Vetiver Grass as a Potential Resource for Rural Development in Bangladesh

M. P. Islam[1], Md. Khairul Hassan Bhuiyan[2], M. Z. Hossain[3]

Bangladesh Agricultural University, [1]Dept. of Farm Power and Machinery, [2]Dept. of Physics & Chemistry, Bangladesh and [3]Dept. of Environmental Science and Technology, Graduate School of Bioresources, Mie University, Japan

engr_parvezfpm@yahoo.com

ABSTRACT

Good quality lands are degraded by water and wind erosion, loss of organic matter, water-logging and salinity in Bangladesh which decreases crop yield and biodiversity. Lands are also contaminated with heavy metals due to growing industrialization. There are lots of expensive methods for controlling soil erosion, soil salinity, and land degradation, which can not be achievable in developing countries. The environment-friendly vetiver grass is available all over Bangladesh and it is economically feasible to control land degradation. Vetiver grass can also be used for other purposes, as mentioned in this paper, and poor people can earn money utilizing vetiver grass. But most of the people are unaware of the utility of this natural resource and therefore, motivation and training on the utilization of vetiver products are necessary.

Keywords: Vetiver grass, land degradation, soil erosion, carbon sequestering, rural economy, Bangladesh

1. INTRODUCTION

Ploughing makes the land surface more susceptible to soil erosion. Surface run-off can easily wash away the topsoil from cultivated lands. This surface erosion reduces land elevation, which makes the land susceptible to flooding. According to the Report of the Task Forces (RTF) on Bangladesh Development Strategies for the 1990s, soil erosion is a serious problem in many parts of Bangladesh as shown in Fig.1. Hilly areas in Sylhet, Chittagong, and Chittagong Hill Tracts are more susceptible to soil erosion. About 55% of Chittagong Hill Tracts is highly susceptible to soil erosion. Heavy monsoon showers remove the surface soil through runoff. Eroded sediments are deposited on the riverbeds, reducing the water carrying capacity and results in overflow of the riverbanks causing inundation of crop lands. The land elevations in other parts of Bangladesh must have reduced over time due to soil erosion. Aside from this, the tilling on the mountain slopes of the Himalayas is responsible for massive soil erosion in Nepal, which eventually causes rapid riverbed aggradations in Bangladesh. Moreover, construction sites in cities can contribute to soil erosion, if silt fences

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or sediment retention ponds are not properly employed. In Bangladesh, no such measures are practiced at the construction sites (Khalequzzaman 2007).

Fig. 1. Present situation of soil erosion in Bangladesh

Source: Left and middle - River erosion (Prothom Alo and Daily Star, 2008b) and Right - man made soil erosion in the hilly areas of Bangladesh (Daily Star, 2008a)

Vetiver grass is able to act as a natural barrier against erosion as well as pollution. It produces massive odorous root system which can be used for the extraction of an essential oil of great economic importance. This grass is being used in China, Australia, Vietnam, Thailand, Philippine and Bangladesh (Fig. 2), for river bank and dyke/stream bank stabilization, mitigation of soil and water pollution. Generally, in Bangladesh this grass, commonly known as 'Kash' is widely used as a low cost rural house construction material and biomass fuel, which results in depletion from its original habitats. Due to rapid growth of industrialization, heavy metals from the industrial, agricultural and domestic effluents being added to our soils, persist in soils and can be absorbed in soil particles or leached into ground water. Human exposure to these metals through ingestion of contaminated food or uptake of drinking water can lead to their accumulation in humans, plants and animals.

Fig. 2. Vetiver grasses grow in Barind tract (left) and riversides (right) of Bangladesh

2. AGRONOMIC FEATURES OF VETIVER

2.1 Crown

The crown of the plant is generally a few centimeters below the surface of the ground. It is a "dome" of dead material, debris, and growing tissue, much of it a tangled knot of rhizomes. These rhizomes are very short - 1 cm or less and are often turned back on themselves. For this reason vetiver stays in clumps and does not spread across the land. To separate the slips for planting, the massive crown is often cut apart. It sometimes becomes so huge that it has to be pulled out of the ground with a tractor and cut with axes. In nurseries, however, young slips are easily separated (NRC, 1993).

2.2 Leaves and Stems

Vetiver grass leaves are somewhat like those of sugarcane, but narrower (Fig. 3). Although the blades are soft at the top, the lower portions are firm and hard. On some vetiver types the leaves have sharp edges. Actually this is due to tiny barbs. There is a lot of variability, however, some plants are fiercely barbed, some are not. The ones used for oil and erosion control tend to have smooth edges. Topping the plants is an easy way (at least temporarily) to remove the bother of the barbs. The leaves apparently have fewer stomata than one would expect, which perhaps helps account for the plant withstanding drought so well. The stems provide the "backbone" of the erosion-control barrier. Being strong, hard, and lignified (as in bamboo), they act like a wooden palisade across the hill slope or plain land. The strongest are those that bear the inflorescence. These stiff and cane like culms have prominent nodes that can form roots, which is one of the ways the plant uses to emerge out of the soil when it gets buried. It also moves up by growing from rhizomes on the crown.

Fig. 3. Vetiver grass leaves (left,) and flower (right)

2.3 Flowers

The flower (inflorescence) and seed head are very large being up to 1.5 m long (Fig. 3). Both are brown or purple in color. The flower's male and female parts are separated. As in maize, florets in the upper section are male and produce pollen; in vetiver, however, those below are hermaphrodite (both male and female) (NRC, 1993).

2.4 Roots

Perhaps most basic to this plant's erosion-fighting ability is its huge spongy mass of roots. These are not only numerous, strong, and fibrous, they tap into soil moisture far below the reach of most crops. They have been measured at depths below 3 m and can keep the plant alive long after most surrounding vegetation has succumbed to drought which is shown in Fig.4.

Fig. 4. Vetiver grass roots (PRVN, 2004) and right at BAU (Bangladesh)

The thin and lacy roots grow downwards rather than sideways, and form something like a curtain hanging in the soil. When two plants are side by side, their roots interlock into an underground network. This combination of features anchors a hedge so firmly that even the strongest floods can seldom undermine it or wash it out. Moreover, the roots fall away at a steep angle, and this conical form perhaps explains why vetiver appears not to affect nearby crops. This possibly shields them from stresses such as salinity, desiccation, herbicides, or pestilence, for example.

2.5 Fertility

One of vetiver's great benefits is that once it is planted it stays in place. It is therefore not pestiferous and seldom spreads into neighboring land. Under certain conditions some seeds are indeed fertile. These conditions seem to be most commonly found in tropical swamps. In the heat and damp, little vetivers spring up vigorously all around the mother plant.

2.6 Ecology

Vetiver grass is an "ecological-climax" species. It outlasts its neighbors and seems to survive for decades while (at least under normal conditions) showing little or no aggressiveness or colonizing ability.

2.7 Diseases

Vetiver grass is remarkably free of disease. However, Fusarium (the most widespread cause of rotting in fruits and vegetables) reportedly attacks it, notably during rains (NRC, 1993). Perhaps of greater importance is the leaf blight caused by Curvularia trifolii (Anon., 1976). This disease of clover and other crops may attack vetiver also during the rainy season. Malaysian researchers recommend that growers top the plants (at a height of 20–30 cm) to remove any infected foliage. Copper-based fungicides such as Bordeaux mixture also control this blight. In Malaysia, a detailed investigation of vetiver grass has located yet more fungal species (Yoon, 1991). These had little effect on the plant itself, but they might eventually prove troublesome in crops grown near vetiver hedges. They include the following species:

- Curvularia lunata (causes leaf spot in oil palm)
- C. maculans (causes leaf spot in oil palm)
- Helminthosporium halodes (causes leaf spot in oil palm)
- H. incurvatum (causes leaf spot in coconut)
- H. maydis (causes leaf blight in maize)
- H. rostratum (causes leaf disease in oil palm)
- H. sacchari (causes eye spot in sugarcane)
- H. stenospilum (causes brown stripe in sugarcane)
- H. turcicum (causes leaf blight in maize).

2.8 Pests

Termites sometimes attack vetiver grass, but seemingly only in arid regions. Except where the termite mound covers the whole plant, only dead stems in the center of stressed plants are affected. Normally no treatments are required. In at least one location in India, grubs of a beetle (Phyllophaga serrata) have been found infesting vetiver grass roots (Anon., 1976). Perhaps the most serious pest threat comes from stem borers (Chilo spp.). These were found in vetiver grass hedges in Jianxi Province of China in 1989. In Asia and Africa, some of these moth larvae are severe cereal pests, for example, the rice borer of Southeast Asia and the sorghum borer of Africa (NRC, 1993). For this reason, vetiver grass planting should be carefully monitored in areas where stem borers are a problem. This is both to protect the hedges and to prevent them from providing safe havens for these crop pests. A severe pruning seems to keep the larva from "overwintering" in the vetiver grass stems and a timely fire might also be beneficial. Because vetiver grass is unfazed by fire, this technique might be

developed into a method for trapping and destroying these pests (NRC, 1993).

2.9 Propagation

Vetiver grass is propagated mainly by root division or slips. These are usually ripped off the main clump and jabbed into the ground like seedlings. Although the growth may be tardy initially, the plants develop quickly once the roots are established. Growth of 5 cm per day for more than 60 days has been measured in Malaysia. Even where such rapid growth is not possible, the plants often reach 2 m in height after just a few months. It is easy to build up large numbers of vetiver grass slips. The plant responds to fertilizer and irrigation with massive tillering, and each tiller can be broken off and planted. It is important to put the nurseries on light soil so that the plants can be pulled up easily. Planting slips is not the only way to propagate vetiver. Other vegetative methods are as follows:

- Tissue culture. Micropropagation of vetiver began in the late 1980s (Marinho de Moura et al., 1990).
- Ratooning. Like sugarcane, the plant can be cut to the ground and left to resprout.
- Lateral budding. Researchers in South Africa have success in growing vetiver "eyes" (intercalary buds on surface of crown) in seedling dishes (NRC, 1993).
- Culms.Young stems easily grow from new roots. This can be an effective means for propagating the plant. 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 (Yoon, 1991).
- Cuttings. It is possible to grow vetiver from stem cuttings. The cuttings, each with two nodes, are planted at a 60° angle and then treated with a rooting hormone such as IAA indole acetic acid. The survival rate is 70 percent (NRC, 1993).

The propagation of vetiver grass in Bangladesh depends upon several factors: agro-ecological zone, land type, soil type, purpose of cultivation and species available (Huq, 2006), which is shown in Table 1.

2.10 Hedge Formation

Normally, hedges are established by jabbing slips into holes or furrows. They can be planted with bullock, trowel, or dibbling stick. In principle, at least, the techniques and machines developed for planting tree or vegetable seedlings could also be employed. To establish the hedge quickly, large clumps can be planted close together (10 cm apart). On the other hand, when planting material is scarce, slips can be spaced as far as 20 cm. In this case, the hedge will take longer time to become close. Prolonged moisture is highly beneficial for the quick establishment of the hedge. For best results, fresh and well-rooted slips, preferably containing a young stem, should be planted early in the wet season (after the point when there is a good chance the rain that will continue). In drier areas it is helpful to plant them in shallow ditches

that collect runoff water. For the most rapid establishment of vetiver grass lines, weeding should be done regularly until the young plants take over. Clipping the young plants back stimulates early tillering and makes the hedge close up faster (NRC, 1993).

Table 1. Comparison of vetiver propagation in Bangladesh

Species	Agroecological zone	Land type	Soil type	Purpose of cultivation	Remark
Benna-Shoba (Vetiver)	Flood plain (Central Part)	Highland & medium high land	Loam, silty loam, sandy loam, silty clay, silty clay loam	Land demarcation and plant protection	Not so important as cash crop
Khus Khus (Vetiveria zizan-oides)	Flood plain and embankment area	Medium high land, medium low land ,lowland	Silty clay loam, silty clay, clay , sandy clay	For thatching as housing and fencing material	Cash crop, exchange crop or chance crop
Ghanda bena (vetiver)	Bottom of hill area or rolling topography or plain land	Sloping land, undulated land, level barind	Clay loam, silty clay, clay, silt loam, very fine sandy loam	As fodder, fuel material, commercial use in industry	High return by cash selling and soil and land conservation
Ecorban (vetiver)	Char land, tidal flood plain, marshy water bodies	unstable alluvial, lowland and unfilled river channel	Sand, sand loam, silt loam, very fine sandy loam, loamy soils.	For river erosion control, land formation, fuel, litter, fodder	High environmental control value, for soil and land reclamation
Vetiveria zizanioid-es (dwarf species)	Roadside, raised platform, embankment, pond embankment	Miscellaneous both highland and medium land or low land	Any type of soil	Newly constructed road, dam, embankment or raised platform for house	Low economic value but high value for land and soil conservation

2.11 Management

Usually, little management is needed once the hedge is established. However, cutting the tops of the plants produces more tillering and therefore a denser hedge. It can grow on both acidic (pH3) and alkaline (pH11) soils, and is tolerant to high levels of various trace metals such as arsenic, cadmium, copper, chromium and nickel (Truong, 1999). It produces up to 2 m high plant with a strong dense and mainly vertical root system often measuring three meters, useful in soil erosion control.

2.12 Controlling Vetiver grass

Vetiver grass is difficult to kill by fire, grazing, drought, or other natural force. However, if necessary, it can be eliminated by slicing off the crown. Because the crown is close to the

surface, it can be cut off fairly easily with a shovel or tractor blade. Although the plant is resistant to most herbicides, it succumbs to those based on glyphosate (NRC, 1993).

3. TRADITIONAL AND POTENTIAL USES OF LIVE VETIVER GRASS

The conventional uses of live Vetiver grass are shown in Fig.5.

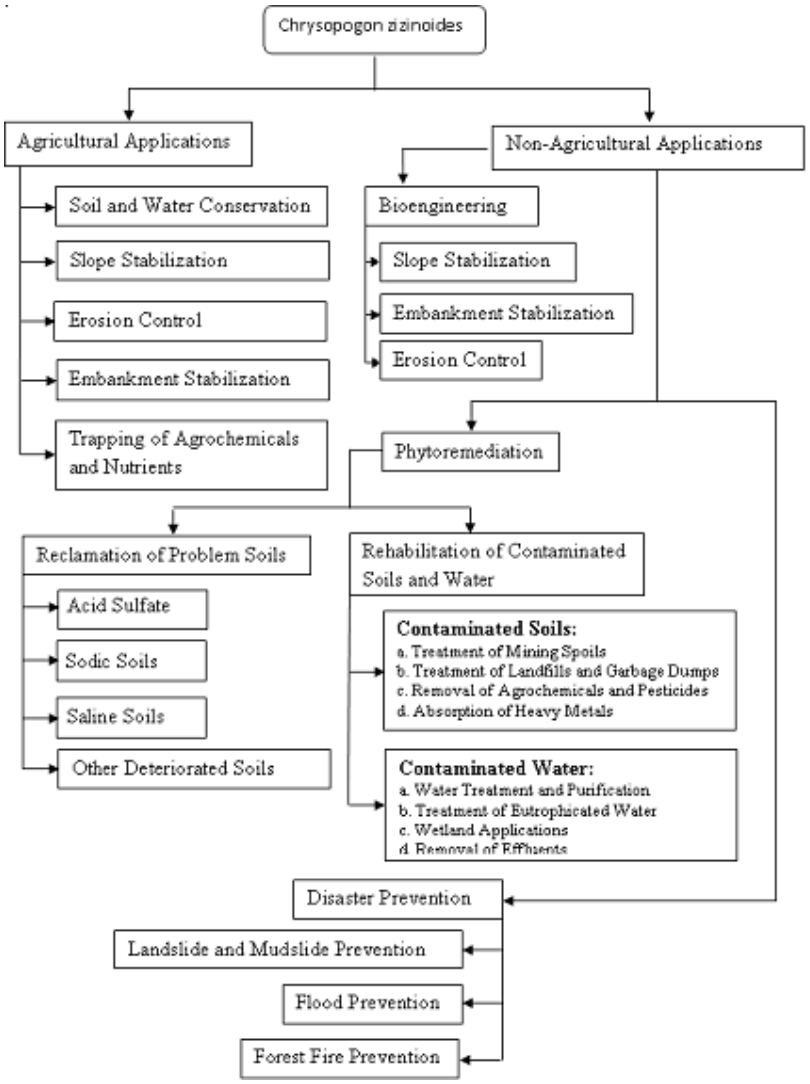

Fig. 5. Conventional uses of Live Vetiver grass

3.1 Controlling Siltation and Soil Erosion

A vast amount of silt gets into ditches, canals, reservoirs, rivers, harbors, estuaries, and other waterways worldwide (Fig. 6a). This would be a massive, perhaps impossible, task to control siltation effectively. The vetiver grass grown in rows across critical watersheds can reduce silt

buildup downstream. The advantage of the vetiver grass system is that it can be applied on a wide scale with little equipment, planning, or logistics.

The farmers and foresters may may use vetiver not only for soil conservation, but for the increased yields fostered by the moisture held back by the vetiver hedges. The by-products of vetiver can also be used for fire control, forage, mulch, thatch, and so on (NRC, 1993).

Fig. 6a. Vetiver grass used to protect the hilly road from mud slide in Thailand (PRVN, 2004) and Vetiver grass used to protect river embankment from soil erosion in Bangladesh (right)

Fig. 6b. Vetiver grass is growing across the roadside of Bangladesh

3.2 Public Works

Vetiver grass could help protect footpaths, railroads, and road cuts from washouts and slips (Fig. 6b). In addition, it has potential benefits for wastewater treatment and flood-control facilities (Fig. 7). It is highly tolerant to a range of trace elements such as As, Cd, Cu, Cr, and Ni. It is suitable for the stabilization, rehabilitation and reclaiming of acid sulfate and trace metals contaminated soils, i.e. phytoremediation. Further, because it can withstand lengthy submergence (more than 2 months has been reported), it can be planted along the edges of dikes, irrigation canals, bridges, and dams to prevent scouring.

Fig. 7. Vetiver grass used for the biological treatment of the soil and wastewater (PRVN, 2004)

3.3 Agriculture

In farming areas, vetiver hedges reduces rainfall runoff, conserve moisture in the soil and the farmers can get higher yields of crops. Vetiver leaves and culms are completely decomposed to become soft, disintegrated, and dark brown to black in color. Vetiver compost contains major nutrients from the decomposition process, i.e. N, P, K, Ca, and Mg with a pH of 7.0. In addition, vetiver compost also provides humic acid that enhances soil fertility. The young vetiver leaves can be ground to feed fish and livestock, but mature leaves cannot be used for such purposes because their nutritive value is lower than other grasses, and because of the high roughness and silica content. The analysis also indicated that vetiver has the content of crude protein lower than that of other grasses used for animal feed (Anon., 1990b and Panichpol et al., 1996).

In the State of Karnataka, India, vetiver is planted along the field boundaries and cut every two weeks or less for use as fodder. Vetiver was found to have relatively higher structural carbohydrates as compared to native grass and rice straw. On the other hand, it also had optimal levels of crude protein, considered to be enough to maximize intake and digestion of the vetiver forage. It was concluded that vetiver may be used as ruminant feed if it is mixed with other good quality feed and forages (Anon., 1990b).

3.4 Forestry

By holding soil and moisture on site and by providing windbreaks, vetiver grass strips would be particularly valuable in the early stages of tree growth. At present, a huge proportion of tree-planting projects are failing because of dismal rates of establishment and survival. Vetiver grass might also act as a barrier against ground fires and creeping grasses, both of which often devastate young tree plantings.

3.5 Flood Control

Wherever in the tropics localized flash flooding is a problem, vetiver grass could be a partial

solution - especially when the flooding is caused by denuded watersheds that can no longer soak up and hold back the rainfall and runoff.

3.6 Desertification

Although rain falls infrequently in arid lands, it often adds up to considerable amounts. Moreover, desert rains are often intense deluges and the water rushes away from upper side to lower side and washes away. Paradoxically, this water in the desert is desperately lost by flooding. Vetiver grass barriers would likely capture the floodwater to recharge the thirsty aquifers beneath and walls of vetiver would also hold back silt in which crops might grow vigorously.

3.7 Sustainable Agriculture

There is currently a great interest in keeping agriculture productive and self-sustaining. Vetiver grass keeps the soil on the site, and could be a key to success in many of the different sustainable-agriculture systems under development for Third World conditions. This and other vegetative systems of erosion control should provide long-term stability and, if combined with good crop-rotation practices, such as the use of green manures and organic mulches, could lead to stable sustainable farming that might even render slash-and-burn cultivation obsolete in many places.

3.8 Economic Development

Vetiver grass hedges can provide a number of products that are especially useful to farmers in the tropics. These products can be harvested without sacrificing erosion control. These will provide farmers with extra income.

Vetiver products include:

- Forage;
- Mulch;
- Thatch;
- Mattress stuffing;
- Animal bedding; and
- Mats, baskets, and screens.

3.9 Blocking Crabs and Rats

Creeping grasses are not the only pests that might be held at the bay. Vetiver's dense network of oil-filled roots may block burrowing creatures of various kinds such as crabs that attack paddy bunds; and moles, mole rats, and other burrowing animals. Trials at Kericho in Kenya have already shown that mole rats cannot abide a vetiver root in their burrows. They cast it out or tunnel around it and block it off, apparently to keep the smell from their living quarters (NRC, 1993).

3.10 Foiling Fires

Vetiver grass burns when the tops of the plant are dry. But its roots, tapping into reserves of deep moisture, keep the plants lush and green long into the dry season. Bands of these succulent plants across hill slopes are said to make good firebreaks. This may not be a wholly reliable method of fire prevention; but many fires in rural Third World areas creep along the ground through the dry grasses and it seems possible, therefore, that stout, unbroken lines of vetiver might be an effective measure to control this kind of fire (NRC, 1993).

3.11 Climate Change - Carbon Sequestering - Biofuel - Vetiver System

Counting both the grass and the root system, vetiver can produce up to 100 tons/hectare of biomass (dry weight) within 8 months. If the grass is only harvested as a biomass fuel, and the perennial vetiver grass is left in the ground and allowed to grow back, year after year lasting for ever with only minimum care and some fertilizer (TVN, 2008).

Petroleum, coal, dry wood and sugarcane bagasse are widely used carbon based fuels, which, upon combustion, release energy for power generation, and produce CO_2 gas as the main product of combustion, which is added to the mix of atmospheric gases. Dry vetiver grass inspite of its higher heating values (7,000 Btu/lb) is not yet used for power generation. CO_2 derived from the combustion of "sequestered" carbons, like coal, petroleum, lignite and tars, increases the existing inventory of CO_2 in the atmosphere along with other noxious gases, whereas CO_2 derived from the combustion of biomass came from the current atmosphere in the first place, by way of photosynthesis, and therefore does not add or remove anything from the existing inventory of CO_2 in the air. Furthermore, the combustion of biomass fuels produces none of the noxious gases of sequestered fossil fuels. For that reason, CO_2 released from burning sequestered fossil fuels has been called "bad carbon" by environmentalists, and CO_2 released from burning biomass carbon is referred to, as "good carbon".

3.12 Ethanol from Vetiver

Kuhirun and Punnapayak (2000) explained the process of producing ethanol from vetiver leaves. Dry leaves were first pretreated with alkali. The simultaneous saccharification and fermentation (SSF) technique was used to convert plant residues into ethanol. The cellulase enzyme for SSF was prepared from Trichoderma reesei; this enzyme activates specific reaction for the release of glucose for fermentation into ethanol. The addition of alkali-pretreated leaves, cellulase enzyme, and fermentation yeast at 40^{o}C, pH 5.0, for seven days yielded ethanol. By using a one-cycle column distillation, the ethanol yield was 13%. The ethanol produced was clear in color with a slight pleasing odor. It is now widely proposed to use mostly cellulosic biomass of vetiver (rather than starches and sugar crops) to produce ethanol (TVN, 2008).

3.13 Green Fuel

Broken vetiver culms and leaves that cannot be utilized for other purposes can be mixed with water hyacinth, as a mixer, in a proportion of 3:2. Then compress the mixture into shafts with a cylinder-shaped fuel squeezer, 1.7 cm in diameter. Fuel shafts can burn easily and produce little smoke, but yield high heat. For example, it takes 5 min. to boil 1 litre of water, and the fuel still keeps on burning for up to 28 min (Babpraserth et al., 1996). Dried vetiver leaves are widely used in rural areas of Bangladesh for cooking purpose which is shown in Fig. 8.

Fig. 8. Dried vetiver leaves (left & middle) & dried leaves are using for preparing tea in a rural tea shop (right)

3.14 Vetiver Oil

The vetiver oil emits a sweet and pleasant odor. It is used particularly in heavy oriental fragrances. Although primarily employed as a scent, it is so slow to evaporate from the skin that it is also used as a fixative that keeps more volatile oils from evaporating too fast. Because it does not decompose in alkaline medium, vetiver oil is especially good for scenting soaps. The dried roots are used in India to prepare the traditional "khus-khus" screens. When moistened, these both cool and scent the air passing through, and they are believed to protect people against insect pests as well.

The oil occurs primarily in the roots, but traces of it in the foliage may nonetheless account for the plant's inherent resistance to pests and diseases. The oil is known to repel insects. People in India and elsewhere have long placed vetiver root among their clothes to keep insects such as moths, heads from lice, and bedding from bedbugs. The oil repels flies and cockroaches as well and may make a useful ingredient in insect repellents.

Chia (2000) described methods of extracting oil from vetiver leaves and roots. The leaves are harvested while fresh, and can either be dried, chopped or fermented before processing. The prepared leaves are put in a container with 2/3 quantity of water and heated in an enclosed lid, boiled at a very high temperature - above 100 degrees centigrade over a long heating period. The generated heat destabilizes the complex compounds which turn into vapor and comes out

with volatile components. The tank is connected to a cooling device by a galvanized pipe (020) which condenses the vapor on coming out of the drum or container. The condensed vapor drips at the outlet into a glass container where the distilled water + essential oils are collected. The essential oil then floats and can be collected by hand. The quantity of oil collected varies between 2 - 3 % of distilled water. The small traces of water collected can further be evaporated with less than 100 degrees centigrade of obtain pure oil.

Roots contain the higher quantity of essential oils with high concentration of bicylic and tricylic sesquiterpenes, hydrocarbons, alcohol & rsquys and carboxylic acids (Chia, 2000). Those that repel insects are minor constituents. Vetiver roots are harvested, washed and dried to reduce water content. These are put in a vessel of 2/3 water quantity in weight. It is then distilled as explained above for leaves. The oil is extremely complex, containing more than 60 compounds. In the main, these are bicyclic and tricyclic sesquiterpenes—hydrocarbons, alcohols, and carboxylic acids. Those that repel insects are minor constituents, including α-vetivone, β-vetivone, khusimone, and khusitone (Chia, 2000). World production of vetiver oil is currently about 250 tons a year. Annual consumption of the vetiver oil in different countries is shown in Table 2.

3.15 Pulp and Paper

Vetiver can be used as a raw material for making pulp and paper. In India, studies that were carried out at the Forest Research Institute, Dehra Dune, revealed that pulps suitable for making strawboards can be made from vetiver by digestion with lime (Anon., 1976). Vetiver has a high content of hemicellulose; its cellulose content is 45.8% (DW). Pilot-plant trials have indicated that vetiver yields a chemical pulp that can be used for making writing and printing papers. Containing short fiber, the pulp has to be used in admixture with 30-40% of a long-fibered pulp.

Table 2. Annual consumption of vetiver oil (Robbins 1982)

Country name	Annual consumption
United States	100 tons
France	50 tons
Switzerland	30 tons
United Kingdom	20–25 tons
Japan	10 tons
Germany	6 tons
Netherlands	5 tons
Other	30–40 tons

3.16 Cement Replacement Material

Vetiver ashes have been experimentally used as low-cost, environment-friendly, and energy-saving construction material. Nimityongskul et al. (2003) reported on the experiment of using vetiver grass ash (VGA) as a new building material specifically for the rural areas of the developing countries. The properties of VGA were investigated in order to consider the possibility of using it as apozzalanic material. The physical and mechanical properties of VGA and cement mortar containing VGA were also determined. They concluded that it is possible to use VGA as a cement mortar.

3.17 Vetiver-Clay Composite Silo

Vetiver can be used as raw material for the construction of low-cost storage bin. At Chitralada Palace in Bangkok, a grain silo made of vetiver-clay composite was piloted (Nimityongskul and Hengsadeekul, 2002; Hengsadeekul and Nimityongskul, 2003). The silo has a diameter and height of 3 m. It is about 1.2 m above the ground and its capacity is 20 m^3. Its foundation was constructed with reinforced concrete, while its ground wall and slab were built with cement-block filled with reinforced concrete. The silo walls were constructed with vetiver-clay bundle, coated with cow-dung mixed with clay and rice husk, while its roof was of bamboo structure thatched with vetiver bundle overlaps. A structural component for ventilation that reduces moisture and temperature forms part of the proposed structure.

3.18 Roof Thatch

People living in rural areas of Asia have long utilized vetiver culms and leaves for roof thatching in the same way as nipa palm leaves. Vetiver grass has a better quality for roof thatching than cogon grass because the culms and leaves of vetiver are coated with wax, and have a unique scent that repels insect and fungal attacks. The durability of a vetiver thatch depends on the neatness of thatch making. The thatches with more or denser vetiver grass will be more durable. The manner in which the thatches are laid on the roof also matters. For example, on a steep roof like that of a traditional Thai house, vetiver thatches can be more durable than on a flatter roofed structure. Vetiver has also been used as roof thatch in several other countries in Africa where thatch is vital for roofing of many rural houses (Grimshaw, 2002). In Ethiopia, vetiver has replaced the traditional thatching grass in some areas as it lasts longer and makes a more rain-proof roof (Anon., 1990a).

3.19 Herbal Drinks

In the hilly regions of Karnataka, India, people make use of vetiver roots to prepare refreshing drinking water (Sastry, 1998). 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 proportions are boiled with four glasses of

water until the liquid is concentrated down to a quarter of a glass". It is then drunk as herbal drink.

3.20 Aromatherapy

Aromatherapy is the use of essential oils for therapeutic purposes. Vetiver oil has been used extensively in modern aromatherapy. It is used to balance the activity of the sebaceous oil glands as well as having deodorizing properties and helping normalize oily skin and clear acne. It also replenishes moisture in dry and dehydrated skin and has rejuvenating effect on mature skin. It prevents stretch marks of pregnant women if applied regularly. It also strengthens the central nervous system, and can overcome depression, insomnia, anxiety, stress, tension and nervousness (Lavania, 2003). It is also used as an aphrodisiac (Wilson, 1995).

3.21 Traditional Medicines

Vetiver roots and leaves have been used in therapeutics treatments. An extensive review of the utilization of vetiver as medicinal plants has already been made by Chomchalow (2001). Thai people know how to use various vetiver parts for medicinal purpose. People in rural areas of Thailand have used vetiver roots in the treatment of dissolving gallstones, reduce fever, and in treating diseases related to bile and the gall bladder, and healing stomach discomfort. Vetiver oil is being used in Ayurvedic system of medicine in India (Lavania, 2003). Vetiver oil is prescribed to relief rheumatism, lumbago, headache, sprain (Anon., 1976), and vetiver drink is prescribed for fever, inflammation and irritability of stomach.

4. CONCLUSION

Bangladesh is a developing country with limited land and per capita income of the people is lower than other developing nations. Vetiver grass, which is available all over Bangladesh, could play vital role for the development of rural infrastructure and the national economy. An integrated management for vetiver cultivation, extension and commercialization for increasing the living standard of the rural people, especially poor women, by engaging themselves with vetiver related activities across the country. At the same time proper research should be carried out to find effective methods of using vetiver for protecting the river embankments, canals, hill and road side, crop land, etc from soil erosion.

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