The Adoption of Vetiver Grass for Soil Erosion Control in Simbu Province

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Abstract

The sustainability of the traditional subsistence system of agriculture in the northern part of Simbu Province of PNG is at risk because of the combined effects of population pressure and the geomorphology of the area. These together have led to the loss of fertile topsoil in village gardens through the effects of rainsplash/surface wash erosion.

From 1994 to 1999 we were involved in a limited but concerted program to introduce vetiver grass, *Vetiveria zizanioides* (Nash), to farmers in a number of provincial districts as an aid in reducing erosion. Workshops were used to introduce vetiver grass technology to villagers who were given limited quantities of vetiver grass planting material.

The latest evidence indicates that use of the technology is spreading from those who attended workshops to those who were unable to attend, and more and more farmers are using it in their gardens. It will be a number of years before vetiver's true impact on farming in the province can be assessed.

SIMBU Province is located in the central highlands of PNG. The altitude in the province ranges from about 160 metres to 4509 metres above sea level, but approximately 70% of the province lies at altitudes between 1000 and 2600 metres above sea level,. Over 40% of the area has an average slope of more than 20° per kilometre. Only in the districts of Karimui and Kerowagi are there substantial areas with slopes of less than 10° per kilometre. There are no large areas of land with gentle slopes suitable for large plantation agriculture as in many other provinces in the country, and most agricultural production is carried out using traditional subsistence or semisubsistence techniques in small gardens. Rainfall in most areas is over 2000 millimetres per year, reaching 5000 millimetres per year in southern Simbu. The fertility status of soils in the province is moderate to moderately low (Humphreys 1984).

Population increases in many of the northern parts of the province have combined with the geomorphology of the area to put stress on the existing agricultural system, which brings the system's sustainability into question. Crop surpluses are generally sold in local markets because there is almost no transport infrastructure for getting this produce to larger regional markets. Levels of disposable income are low. People are looking for any means of increasing or at least maintaining fertility that do not require large amounts of finance to implement. If agricultural production from either the traditional subsistence gardening system or the intensive commercial cash cropping industry is to be sustained or increased, improved methods of land-use management are essential.

There are a number of technologies that may provide part of the answer to the dilemma faced by

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village gardeners. One of these techniques is the growing of vetiver grass, *Vetiveria zizanioides* (Nash), in hedges on the contour to control erosion in gardens. In about 1988, vetiver grass was introduced into the province for this purpose, though it was not until the Simbu Agroforestry and Land Use Project (SALUP) (1993–96) and the following Natural Resources Management Project (NRMP) (1997–99) were carried out that much impetus was given to spreading the technology to village gardeners.

Vetiver grass hedges, by themselves or, better still, used in combination with some of the existing traditional land-use management techniques, have the potential to be a practical, cost-effective solution to many of the soil-loss problems facing PNG agriculture. The grass is not the only remedy for these problems. However, when integrated with other management and soil erosion control practices, it can improve the sustainability of, and increase returns to, the farming sector in terms of improved crop production and increased earnings from the sale of surpluses.

While the work on vetiver grass has been done in Simbu Province, the insights gained should be equally applicable to other areas of the highlands—and indeed to PNG lowland locations, particularly those with slopes and with soils that are prone to erosion.

This paper documents the methods we have used to introduce the grass as an erosion control tool to villagers in the PNG highlands and provides a practical guide for its use. The information comes from practical experience gained in introducing the grass to village farmers and observing how they have used it in their gardens since June 1994, from researching the available international reference material and from information collected at international conferences on vetiver grass held in Thailand in 1996 and 2000.

The Soil Erosion Equation

Two types of soil erosion have been identified as being important in Simbu Province: mass movement, which accounts for about 75% of the total estimated erosion in the province, and rainsplash/surface wash. However, rainsplash/surface wash is the most important erosion factor on cultivated land, and leads to soil loss of about 11 tonnes per hectare per year (Humphreys 1984). This type of erosion is the more important for village gardeners, as the topsoil lost contains much of the organic fraction of soil, which has a major effect on plant growth and production.

Given the increase in population density since the time of Humphreys' study, with a consequent increase in the length of the cropping cycle and a reduction in the length of fallow in village gardens, it can be assumed that the above figure is conservative. Villagers report declining production levels in their gardens that can be attributed, in part, to topsoil loss from erosion.

Vetiver Grass

Origin and present worldwide distribution of vetiver grass

V. zizanioides originated in India and Southeast Asia, where it has been cultivated for hundreds of years and where farmers have used it traditionally to stabilise bunds in flood-irrigated fields.

The grass is grown in many tropical and subtropical countries, including Fiji, some of the islands in the Caribbean, the Philippines, Indonesia, China, Africa, Australia and both Central and South America.

Over the past 20 years or so, vetiver grass has acquired an international reputation as a weapon in the fight against soil erosion. It has proved to be a versatile biological erosion control tool that can be used in manually worked traditional agricultural systems in developing countries as well as in the more mechanised systems used by developed nations.

Characteristics of vetiver grass

- There are a number of species of vetiver grass, but only *V. zizanioides* has all the ideal characteristics for controlling soil erosion.
- Some *Vetiveria* species produce viable seeds, but the variety grown in PNG has not produced flowers or seeds under our growing conditions.
- Vetiver is a perennial species and grows in the place it is planted for many years without spreading. Clumps do not produce runners or rhizomes so it does not spread vegetatively from the original place of planting.
- The plant can survive and grow in a wide range of soil and climatic conditions. It can be used to help rehabilitate eroded or disturbed soils such as those often found on steep gardens, excavated roadside cuttings and embankments or mine dumps with heavy metal contamination.
- In some countries vetiver is grown at altitudes up to 2500 metres, though the lower temperature at these high altitudes reduces growth rates. In PNG it is presently being grown near the ocean and as high as 2700 metres.

- Once established, the grass is able to stand both wet and dry conditions and is not killed by the light frosts that can be experienced in some parts of the highlands or by inundation. Vetiver hedges did not die during the severe drought in 1997–1998, even though there was little active growth until rains fell.
- The erect leaves are suitable for use as roof thatch or garden mulch and grow to 1.5 metres. May grass (*Melinis minutiflora*) has killed *kunai* grass (*Imperata cylindrica*) in many parts of the highlands, and vetiver grass comes as a welcome alternative thatch where this has occurred.
- The coarse leaves are not attractive to animals as fodder. Pigs do not seem to root close to the plants or eat the roots. Cattle, sheep and goats will sometimes eat very young leaves.
- Erect stems are not often seen and are usually short.
- A thick almost impenetrable barrier fence or hedge is formed when plants are grown in a line close together. This hedge is very effective at impeding the flow of running water and allowing soil to settle from the water as it percolates slowly between the densely growing stems of grass.
- The clumps that are formed can be separated into individual slips or tillers, which are used for planting. Large clumps can have over 100 slips. Clumps 6–8 months old produce the best planting material as they are usually still growing vigorously, they are easy to dig out and the slips are easily separated.
- When slips taken from actively growing clumps are planted, they will quickly grow new leaves and roots. As long as soil moisture and fertility conditions are good, the slips should be well established within 3–6 months.
- The growing point (crown) of the clump is just below ground level so that burning or trampling by animals causes little damage.
- When soil collects on the upslope side of a clump, the crown of the plant grows higher and keeps pace with the raised soil level so that it maintains its height relative to the soil surface and is not buried.
- The roots are strong and tend to grow down (in ideal conditions to depths of over 5 metres), rather than spreading horizontally near the surface. Thus the grass does not seriously compete for water and nutrients with crop plants growing close to it.
- The roots form a dense wall under a vetiver grass hedge, which makes it particularly resistant to water erosion or landslides as well as providing good protection to stream or fishpond banks on which it is growing.
- Once the clumps are well established, trimming the leaves to 10–20 centimetres increases the amount of tillering, thereby thickening the clump.
- Diseases and insect pests seem to have little effect on the plants.

Using vetiver grass

For erosion control

Farmers in Simbu Province often use steep slopes for gardening, so the main use of vetiver grass is to control erosion. Hedges of vetiver grass planted across the slope are capable of controlling erosion by themselves, particularly when planted on the contour. However, the hedges are more effective in combination with other cultural practices such as soil retention barriers, mulching, planting rows of nitrogen-fixing trees such as casuarinas and periodic fallowing in gardens.

When planted in a row across the slope, vetiver grass forms a dense hedge. The water cannot run through the grass quickly. Any soil that it is carrying is filtered out and deposited on the top side of the hedge. Over time, this soil forms a terrace above the line of vetiver grass. In some parts of the world, terraces up to 2 metres high have built up over a period of 30–50 years. The soil in these terraces usually has a concentration of plant nutrients and organic matter, as it is largely an accumulation of topsoil washed down from higher up the slope. This accumulation of soil does not bury the grass, as the height of the growing point keeps pace with the build-up of soil.

Once the grass hedge is well established on very steep slopes, the leaves and stems will trap clods dislodged during cultivation and prevent them rolling further downhill, in the same way as soil retention barriers do.

Ideally, vetiver grass hedges or soil retention barriers should be established on the contour with a maximum of 2-metre vertical or 5-metre surface intervals between them (whichever gives the smaller surface distance). This will provide maximum erosion protection. These intervals allow the water speed to be reduced to a level where it causes little rilling while still providing space between the barriers for cultivation of the crop. However, on steeper slopes the vertical interval may need to be increased so there is enough space between the hedges for the crop plants. Individual farmers will have to decide on a distance that is acceptable to them. On steep land, the surface distance between hedges should never be more than 5

metres. Larger distances make it difficult to control the speed of water running down the slope during the high rainfall events that occur occasionally.

Vetiver grass should be planted into new gardens when they have been cleared after a period of fallow but before the first planting of food crops is made. Soil retention barriers should be constructed before the grass is planted.

Once the grass hedges are established, it may be advantageous to trim the leaves to about 20 centimetres before the next crop is planted. This is because the overhanging leaves can make it more difficult to plant the crop close to the hedge, particularly on the downslope side. This will help to thicken the hedge. The cut hedge is still able to hold soil that is dislodged during cultivation. The cut leaves can be used as mulch on the newly planted crop. It is a good practice to put any trash from the garden against the upper side of the hedge. This helps to control erosion and contributes to the soil organic matter.

For thatch

Leaves trimmed from established plants in erosion control hedges or nurseries can be used as thatch in the same way as *kunai* grass (*I. cylindrica)*. The leaves regrow quickly and cutting them does not harm the plant.

For mulch

The leaves are suitable for use as a crop mulch. This system will return organic matter and some nutrients to the crop, will protect the soil from the effects of rain damage and will reduce weed growth.

For marking boundaries

Hedges of grass can be used to semipermanently mark property boundaries and to replace rows of *tanget (Cordyline fruticosa)* for marking fence lines. The grass will also stabilise the boundary line against erosion.

For vetiver oil production

Vetiver oil is extracted from the roots of the plant and is used in the manufacture of perfumes, soaps, food flavouring and insect repellents. It is unlikely that much grass will be used for this purpose in PNG. This is because labour requirements are large, financial returns are small, processing of the oil is difficult, expensive infrastructure is required and the world market for the oil is largely supplied from the existing sources. The grass must be grown in sandy soils to facilitate the harvesting of roots.

However, small bundles of washed roots can be placed under mattresses or hung in houses, where the pleasant smell from them will discourage bed bugs and fleas. Some villagers claim the roots and leaves also discourage rats and cockroaches.

Benefits to farmers

Farmers will not receive direct financial benefit from vetiver grass, unless a big demand develops for planting material and users are prepared to pay for it. They will receive many indirect benefits. These include the following.

- The number of cropping cycles can be increased and yields will be sustained for longer before the garden must be fallowed, because less of the nutrients in the garden topsoil are lost by erosion.
- When the leaves are used for mulch, there is better recycling of soil nutrients to the topsoil as the roots extract nutrients from deep in the soil. These nutrients are released when the mulch decomposes. The organic matter levels in the soil are also improved.
- Labour requirement is reduced over several crop cycles. This is because, once the vetiver grass contour hedges have been established in the garden, they do not need to be replaced each year as is necessary for soil retention barriers.
- After 6–9 months in the garden, soil retention barriers rot, allowing the soil they have trapped to be lost downslope. However, if vetiver grass is planted at the same time as the barriers are constructed, the grass roots will hold this soil in place preventing its loss.
- Over a number of years terraces will form above the vetiver grass hedges without any effort on the part of the farmer. Nutrient levels will be high in the soil accumulated in these terraces. These sites are particularly suitable for crops such as corn and green vegetables, which have a high nutrient demand.

Vetiver Grass Extension Experiences in Simbu Province

Initial experience

The methods used to establish vetiver grass in the first introductions to Simbu Province before SALUP and NRMP did not work very well. At first it was recommended that the slips be planted with 20-centimetre spacing, but after four years or so very few complete

hedgerows had been established and many had gaps that concentrated water flow and caused more rilling than if the hedges had not been present.

Recommendations

The early experiences in Simbu Province highlighted the need to emphasise the following points during village workshops.

- The grass should be planted into a new garden *after* it has been cleared, dug and soil retention barriers constructed, but *before* the crop has been planted.
- The hedge should be planted so that the gaps between the slips are less than three finger widths or 5 centimetres.
- Fresh, actively growing clumps should be used for planting material, as they will grow quickly.
- Farmers should plant their own vetiver grass nurseries to ensure they have their own onfarm supply of grass.
- The grass hedges should be planted on the contour wherever possible. The vertical interval between successive hedges should be about 2 metres. On very steep hillsides (100% slope or more) the vertical interval can be increased to up to 4 metres, when necessary, to satisfy the needs of the gardener for enough space between the hedges.
- Mulch should be placed around the slips at planting time to maintain good growing conditions for them during dry weather.

Methods Used to Introduce Vetiver Grass Technology into the Farming System

Over a period of a few months, we and our team of assistants evolved methods for running short workshops to introduce vetiver grass to villagers, with the following components.

The team

The team consisted of the following people:

- the two authors of this paper, who provided the major technical input;
- when possible, a woman, who also gave technical input, and talked with women in particular; and
- an old man who had practical experience with using vetiver grass and was convinced of its value, who was a voluntary member of the team (he was from a village where vetiver grass was introduced in 1994 and had practical experience from using it in his gardens).

At least one of the project's labourers who also had a depth of experience with the grass took part in the presentations.

Language

All workshops were conducted directly in *Tok Ples* if possible or in *Tok Pisin* which was translated into *Tok Ples*. Translators were either members of the team or members of the local community with suitable translation skills.

Initial contact and workshop arrangements

Initially, the team approached villages to see if they were interested in receiving a visit to be told about vetiver grass. Often this was done as a result of a contact arranged by Division of Primary Industry (DPI) officers or other people who had access to the village. Sometimes it was by chance contact with a villager who came to the project site to purchase citrus seedlings, which the project was also producing. Others walked past a workshop being held at a site near a road or market or at a community school. Curiosity got the better of many people when they saw clumps of grass in the back of the vehicle when the team was on its way to workshops. The team was often flagged down on the road on the way to or from a workshop and asked for information. These chance meetings often translated into an invitation to go to the person's village for a workshop at a later date. A radio broadcast also created a lot of interest and resulted in a number of invitations to run workshops in villages the team had not already visited.

Materials taken

The team took the following materials:

- as many clumps of grass as could be fitted in the back of the project vehicle (the long leaves were trimmed from most of these, but a couple were left with the leaves intact so that villagers would appreciate what the plant would look like once it was grown; the leaves also reinforced how they could be used for thatch);
- a number of multipurpose tree species seedlings such as *Leucaena* or *Calliandra* (their use for improving the nutrient status of the soil was explained and management methods such as coppicing were discussed);

- an A-frame for marking out contours for planting the vetiver grass hedges on;
- copies of the vetiver grass booklet and other extension booklets; and
- a sample of vetiver oil.

Workshop procedures

After introductions the team talked with the participants about the problems they were having with erosion and the methods they were already using to try to control this problem; then they proposed vetiver grass as a way of making the methods they were already using work better. They emphasised the very low risk of the grass becoming a weed as compared to May grass (or molasses grass, *Melinis minutiflora)* or cow grass (or elephant grass, *Pennisetum purpureum*), the need for the villagers to make their own nursery from the slips given to them, the necessity of planting the grass slips close together, the need to use good quality slips, and the advantages of planting the hedges on the contour. They also discussed the way the hedges could save them from having to replace the soil retention barriers on a regular basis, the value of the grass for thatch, the fact that trimming helped to thicken the hedges quicker, and the fact that a bunch of washed roots can be used to deodorise a house and discourage pests.

Technology demonstration

After a period of usually animated discussion, the group adjourned to a convenient nearby garden for a demonstration. The demonstrations included preparing the slips for planting, marking out contour lines and actually planting a line or two of the grass. Everyone in the group participated in the process. Where possible, the team used a strategically sited demonstration plot that was clearly visible from thoroughfares in the village or from the road that passed it.

Distribution of materials

Following the demonstration, any planting material not used in the demonstration was distributed, along with the tree seedlings and the extension books.

Follow-up visits

The team always planned to make a follow-up visit to every place where a workshop was conducted. The aim was to address any difficulties the villagers encountered, to look at the progress of planting and to take an additional load of planting material to give to those who missed out in the first distribution. The team emphasised that they were unable to continue to supply more planting material as they had limited supplies and wanted to take them to people who had not already been visited.

Adoption by Villagers

Quite a few farmers obtained small quantities of planting material and planted it on their own initiative with little input from project staff. Not all have used the recommended planting methods, spacings or hedge placements.

Villagers who initially voiced some reservations about the value of the grass later become very enthusiastic advocates for its use as they continued to assess it over a number of years.

Hedges planted in very degraded soils have grown slowly. These soils are generally very shallow (typically less than 10 centimetres) and on very steep slopes; the topsoil has a very low organic matter content. The hedges on these soils have persisted, however, and small amounts of soil have accumulated above them. Some farmers expect quick results and it is necessary to counsel patience as it takes many years for appreciable increases in soil organic matter to occur.

Planting on the contour is a departure from traditional methods, and continued extension effort will be required if it is to be generally accepted. However a number of farmers have recognised the potential of planting the hedges on the contour and have used an A-frame to plant additional hedges in their gardens.

Because the grass takes one to two years to become properly established and show its effectiveness, particularly when growing conditions are difficult, it is necessary to make sure that farmers are willing to be patient and wait for this to occur.

Some Key Points of the Team's Success

The basis of the team's success was that:

- the technology was taken to and demonstrated in the villages by people the villagers could relate to;
- village gardeners could relate to the technology, which enhanced and improved on existing practices;
- the message was simple, practical and clear;

- the technology did not cost money and worked with the existing inputs of tools and labour available to the farmer; and
- other farmers could adopt the technology without inputs from the team, government extension agents or other organisations.

In other words, the success or failure of the technology had to depend on it selling itself on merits that villagers had to be able to recognise themselves. It became their technology.

The success of vetiver grass technology in Simbu Province cannot be finally judged for another 10 years. By then, it will either be simply another curiosity grown by a few, wondered about by a few more and unknown by the vast majority, or it will be a technology that will be used by many and that will have its own 'traditional' cultural methods that may not resemble the methods that the team introduced. In this case, it will be something that will suit farmers in their constant battle to produce food under difficult conditions from limited land for a growing population.

A visitor investigating the vetiver grass project said that 'the use of vetiver grass was spreading in a manner resembling the spread of coffee as a smallholder crop in the 1960s and 1970s' (G.S. Humphreys, consultant to CARE Australia, Natural Resources Management Project, pers. comm.).

References

Humphreys, G.S. 1984. The Environment and Soils of Simbu Province, Papua New Guinea, with Particular Reference to Soil Erosion. Port Moresby, Department of Primary Industry, Research Bulletin No. 35.

Further Information

The Vetiver Network publications that provide much of the technical basis for the development of the vetiver grass program included:

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