HAITI AGROFORESTRY RESEARCH PROJECT

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ASSESSMENT OF HEDGEROW PERFORMANCES IN THE HAITIAN CONTEXT

by

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SUMMARY.

Hillside farming in Haiti is practiced primarily by small farmers, and measures must be taken to help them at least maintain or possibly improve their production capacity. The introduction of techniques, such as hedgerow farming is evaluated in terms of their impact on crop production and soil fertility and conservation.

The overall project objective is to provide the farmer with a stable and reliable source of income, using agroforestry as a vehicle for increasing agricultural production through diversification of output, thus adding to the risk aversion, together with preserving the environment. Agroforestry is believed to provide a sustainable form of agriculture.

In addition to conserving soil, hedgerows are shown to at least stabilize crop production. The added benefit from the hedgerows expands total agricultural output. As a result, hedgerow are shown to be a sellable agroforestry practice, well adapted for Haiti. Even very young hedgerows are shown to have a positive effect on yields. The lost space taken by the hedgerows

is compensated by increased yields in another portion of that field. Yield increases, up to 50% above the average yield of the field have been observed in the portion of the field immediately above the hedgerow.

The soils on the hillsides are very degraded and the potential is limited for achieving decent yields, but the mixed cropping that is traditionally practiced in Haiti can secure a diversified low output to the farmer. At the level of output that was observed, the mixed intercropping did not seem to affect the yields of any particular crop.

In the soils in alluvial plains, crop yields are shown to almost double compared to their level on the hillsides. Intensification techniques should be introduced for these type of soil with higher potential. This would enable to remove some of the pressure from the hillside farms, that should be devoted for perennial agricultural or forest production.

The dynamics of hedgerow development is an important aspect of hedgerow efficiency and will need to be addressed for a full understanding and perception on how this technology can be further improved and developed.

Suggestions are also given for continuation of the research effort on hedgerow farming.

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Introduction.

The reduction of the duration of the fallow together with the loss of nutrients due to the removal or destruction of crop residues and the washing away of fine soil particles (clay) through the erosion process, induces the decline in soil fertility and land degradation. The exploitive kind of agriculture that prevails in Haiti is the basis for the draining of natural resources and the decline in the sustainability of the agriculture. The population growth far exceeds food production capacities needed to meet the need for food, and farmers are expanding cultivated fields towards land on very steep slope that would normally not be intensively cultivated. In addition, the increasing needs for firewood lead the farmers to repeatedly strip the hillsides from the natural forest regrowth, thus drastically decreasing the quality of the fallow and, in turn, by not allowing the regeneration of soil fertility, accelerate the soil degradation process.

Hillside farming in Haiti is practiced primarily by small farmers, and measures must be taken to help them at least maintain or possibly improve their production capacity. The introduction of techniques, such as hedgerow farming is evaluated in terms of their impact on crop production and soil fertility and conservation.

The agricultural environment has changed drastically over the years due to the accelerated land degradation. Traditionally, Haitian farmers are practicing mixed cropping, a low input low output type of production system where they grow a wide variety of food crops together in the same field. These production techniques have not changed significantly over the years. The crops compete for nutrient and moisture but the farmer uses mixed cropping and diversification as a way to avert risks against possible failure of one particular crop due to disaster or any other cause. With the reduction of the duration of the fallow, it became a resource exploitive situation where the demand for labor and the pressure on land resources is very high. On the positive side, the farmer is trying to keep a quasi continuous soil cover which is very important in conserving soil on the steep hillsides. Without fallow or any other form of soil regeneration, however, yield are bound to keep decreasing. Hedgerows have a definite role to play in the soil regeneration process and prevent further degradation.

The overall project objective of the Agroforestry Outreach Project is to provide the farmer with a stable and reliable source of income, using agroforestry as a vehicle for increasing agricultural production through diversification of output, thus adding to the risk aversion, together with preserving the environment. Agroforestry is believed to provide a sustainable form of agriculture.

Forestry products in the agroforestry context are regarded as an additional income generating commodity to be added to an already complex production system. To illustrate the use of forest products, the experience of some farmers in Haiti during the last year is useful. The spring of 1989 was very dry and was a particularly difficult time in the North-West region. Crop production was virtually nil. The trees planted early in the project, however, provided the participating farmers much needed income during these very difficult times.

Farmers are generally well aware of soil erosion and conservation problems, and realize that something needs to be done. Hedgerow technology is perceived as one possible solution. Field observations show that it works, and this is sufficient to keep promoting its use, but a quantitative assessment of the impact of hedgerows on crop production and of their performance in conserving soil needs to be made. This report will address these two issues.

Research infrastructure in terms of experiment stations are almost not existent in Haiti, and they are not available in the regions where our activities take place. The grantees have a few demonstration sites that we can use. However, the extent of our activities on these sites was limited because of limited resources in personnel. It was also agreed that the bulk of our activities would occur in farmers field, using on farm research techniques. On farm research is often using unreplicated dispersed experiments (Hauser, 1970), where farmers with similar treatments are considered as replications, but treatments are not replicated at the farm level. Early on we found extremely high variability in farmers field and we deviated somewhat from these general principles and adapted them to our local conditions.

Preliminary results presented during the workshop on hedgerows held in Cap Haitian in December (Rosseau et al, 1989) showed that hedgerows were efficient in conserving soil and that the overall yield of the field is at least stabilized. The farmers have been arguing that hedgerows would take some of his field away from production and thus decline his yields. Our results are showing that hedgerow technology is a valuable technique that can at least stabilize the yields in farmers field.

Materials and methods.

All sites are characterized in terms of slope, altitude, aspect, and parent material. On selected benchmark sites a complete soil profile description was done. These soil descriptions are concealed in a separate report (Guthrie et al 1990).

1) Crop measurements.

The portion of the field between consecutive hedgerows, where measurements are taken, is divided into three bands; one just above (band A), one in the middle portion between these hedgerows (band M) and one just below the hedgerow (band B). When the distance between the hedgerows is too narrow (4 meters or less) to allow dividing the space in three bands, only two bands are defined.

In each of these bands a minimum of three circular sample plots are taken for crop yield measurements. Bands A and B are those where the hedgerow is expected to have the most effect on crop yields. Their width is not to exceed 3 meters and the radius of the sample plot is thus not more than 1.0 meters. In band M (center) the radius of the sample plot can be 1-2 meters. Ideally, as a check, we need to sample a field that does not have hedgerows, but is in a very similar situation from physiographic and soil point of view. This is however sometimes difficult, and when that check plot cannot be identified, the next best check is the center band that is the least affected by the hedgerow. We realize that this is not the ideal check because that center plot can be affected by the hedgerow, mainly when we deal with a several years old hedgerow.

In each band the location of sample plots is defined at random. Discarding a 1 to 2 meters buffer, the center of the first plot is chosen at random between one of six objects or by throwing a dice for example. The center of subsequent plots in the band are located every 10 meters. A minimum of three samples are taken in each band, and the distance between plots may need to be adjusted accordingly. The residual end sections of the bands are treated as buffer zones and are not sampled.

The variables recorded on the data sheets for crop yields will vary depending on the crops measured. In each sample plot a complete inventory of what is found is needed. This inventory will include <u>all</u> species names, including trees and shrubs, natural or planted. In a mixed cropping situation the yields for any specific crop such as maize (<u>Zea mais</u>) or sorghum (<u>Sorghum bicolor</u>) for example, is thought to be influenced by the competition of the associated crops, trees or shrubs. For trees or shrubs, the number of branches is counted and their sizes, diameters and heights, measured. When branches sprout from a stump the diameter of that stump is also measured. For agricultural crops, the count will include the number of hills, the number of plants in each, as well as the count of ears, heads, pods, etc., when applicable. A hill is defined as the seed hole where the seeds are planted. In a hill we can find a single or multiple species. In addition to the counts, average plant heights are measured for each hill when applicable, and for pigeon pea (Cajanus cajan) and cassava (Manihot utilissima), the diameters are also measured. As a general rule, all measurements that are relevant indicators of crop performance or are a mean of assessing the degree of competitivity, are taken. Counts for ears and heads are separated into productive or fertile units (producing consumable grain) and aborted ones. Damages from insects and diseases are also recorded. The percentage of productive ears or heads to the total number of units counted is then calculated. The percentage of productive plants (producing harvestable ears or heads) is also derived. For each plot, the harvested ears are weighed in the field and recorded as wet weight. The sample is then dried and weighed as dry weight. The ears or heads are shelled and the grain weight measured.

2) Hedgerow measurements.

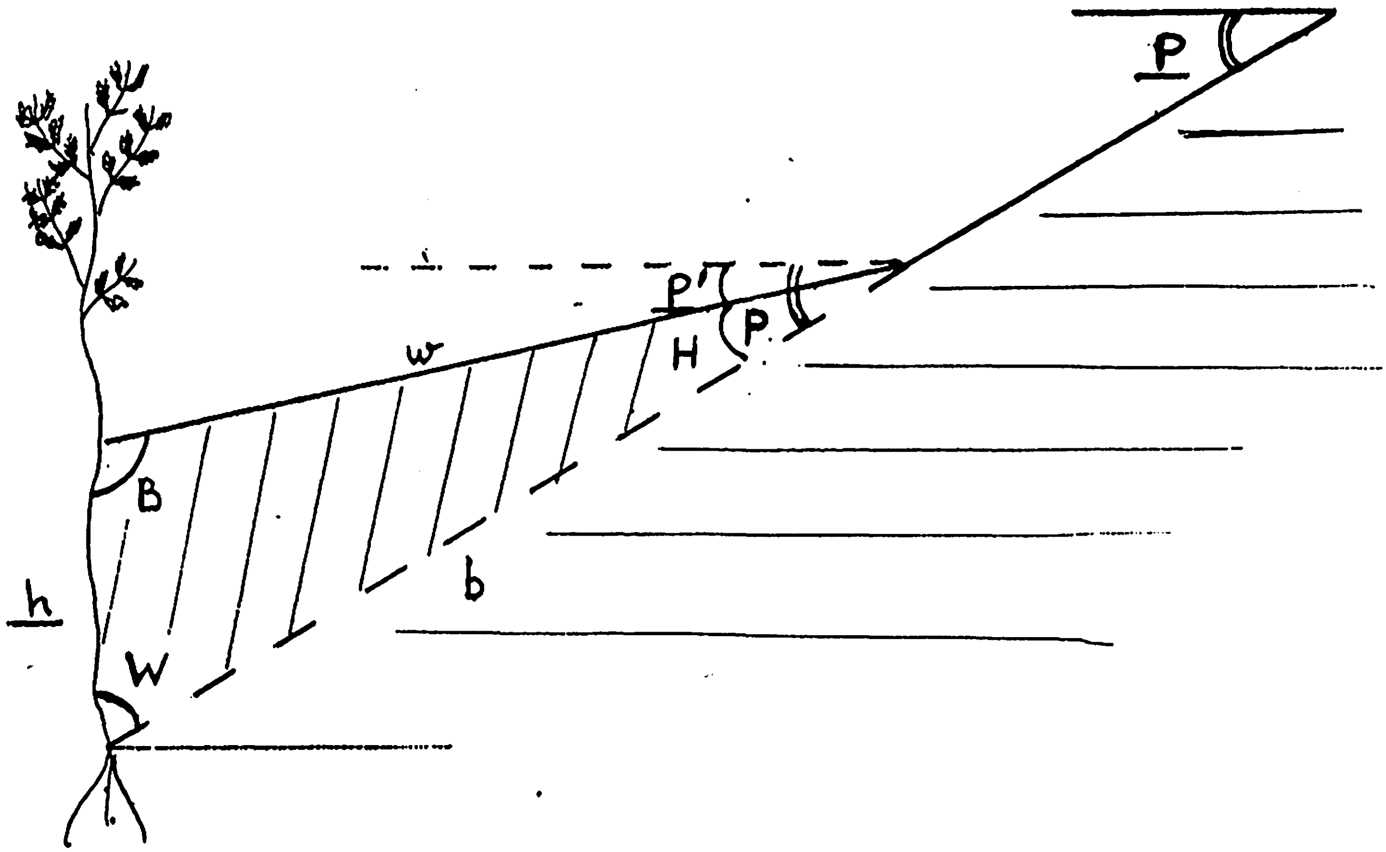
a) Hedgerow characterization.

Hedgerows are fully characterized in terms of plant density, diameter, height and management. This characterization is done in a similar fashion as the sample plots taken for crop measurements, on a 1 meter sample plots. Discarding a 1 to 2 meters buffer, the center of the first 1 meter hedgerow plot is chosen at random by choosing one of six objects or by throwing a dice for example. Other 1 meter plots are located every 10 meters from the center of that first plot. No less than three sample plots will be taken and when the hedgerow length is less than 30 meters, the 10 meter spacing in the hedgerow will have to be adjusted. On each one meter plot all plant diameters are measured. The count of the number of diameters will give the plant density. The average height of the hedgerow is measured by taking several measurements over the whole length of the hedgerow. Details on the procedure and the complete data recording form can be found in a separate report (Hunter et al 1989).

Other characterization of the hedgerow includes the spacing between hedgerows and their length, the length of existing breaches if any, the identification of the cause, the extent and the nature of damages to the hedgerows by grazing animals, diseases and insects. When trees are left to develop in the hedgerow, they are also fully characterized in terms of diameters and height so that their volume can be calculated. In addition to planting dates and methods, recording hedgerow management practices includes pruning schedules and the pruning height.

b) Hedgerow performance in saving soil.

On each of the sample plots, three measurements of the height of the saved soil is measured. The root collar of the hedgerow plant is taken as reference point. At each point of measurement, the slope of the saved soil is also measures. That slope of the saved soil, combined with the slope of the field and the height of the saved soil, allow to calculate the surface of the triangle using trigonometry formulas, and then a volume of soil saved. Figure 1 illustrates the procedure.



$$\text{VOLUME} = \text{SURFACE} \times L \quad (1)$$

$$\text{SURFACE} = \tfrac{1}{2} \cdot h \cdot w \cdot \sin B \quad (2)$$

$$\frac{w}{\sin W} = \frac{h}{\sin H} \Rightarrow w = \frac{h}{\sin H} \cdot \sin W \quad (3)$$

$$\begin{cases} W = 90° - P & (4) \\ H = P - P' & (5) \end{cases}$$

$$B = 180 - (W + H) \quad (6)$$

$$\text{VOLUME} = \frac{1}{2} \cdot h \cdot \left[\frac{h}{\sin(P-P')} \cdot \sin(90° - P) \right] \cdot \sin(90° + P')$$

Figure 1. Calcul de l'accumulation de sol en amont de la haie vive.

3) Role of the farmer.

The farmer is only asked to provide his field for measurements. No treatments are superimposed to his field, but treatments are defined amongst his management practices and the position of the sample plot in the field. By taking a number of farms we have a range of management practices that will allow us to make valuable recommendations.

4) Location of the farmers.

Farmers are concentrated in three regions of Haiti, in the North-West around Bombardopolis, in the lower Central Plateau around Mirebalais, Lascahobas and Belladere, and in the South-West around Maniche. We targeted twenty farmers in each region.

In the North-West the climatic conditions did not collaborate with us; the sorghum (Sorghum b.) crop was lost to us in 1988 because heavy winds and rain blew the crop down to the ground and the farmer harvested the crop in a hurry some three or four weeks early. The spring crop for 1989 completely failed because of a very severe drought. Only the sorghum (Sorghum b.) crop was harvested in December of 1989. These yields have not yet been analyzed and will thus not be included in this report.

In the Central Plateau, three farmers that were measured for crops are reported on. Other farms were studied for their hedgerows or trees only, and are discussed in another report.

In the South in the Maniche area, seven farmers are reported on in this report. The Maniche area consists of a fairly wide and large alluvial plain, surrounded by steep hillsides. Farmers were chosen both in the alluvial plain and on the slopes.

Results and discussion.

1) Lower Central Plateau region.

a) André Pierre. Sorghum (Sorghum b.).

André Pierre's field in Lascahobas is on an iceptisol. A complete soil profile description, including soil analyses, for the field just next to the field where measurements are taken is given in a separate report and was described as a Typic Ustropept, coarse-loamy, mixed (Guthrie et al 1990). The parent material is mixed, partly derived from shales and consist of unconsolidated marine sediments. There is however a very strong influence of calcareous material as it is shown through the soil analyses. Soil fertility is low, mainly for phosphorus, but levels of potassium and magnesium are good. The slope of the field is 46% with a south aspect, 170 degrees. Sorghum (Sorghum b.) and pigeon pea (Cajanus c.) had been planted between hedgerow that were about 0.30 meter in size. A total of six plots were measured, divided into two blocs along the slope and three plots were taken in each. This design was chosen because there was no visible effect of the hedgerow on crop yield. As a result, the hedgerows, being so young and so small, were assumed to have no effect on the crop. This was confirmed by the analyses and data were treated accordingly.

MEASUREMENTS BY PLOT.

BLOC	REP	YIELD kg/ha	SORGHUM HILL COUNT per ha	SORGHUM PLANT COUNT per ha	SORGHUM HEADS PRODUCED COUNT per ha	SORGHUM HEIGHT m	AVERAGE NUMBER PLANTS PER HILL	AVERAGE NUMBER HEADS PRODUCED PER HILL
1	1	293	13,528	124141	35014	2.29	9.2	2.9
1	2	370	10,345	101859	42972	2.47	9.8	4.5
1	3	775	3,979	54908	38197	4.10	13.8	9.6
2	1	875	9549	51725	35810	3.81	5.4	3.8
2	2	450	9549	47746	29443	3.20	5.0	3.1
2	3	780	12732	80373	54112	3.42	6.3	4.5

continued.

BLOC	REP	YIELD kg/ha	SUM SORGHUM+ PIGEON P HILL COUNT per ha	PIGEON PEA HILL COUNT per ha	PIGEON P PLANT COUNT per ha	PIGEON PEA HEIGHT m
1	1	293	25465	11936	15120	2.247
1	2	370	16711	6366	6366	2.300
1	3	775	8754	4775	4775	2.033
2	1	875	23873	14324	16711	2.339
2	2	450	13528	3979	5570	1.920
2	3	780	19894	7162	7958	2.111

TABLE OF MEANS, STANDARD DEVIATIONS AND COEFFICIENTS OF VARIATION BY BLOC.

	BLOC	YIELD kg/ha	SORGHUM HILL COUNT per ha	SORGHUM PLANT COUNT per ha	SORGHUM HEADS PRODUCED COUNT per ha	SORGHUM HEIGHT m	AVERAGE NUMBER SORGHUM PLANTS PER HILL	AVERAGE NUMBER HEADS PRODUCED PER HILL
MEAN (3 obs.)	1	480	9284	93636	38728	3.0	11.0	5.678
STANDARD DEV	1	259	4862	35341	4005	1.0	2.5	3.486
C.V.%	1	53.9	52.4	37.7	10.3	33.8	22.8	61.4
MEAN (3 obs.)	2	701	10610	59948	39789	3.5	5.6	3.789
STANDARD DEV	2	223	1838	17800	12807	0.3	0.7	0.726
C.V.%	2	31.8	17.3	29.7	32.2	8.9	12.0	19.2

continued.

	BLOC	YIELD kg/ha	PIGEON P HILL COUNT per ha	PIGEON P PLANT COUNT per ha	PIGEON P HEIGHT m	SUM SORGHUM+ PIGEON P HILL per ha
MEAN (3 obs.)	1	480	7692	8754	2.2	16976
STANDARD DEV	1	259	3761	5570	0.1	8359
C.V.%	1	53.9	48.9	63.6	6.4	49.2
MEAN (3 obs.)	2	701	8488	10080	2.1	19099
STANDARD DEV	2	223	5298	5866	0.2	5218
C.V.%	2	31.8	62.4	58.2	9.9	27.3

ANALYSIS OF VARIANCE

DEP VAR: YIELD   N = 6 R^2= 0.85

SOURCE OF VARIATION	DF	MEAN-SQUARE	F-RATIO
BLOC	1	5980.514	0.383 (ns)
SORGHUM HEIGHT	1	186623.121	11.964 (*)
ERROR	3	15598.940	

(ns) not significant
(*) significant at significance level alpha=0.05.

The number of hills varies very widely from the 4000 range to 13500 per hectare, which corresponds to an average spacing of 2.5 and 0.74 m respectively. In bloc 1, which is located towards the top of the slope in the least favorable situation regarding soil fertility and moisture regime, yields are negatively correlated with the number of hills. This is indicative of severe land degradation and poor soil fertility in this part of the field. The size of the sorghum (Sorghum b.) follows the same general trend in both blocs and the analyses of variance shows a significant relation between plant size and crop yield. In bloc 2 there seems to be no effect of the number of hills on crop yields. It is interesting to note that, on average, the number of hills and sorghum (Sorghum b.) heads harvested are about the same in both blocs, 10,000 and 39,000 per hectare respectively, but the number of plants is almost 60% higher in bloc 1 compared to bloc 2. The crop being under more stress in bloc 1, one would normally recommend lighter planting, but the farmer, with an 11 plants per hill average in bloc 1, is planting almost twice as many plants per hill as on bloc 2. It is possible that the farmer, knowing his field, hopes to harvest the same amount of crop everywhere in his field and, accordingly plants more. Yields are about 30% lower in bloc 1, however, than in bloc 2. Only 41% of the sorghum (Sorghum b.) plants are productive in bloc 1 as compared to 66% in bloc 2. This difference can be due to the greater competition in bloc 1. The sorghum (Sorghum b.) is planted more uniformly in bloc 2 than in bloc 1, as indicated by the coefficients of variation, which could also indicate that the farmer took better care of the best section of his field.

The pigeon pea (Cajanus c.), on the other hand, seems to have been planted in the same way over the whole field. The number of hills (7,692 and 8,488) and the number of pigeon pea (Cajanus c.) plants (8,754 and 10,080) are very similar in both blocs. Plant sizes are also the same (2.2 and 2.1 m), indicating that the pigeon pea (Cajanus c.) is probably more resistant to stress than the sorghum (Sorghum b.). Except for sorghum (Sorghum b.) height, all other parameters were not shown to have a statistical effect on yield. The two blocs sampled were not shown statistically different. This can be explained in part by the very high variability observed in the field.

b) Gabriel Saintil. Sorghum (Sorghum b.).

Gabriel Saintil's field also in Lascahobas is on a Mollisol. A complete soil profile description, including soil analyses, is given in a separate report and the soil was classified as a Typic Haplustoll, loamy, mixed, shallow, isohyperthermic (Guthrie et al 1990). The parent material is mixed due to the colluvial process and the various soil horizons consist of a superposition of material from various origins. Soil fertility is low, mainly for phosphorus, but levels of potassium and magnesium are good. The slope was measured at 28% with a south aspect, 185 degrees. This mixed cropped field was planted, at the time of measurement, mostly with sorghum (Sorghum b.) and pigeon pea (Cajanus c.) but other species, cassava (Manihot u.), sweet potato (Ipomea batatas), gombo (Hibiscus Esculentus) and various tree species, were found in various quantities depending on the location in the field. These crops were planted between Leucaena leucocephala hedgerows planted in May of 84. These hedgerows had been cut twice, once in June 87, and once in August 88, after planting the crops. The material cut from the hedgerow was put on the uphill side against the hedgerow to increase their soil and water conservation effect. The farmer left a few trees growing in the hedgerow for future use as poles or firewood. He also had planted elephant grass (Pennissetum purpureum) in the hedgerow and in some parts of the hedgerow the grass was competing quite heavily with the leucaena (Leucaena l.). A lot of damages by grazing animals were also observed leading to a large amount of breaches of various sizes, reducing the soil conservation efficiency of the hedgerow. The portion of the field between the hedgerows was divided in three bands, two bands were selected uphill and in the center position between the hedgerows, while only one band was selected downhill from the hedgerow. In addition, as an added check plot and for reference, one additional plot was selected in the upper part of the field, close by the farmer's house. This last plot is referred to as "lakou" in the analyses. In the table of analyses of variance the plot variable refers to the five bands plus the plot called lakou, for a total of six plots.

TABLE OF MEANS, STANDARD DEVIATIONS AND COEFFICIENTS OF VARIATION BY POSITION.

	POSITION	YIELD kg/ha	SORGHUM HILL COUNT per ha	SORGHUM PLANT COUNT per ha	SORGHUM HEADS PRODUCED COUNT per ha	SORGHUM HEIGHT m	PIGEON P HILL COUNT per ha	PIGEON P HEIGHT m	TOTAL HILL COUNT per ha	TOTAL OTHER PLANT COUNT per ha
MEAN (4 obs.)	LAKOU	278	8488	35014	23696	2.2	2122	1.0	13440	4951
STANDARD DEV		167	2001	11162	13340	0.4	2709	1.2	1826	1415
C.V.%		60.3	23.6	31.9	56.3	19.0	127.7	116.1	13.6	28.6
MEAN (4 obs.)	DOWNHILL	174	8754	27056	23077	2.0	1592	0.4	10345	1592
STANDARD DEV		61	4775	16540	14788	0.4	3183	0.8	4775	3183
C.V.%		34.9	54.5	61.1	64.1	21.6	200.0	200.0	46.2	200.0
MEAN (8 obs.)	CENTER	261	13528	43370	29046	2.0	3581	1.9	19099	6366
STANDARD DEV		158	6309	32813	22212	0.3	2656	1.2	6806	5643
C.V.%		60.7	46.6	75.7	76.5	16.5	74.2	463.4	35.6	88.6
MEAN (8 obs.)	UPHILL	394	12334	52919	31035	2.1	6366	1.6	20690	8356
STANDARD DEV		581	4942	28569	27527	0.8	4812	0.9	6590	5627
C.V.%		147.6	40.1	54.0	88.7	41.2	75.6	59.3	31.8	67.3

ANALYSIS OF VARIANCE

DEP VAR: YIELD N = 23 R^2=0.72

SOURCE OF VARIATION	DF	MEAN-SQUARE	F-RATIO
PLOT	5	148740.312	2.273 (ns)
REPLICATION	3	196579.755	3.004 (ns)
SORGHUM PLANT COUNT	1	716376.488	10.948 (**)
TOTAL OTHER PLANT COUNT	1	176084.800	2.691 (ns)
ERROR	12	65434.053	

(ns) not significant
(**) highly significant at significance level alpha=0.01.

Yields vary very widely depending on the position of the plot in relation to the hedgerow. Three plots were located in the hedgerow field between the hedgerows while a fourth one was located directly by the farmers house (lakou) on a much gentler slope. This last plot is used to compare the yields obtained in the hedgerow field. The yields of the center plot between the hedgerows is considered a check plot. This plot is presumably the least affected by the hedgerow. The average yields of that center plot and the yield of the field by the house (lakou) are the same. Comparing yields, the average yield of the plot downhill from the hedgerow is about one third lower than in center plot, while yields of the plot uphill from the hedgerow are fifty percent higher. The size of sorghum (Sorghum b.) does not vary between the positions indicating that the plants developed equally through the fields. The average spacing between hills (all species confounded) is derived and ranges from 0.70 m to 0.98 m uphill and downhill from the hedgerow, respectively. Overall, on average there is twice as many hills planted in the center and in the uphill part of his field. The number of sorghum (Sorghum b.) plants vary widely from one position in the field to the other and range from 27,056 to 52,919 downhill and uphill from the hedgerow, respectively. The number of heads harvested, however, does not vary as much, but expressed in terms of productive plants, it is strongly related to the competition from other plants. Indeed, where we have the least competition, the plot downhill from the hedgerows, 85% of the sorghum (Sorghum b.) plants have productive heads, while in the plot uphill from the hedgerow, which is also the most densely planted, only 59% of the plants are productive. The farmer planted more sorghum (Sorghum b.) and up to four times more pigeon peas (Cajanus c.) in the more fertile uphill plot than in his least fertile downhill plot. It would be helpful to the farmer if we could help him identify techniques that would allow him to take more advantage of those improved cropping conditions. In the portion of the field below the hedgerow, the farmer planted only sorghum (Sorghum b.) and pigeon peas (Cajanus c.), but the average size of the pigeon pea (Cajanus c.) remained low. The pigeon peas (Cajanus c.) developed best in the center and the uphill portion of the hedgerow field. The variability of the measurements in this field is extremely high, and conclusions are difficult to draw. The general trend, however, indicates higher yields in the portion of the field uphill from the hedgerow. It must also be recognized that planting more in the most favorable parts of the field increases competition, which in turn, affects the ratio of productive plants. As shown in the table of analyses of variance, the parameter that most affects the yields is the total number of sorghum (Sorghum b.) plants. The total number of other crops cultivated in association with the sorghum (Sorghum b.) does not have a significant effect on yields. Both are positively correlated with yields. This indicates, as may be expected, that higher fertility levels supports higher plant density. On the other hand, it is important to bear in mind that increased competition also seems to have an effect on the percentage of productive plants. These results show a need for additional investigation on how a compromise optimizing output can be reached.

c) Lys Valery. Maize (Zea m.).

Lys Valery's field is in Belladere and has not been classified in the soil taxonomy. Tentatively we can say that it is also a Mollisol. The parent material is the same as for the two previous farmers. The slope is extremely steep and estimated at 80% . The soil depth on this field is variable because in some parts of the field erosion was severe leading to a shallower soil, but the moisture regime is generally good. The cropping system is mixed and, for these analyses, among the crops, maize (Zea m.) is considered as the main crop and peanuts (Arachis hypogea), pigeon pea (Cajanus c.), cassava (Manihot u.) and sorghum (Sorghum b.), as the associated crops. Other crops such as plantain (Musa paradisiaca), yams (Dioscorea alata), and sugar cane (Sacharum officinarum) were also found, as well as numerous kinds of natural trees. The farmer was establishing a leucaena (Leucaena l.) hedgerow to control erosion. Given the steepness of the slope, the farmer had put a series of straw strips in contour on which he had planted the hedgerow. He had apparently planted the hedges with a minimum of land preparation to prevent further erosion. These hedgerows were planted in the spring of 1989, at the same time as the maize (Zea m.). Similarly to André Pierre, the field was divided in blocs in a toposequence. Five plots were sampled in blocs 1 and 3, in the top and the bottom part of the field respectively, while only three plots were sampled in bloc 2 in the middle part of the field.

TABLE OF MEANS, STANDARD DEVIATIONS AND COEFFICIENTS OF VARIATION BY BLOC.

	BLOC	YIELD kg/ha	MAIZE HILL COUNT per ha	MAIZE PLANT COUNT per ha	MAIZE EARS PRODUCED COUNT per ha	RATIO PRODUCTIVE EARS %	MAIZE SIZE m	SORGHUM HILL COUNT per ha	NON MAIZE HILL COUNT per ha	TOTAL HILL COUNT per ha
MEAN (5 obs.)	1	713	8435	24828	20849	93	1.6	8754	17029	25465
STANDARD DEV	1	344	1832	7193	4337	5	0.2	2320	8872	7528
C.V.%	1	48.2	21.7	29.0	20.8	5.3	13.6	26.5	52.1	29.6
MEAN (3 obs.)	2	593	7427	21221	16181	97	1.5	8488	12467	19894
STANDARD DEV	2	453	3216	11263	11486	4	0.1	3013	3588	1592
C.V.%	2	76.4	43.3	53.1	71.0	4.6	6.8	35.5	28.8	8.0
MEAN (5 obs.)	3	523	8754	25305	20372	93	1.5	7639	11618	20372
STANDARD DEV	3	293	2578	7825	5052	7	0.2	3758	1997	3923
C.V.%	3	56.1	29.5	30.9	24.8	7.3	10.8	49.2	17.2	19.3

ANALYSIS OF VARIANCE

DEP VAR: YIELD   N = 13 R^2=0.72

SOURCE OF VARIATION	DF	MEAN-SQUARE	F-RATIO
BLOC	2	83594.640	1.787(ns)
MAIZE EARS PRODUCED COUNT	1	750457.240	16.044(**)
SORGHUM HILL COUNT	1	131380.002	2.809(ns)
ERROR	8	46775.341	

(ns) not significant
(**) highly significant at significance level alpha=0.01.

This field is on a very steep slope (80%) and is fairly homogenous, as shown by similar average yields in each bloc. The farmer is aware of the potentially severe erosion, and is planting leucaena (Leucaena l.) hedgerows. The farmer planted his crops in a fairly uniform way and the crops developed accordingly, as shown by the number of hills of maize (Zea m.) and sorghum (Sorghum b.) as well as the size of the maize. The yields are low however, but the number of maize (Zea m.) hills is less than half the total number of hills in his field. This is a true example of mixed cropping indicating that the overall output is the farmer's ultimate goal rather than the maximum yield on any particular crop. There are more hills of non-cereal crops in bloc 1, probably because this is where the access path to his field comes. The overall average planting density is one hill every 0.63 m. Regarding maize (Zea m.), over 90% of the ears were productive. The farmer planted the maize (Zea m.) hills at an average 1.1 m spacing and 3 plants per hill. On average, more than 80% of the maize (Zea m.) plants were productive. As expected, the amount of ears harvested has a major impact on crop yields. The associated crops had no significant effect on maize (Zea m.) yields. It is interesting to note that the total number of hills is the highest in the part of the field where the maize (Zea m.) yields are also the highest, indicating that there are uncontrolled factors, probably fertility or moisture, affecting the yields. Analyzing this field shows two important things: (1) There are sites in Haiti that are not completely degraded even though they are on very steep land; (2) In a situation like this, hedgerows can play a major role in conserving soil. The farmer is aware of it and is doing something to prevent further degradation, which is very encouraging.

2) Cayes region.

a) Arnol Favor. Maize (Zea m.).

Arnol Favor's field is on an iceptisol. A complete soil profile description, including soil analyses, for Elien Pierreville, a field just next to the field where these measurements are taken is given in a separate report and was described as a Typic Ustropept, loamy, mixed, shallow (Guthrie et al 1990). The parent material is described as limestone and the soil consists of colluvial material. The pH is high pH 8.1 and the soil has fertility limitations. The field at an elevation of 180 meters, is on a 60% slope with an easterly aspect at 90 degrees. The farmer participated in a previous project that built stone walls as erosion and soil conservation measure.

These structures had obviously had a positive effect, but are now in very bad state of repair and became ineffective. Leucaena (Leucaena l.) hedgerows have been planted in 1985. The field is planted in mixed crops with maize (Zea m.) as the main crop and pigeon pea (Cajanus c.) as the associated crop. Three blocs were defined according to a toposequence. The two upper blocs covered the whole width of the field, while the third one was very narrow and located at the lowest part of the field.

TABLE OF MEANS, STANDARD DEVIATIONS AND COEFFICIENTS OF VARIATION BY BLOC.

	BLOC	YIELD kg/ha	MAIZE HILL COUNT per ha	MAIZE PLANT COUNT per ha	MAIZE FERTILE EARS COUNT per ha	RATIO FERTILE EARS %	MAIZE SIZE m	PIGEON P HILL COUNT per ha	PIGEON P PLANT COUNT per ha	PIGEON P SIZE m	TOTAL HILL COUNT per ha
MEAN(6 obs.)	1	1367	11318	32302	26879	78	1.8	7545	7545	0.9	18863
STANDARD DEV	1	799	1265	5015	8151	8.5	0.4	1461	1461	0.1	2130
C.V.%	1	58.4	11.2	15.5	30.3	10.9	21.0	19.4	19.4	13.9	11.3
MEAN(6 obs.)	2	850	9903	24993	16269	57	1.6	6838	6838	0.8	16741
STANDARD DEV	2	881	1789	6853	12677	38.3	0.5	1654	1654	0.1	3023
C.V.%	2	103.6	18.1	27.4	77.9	67.0	34.2	24.2	24.2	17.9	18.1
MEAN(2 obs.)	3	1275	11318	29709	28294	87	1.6	7073	7073	0.9	18391
STANDARD DEV	3	751	0	0	0	0	0.3	4001	4001	0.4	4001
C.V.%	3	58.9	0	0	0	0	21.1	56.6	56.6	44.3	21.8

ANALYSIS OF VARIANCE

DEP VAR: YIELD N = 14 R^2=0.81

SOURCE OF VARIATION	DF	MEAN-SQUARE	F-RATIO
BLOC	2	108284.809	0.594 (ns)
MAIZE FERTILE EARS COUNT	1	5766728.130	31.621 (***)
PIGEON P PLANT COUNT	1	305688.681	1.676 (ns)
ERROR	9	182372.625	

(ns) not significant
(***) very highly significant at significance level alpha=0.001.

This field had some older stone wall terraces that were no longer functional. The yields observed are highly variable. The collapsing of the stone walls, in particular in bloc 2, induced stoniness and added heterogeneity to the field. In this mixed cropping field, the farmer only planted maize (Zea m.) and pigeon peas (Cajanus c.). Management practices in terms of plant density are fairly uniform, ranging from 0.9 to 1.0 m between maize (Zea m.) hills. The number of plants per hill are also similar, ranging from an average of 2.5 to 2.85 plants per hill in bloc 2 and 1 respectively. In bloc 2, the ratio of maize (Zea m.) harvested both in terms of productive ears (57%) as productive plants, only 65% of the plants on average, is much lower, thus affecting the maize (Zea m.) yield accordingly. The maize (Zea m.) plants have, however, developed uniformly throughout the field as shown by their size. The average plant density for all plots is also uniform; the average distance between hills is 0.73 to 0.77 m. The size of the pigeon pea (Cajanus c.) plants remains the same throughout the field. The analyses of variance shows that the pigeon pea (Cajanus c.) does not compete with maize (Zea m.) and does not have a significant effect on the maize (Zea m.) yields.

b) Estelin Favor. (Zea m.)

Estelin Favor's field has not been classified in the soil taxonomy. Tentatively we can say that it is either also an Entisol similar to the one mentioned above or possibly an Alfisol as described for a profile nearby, Victor Semelca's field on sloping land (different from the field on which results are discussed later), where a profile was described as a Udic Haplustalf, coarse loamy, mixed, isohyperthermic and results given in a separate report (Guthrie et al 1990). The parent material is the same as for the previous farmer. The field has a slope of 45% with an easterly aspect of 90 degrees. The crop harvested here was maize (Zea m.), but the field was planted in mixed crops and included pigeon pea (Cajanus c.) and sorghum (Sorghum b.). However, only pigeon pea (Cajanus c.) was counted as associated crop, because the sorghum had just been planted. No hedgerows were planted, nor any other anti erosion or soil conservation structure installed. Seven blocs were sampled along a toposequence.

TABLE OF MEANS, STANDARD DEVIATIONS AND COEFFICIENTS OF VARIATION BY BLOC.

	PLOT	YIELD kg/ha	MAIZE HILL COUNT per ha	MAIZE PLANT COUNT per ha	MAIZE EARS FERTILE COUNT per ha	RATIO FERTILE EARS %	MAIZE SIZE m	PIGEON P PLANT COUNT per ha	PIGEON P SIZE m
MEAN (3 obs.)	1	479	14854	28412	19688	77	1.1	2358	1.2
STANDARD DEV	1	137	3938	14515	6088	23	0.2	2161	1.1
C.V.%	1	28.7	26.5	51.1	30.9	30.0	22.8	91.7	97.4
MEAN (3 obs.)	2	77	5305	10610	7427	50	0.8	6366	1.4
STANDARD DEV	2	96	1838	6626	8011	50	0.2	0	0.3
C.V.%	2	125.3	34.6	62.4	107.9	100.0	23.7	0	23.0
MEAN (3 obs.)	3	441	13204	22164	19334	91	1.0	0	0.0
STANDARD DEV	3	263	4322	8289	6979	8	0.1	0	0.0
C.V.%	3	59.6	32.7	37.4	36.1	8.5	9.7	.	.
MEAN (3 obs.)	4	814	18391	35368	29237	81	1.2	1415	0.6
STANDARD DEV	4	402	2450	9903	8044	1	0.2	2450	1.0
C.V.%	4	49.4	13.3	28.0	27.5	1.6	15.4	173.2	173.2
MEAN (3 obs.)	5	573	12732	24993	21221	87	1.3	1886	0.4
STANDARD DEV	5	178	2450	2161	1415	7	0.4	3267	0.7
C.V.%	5	31.1	19.2	08.6	6.7	7.9	29.0	173.2	173.2

MEAN (3 obs.)	6	675	14147	25936	24050	90	1.2	0	0.0
STANDARD DEV	6	469	4244	6686	7073	4	0.2	0	0.0
C.V.%	6	69.5	30.0	25.8	29.4	4.5	14.3	.	.
MEAN (3 obs.)	7	543	11789	22635	21221	91	1.3	472	0.2
STANDARD DEV	7	260	5717	6167	6167	4	0.1	817	0.3
C.V.%	7	47.9	48.5	27.2	29.1	4.8	09.8	173.2	173.2

ANALYSES OF VARIANCE.

DEP VAR: YIELD N = 21 R^2=0.65

SOURCE OF VARIATION	DF	MEAN-SQUARE	F-RATIO
PLOT	6	26286.119	0.358 (ns)
REPLICATION	2	3804.361	0.052 (ns)
MAIZE HILL COUNT	1	409154.488	5.577 (*)
PIGEON P PLANT COUNT	1	7676.934	0.105 (ns)
ERROR	10	73365.578	

(ns) not significant
(*) significant at significance level alpha=0.05.

Maize (Zea m.) yields are highly variable, between as well within plots as shown by the high coefficient of variation. Except for plot 2, crop management in terms of plant density, the number of hills per hectare and the number of plants per hill, is quite uniform. Excluding plot 2, spacing between hills ranges from 0.74 to 0.92 m, averaging 0.85 m, with an average of 1.89 plants per hill. The reason for the much lower plant density in plot 2 was not identified. The maize (Zea m.) developed uniformly as indicated by the plant size. The ratios of productive ears generally increases from bloc 1 to bloc 7, 77% and 91% respectively. This is confirmed by the calculated ratio of productive plants also. The ratio increases steadily from 69 to 94 from bloc 1 to bloc 7, showing a clear gradient. This is most likely due to improved soil conditions on the bottom of the slope, which benefits from better moisture regime. The rather poor development of the pigeon pea (Cajanus c.) does not, however, confirm this. The analyses do not show differences between plots, even though plot 2 had a substantially lower yield than the other plots. The presence of pigeon peas (Cajanus c.) did not affect the crop yield.

c) Senes Saintius (Sorghum b.)

Senes Saintius' field has not been classified in the soil taxonomy. Tentatively we can say that it is either also an Entisol similar to the one mentioned above or possibly an Alfisol as described for a profile nearby, Victor Semelca's field on sloping land (different from the field on which results are discussed later), where a profile was described as a Udic Haplustalf, coarse loamy, mixed, isohyperthermic and results given in a separate report (Guthrie et al 1990). The parent material is the same as for the previous farmers. The field is at an elevation of 130 meters, with a slope of 45% and a North North West aspect of 330 degrees. The crop harvested here was sorghum (Sorghum b.), but the field had been planted in mixed cropping with maize (Zea m.) and in addition there were various tree species in the field. The field had been in fallow for three years prior to the planting of the crops in August of 1988. Mixed hedgerows, leucaena (Leucaena l.) and elephant grass (Pennissetum p.) were also planted in September 1988 and the spacing between hedgerows ranging from 9.4 to 12 meters, averaging about 10 meters between the two hedgerows at the top of the field and 11.5 meters in the between the hedgerows in the lower part of the field. A total of nine bands were measured and only two samples were taken in each. The bands were equally balanced between uphill, downhill and center.

TABLE OF MEANS, STANDARD DEVIATIONS AND COEFFICIENTS OF VARIATION BY POSITION.

	POSITION	YIELD kg/ha	SORGHUM HILL COUNT per ha	SORGHUM PLANT COUNT per ha	SORGHUM HEADS PRODUCED COUNT per ha	AVERAGE NUMBER SORGHUM PLANTS PER HILL	SORGHUM HEIGHT m
MEAN (6 obs.)	DOWNHILL	107	15915	87004	27587	5.5	1.1
STANDARD DEV		69	7797	45892	12518	2.0	0.1
C.V.%		64.3	49.0	52.7	45.4	37.3	13.7
MEAN (6 obs.)	CENTER	213	23578	123079	59653	5.2	1.1
STANDARD DEV		110	7414	27286	25938	1.3	0.1
C.V.%		51.4	31.4	22.2	43.5	23.3	11.6
MEAN (6 obs.)	UPHILL	302	26526	169765	77986	6.4	1.3
STANDARD DEV		131	6259	86253	32633	2.1	0.2
C.V.%		43.5	23.6	50.8	41.8	33.7	16.8

ANALYSIS OF VARIANCE

DEP VAR: YIELD N = 18 R^2=0.58

SOURCE OF VARIATION	DF	MEAN-SQUARE	F-RATIO
POSITION	2	6022.051	0.653 (ns)
REPLICATION	1	7734.804	0.839 (ns)
SORGHUM HEADS PRODUCED	1	45564.066	4.943 (*)
ERROR	13	9218.528	

(ns) not significant
(*) significant at significance level alpha=0.05.

Sorghum (Sorghum b.) yields are very low. They are also highly variable as shown by the coefficients of variation. The very young hedgerows were established in 1988, and the beneficial effect on sorghum (Sorghum b.) yield can already be measured. In this particular situation the beneficial effect can be due to the land preparation prior to planting the hedgerow, rather than the effect of the hedgerow itself. It is indeed widely recommended to make a contour terrace on the upside part of which the hedgerow is planted. The rational behind this practice is to create a more favorable environment promoting the rapid growth of the hedgerow. On the other hand, in the event of heavy downpour rains, which are not uncommon in Haiti, washing away of the hedgerow seeds have been observed.

The bands immediately above the hedgerow yield 46% higher than the average yield of the field. The bands immediately below the hedgerows yield only 52% of the average yield, but was also only 72% as densely planted. The bands immediately above the hedgerows, not only are 20% more densely planted, but the hills also have 6.4 plants each as compared to 5.2 and 5.4 elsewhere. Hills are planted 0.79 m apart in plots below the hedgerows while they are only about 0.63 m apart elsewhere in the field. On average, 32% of the plants are productive in the plots below the hedgerow as compared to 47% elsewhere. The size of the sorghum (Sorghum b.) averages 1.2 m is about the same in all parts of the field. The analyses of variance does not show significant differences between the position of the bands regarding the hedgerow.

d) Victor Samelca. (Zea m.)

Victor Semelca's field has not been classified in the soil taxonomy. Tentatively, we can suggest that it is a Mollisol similar to the profile at Semilien Saint Victor, also in the alluvial plain in the Maniche area and described as a Udic Haplustoll, clayey skeletal, mixed, isohyperthermic (Guthrie et al 1990). The field was planted in mixed cropping, maize (Zea m.) as the main crop and pigeon pea (Cajanus c.) as the associated crop. In the samples taken which are representative of the field, no tree species were found to interfere with the crops. Seven sample plots were measured and they are grouped in three blocs. One bloc with three plots was located close to a ravine in the lowest part of the field. The three blocs were placed in a gradient away from that ravine. The elevation of this field is 90 meters, with a very gentle slope to the ravine.

TABLE OF MEANS, STANDARD DEVIATIONS AND COEFFICIENTS OF VARIATION BY BLOC.

	BLOC	YIELD kg/ha	MAIZE HILL COUNT per ha	MAIZE PLANT COUNT per ha	MAIZE EARS PRODUCED COUNT per ha	RATIO PRODUCTIVE EARS %	MAIZE HEIGHT m
MEAN (3 obs.)	1	693	10876	25465	22547	87	1.2
STANDARD DEV	1	344	3925	9939	8434	3.0	0.2
C.V.%	1	49.7	36.1	39.0	37.4	3.4	19.5
MEAN (2 obs.)	2	1473	13130	30239	26658	88	1.4
STANDARD DEV	2	54	1688	7878	5064	7.7	0.4
C.V.%	2	3.7	12.9	26.1	19.0	8.8	32.7
MEAN (2 obs.)	3	1138	14324	33024	32627	93	1.3
STANDARD DEV	3	503	0	563	5627	7.1	0.1
C.V.%	3	44.2	0.0	1.7	17.2	7.7	4.6

ANALYSIS OF VARIANCE

DEP VAR: MZYLD N = 7 R^2=0.89

SOURCE OF VARIATION	DF	MEAN-SQUARE	F-RATIO
BLOC	2	256629.043	5.357 (ns)
MAIZE EARS PRODUCED	1	349258.211	7.290 (ns)
ERROR	3	47907.132	

(ns) not significant

The average yield for the whole field is 1034 kg/ha. Bloc 1 is yielding only 66% of the average yield, but is also the least densely planted. Its average spacing between hills of 0.96m compares with 0.87 and 0.83 in blocs 2 and 3 respectively. An equal number of plants are found in each hill and the size pf the crop shows that it developed fairly uniformly throughout the field. 88% and 98% of the plants are productive in bloc 1 and 2 while 98% are found productive in bloc 3. Of all the ears produced, 87, 88 and 93 percent are productive in bloc 1, 2 and 3, respectively. This field was sampled as a point of reference to assess and compare the production of a field in a more favorable situation with hillside farming.

e) Other data collected.

Yields collected at three other farmers which are in a somewhat similar soil and physiographic conditions as Victor Semelca are briefly discussed.

An experiment on different cropping practices was set up in the Maniche area in the alluvial plain. Two farmers were receptive to the idea and we planted an experiment, as planned, in April. One of the farmers (Semilien Saint Victor) was in the alluvial plain while the other one (Oscar Peransin) was on sloping land, 35% slope and South aspect (160 degrees), and colluvial material. The elevation of both farmers ranged between 90 and 120 meters. Extensive drought periods in May made replanting necessary and the experiment failed because it made the crop response very heterogenous. Yields were very low (126 kg/ha) and analyses is meaningless.

Marc Saint Victor. (Zea m.)

This field covers both the hillside as well as the alluvial plain. The hillside has a 35% slope and a North-East aspect (45 degrees) and an average elevation of 100 meters. Two samples were taken on the hillside, where the soil was developed on colluvial material, while the two other samples were taken in the lowland plain, where the soils are a mixture of alluvial and colluvial material.

TABLE OF MEANS, STANDARD DEVIATIONS AND COEFFICIENTS OF VARIATION BY BLOC.

BLOC	YIELD kg/ha	MAIZE HILL COUNT per ha	MAIZE PLANT COUNT per ha	MAIZE EARS PRODUCED COUNT per ha	RATIO PRODUCTIVE EARS %	MAIZE HEIGHT m
1	1331	28294	67906	50929	95	1.7
2	1553	25465	52344	45271	91	1.9
3	2758	22635	59418	53759	97	2.6
4	2820	36782	79224	69320	91	2.5

The yields of plot 1 and 2 on the hillside are lower than the one's on the flat land. Maize (Zea m.) yields on the plain are on average almost twice the yields the hillside portion of the field. The size of the maize (Zea m.) is also shorter on the hillside, indicating a less favorable environment.

Spacing between hills range from 0.67 to 0.52 meters, and the average number of plants in each hill ranges from 2.0 to 2.6. The percentage of productive plants and productive ears ranges from 75 to 90% and 91 to 97% respectively. The plant size ranges from 1.7 to 2.6 meters. The lowest yield is related to the smallest average plant size and the lowest percentage of productive plants. There seem to be no direct link between crop yield and the average spacing or the average number of plants per hill.

Faner Cincer. (Zea m.)

TABLE OF MEANS, STANDARD DEVIATIONS AND COEFFICIENTS OF VARIATION BY BLOC.

PLOT	YIELD kg/ha	MAIZE HILL COUNT per ha	MAIZE PLANT COUNT per ha	MAIZE EARS PRODUCED COUNT per ha	RATIO PRODUCTIVE EARS %	MAIZE SIZE m	PIGEON P HILL COUNT per ha	PIGEON P PLANT COUNT per ha	PIGEON P SIZE m
1	1719	19806	43856	41026	97	1.6	9903	11318	1.1
2	850	12732	26879	21221	94	1.6	1415	1415	1.1
3	788	12732	29709	24050	100	1.1	2829	2829	1.2

This is another field in the alluvial plain. One of the plots yielded about twice as much as the other two ones. This part of the field is probably more fertile than the rest of it since the farmer planted higher density of both corn and pigeon pea (Cajanus c.). The link between higher yields of maize (Zea m.) and the larger number of pigeon pea (Cajanus c.) plants is probably due to uncontrolled factors and not to the simple presence of pigeon pea (Cajanus c.). It is a generally the attitude of the farmer to take maximum advantage of a given situation in order to meet his objectives. A sound socio-economic analyses will help us better understand the decision making of the farmers in meeting their objectives together with optimizing the use of resources and maximizing income. This will be a difficult task, but is greatly needed to orient the decision making of donor agencies as well as the farmers.

3) Hedgerow characterization.

The following table provides the average figures for the measurements we performed in two regions. The average tree density per meter is only 45, and with an average diameter of 3.7mm less than 20% of the hedgerow length consist in trees, leaving adequate room for runoff.

Average values for variables measured on AOP hedgerow gardens in two regions of Haiti.

Variable	Region: Northwest	Region: Central Plateau
Age of hedgerows (years)	2.5	2.5
Length of hedgerows (m)	36.2	25.0
Number of trees per meter	45.5	44.3
Tree diameter at 0.1 m (mm)	3.6	3.8
Tree height (m)	1.8	1.2
Pruning height (cm)	43.0	23.0
Percentage breaches in the hedgerow	26.0	-
Distance (hor.) between hedgerows (m)	11.5	3.9
Distance error (horizontal distance/ recommended distance)	1.55	1.28
Slope of landform (%)	31.6	59.3
Annual volume of soil saved (m^3 /ha)	38.0	49.4

The average tree diameter is small because of a large number of very small trees in the hedgerow. The origin of these small seedling is often not very clear. They could have come from reseeded hedgerow to close breaches or they could simply come from natural seeds from adult trees that are developing in the hedgerow for wood production. With time, however, competition from the larger and more vigourous trees will reduce the number of very small trees. On the other hand small trees also have their role to play in the performance of the hedgerow, mainly during the regeneration of the hedgerow after pruning.

In future programs the dynamics of the hedgerow development will have to be assessed and included in our research procedures.

The hedgerow is, however, efficient in slowing down the water flow down to a level that allows soil particles to settle.

The pruning heights vary a lot between the two regions. Weigel and Zimmermann in 1987 recommended 8-6 meter spacing between hedgerows on 25 - 35% slope and 3 meter spacing on slopes above 50%. We calculated a coefficient of correctness (distance error) to indicate how close the hedgerows were to the recommended spacing. The closest this coefficient to 1 the better the recommendation is followed.

By multiplying the volume of soil by its specific gravity, 1.8 as an accepted average for non organic mineral soils, the soil saved amounts to 68.4 and 88.9 tons per ha and per year for the farmers that we measured in the North-West and the lower Central Plateau respectively.

CONCLUSIONS AND RECOMMENDATIONS.

Results from crop yield measurements are showing that the farmers are certainly not loosing any yield due to hedgerows. Yields in the portion of the field uphill from the hedgerow showed yield increases up to 50% above the average yield of the field. We also have to keep in mind that hedgerow also induces a decline in crop yields in the portion of the field just below the hedgerow. Between the increase and the decline in yield we found a net gain ranging from 0 to 17%, averaging at 5%. These numbers are preliminary and need to be refined, but they already prove one important fact, which is that hedgerow at least stabilize yields. Future research need to focus on identifying means to optimize crop production in the enriched zone above the hedgerow. Yields are higher, but there is also a tendency to increase plant density which also affects productivity. We need to also assess the hypothesis that hedgerows planted close together do not show the depression in yields. In the Philippines on shallow limestone based soil and on steep slopes, similar to Haiti, Leucaena (Leucaena leucocephala) was planted as a fallow and harvested after three to four years. Tree stems or branches were then driven into the soil, with branches laid on the uphill side to retain the soil and prevent soil loss. Leucaena (Leucaena l.) trees are coppiced twice during the cropping season and corn and tobacco has been successfully grown for decades (MacDicken, 1990). In semiarid tropics, because of strong competition for moisture, alleys were found to have a depressing effect on yields, from 17 % in year 1 to up to 80% in year 5, unless the alleys were planted far apart (Singh et al 1986, cited in Vandenbeldt, 1990). In particular low rainfall and dry years, like we encountered in the North-West in 1989, in certain regions of Haiti, we may encounter competition from the hedgerow. We do not think, however that this should prevent the continuation of the effort in expanding the hedgerow technology, because the period of return of such a drought is probably fairly long.

Let us not forget that Haiti is considered as part of the humid tropics, and therefor in the next phase of the project, we should base our experimentation accordingly. In particular, by carefully choosing farmers in situations ranging from widely to narrowly spaced hedgerows, we could find the necessary clarifications regarding the most appropriate spacing for the best results regarding both soil conservation aspect together with maximizing crop yields.

In order to "sell" hedgerow technology to the farmer, it is essential that we are able to show that hedgerows at least stabilize yields. It is encouraging that we showed even very young hedgerow having positive effect on yields. As we also discussed during the first year, this yield increase may be due to land preparation. Hedgerows are taking space away from the field, and unless it is compensated by increased yields in another portion of that field, the practice would be unacceptable to the farmer. Hedgerows actually perform in a way so that the farmers do not lose from the practice. The acceptance of the hedgerow technology adapted to the Haitian conditions may in fact increase the output and income for the farmer. The results presented here, show that the crop yields are unaffected, and whatever the hedgerow produces in terms of wood or forage is all additional output.

Field measurements taken in farmers field are showing that, within the range of our observations, in the traditional mixed agricultural practice that prevails in Haiti, the associated crop does not seem to affect the yields of the main crop. The introduction of improved varieties or intensified agricultural practices may lead to different impacts of the associated crop.

Results are also showing that soils on hillside farms are very degraded and the potential for decent yields is low. Mixed cropping can however secure a diversified output to the farmer, insufficient, however, to provide an acceptable level of income. In the low lands, where the soil fertility is variable due to the nature of the parent material, the potential for production is much higher, and could justify using agricultural inputs, together with a certain level of mechanization. They are already using animal traction for land preparation and certain cultural practices. Fertilizer use needs to be expanded and the fertilizer formula refined through well managed tests in farmers field. We realize that this is beyond the scope of this agroforestry project, but, on the other hand we need to integrate the agroforestry technology in the whole agricultural production picture. Promoting intensified agricultural production in the better soil conditions would enable to remove some of the pressure from the hillside farms, that should be devoted for perennial agricultural or forest production.

Agroforestry has a definite role to play in sustaining agriculture in Haiti. On the hillsides, hedgerows will slow the land degradation process together with at least stabilizing the yields. Ones the hedgerows are successfully in place and properly maintained, improved crop varieties can be introduced to ensure the farmer with a much better level of income. On the most degraded hillside soils, hedgerow will slow down further degradation and tree planting will regenerate soil fertility in the same way as would a fallow. We can envision that after a few years, crops could again be planted successfully. This land would however not be lost for the farmer because the trees will have provided him some income.

Hedgerows are shown to be effective in conserving soil. Gene Hunter estimated the soil savings at 70 to 90 tons per ha and per year, depending on the slope. This was based on preliminary calculations done on measurement made as we were still refining our procedures. Measurements are currently in progress using the procedures described in this report. Results from these new measurements will give a more accurate evaluation still, because the field measurements will have been done more consistently, with a proven methodology.

The dynamics of the hedgerow will have to be assessed in order to determine the exact role of the numerous very small trees that was found in the hedgerows. This aspect will be included in the data collection process of the ongoing on farm research.

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