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Natural vegetative strips in degraded calcareous soil environments:Successful stabilization of steep slopes in Central Philippines

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ABSTRACT

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While a good understanding exists of the effects of low-cost natural vegetative contour strips (NVS) and their contribution to enhanced land productivity in deep acidic soil environments, little is known about the benefits and constraints of this soil conservation technology under severely degraded calcareous soil conditions. Shallow calcareous soils are common in Central Philippines covering more than half of the total land area of the Visayan islands. Based on the results from the documentation of the traditional use of NVS in Bohol, the World Agroforestry Centre (ICRAF) has conducted on-farm trials since May 2001 to assess the local practice in more detail. Observations made over a period of 1 1/2 years since NVS establishment, confirmed that the vegetative strips are highly effective in collecting eroded sediments in soils derived from either limestone or marl. The accumulation of the eroded in and above the NVS resulted in the formation of terraces that made landcultivation easier and further reduced soil erosion. Consequently, the maize yield on lower terrace zones improved right from the 1st cropping season after NVS establishment, presumably because of the deeper soil and higher water retention capacity resulting from the accumulation of sediment behind the NVS. Improved maize growth compensated for the 20% loss of crop area to the vegetative strips. Together with the findings derived from research on deep acidic soils in Northern Mindanao, findings of this research support the exploration of the NVS technology from ICRAF's research sites to the major soil environments of the Philippine uplands.

Keywords: natural vegetative strips, soil conservation, calcareous soils, indigenous knowledge

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INTRODUCTION

The use of natural vegetative strips (NVS) is one of the many indigenous strategies that have been applied by farmers in the Philippine uplands to conserve natural resource and sustain annual crop production on cultivated slopes. The best-known example of an indigenous soil and water conservation technology in the Philippines is the Banaue rice terrace system in Northern Luzon. These terraces have been established and used on steep slopes for hundreds of years (PURC, 1980; Celestino and Elliot, 1986). Contour rock walls are another soil and water conservation structure that have been used traditionally in several regions of the Philippines (PURC, 1980). An indigenous technology which might have been practiced for hundreds of years among farmers in the Naalad area of Cebu island involves the use of Ipil-ipil (*Leucaena leucocephala*) stems which are bundled into rows across the slope when the fallow is cleared (PURC, 1980; IIRR *et al.*, 1992).

Farmers' practice of maintaining 0.5 to 1 m wide strips of natural vegetation at regular intervals across the slope as buffers to eroded sediment and run-off water has been documented by Tung and Alcober (1991) for Leyte island, and by Garrity *et al.* (1993) and Stark (2000) for Northern Mindanao. The NVS technology evolved locally as a farmer modification of introduced leguminous tree hedgerows in Claveria, Northern Mindanao, and has spread spontaneously among hundreds of farmers cultivating degraded sloping lands in the area. In Central Philippines (Matalom, Leyte Island, the NVS have been used traditionally for at least four decades without any outside intervention (Stark, 2000).

The use of natural vegetative strips for soil conservation on sloping fields has received more attention in research and development circles in recent years for several reasons:

- NVS require minimal labor and zero cash inputs in establishment and maintenance and, therefore, provide a low-cost alternative to the establishment of planted buffer strips of either leguminous tree hedgerows or grasses
- NVS are very effective in reducing soil loss. Research conducted by the World Agroforestry Centre (ICRAF) in Northern Mindanao since 1995 showed that narrow strips of natural vegetation reduce sediment loss from cultivated hillsides of 25-45 percent slope by up to 95 percent.
- The natural vegetative strips cause minimal competition with adjacent

crop rows, as long as they are pruned at least once before and once during a three to four month cropping period:

- The technology is adaptable to the range of farmers' landuse choices. NVS are often used as a base for planting fruit and timber trees, i.e. as starting point for converting bare and degraded sloping fields into productive agroforestry farms and
- The technology is acceptable for tenant farmers, since it requires very minimal investments.

These findings are based on studies conducted on the deep acidic soils, typical for the majority of the uplands in the Philippines and Southeast Asia. For the above reasons, the NVS technology has spread rapidly with minimal technical support from ICRAF. More than 5000 farmers in Misamis Oriental and Bukidnon, Northern Mindanao are now using the technology as a component of sustainable upland farming. Initiatives are currently underway to validate the NVS technology in other parts of Southeast Asia (Indonesia and Vietnam) that have similar bio-physical and socio-economic conditions as the benchmark site in Northern Mindanao.

One limitation of the technology is that the strips produce only little pruning biomass (about 1 t oven-dried material per ha per year) that could be applied as mulch or green manure. The NVS system relies, therefore, on the import of nutrients to maintain crop yield on the cultivated alleys (terraces). Another observation is the development of a soil fertility gradient caused by the redistribution of topsoil and nutrients from the upper zones of each individual alley down to the lower parts of the alley, i.e. sediments removed through erosion (caused by run-off water and plowing) are partly deposited within or above the buffer strips. This can also be observed in other contour hedgerows systems, but the effect is more visible in the NVS system where it is not overlaid by competition effects. This so called soil (fertility) "scouring" effect was studied in Northern Mindanao (Garrity, 1996; Agus, 1993; Stark, 2000), and strategies were identified that farmers had used to address this problem. Applying more mineral fertilizer, lime or plant residues on the degraded upper alley zones (Stark, 2000) or reducing the number of land cultivations on the alleys (Thapa, 1997) were identified as possible strategies to minimize the negative effects of soil fertility scouring. Another study in Northern Mindanao investigated the appropriate spacing between the contour strips. Increasing the vertical interval between the NVS from the commonly recomended 1-1.5 meters to 2-4 meters was suggested to balance between the need to reduce sediment loss, on one side, and the need to minimize crop area loss, on the other side (Mercado, 1999).

While a good understanding exists of the effects of low-cost natural vegetative contour strips (NVS) in deep acidic soil environments, little is known about the benefits and constraints of using NVS under severely degraded calcareous soil conditions. Calcareaous soils cover about 20% of the total land area of the Philippines (Asio, 2001, pers.com.) and are also wide-spread in other parts of Southeast Asia. They therefore, characterize an important environment that millions of upland farmers depend upon for a living in the region. Shallow calcareous soils are particularly common in Central Philippines covering more than half of the total land area of the Visayas islands. Under shallow soil conditions, the effects of soil scouring can be severe because the entire soil may be removed down to the parent rock material.

A study has been conducted since 2000 by the World Agroforestry Center (ICRAF) to fully assess NVS systems under shallow calcareous soil conditions typical for the central Philippines. Objectives of this study are:

1. To document the indigenous use of NVS under shallow calcareous soil conditions and identify options for further improving the technology - based on local practice - to enhance and complement its productivity and conservation benefits. And
2. To quantify the impact of natural vegetative strips on the conservation of natural resources and overall farming system productivity on steeply sloping land in typical shallow calcareous soil environments. Specifically (a) to quantify soil loss from steep hillsides of 45 to 60 % slope and the contribution of natural vegetative strips to slope stabilization, and (b) to assess the effects of different NVS spacing on off-field sediment loss, terrace development, soil fertility on the alleys, crop yield and overall system productivity.

Another set of trials, established in 2001, looked at the effects of NVS on the performance of mango trees *(Mangifera indica)* planted just above the vegetative buffer strips. As also observed in Mindanao, farmers commonly plant fruit and timber trees in or just above the NVS to add more value to the strips taken out of crop production. Mango is the number one most popular fruit tree species in the Visayas. Mango thrives particularly well on calcareous soils and under seasonally dry climatic conditions, typical for large parts of the Central Philippines. The experimental hypothesis is that fruit trees will benefit greatly from more fertile sediment and nutrients (applied to the associated field crop) collected in or just above the buffer strips, and that increased rooting depth in the zone just above the NVS enhances nutrient use efficiency and water availability.

Results of the study to assess NVS under shallow calcareous soil conditions will complement our findings derived from research on deep acidic soils, and will, thereby, support the wide-scale dissemination of the NVS technology as a component of integrated natural resource management in the Philippine uplands.

MATERIALS AND METHODS

The research was conducted in shallow calcareous upland sites on the islands of Bohol and Leyte (Figure 1). Selected sites were representative of the bio-physical and socio-economic conditions of large parts of the central Philippines. The study was done in two steps: (1) documentation of the traditional use of NVS in the municipality of San Isidro, Bohol, in November 2000 and (2) assessment of the technology in on-farm technology validation trials in the municipalities of Tabango and Baybay, Leyte, since May 2001.

Technology documentation. The survey of the traditional NVS system, conducted in November 2000, was done in the Municipality of San Isidro, Bohol (9°84' N, 123°95' E), since this is one of the few sites in the central Philippines where the indigenous use of NVS has been observed (Figure2). Individual interviews were conducted among 22 farmers, randomly selected from a total of about 60 NVS adopters in three villages (Bariong Daan, Masunoy and Candungao). These villages are located in the upper, most degraded part of the municipality. Field crops grown in the area aside from native maize are sweet potato, cassava and peanut. Farmers apply small

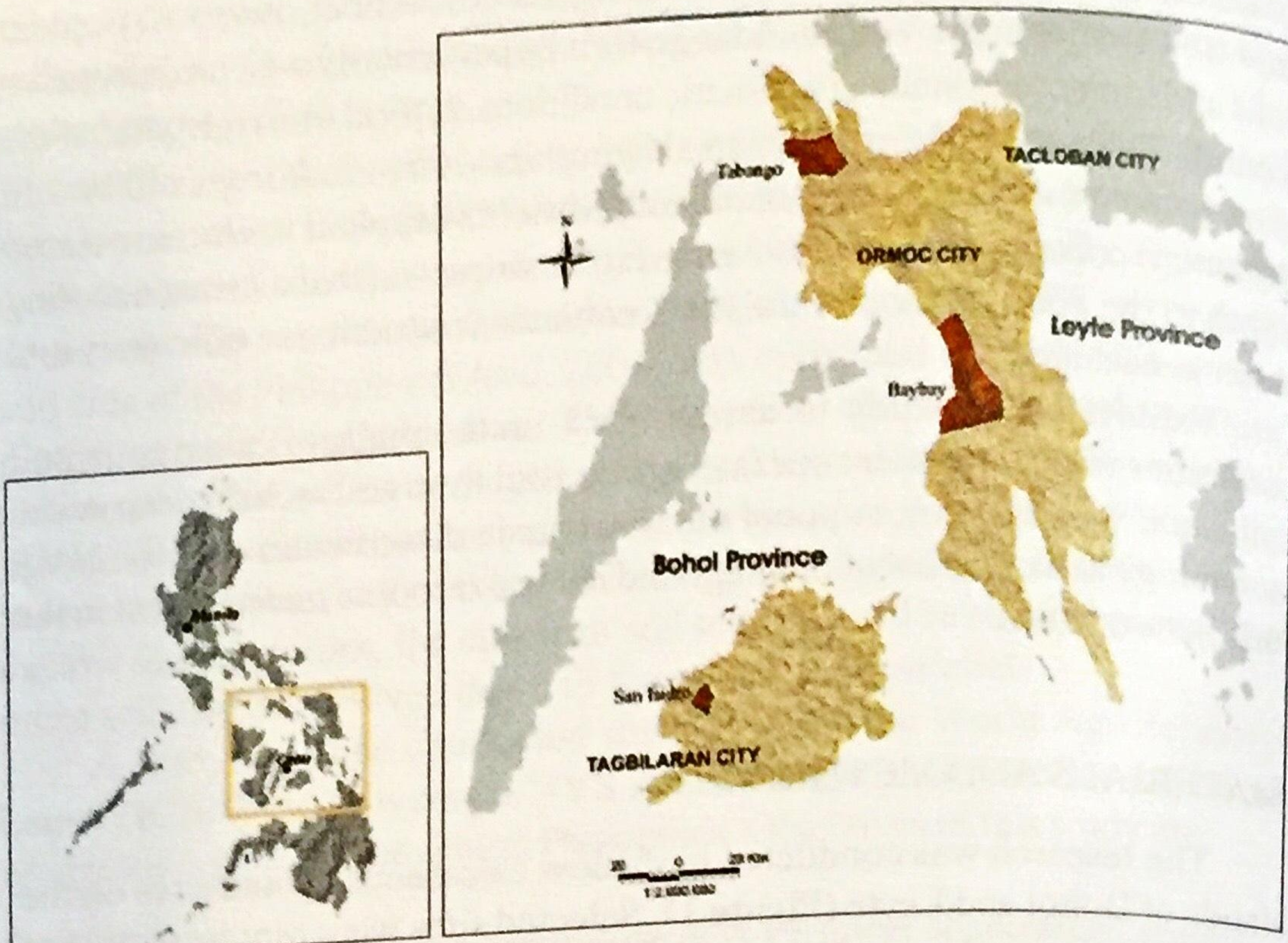

Figure 1. Location of the survey site in Bohol (San Isidro) and the on-farm research sites in Leyte (Tabango and Baybay)

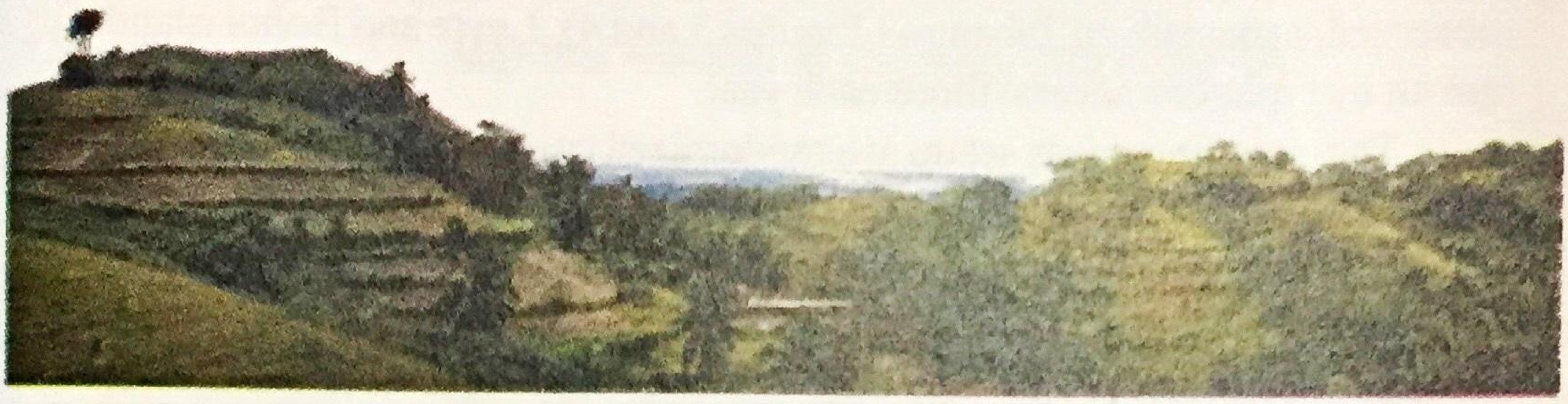

Figure 2. On-farm trials are based on the indigenous use of natural vegetative strips in the central Philippines (this example: San Isidro, Bohol)

amounts of mineral fertilizer and fallow the fields to maintain soil fertility. A focus group discussion (FGD) was conducted in October 2002 with four farmers who have used NVS for at least 3 decades. This was done to clarify and complement some of the information gathered in the previous survey. The interview and the FGD focused on the following key issues: origin of the technology, its benefits and constraints, establishment and management of the NVS system, scouring effects, farmers' strategies to maintain soil fertility on the developing terraces, and farmers' practice in or plans for modifying and improving the system.

On-farm research. On-farm, researcher-controlled experiments have been conducted since May 2001 on two representative farmers' fields in Leyte (Barangay Poblacion, Municipality of Tabango [11°30' N, 124°37' E], and Barangay Punta, Municipality of Baybay [10°59' N, 124°77' E]). In Tabango, soil erosion has been a major constraint to agricultural productivity because more than 50 % of the municipality are characterized by moderately to steeply sloping terrain and because even hillsides with slopes of 50 % and more are cultivated for annual crop production. Soils in the area can be largely classified as Inceptisols. The dominating soil type in Tabango is Lugo clay developed from calcareous parent material (marl). The situation is similar in Baybay, but here degraded coconut farms and abandoned grass lands dominate the landscape. The soil type at the research site in Baybay is Faraon clay, derived from coralline limestone parent material. The top soil in both trial sites is shallow (10 - 30 cm), low in nutrient content, and has an average pH of 7.5 to 8.5 (1:1 soil:water). Even though rainfall is quite evenly distributed throughout the year (type IV climate) and averages 2,600 mm annually, temporary droughts are observed, especially in Tabango (Figures 3 and 4). Leyte and Bohol islands are hit by typhoons several times each year.

The experiment was set up in a randomized complete block design with three replications each on two farms (one farm in Tabango and one in Baybay; Figure 5). Experimental treatments (that were based partly on the findings of the initial survey) are:

1. Control (no NVS)
2. NVS at 4 meter vertical interval (VI)
3. NVS at 2 meter VI
4. NVS at 1 meter VI

Experimental plots are 6 m wide and between 23 m (at Tabango site, slope = 55 - 60 %) and 30 m (at Baybay site, slope = 45 %) long ; sediment traps (trenches made of bamboo) are located below the experimental plots and sheets of galvanized iron are used as plot borders. The NVS were established in March 2001 by leaving 50 cm wide contour strips unplowed during land preparation. Since corn is the most common field crop in the Central Philippine uplands, an improved maize variety recommended by the Leyte State University (LSU), "Visca Var II" or "VM-II", was used as the trial crop. VM-II is a white, open-pollinated variety that can yield up to 6 t/ha higher than native varieties in the area. Two crops of corn are grown each year. The first trial crop was planted in late May 2001 and harvested early September, while the second cropping seasons began in mid October and ended in mid February 2003. NPK fertilizer was applied at 45-30-30 kg/ha, which is half the recommended rate. The low rate was used to enhance stress on the maize crop and scouring effects, and because it is farmers' common practice to apply fertilizer below the optimum level. Data collection included the measurement of plant height, grain yield and total dry biomass of the corn plants, and the quantification of sediment loss.

In the exploratory trial on the effects of NVS on mango trees planted along the contour strips, the trees received a basal fertilizer application (125 g per tree of "14-14-14" NPK) only during planting, while the improved maize variety planted on the alleys and in-between the trees received fertilizer at half the recommended rate (45-30-30 kg NPK / ha) every cropping (i.e. twice per year). Plant height and stem diameter of the mango trees were measured every six months.

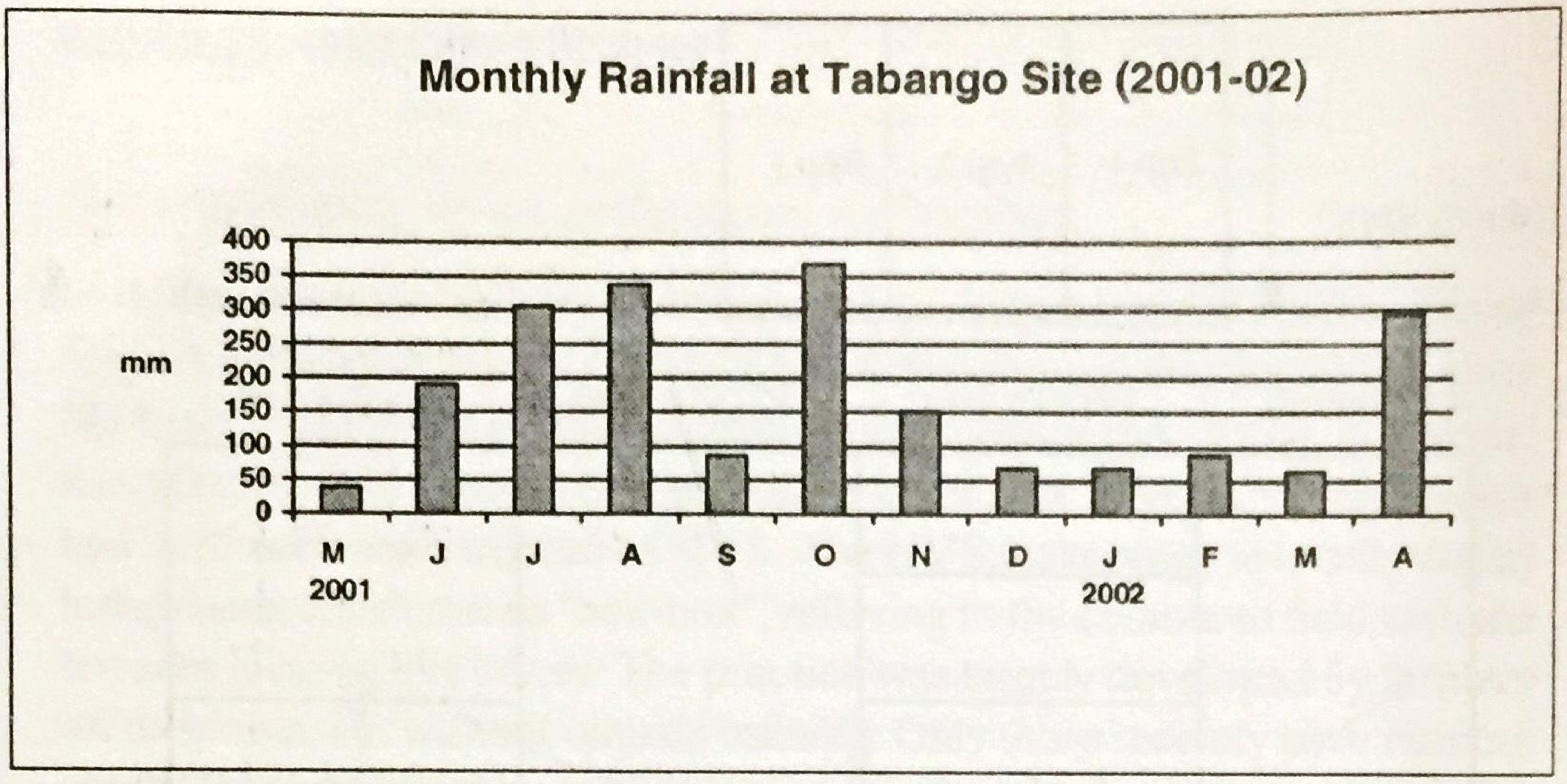

Figure 3. Monthly rainfall at Tabango site from May 2001 to April 2002, and duration of trial crop seasons

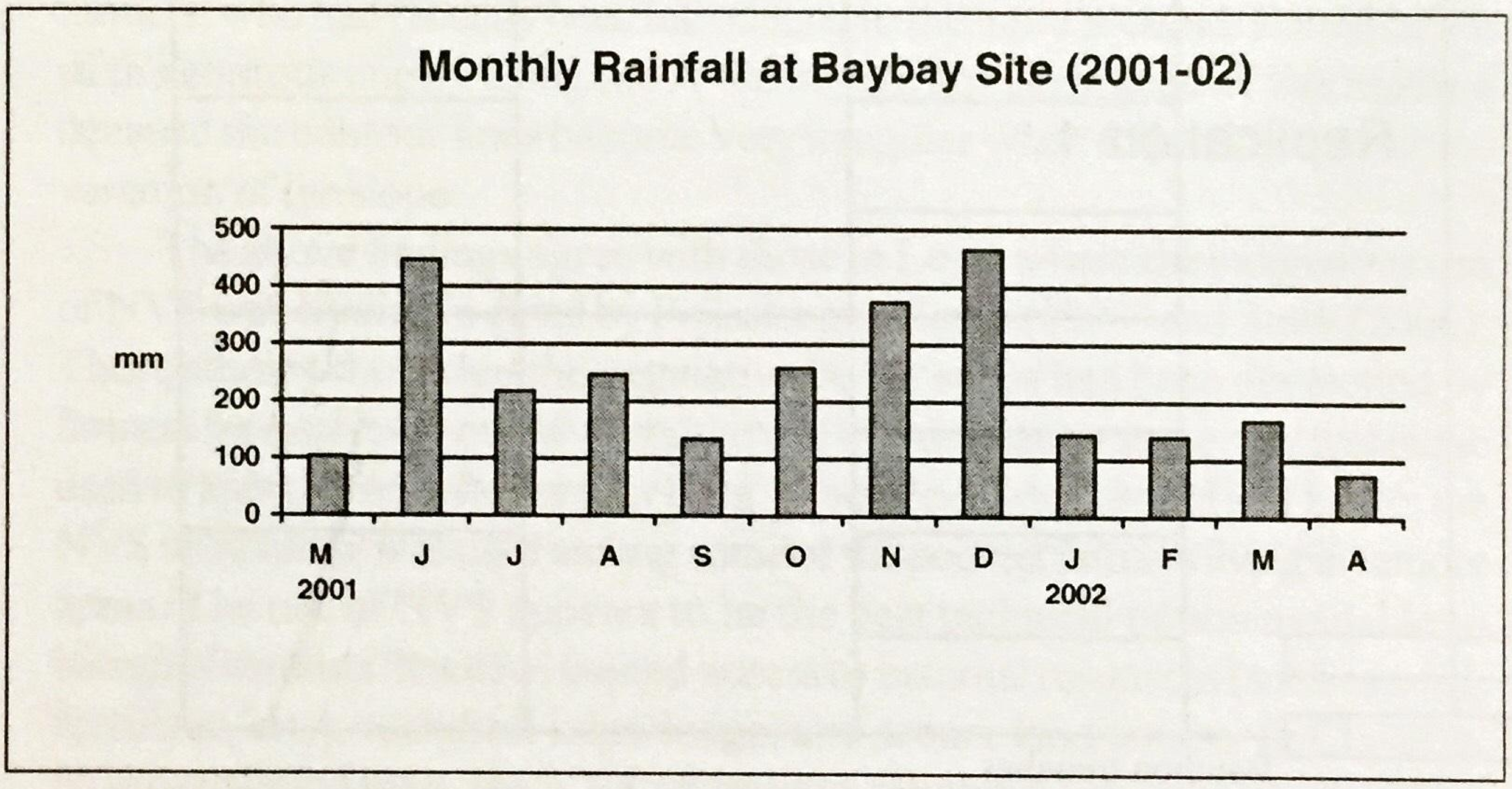

Figure 4. Monthly rainfall at Baybay site from May 2001 to April 2002, and duration of trial crop seasons

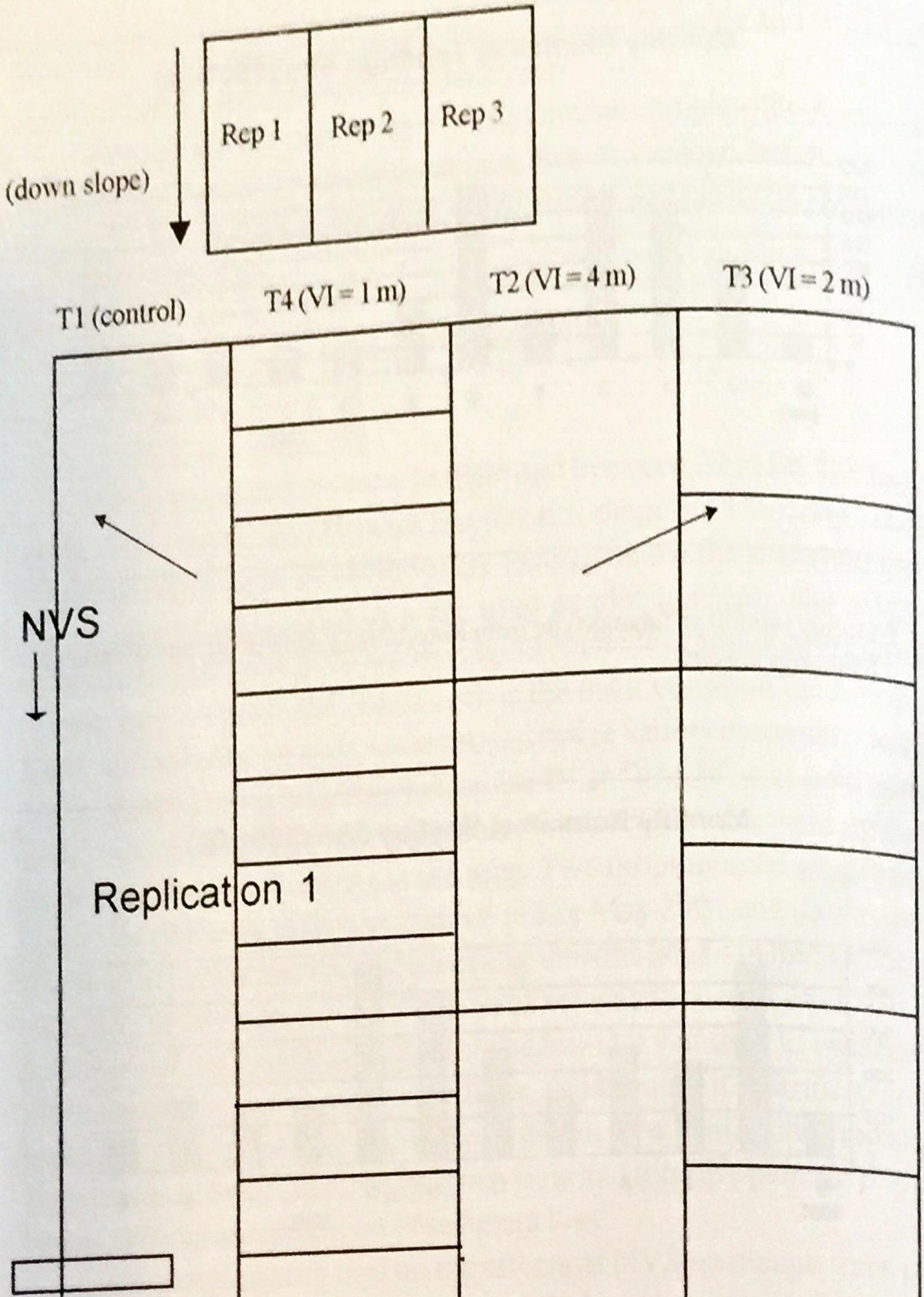

Figure 5. Trial layout. Replication 1 of Baybay site.

RESULTS AND DISCUSSION

Documentation of an indigenous technology

The interview survey and focus group discussion conducted among farmers in the Municipality of San Isidro, Bohol showed that the NVS system has been in use in the area for at least 70 years (since the 1930s). However, more farmers had adopted the technology in the past 20 years. Some farmers had used rock walls instead of NVS. The NVS technology is locally called luang-luang which means "box-box", referring to the contoured field with the terraces looking like boxes. The practice was largely developed by farmers on their own, i.e. without outside training. Only more recently have farmers copied the technology from neighboring farms, and a few were trained by the local office of the Department of Agriculture. The technique to locate the exact contour lines (e.g. through the use of an A-frame) was not known among farmers in the area until very recently. Buffer strips of 0.5 to 1 m width were, therefore, established along semi-contour lines by simple eye-estimate. Some farmers, who had recently been introduced to the more accurate identification of the contour line by using the A-frame, are not convinced of this method because the contour lines become very irregular when following the micro-variation of the slope.

The above findings agree with those in Leyte where the indigenous use of NVS was studied in detail by Fujisaka and Cenas (1993) and Stark (2000). These studies show that the vegetative buffer strips had been developed by farmers themselves about 60 years ago and eye-estimate was the only technique used to approximate the contour lines. In both locations, Bohol and Leyte, the NVS technology was used among some of the poorest farmers living in remote areas. The use of NVS appears to be the best technical option available to marginal farmers that have limited access to external resources (such as seed, fertilizer, etc.), technical knowledge, and secure land tenure. In Claveria, Northern Mindanao, the NVS technology evolved only in the mid 1980s, modified from previously introduced leguminous tree hedgerows, mainly to reduce establishment and maintenance labor.

The traditional labor exchange systems (called Hungos in Bohol) has enhanced the dissemination of this conservation practice. Most farmers established the NVS system in their farm with the help of five to ten neighbors. Labor was, therefore, not mentioned by any respondent as a constraint of the NVS technology. In fact, none of the 22 respondents mentioned any constraint associated with the practice. During the focus group discussion, however, rat infestation and a higher population of snakes in the contoured fields was noted as a down-side of the vegetative buffer strips. Farmers observed that soil fertility was maintained and that land cultivation became easier on the terraces developing behind the buffer strips. They claimed that land value increased by up to 50 % after fields had been contoured.

Soil scouring was observed by almost all respondents shortly after the NVS establishment (after 1 - 2 years) and the effects were in many fields severe (rocks exposed on upper alley zones). Most farmers know that scouring is a result of soil erosion caused by land preparation and heavy rain. Even though most farmers believe or have observed that the effect will not easily disappear (only when natural terraces have become level after at least 4 - 5 years), scouring was not considered as a constraint of the NVS technology. Some farmers (8 out of 22) used their own strategies to reduce soil degradation on shallow upper alley soils, such as:

- apply mineral fertilizer;
- plant longer-duration root crops, such as sweet potato, on alleys;
- mix topsoil of degraded upper alley zones with lower - more fertile - alley zones by harrowing;
- minimize plowing operations; and/or
- reduce alley width to avoid exposure of rocks.

These findings are consistent with those obtained from Leyte and Northern Mindanao in previous studies (Stark, 2000). Under the deep acidic soil conditions of Claveria, Misamis Oriental, NVS farmers commonly apply higher amounts of mineral fertilizer, biomass mulch and/or lime to the degraded upper alley zones to overcome the negative effects of scouring. However, one major difference observed in farmers' management of NVS systems in deep vs. shallow soils is the distance between the contour strips. Some farmers in the shallow calcareous soil environment of Bohol have learned through experience that narrower distances between the buffer strips reduce the effects of soil scouring and prevent the exposure of rocks. In contrast, most farmers cultivating deep soils in Northern Mindanao prefer wider spacing of the alleys between NVS to minimize crop area loss.

We observed that only few NVS in San Isidro were enriched with planted species, such as coconut, banana, napier grass (*Pennisetum purpureum*) for animal fodder, pine-apple and papaya, but most farmers expressed their interest in planting trees and more fodder grasses on the contour strips in the future.

On-farm technology assessment

The decision to focus on the appropriate width between the buffer strips - aside from comparing the NVS technology to cultivating the slope without buffer strips - was made after studying the indigenous practice in San Isidro, Bohol.

Observations made over a period of 1 ½ years since NVS establishment (Note: data were only analyzed for the first two cropping seasons), confirmed that the vegetative strips are highly effective in collecting eroded sediment in soils derived from either limestone or marl. The closer spacing between the vegetative buffer strips (i.e. the higher NVS density on the slope) resulted in a significantly higher soil loss reduction. However, even at the vertical distance of 4 m, soil loss was reduced by 25 % in the Tabango site and by almost 90 % on Punta site. The difference in the efficacy to control sediment loss can be attributed to the difference in slope and vegetation cover of the NVS. The slope in Punta is 45 %, compared to 57 % in Tabango, and densely vegetated with cogon (*Imperata cylindrica*). At the highest NVS density (i.e. vertical interval of 1 m), soil loss was reduced by 93 % in Punta and by 83% in Tabango. The accumulation of the eroded sediment in and above the NVS resulted in the formation of terraces that made land cultivation easier and further reduced soil erosion. Contour bunds were on the average 70 cm high on the 45 % slope (Figure 6) and 83 cm high on the 57 % slope. This rapid terracing of the contoured slope can be largely attributed to soil movement during land preparation. The soil movement due to water erosion during heavy rainfall is

Figure 6: Natural terrace development is rapid under steep slope conditions: bund heights of the developing terraces reached 80 cm after one year (this example: Baybay research site; with research assistant Julito Itumay - left - and farmer cooperator Ronelito Mazo)

only of secondary importance, as was earlier proven in ICRAF's research sites in Northern Mindanao (Thapa, 1997).

Consequently, the maize yield on lower alley zones improved right from the first cropping season after NVS establishment, presumably because of the deeper soil and higher water retention capacity resulting from the accumulation of soil behind the NVS. Improved maize growth especially in the treatment with the highest NVS density (1 m vertical interval) compensated for the 20 % loss of crop area to the vegetative strips.Maize grain yield was not significantly reduced by the presence of NVS, even though the strips reduced the cropping area and caused some competition on the maize crop for nutrients and water (Tables 1-7). This is a very positive result, because the data obtained from previous research in the deep acidic soil environment of Claveria, Northern Mindanao indicate that the area loss is usually not compensated by improved crop yield (Mercado *et al.*, 1999).

The data of the two cropping seasons, however, also stress that the installation of NVS alone may not be sufficient: while it is obvious that soil loss is minimized, there is no total crop yield increase in the plots with NVS compared to the un-contoured plots in the short run. Improved yield only compensates for the area loss. We have, therefore, encouraged farmers to

Table 1. Effect of NVS and different NVS densities on maize growth and yields - Baybay site, 1st crop 2001

Treatment	Grain yield 1 (t/ha)	Grain yield 2 (t/ha)	Total dry matter yield 1 (t/ha)	Total dry matter yield 2 (t/ha)	Plant height (cm)
T1(control)	0.78 a	0.78 a	4.09 b	4.09 b	207.17 b
T2 (4 m VI)	0.97 a	1.02 a	4.75 b	4.99 a	230.72 a
T3 (2 m VI)	0.83 a	0.92 a	4.08 b	4.50 b	219.72 a
T4 (1 m VI)	0.97 a	1.16 a	3.56 b	4.29 b	221.47 a
LSD (5%)	0.36	0.40	0.44	0.43	12.36
N	12	12	12	12	12
CV%	20.59	20.63	5.29	4.86	2.81

Table 2. Effect of NVS and different NVS densities on maize growth and yields - Tabango site, 1st crop 2001

Treatment	Grain yield 1 (t/ha)	Grain yield 2 (t/ha)	Total dry matter yield 1 (t/ha)	Total dry matter yield 2 (t/ha)	Plant height (cm)
T1(control)	1.16 a	1.16 a	5.29 a	5.29 a	253.19 a
T2 (4 m VI)	1.49 a	1.58 a	5.67 a	6.02 a	247.13 a
T3 (2 m VI)	1.08 a	1.21 a	4.87 a	5.47 a	248.54 a
T4 (1 m VI)	1.08 a	1.32 a	4.48 a	5.59 a	242.09 a
LSD (5%)	0.74	0.79	1.56	1.64	31.95
N	12	12	12	12	12
CV%	30.96	29.96	15.37	14.66	6.46

Means in a column followed by the same letter are not significantly different from each other at the 5% level; LSD test. Grain yield 1 is actual total yield per plot (on a per ha basis), i.e. including the area occupied by the NVS; Grain yield 2 is the total yield per cropping area only, i.e. the area occupied by the NVS within one plot is not included (but converted to crop area). The same applies to the Total dry matter yield 1 and 2. ----- VI = vertical interval.

Table 3. Effect of NVS and different NVS densities on maize growth and yields - 2 sites combined, 2nd crop 2001

Treatment	Grain yield 1 (t/ha)	Grain yield 2 (t/ha)	Total dry matter yield 1 (t/ha)	Total dry matter yield 2 (t/ha)	Plant height (cm)
T1(control)	0.97 a	0.97 a	4.69 a b	4.69b	230.18 a
T2 (4 m VI)	1.23 a	1.30 a	5.21 b	5.51 a	238.93 a
T3 (2 m VI)	0.95 a	1.06 a	4.48 b	4.99 a b	234.13 a
T4 (1 m VI)	1.01 a	1.24 a	4.02 b	4.94 a b	231.78 a
LSD (5%)	0.37	0.39	0.72	0.75	15.25
N	24	24	24	24	24
CV%	28.04	27.37	12.45	11.92	5.19

Table 4. Effect of NVS and different NVS densities on maize growth and yields - Baybay site, 2nd crop 2001

Treatment	Garin yield 1 (t/ha)	Grain yield 2 (t/ha)	Total dry matter yield 1 (t/ha)	Total dry matter yield 2 (t/ha)	Plant height (cm)
T1(control)	0.80 a	0.80 b	4.20 a	4.20 a b	183.42ab
T2 (4 m VI)	0.80 a	0.84 a b	4.20 a	4.42 a	191.35 a
T3 (2 m VI)	0.95 a	1.04 a	3.89 a	4.28 a	181.19 b
T4 (1 m VI)	0.80 a	0.96 a b	2.73 b	3.29 b	184.23ab
LSD (5%)	0.22	0.23	0.86	0.94	8.51
N	12	12	12	12	12
CV%	13.40	12.43	11.40	11.68	2.30

Means in a column followed by the same letter are not significantly different from each other at the 5% level; LSD test. Grain yield 1 is actual total yield per plot (on a per ha basis), i.e. including the area occupied by the NVS; Grain yield 2 is the total yield per cropping area only, i.e. the area occupied by the NVS within one plot is not included (but converted to crop area). The same applies to the Total dry matter yield 1 and 2. ----- VI = vertical interval.

Table 5. Effect of NVS and different NVS densities on maize growth and yields - Tabango site, 2nd crop 2001

Treatment	Grain yield 1 (t/ha)	Grain yield 2 (t/ha)	Total dry matter yield 1 (t/ha)	Total dry matter yield 2 (t/ha)	Plant height (cm)
T1(control)	1.61 a	1.61a	4.76 a	4.76 a	172.66 a
T2 (4 m VI)	1.59 a	1.69 a	4.25 a b	4.51 a	176.38 a
T3 (2 m VI)	1.45 a	1.62 a	3.94 a b	4.42 a	176.64 a
T4 (1 m VI)	1.32a	1.64 a	3.35 b	4.17 a	170.67 a
LSD (5%)	0.38	0.45	1.29	1.43	9.87
N	12	12	12	12	12
CV%	12.82	13.62	15.87	16.04	2.84

Table 6. Effect of NVS and different NVS densities on maize growth and yields - 2 sites combined, 2nd crop 2001

Treatment	Garin yield 1 (t/ha)	Grain yield 2 (t/ha)	Total dry matter yield 1 (t/ha)	Total dry matter yield 2 (t/ha)	Plant height (cm)
T1(control)	1.21 a	1.21 a	4.48 a	4.47 a	178.04 b
T2 (4 m VI)	1.20 a	1.27 a	4.22 a	4.46 a	183.87 a
T3 (2 m VI)	1.20 a	1.34 a	3.91 a	4.35 a	178.92ab
T4 (1 m VI)	1.06a	1.30 a	3.04 b	3.73 a	177.45 b
LSD (5%)	0.20	0.22	0.69	0.76	5.80
N	24	24	24	24	24
CV%	13.46	13.88	14.00	14.26	2.57

Means in a column followed by the same letter are not significantly different from each other at the 5% level; LSD test. Grain yield 1 is actual total yield per plot (on a per ha basis), i.e. including the area occupied by the NVS; Grain yield 2 is the total yield per cropping area only, i.e. the area occupied by the NVS within one plot is not included (but converted to crop area). The same applies to the Total dry matter yield 1 and 2. ----- VI = vertical interval.

Table 7. Effect of NVS and different densities on sediment loss (July 2001-June 2002)

Treatment	Sediment loss (t/ha)		
	Baybay Site	Tabango Site	Both sites combined
T1 (control)	35.22 a	131.63 a	83.42 a
T2 (4 m VI)	4.38 a	100.24 b	52.31 b
T3 (2 m VI)	2.64 a	45.69 c	24.16 c
T4 (1 m VI)	3.19 a	22.33 c	12.76 c
LSD (5%)	38.68	27.20	21.05
N	12	12	24
CV (%)	170.43	18.16	38.77

make use of the buffer strips by planting forages, trees or other crop perennials on the NVS. We have also started to look into measures to further improve soil fertility on the cultivated alleys, e.g. by integrating leguminous crops into the corn-fallow cropping system.

Data of the third cropping season are currently being processed (Note: corn was harvested in mid September). It seems that the vigorous growth of the now well-established NVS have caused significant competition on the adjacent crop rows. Also the infestation of the NVS with mice was severe in this cropping season and many maize cobs were damaged. The competition by the NVS and the damage caused by mice may have significantly reduced corn yield in the treatments with the higher NVS density. Also Mercado *et al.* (1999) noted a significant reduction of crop yield in the NVS treatments compared to the control on the deep acidic soils of Claveria after the second cropping season. They attributed this to crop area loss, competition and soil fertility scouring, and the fact that the recommended fertilizer rate was applied throughout all treatments which sustained good yield levels in the control.

The effects of soil fertility scouring were visible in all treatments, but most clear when NVS density was higher (vertical intervals of 1 m and 2 m). In the treatment with the highest NVS density (VI = 1 m), the alley width was about 2 m and there were only two rows of corn per alley; the terraces were well developed. In all NVS treatments, corn yield on the row(s) directly above the NVS was 50 to 100 % higher compared to zones on the upper degraded part of the individual alleys.

In the exploratory trial on the effects of NVS on fruit trees, no effects on the performance of mango trees have been observed after two cropping cycles of corn. This was expected since research on trees requires long-term observations. But also, mango trees may not respond as positively to the benefits provided by NVS (in terms of deeper top soil and higher moisture availability) because mango trees are deep rooting and adapted to poorer and drier soil conditions. The trial will be continued for at least another year to document medium-term effects of the NVS treatment on tree growth.

CONCLUSION AND RECOMMENDATIONS

Research on the indigenous use of natural vegetative strips in shallow calcareous soil environments has complemented our understanding of this low-cost conservation farming practice on deep acidic soils and strengthened our confidence in recommending the technology more widely in the Philippines and other places. The evolution of NVS is a response to the need for simple, low-cost conservation farming practices for resource-poor farmers with little access to markets, information and secure land tenure. Unlike in Northern Mindanao, the technology has been disseminated among neighboring farmers through the traditional labor exchange system in San Isidro, Bohol. Our extension efforts, that complement all our research work and aim at scaling up the impact of agroforestry research, have built on this traditional channel of knowledge dissemination.

Although farmers observed soil fertility scouring and acknowledged that the effect would not be overcome in the short run, they did not consider it as a problem. However, the shallowness of the soil in this environment has resulted in the exposure of rocks on the upper zones of the cultivated alleys, which calls for narrower alley spacing (i.e. less distance between the vegetative strips) and reduced tillage to minimize soil movement.

Data collected from the two initial cropping seasons of the on-farm trial on NVS indicate that the technology is at least as affective in reducing soil loss from cultivated slopes in shallow calcareous soil environments as under deep acidic soil conditions. Even hillsides with slopes up to 60 % can be successfully stabilized. The improved crop yield in treatments with higher NVS density can be attributed to the increased soil depth on the zones directly above the vegetative buffer strips. Whether higher soil moisture in the zones near the NVS plays a role, need to be investigated. The competition effects of the vigorous buffer strips on adjacent crop rows and the higher rat infestation that has been observed recently, can be addressed by increasing the pruning frequency and reducing the cutting height of the NVS.

The on-farm trials to (i) assess NVS in comparison to open field farming (without conservation measures), (ii) identify the appropriate spacing between the buffer strips and (iii) evaluate the effects of NVS on the growth of mango trees will continue for two more cropping seasons to assess the longer-term effects of the treatments. We will also analyze soil samples that have been taken yearly from the cropped field to assess the effects of NVS on soil fertility and scouring. To get a holistic picture of conservation farming using natural vegetative strips, we will also conduct an economic assessment of the NVS technology (through formal household surveys).

Even though NVS reduce soil loss on cultivated slopes to negligible amounts, they cannot alone raise soil fertility and crop yield levels since they produce only a small amount of biomass. It is, therefore, recommended to explore other - complementary - options for soil fertility maintenance, such as inter, relay and cover cropping with leguminous crops, minimum tillage and other practices that can complement the positive effects of contour buffer strips. Efforts have already been made to assist NVS farmers by providing small amounts of seed of legume crops (peanut and rice bean - *Phaseolus calcaratus*) in a roll-over scheme, i.e. the recipients have to pass on seed to other interested farmers after harvesting. This initiative will be continued and the impact on soil fertility maintenance / improvement and household economy will be more systematically documented.

Another issue that warrants further study is the contribution of NVS to the balance between pest and predator populations in cultivated fields. While in Europe farmers are encouraged to leave a few meters around cultivated fields to grow with natural vegetation as host for predators of the major crop pests, this concept needs yet to be explored in the context of sustainable farming in the humid tropical uplands.

Aside from sharpening our knowledge regarding the plot-level understanding of NVS and complementary soil management strategies, we also need to relate our work to the wider landscape level. The contribution of the conservation farming technology to watershed functions need to be quantified. This would primarily involve an assessment of the impact of the NVS technology on off-farm sediment, water and nutrient movements, and the consequent effect on the quantity and quality of water flows in major rivers that drain the respective upland catchment areas. Such landscape level understanding of the impact of the indigenous NVS technology and associated (improved) soil management strategies will further support efforts to extrapolate the practice to a much wider scale.

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