud tunneling.

The same enclosure with vetiver planted at its base has no trace of termites.



Vetiveria nigritana still grows well on top of termite mound without having any effects on the roots. Termites usually eat the roots of plants and new trees planted for reforestation. Vetiver resists attacks from West African termites.

R. Vetiver roots sold all over Senegal and Mali. Each root bundle sells for 50 FCFA (US\$ 0.08) and is used to "purify" drinking water.

