Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.5, No.21, 2015

Significance of Vetivar Grass (Chrysopogon zizanioides) in Coffee Based Farming System of Ethiopian (A Review)

Ashenafi Ayano
Jima Agricultural Research Center,P.O.Box 192, Jimma, Ethiopia

Abstract
Vetiver grass (*Vetiveria zizanioides* L) is very valuable grass species. It is distributed mainly in Asia, Africa, and America. This plant species is considered as an excellent erosion control over many parts of the world. The unique deep rooting system of vetiver helps to prevent soil erosion and water run-off. Most coffee growing areas of Ethiopia are steep and gently sloppy areas which requires terracing and erosion control. Jimma Agricultural Research Center (JARC) of the Ethiopian Institute of Agricultural Research introduced vetiver grass for the first time to JARC, Ethiopia. The coffee research center contributed more to exploit the unique nature of vetivar that it grows under extreme and wide range of ecological and soil conditions. Research from Jimma Agricultural Research Center (JARC) has demonstrated that rainfall runoff is very significantly reduced by use of vetiver hedges, even on bare land, the soil loss is also dramatically reduced by the third year of establishment. The research carried out in other parts of the world indicated that due to improved soil moisture retention and soil fertility preservation, significant crop yield increases have been recorded between 30-50 per cent - when farmers make use of vetiver hedgerows. Ethiopian farmers and modern coffee farms also benefit from using vetiver as mulch, improving soil organic matter and nutrient recycling. Different coffee farms are also thriving to adopt the technology for treating the effluent discharged from coffee pulpery. The significance of vetivar plant in Ethiopian agriculture can benefit not only for conservation purpose but also it is becoming almost vital in coffee production system due to its diverse value in the sector. Currently most conservationists and agriculturalists agree that the use of Vetivar system in Ethiopia should be scaled-up, as well as introduced for non-farm purposes to exploit its additional advantages.

1. Introduction

Vetiver is a perennial grass belonging to the poacea family. Carey (2006) reported that Vetiver grass (*Vetiveria zizanioides* L), is native to South and South East Asia, where it has been used for centuries to mark boundary lines, stabilize steep slopes and rehabilitate degraded lands. South India is considered as vetiver center of origin from where it is said to have spread. The grass has short rhizomes and massive, finely structured root system that grows very quickly in some applications. Its root depth reaches 3-4 m in the first year. Vetivar can grow up to 1.5 meters high and form clumps as wide. The deep root system makes the vetiver plant extremely drought tolerant and very difficult to dislodge when exposed to a strong water flow. Similarly, the vetivar plant is also highly resistant to pest, disease and fire (EIAR.,2009).

Though it originates in India, vetivar is widely cultivated in the tropical regions of the world. It is distributed mainly in Asia, Africa, and America. The world's major producers include Haiti, India, Java, and Réunion. Several aspects of vetivar make it an excellent erosion control plant in warmer climates which makes it an excellent stabilizing hedge for stream banks, terraces. Most coffee growing areas of Ethiopia are steep and gently sloppy areas which requires terracing and erosion control. The close-growing culms also help to block the runoff of surface water.

It grows luxuriantly in well drained sandy loam soil and in areas with annual rainfall of 1000 – 2000 mm and with temperatures ranging from 21 ^{0} C to 44.50 ^{0} C. Vetivar propagates itself by small offsets instead of underground stolen, noninvasive and can easily be controlled by cultivation of the soil at the boundary of the hedge.

Vetivers in Ethiopia performed very well in altitude ranges of 1200-3200masl, rainfall ranges of 500-2200mm per annum and wide ranges of soil type. Dick Grimshaw, 2009 indicated the unique nature of vetivar in that it grows under extreme and wide range of conditions and long living perennial grass growing in air temperature -15 to >55 ^{o}c, soil P^H from <3 to >10 and annual rainfall <300 mm to >5000 mm and tolerant to high level of heavy metals, saline tolerant, fire tolerant, tolerant to long and submergence to water, resistance to most pests and diseases, deep rooted and good root strength, non competent and non invasive. This gives chance to widely utilize vetivar in all coffee growing areas of Ethiopia. Vetiver is multiplied vegetatively, providing a simple but significant source of income for farmers. In Ethiopia, farmers also sell vetiver to other stakeholders and becoming additional income source (Habtamu Wubshet 2009).

2. The broad benefits of vetiver

2.1. Soil conservation

Greater use of conservation agriculture could not only help bring global food yields back up but also deliver

several important environmental benefits. Aside from restoring soil health, it saves on energy use in agriculture, offering the potential of reducing the footprint of a sector which currently accounts for some 30 percent of global greenhouse gas emissions. It could further mitigate climate change by helping appropriate carbon in the soil and also potentially save water since healthy soil retains more moisture and needs less irrigation. Many countries like India, Zimbabwe, Brazil, Kenya etc do have very good experience in conservation agriculture to reduce erosion and increase production by using vetivar in soil and moisture conservation. In an experiment made for demonstration in Thailand less amount of dry soil loss was also reported by Howeler et al (2002).

The unique deep rooting system of vetiver helps to prevent soil erosion and water run-off. Research from Jimma Agricultural Research Center (JARC) has demonstrated that rainfall runoff is very significantly reduced by use of vetiver hedges, even on bare land, and that soil loss is also dramatically reduced by the third year of establishment. The results confirm that, research carried out in other parts of the world indicated that, as a vetiver hedgerow ages, it increases in efficiency. Due to improved soil moisture retention and soil fertility preservation, significant crop yield increases have been recorded between 30-50 per cent - when farmers make use of vetiver hedgerows.

Vetivar grass has a potential to improve the natural resource base in degraded areas of the country. Besides it is very important for stabilizing soil and water conservation practices in the entire watershed to bring about long-term positive impact.

In an experiment conducted in Fiji, ginger crops planted under farmers' practice (no conservation barrier) produce the most soil loss and runoff. In 1996, during heavy rainfall, soil loss amounted to more than 50t/ha in a cropping cycle. Results point out that vetiver and pineapple are successful in minimizing soil loss (table 1). In table 2 also the data suggest that between vetiver and pineapple treatments, pineapple barriers are less effective than vetiver strips (T. Nakalevu *et al*. 2001).

Table 1. Annual soil loss (t/ha) and runoff (mm) (all treatments cropped with ginger)

Treatment	1992	1995	1996	1997	1998	1999
Farmers' practice	0.53	22.60	50.02	25.82	1.73	4.29
Pineapple barrier	0.11	0.64	0.33	19.22	0.89	0.04
Vetiver barrier	0.27	0.42	0.21	0.80	0.04	0.03

Source: T. Nakalevu *et al*. 2001.

Table 2. Annual soil loss (t/ha) and runoff (mm) (all treatments cropped with taro)

Treatment	1992	1993	1996	1997
Farmers' practice	0.04	2.60	15.46	1.67
Pineapple barrier	0.04	0.21	0.12	5.05
Vetiver barrier	0.08	0.13	0.14	0.09

Source: T. Nakalevu *et al*. 2001.

2.2. Vetivar Introduction to Ethiopia and its Distribution

Mr. Fernie, a British agronomist arrived at the then Jimma Research Center (JRC) of the Ethiopian Institute of Agricultural Research and Mesfin Amha (the then senior coffee researcher) had traveled to Yamungi, Tanzania in 1971 on the way back they brought vetiver grass for the first time to JRC, Ethiopia (EIAR. 2009). Shortly after introduction of Vetiver grass to Ethiopia, an observation trial was conducted and samples were sent to Tropical Institute, England for oil content analysis.

In 1984 vetiver was distributed for the first time out of the JRC to nearby coffee state farms and a development site of Menschen für Menschen (MfM) a German-based NGO to utilize the plant as mulch and as soil and water conservation purposes. The first nursery was established in the early 1990 by MfM in south western part of the country. Some 17,000 Illubabor farmers are now estimated to be using vetiver, the technology having spread from farmer to farmer, using farmer-supplied planting material. In subsequent years, it was introduced to other areas covering the different weredas of Illuababora, Debrezeit, and Holetta Research Center mainly for soil erosion control. In 1990s, it was distributed throughout the country. Ultimately, the grass is now being used by farmers, rural road experts, urban dwellers small-scale cottage industries, and wetlands development projects for various purposes.

During the mid 1990s, Vetivars was also introduced to GTZ-funded integrated food development projects in northern Ethiopia. Within four years, over 800 nurseries were supplying vetiver planting material to protect some 150,000 hectares of farm land. Today, GTZ as well as the Swedish donor, SIDA, along with around 100 NGOs, are promoting the technology across Ethiopia (Dick Grimshaw, 2009).

2.3. Vetivar in coffee based faming system

The grass has been used intensively for soil and water conservation and stabilization of steep slopes. The effects

of vetiver hedges on water flooding and soil erosion were studied at JRC. The findings were successful in reducing flood velocity and limiting soil movement, resulting in very little erosion in the third year. A study under coffee-based cropping system showed that vetiver hedgerow is effective in reducing the soil loss during the third cropping season. It was also noted that, the use of vetiver grass together with physical measures is very important to control the gully side and heads from further erosion.

The then coffee plantation development enterprise (CPDE) the plantation sites are situated in areas with slope greater than 5% which are prone to soil erosion by runoff water. To protect the loss of this soil by erosion high density planting, contour planting and vetiver growing is employed (Baye M., and Terefe B., 2009).

As indicated in the Figure 1 and 2; it shows the planted vetiver grass across the slopes in coffee blocks at CPDE for the purpose of preventing the soil from erosion. Once established such hedges need no maintenance and protect the land from erosion for years, as they build up natural terraces

Figure 1: shows the planted vetiver grass across the slopes in coffee blocks at CPDE
Source: Baye M., and Terefe.B., 2009

Figure 2. Erosion sediment trapped by vetiver hedgerow in coffee plantations
Source: Baye M., and Terefe.B., 2009

In an experiment which was conducted at JARC to study the effect of soil erosion control under un-shaded coffee plantation, it was observed in the first cropping season, none of the techniques was effective in reducing soil erosion. In the second and third season, however the farmers practice was effective in reducing soil loss (0.1 and 0.03ton /ha) since the ground cover was good enough to protect the soil from direct rainfall impact. Vetivar hedge raw (3.66 t/ha) and bench-terrace (4.59 ton /ha) were only effective in the third season. Soil bund was not effective in all the three cropping season (Table 3). In all cropping seasons the result of bare plot showed that the soil losses of 193.40, 207.4 and 139.35 ton/ha were far apart from the acceptable soil loss rate and proved that there is a serious erosion problem in the region; especially on annually cultivated fields. This most probably due to the rolling, undulating- topography, high and intensive rainfall (Tesfaye Yaekob et al 2007).

Table 3. Effect of different soil erosion control techniques on the level of runoff in coffee plots

year	Rainfall (mm)	Soil erosion controlling techniques				
		Bare land	Level bund	Farmers practice	Vetivar hedge raw	Bench terrace
2001	1595.7	188.5	137.7	103.3	139.3	100.1
2002	1450.9	182.8	116.3	3.9	65.3	102.8
2003	1348.0	139.4	63.48	1.95	17.29	25.88
Mean	**1464.9**	**170.2**	**105 .8**	**36.4**	**74.0**	**76.3**

Source: Tesfaye Yaekob et al 2007

2.4. Utilization of vetivar for mulch in coffee farms

The benefits obtained from mulch includes suppressing weeds, conserving moisture, improving the fertility of the soil, protecting erosion, regulating the soil temperature and ultimately contribute to better quality coffee. Ethiopian farmers also benefit from using vetiver as mulch, improving soil organic matter and nutrient recycling. It has a lot of advantages, and the way it utilized demonstrated in the following (Figure 3 and 4).

For the last four decades, vetiver has been planted successfully in coffee-based farming systems in Southwest Ethiopia. The primary purpose of introducing the grass was mainly for its oil content. Nevertheless; in later years, investigation on the effect of vetiver grass as mulch for coffee was investigated along with other mulch materials. The results were vivid, in that, the grass demonstrated to be a better mulch material vis-à-vis its effect in controlling the expansion of noxious grass weeds such as couch grass (Digitaria abyssinica) from plot to plot (EIAR. 2009). Vetivar grass also used as temporary shade for young coffee seedlings to prevent severe sun scorching during long dry months (figure 5).

Figure 3 and 4. Vetiver grass used as mulch material for young coffee plantations in Ethiopia

Figure 5. vetivar as temporary shade in Ethiopia

2.5. Coffee effluent discharge

Red cherry that is arriving the pulpery is pulped where epicarp (red skin) is removed leaving behind the parchment coffee. The parchment is covered with pulp rich in sugary material (mucilage) which is removed by fermentation and /or mechanical mucilage remover and washing. The water from the first washings of the fermented coffee (effluent) is polluted to be used. For effluent treatment many technologies are adopted and vetiver is one. It is reported that using vitiver grass for successfully treating the effluent. In Ethiopia different coffee farms are thriving to adopt the technology for treating the effluent discharged from coffee pulpery. Figure 6 shows the vetiver system designated for effluent treatment. Here the effluent is flowing over the vetiver system through the ditches, where it slows down the flow of the effluent, drops the effluent and clean water oozes through the vetiver system.

Figure 6. Vetiver system used to treat effluent discharged from pulpery

2.6. Environmental protection Through Effluent management

As with other countries in the Great Rift region, Ethiopia is facing the drying up of lakes, reduced river flows and increasing sedimentation. Using vetiver, however, provides an effective flood and sediment control measure on the flat plains surrounding these lakes. Vetiver has also been shown to effectively reduce leaching of nitrates and phosphates, and the biological oxygen demand (BOD) of micro-organisms, resulting from intensive farming operations and urban waste, by more than 90 per cent.

The heavy metals contamination of the environment by soil erosion in agricultural lands, urban wastes and by-products of rural, industrial and mining industries attracts world-wide concern, especially in developing countries (Tordoff et al., 2000). Economically there is an urgency to decontaminate or re-vegetate the mine wastelands in order to improve environment. Although there are many methods used to treat them, most of them are either expensive or impossible to carry out, as the volume of contaminated material is very large, such as the coal mine tailings. Therefore, a more economical and practical approach is urgently needed at present, especially for the developing countries.

However, re-vegetation of these sites is often difficult and slow due to the hostile growing conditions, which include toxic levels of heavy metals. Therefore, selection or screening of plant species which are tolerant to toxic levels of heavy metals has attracted much attention in the treatment of the abandoned mine wastelands. There is a wealthy of evidence to show that vetiver grass is highly tolerant to the hostile soil conditions and widely used as a natural, effective, and low-cost alternative mean to vegetate the heavy metal-contaminated lands. In the experiment conducted in China to study the tolerance of vetivar for heavy metal contamination result showed that, it is very useful to apply nitrogen fertilizer when vetiver grass is used to re-vegetate the metalliferous mine wastelands. (J. Pang.,et al. 2003)

The areas of heavy metal-polluted soils increased significantly throughout the world during past several decades, as the results of industry development, mining activity, irrigation of waste water (Tordoff et al., 2000) which has become a global problem because of its deleterious influences not only on plant growth (yield and quality) and environmental quality, but also on the health of human beings. Therefore, much effort has been made to decontaminate the polluted soil by using chemical, physical or biological methods. For metalliferous mine wastelands, both the physco-chemical methods and biological methods are impossible to be used to decontaminate the heavy metal polluted wasteland as a consequence of the large amount of waste products of mining and ore-processing operations. Use of a vegetation cover gives a cost-effective and environmentally sustainable method of stabilizing and reclaiming wastes such as mine-spoils and tailings (Tordoff et al., 2000). Thus, screening of plant species which are high tolerance to high-level heavy metals is urgently needed in this

aspect.

Vetiver grass (V. zizanioides), due to its unique morphological and physiological characteristics, has been widely known for its effectiveness in erosion and sediment control, and has also been found to be highly tolerant to extreme soil conditions including heavy metal contamination. Nowadays vetiver grass has been widely used as an alternative method for rehabilitation of mine tailings in several countries, including in China.

Vetiver's ability to tolerate high levels of toxic heavy metals, retaining them in its massive root system, also provides an ideal technique for the stabilization and clean-up of mining tailings (waste) (Dick Grimshaw, 2009).

Experience from across Ethiopia clearly demonstrates that vetiver hedgerows are directly responsible for improved ground water recharge, including spring flow renewal, wetland restoration, and better stream flow. In Ethiopia there are different promoters of vetivar; among which Wetland and Natural Resources Association (EWNRA) is currently one of the strongest promoters of vetiver hedgerows and, with support from various donors (Afework H.,2009)

3. Summary and Conclusion

About 85% of the land surface of the country is considered prone to moderate to very sever soil degradation. To mitigate this problem strongly working on vetivar system is current critically needed issue. Above the ground, vetiver (*Chrysopogon zizanioides)* looks much like other coarse, clumplike tropical grasses with, at first glance no apparent attributes. But looking closer, and particularly beneath the surface, the unique deep rooting system gives some indication of the value of this plant in mitigating soil degradation.

The significance of vetivar plant in Ethiopian agriculture can benefit not only for conservation purpose. It is becoming almost vital in coffee production system due to its diverse value in the sector.

Currently most conservationists and agriculturalists agree that the use of Vetivar System in Ethiopia should be scaled-up, as well as introduced for non-farm purposes. On top of soil and water conservation vetivar grass has multiple uses, effective, simple to use, cheap and labour intensive; and grown over wide range of climatic and soil conditions, this makes it particular to work on it in many aspects. It is proven, low cost, easy to use, and it is easily adaptable technology.

On the other hand farmers can diversify very easily their production system. For example if farmers grow vetivar in their fields they can control soil erosion simultaneously controlling some insect pests from their crop, and can be good source of mulch to grow coffee and other horticultural crops and farmers able to get cheap forage source for their animals. On top of this if the current agricultural technology advanced one step at the end of the day farmers can sell the roots of vetivar as raw material for production of essential oils for processing industries and as a result other products like perfumed soap, perfume, sandalwood and other products produced.

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