Effect of Natural Vegetative Filter Strips Density on Crop Production and Soil Loss[1]

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Abstract

Natural vegetative filter strips (NVS) are an attractive contour hedgerow system because they are simple to establish and maintain, control erosion effectively, and compete less with associated annual crops than other alternatives. The recommended practice has been to space the hedgerows every 1 meter drop in elevation. This results in close hedgerow spacing (3-6m apart) which removes considerable area from crop production. We hypothesized that acceptable soil loss may be possible with fewer hedgerows, and tested the effect of hedgerow density on soil loss in an experiment on a field with 50 meters slope length and 45% slope. A single NVS reduced soil loss by one half compared with the open-field control. As hedgerow density increased (4m, 2m, 1m) soil loss declined, but at a decreasing rate. Erosion did not differ significantly from the 2m and 1m drop, although the number hedgerows doubled. Maize yield declined with increasing number of hedgerows. We conclude that it is most practical to establish hedgerows at a 2m or 4m elevation distance. Even a single hedgerow is a good start for a farmer to tackle erosion with minimal investment and without significant loss of crop area.

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Introduction

Soil erosion is one of the major problems besetting the uplands that caused rapid soil quality degradation, nutrient depletion and decline in crop productivity (El-Swaify, 1993; Lal, 1984; Stocking and Peake, 1986; Turkelboom et al, 1993), and is recognized as major problem in cultivated sloping uplands in southeast Asia (Cruz, Francisco and Conway, 1988; Fujisaka et al, 1944; Garrity, 1993; Garrity et al, 1995). Contour hedgerow systems using nitrogen fixing trees have been promoted to minimize soil erosion, restore soil fertility, and subsequently improve crop productivity (Huxley,1986; Kang and Wilson, 1987; Young, 1986, 1987), and has been a common feature of extension programs for sustainable agriculture on the sloping uplands in southeast Asia (Garrity,1996). This innovation has not been widely adopted by the upland farmers (Fujisaka, 1994) despite of positive results have been observed and reported in number of experimental and demonstration sites. Constraint that limit the effectiveness and adoption of pruned-tree hedgerows include the tendency for the perennials to compete for growth resources and hence yields of associated crops planted in adjacent rows, and the inadequate amount of phosphorus recycled to the crop in the prunings (Garrity, 1996). But the major problem is the enormous amount of labor needed to prune and maintain them. Farmer's labor investment to prune their leguminous-tree hedgerows was about 31 days per hectare, or 124 days annual labor for four prunings (ICRAF, 1996). There is a dearth need for simple, less labor intensive but effective contour hedgerow system.

The use of natural vegetative strips (NVS) is proven to be an attractive alternative because of its simplicity in establishment and maintenance. NVS is laid out along the contour lines by leaving 40-50 cm of unplowed strips spaced at desired intervals usually 6 to 10 meters apart. The contour lines are determined by using an A-frame. The natural vegetation that is naturally growing in the strips filters the eroded soils, slows down the water lateral flow and enhances water infiltration that makes it very effective for soil and water conservation. Researchers found that these natural vegetative contour strips have many desirable qualities (Garrity, 1993). They needed very less pruning maintenance compared with fodder grasses or tree hedgerows, and offered little competition to the adjacent annual crops compared to the introduced species (Ramiaramanana, 1993). They were efficient in minimizing soil loss (Agus, 1993). And they did show a tendency of to cause greater weed problems for the associated annual crops (Moody, 1992 as cited in Garrity, 1996). Natural vegetative strips (NVS) were found to be an indigenous in practice on a very limited scale in other localities, including in Batangas (Garrity, 1996) and in Leyte Provinces between 1944 to 1977 (Fujisaka, 1993)

Despite of the benefits of natural vegetative contour strips, farmers are still concerned about the cropped area loss (field area allocated as hedgerows), and the consequence of eventual scouring of the upper alleyways (Garrity, 1996; Garrity and van Noorwijk, 1995; Tulkelboom et al, 1993). The more number of strips always correspond to a more reduction of cropped area and the scouring of the upper alleyways. The rule of thumb has been to space the hedges at 1 meter vertical drop (Watson and Laquihon, 1986) which translate into approximately 6 meters wide alleyways at 20% slope. This is translated into 15% cropped area loss due to hedgerows. The crops in the alley must increase up to 15% at least to compensate for this cropped area loss.

It is logical to assume that a fairly dense pattern of hedgerows is useful in minimizing soil loss. But dense hedgerow pattern does remove a larger portion of the field area from crop production, thus reducing the attractiveness of this soil conservation technology in terms of adoptability. Hence, this experiment was aimed at determining the relationship between hedgerow density and soil loss. If this question can be answered satisfactorily it is possible to determine with greater precision the implications of starting with less pattern of strips.

Our experimental hypothesis was soil loss is negatively correlated with hedgerows density, but follow an asymptotic curve that indicates a much smaller reduction in marginal soil loss as the density of strips increases. Our hypothesis is based on our experience with the Modified Universal Soil Loss Equation (MUSLE), is that the soil loss will not increase proportionally relative to the slope length. Thus, a reduction in hedgerow density to 1/2 or 1/4 the density normally recommended will be associated with the increase in off-field soil loss much less than double or quadruple that indicated if the two factors were proportionally related. This experiment will provide data to calibrate the MUSLE for tropical acid upland soils with natural vegetative filter strips installed at variable distances.

The data will provide clear guidance as to the functional relationship between hedgerows density (alley width) and the concomitant soil loss expected. Better tradeoff may enable the development of management recommendations for wider hedgerow spacing more consistent with practical farming demands for less than 5 to 10% reduction aggregate crop area.

One further issue to be explored is whether wider alleyways (i.e. greater elevation drop between hedgerows) will exacerbate the development of upper alley scouring effects. This might be expressed as the depth of soil removed from the upper alley will be greater as the terraces flatten out.

Materials and Methods

This experiment was conducted in a sloping land of about 45% slope owned and managed by the Misamis Oriental State College of Agriculture and Technology (MOSCAT), as an institutional collaborator of this research. The soil is classified as Ultic Haplorthox with pH ranges from 4.2 to 5.1, with an average value of 4.7. The site is part of the college corn production income generating project. This experimental site is located at Lupoc, Ani-e, Claveria, Misamis Oriental, Philippines. The land preparation, crop establishment, maintenance, and protection were borne by the college. These different field operations were uniformly applied throughout the experimental field. The NVS or the different treatments were laid out before these land preparations were done in March 1995.

There were five treatments: T1- no NVS (control), T2- one NVS at the middle of about 50 meters long, T3- three NVS spaced at about 4 meters vertical drop, T4- seven NVS spaced at about 6 meters apart or 2 meters vertical drop, and T5- fifteen NVS spaced at about 3 meters apart or 1 meter vertical drop of this 45% slope. These 5 treatments were replicated 3 times in a randomized complete block design (RCBD).

Trenches of 6 meters long, 50 cm deep, and 50 cm wide lined with bamboo splits were installed at the bottom of each treatment to collect eroded soils. Galvanized iron sheets outlined the erosion plot which extends to the whole length of the plot (48 meters long average) and 6 meters wide. The eroded soils were collected once or twice a month or as soon as we observed soil in the trenches. The soil samples were weighed and subsamples were taken and oven dried to determine the moisture content.

During the onset of rainfall and after the thorough land preparation which means having 2-3 plowings and 1-2 harrowings, the field was furrowed at approximately 60 centimeters apart. Three bags of diammonium phosphate (18-46-0), 1 bag of potash (0-0-60), 20 bags of chicken manure, and 1 bag of furadan 3G were applied in the furrow as basal per hectare. Lime was applied before the last plowing and harrowing at the rate of approximately 2 tons per hectare. Maize (Pioneer hybrid #3014) was used and planted at approximately 30 cm apart between hills in 70 cm apart between furrows. Interrow cultivation was done at 7 days after emergence (DAE), off-baring at 15 DAE, and hilling-up at 30 DAE. Right before the hilling up 3 bags of urea (46-0-0) were applied as sidedressing. Followed up by handweeding at 40-45 DAE. The maize was ready for harvest approximately 110 DAE. Maize was harvested by cutting the plants at ground level row by row from the bottom of the plot to the top. Samples were processed and weighed row by row. Subsamples were taken to determine moisture content. Cobs were shelled and grains were dried and weighed, and moisture content was adjusted to 14% row by row.

Results

Crop productivity

During the 3 successive croppings, rainfall distribution were good, and it is presented in Figure 1. The crops had not suffered drought stress. Table 1 showed the grain yield and total dry matter yield. There were no significant treatments effect during the first 2 croppings, but the differences were observed to be significant during the 3rd cropping. The treatments with more hedgerows had lower yields compared with no or fewer hedgerows. The total dry matter yield has the same pattern with grain yield. The reduction in grain yield and total dry matter yield were attributed to more cropped area loss. The net number of crop rows are smaller in treatments with denser hedgerows compared to fewer ones. Although, the plant height (Table 2) is not showing significant differences but the control is numerically higher mean plant height. The plant height is the mean of all the rows from the bottom to the top of the plot in each treatment which is about 50 meters long.

The pooled analyses for the 3 croppings are presented in Table 4. The analyses of variance indicates that cropping effect is significant across all parameters tested. As indicated in the earlier tables that there were significant differences in treatments effect during the third cropping. Treatments having denser hedgerows were having lower yields.

Maize row spacing, cropped area loss, alley width, and pruning labor required as influenced by different natural vegetative strips density are presented in Table 5. The average row spacing is computed based on the total length of the plot divided by the total number of rows in a given plot. The average row spacing in T1 (no hedgerow) is 70 cm while in T5 (fifteen hedgerows) is 88.89cm. The mean row spacing is wider in denser hedgerows compared to less dense or no hedgerow. This relates to a more cropped area loss in dense hedgerows (21.74%) compared with less dense hedgerows. The alley width is a function of vertical drop. The higher the vertical drop the wider the alleys. One meter drop gives an average 3 meters wide alley in an average slope of 45%. The pruning in mandays per hectare is directly related to the number of hedgerows but inversely related with the vertical drop. The more number of hedgerows require more mandays to prune. There were 2 pruning operations in each cropping. The major NVS species were *Chromolaena odorata, Imperata cylindrica, Ageratum conyzoides, Roetboella cochinchinensis.* In one meter vertical drop of 3 meters wide between alleys require 29 mandays to prune a hectare while a less dense hedgerow requires about 10 percent only. The amount of labor required in pruning the NVS hedgerow is directly proportional to the number of hedgerows: the denser the hedgerows the higher the amount of labor required to prune.

Soil loss

The soil loss as affected by different natural vegetative strips is presented in Table 6. The table shows 2 years of data. Year 1 covers from May 14, 1995 to May 8, 1996 while year 2 covers from March 23, 1996 to March 31, 1997. The slope length of the erosion plot is 48 meters long and 6 meters wide, and the mean slope is 45%. No hedgerow (T1) is significantly higher in soil loss in both years. During the first year soil loss was at 23.27 tons per hectare per year, and 53.83 during the second year. The difference in value was due to more rainfall during the second year (Figure 1). One hedgerow is effective in reducing soil loss which was about 67% during the first and 59 percent in the second year. Although there were numerical differences in soil loss in both years in with hedgerow treatments (T2 to T5) but there were no statistical differences. This can be attributed to high coefficient of variation of 82.92% and 78.32% in the first and second year, respectively. Dense hedgerows (T5- one meter drop) control erosion from 86% during the first year to 96% during the second year. When the number of hedgerows was reduce to half (T2 - two meters drop), the efficiency of the hedgerows reduce slightly to 84% in the 2nd year to 77% in the first year. Soil loss in T4 and T5 were still in acceptable rate under intensive agriculture in the USA, which is also accepted to the tropics despite the different environmental contexts (El-Swaify, 1993)

Having one NVS at the middle of the field of approximately 48 meters long reduced soil erosion by more than 67% during the first year, and 59% in the 2nd year. Having 3 hedgerows spaced at about 12 meters apart at 4 meters vertical drop reduced soil loss by 74% during the first year and 66% in the second year.

Hedgerow pruning and biomass

The amount of labor involved in pruning and spreading the NVS was given in table 6. The number of mandays required to prune and maintain the NVS is directly proportional to the density. The most dense hedgerows at one meter vertical drop (T5) require 29 mandays to prune a hectare per cropping season. Increasing the vertical drop to 2 meters reduces the number of NVS by half, and there was a corresponding reduction of labor. Having one NVS at the middle of the slope require 3.5 mandays to prune the NVS per cropping, and having three NVS require 7 mandays. It was also observed that the denser the NVS the time required per unit length is getting a little smaller. There is economy of scale.

The hedgerow biomass and nutrient content are given in Table 7. There were 7 pruning schedules. The 4 major NVS species were *Chromolaena odorata, Imperata* *cylindrica, Rottboellia cochinchinensis, Ageratum conyzoides,* and combined minor species and collectively called as 'others" which include: *Pennisetum polystachyon, Mukania cordata, Passiflora poetida, Elephantopus tomentosus, Setaria geniculata, Bidens pilosa, Borreria laevis, Paspalum conjugatum, Crassocephalum crepidiodes, Mimosa pudica, Centella asiatica, and Cleome rutidosperma.* Each pruning schedule was analyzed separately by ANOVA using SAS. NVS species weights were significant in each pruning schedule. The species composition is getting diverse as the cropping progressed. There were more annual weeds invading to the NVS. The danger of NVS may invade to the alleys is not feasible but the other way around because NVS are usually dominated by perennials species. The weeds that had invaded to the NVS may possibly be the source of weed seeds to the alley if the hedgerow is not prune regularly like *Rottboellia cochinchinensis.*

Chromolaena odorata has more NPK contents compared with other NVS species The grasses (*Imperata, Rottboellia, and Ageratum*) have lower nutrients contents compared to broadleaves (e.g. *Chromolaena*).

The amount of biomass and the corresponding nutrients (NPK) contribution are directly proportional with the density of NVS i.e. the denser the NVS the higher the biomass. Having one NVS at the middle yielded (T2) 103.59 kgs. of total biomass per cropping thus contributing 2 kilograms of N, 8.30 grams of P, and 1.97 kilograms of K. Putting 15 NVS produced 679 kgs. of total biomass with NPK contribution of 14.63, 0.53, and 12.50 kilograms, respectively.

Discussion

Natural vegetative contour strips has been looked at as an option to leguminous-tree based contour hedgerow systems because of being simple, less cost in establishment and maintenance (Garrity, 1996), and less competitive to associated food crops (Ramianamanana, 1993) but it is effective in controlling soil erosion (Agus, 1993), and it is farmer's invented technology (Fujisaka, 1994; Garrity, 1996). NVS serves as a foundation for establishing fruit and timber trees that enables the farmers to diversify species on their farms, and will lead to a good and stable agroforestry system which is environmentally friendlier.

However the intriguing issues of cropped area loss, pruning labor and scouring effect are still haunting in the minds of farmers, researchers and extension workers that may slow down adoption rate by the sloping upland farmers. The study is aimed primarily on looking at the effect of the NVS density on crop production and soil loss. This is to address the above issues without compromising the soil loss and crop productivity.

The annual soil loss of 39 ton $ha^{-1}yr^{-1}$ in T1 (control) did not affect the crop productivity because of the following reasons: a.) application of fertilizers, such as: diammonium phosphate, Urea, lime and chicken manure, were high that enable to replenish the eroded soils and nutrients, b) the number of plants are high in no hedgerow treatments, c) no scouring of the upper alleyways and no hedgerows competition, and no cropped area loss. Barbers (1990) reported that on deeps soils, erosion may have a negligible effect for a short time. He also found out that erosion rates of around 150 to 200 t/ha/yr in east Java have not significantly affected crop yields. Lal (1990) suggested that on soils with favorable subsoil properties, nutrient loss through erosion may be replaced using fertilizers so that crop production levels can be maintained. This maybe the general observation of few farmers in Claveria particularly the vegetable growers that they don't adopt soil conservation measures, and in fact vegetable crops rows are usually oriented up and down the slope. However, few tropical soils have favorable sub-soil characteristics and usually results in drastic declines in crop productivity as the depth of soil surface soil declines (Lal, 1984). In general, yield declines 60 percent on average with first 5 cm of top soil lost, 65 percent after the loss of 10 cm and 80 percent following the loss of 20 cm (Doolette and Smyle, 1990).

Upland farmers recognized soil erosion and nutrient depletion as a major problems (Fujisaka, 1993; Garrity, 1993). They are aware of the need to control soil erosion, and interested to adopt suitable soil conservation measures. But farmers usually evaluate the appropriateness of the innovations or the new technology specifically for his own situation. This may involve simply thinking about how the new technology might affect the farming operations or family (Follet and Stewart, 1985). Although NVS are simple to establish, but too dense (3 meters apart) may significantly affect farmers field operation in terms of convenience and labor requirement that inhibit farmers to adopt. Having too dense hedgerows do not provide added benefit but they give additional burden on labor and farming inconvenience.

The amount of labor required to prune and maintain the NVS is directly proportional to the density: the denser the NVS the more labor required. Although the alter ego for upland farmers to adopt soil conservation is soil erosion control, allocating 29 mandays per cropping to maintain the hedgerow is unaffordable to most of the farmers.

The amount of biomass and nutrient contribution of NVS to the crop production is directly related to the density of NVS i.e. the denser the more biomass and nutrient contribution. However, the amount of nutrients contributed does not justify the amount of labor invested in dense NVS, and they are incapable of recycling phosphorus (Garrity, 1996) which is the most limiting nutrient in acid upland soils (Garrote et al, 1986; ICRAF, 1996)

The NVS pruning biomass are declining as the cropping progresses which usually require two prunings per cropping. This frequency of pruning gives pressure to the perennial NVS that provides an opportunity to the annual weeds to colonize the hedgerow. It was also observed that more annual weeds were observed in the hedgerow as the NVS is frequently pruned. This may be the threat of NVS (hedgerow) to become the source of weed seeds to the alley thus requiring more frequent pruning to avoid the annual weeds to produce seeds for the alley. Frequent pruning is required when the NVS is dominated with annual weeds to avoid producing seeds to the alleys.

Conclusion

Upland farmers recognized soil erosion and nutrient depletion as a major problem. They are aware of the need to control soil erosion, and willing to adopt suitable soil conservation technology, but usually they evaluate the appropriateness of the technology for his situation, and think about how the new technology affect their farming operations or family.

The conventional leguminous-tree hedgerow systems, although showed good results in some areas, they are not widely adopted by farmers because of some constraints associated with them such as: the tendency for the perennials to compete for growth resources (both above and below ground), inadequate amount phosphorus recycled by the prunings, and enormous amount of labor needed maintain.

NVS provide the alternative option because they are simple to establish and maintain, control erosion effectively, and compete less with the associated annual crops. However, close NVS (hedgerow) spacing will remove considerable area from crop production, and it will likely be rejected by the farmers.

The results of the study indicates that one single hedgerow reduced soil loss by more than one-half compared with open-field control. As hedgerow density increased soil loss declined, but at decreasing rate. Maize yield declined with increasing number of hedgerows. The amount of labor required to maintain NVS is directly proportional with density. Pruning biomass and nutrient contribution from NVS are also directly associated with density. Too dense hedgerows (1 meter drop) which require more labor to maintain (29 mandays per cropping and 17% crop area loss) does not provide the added benefit to the soil conservation and crop production.

Frequent pruning on NVS dominated by broad-leaved perennial species (*Chromolaena odorata*, etc.) will likely be colonized by annual weeds which will later on require more pruning frequencies to avoid annual weeds to produce seeds for the alley. However, further study is needed to fully understand this phenomenon.

We further conclude that it is more practical to establish hedgerows at a 2m - 4m elevation distance on steeper slopes. Even a single hedgerow is a good start for farmers to tackle erosion with minimal investment and without significant loss of crop area.

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Table 1. Grain yield and total dry matter yield of maize (Pioneer hybrid #3014) as influenced by different natural vegetative strips (NVS) density in an acid upland soil. Claveria, Misamis Oriental, Philippines.

Treatments		Grain yield (tha-1)				Total dry matter yield (tha-1)			
		1st Crop	2nd Crop	3rd Crop	Mean	1st Crop	2nd Crop	3rd Crop	Mean
T1		3.97 a	2.79 a	3.62 a	3. 46 a	9.62 a	5.75 a	7.13 a	7.50 a
T2		3.50 a	2.60 a	3.22 b	3.11 ab	8.52 a	5.31 a	6.28 b	6.70 ab
T3		3.62 a	2.49 a	3.34 ab	3.15 ab	8.41 a	5.05 a	6.48 ab	6.64 ab
T4		3.78 a	2.40 a	2.90 c	3. 01 b	8.45 a	4.76 a	5.32 c	6.18 b
T5		3.20 a	2.34 a	2.65 c	2.75 c	7.76 a	5.43 a	5.12 c	6.10 b
Mean		3.62	2.52	3.15	3.09	8.55	5.71	6.07	5.26
R2		0.58	0.48	0.90	0.81	0.44	0.72	0.89	0.42
CV %		13.71	10.03	5.33	6.05	14.21	7.78	5.96	11.74
LSD		0.93	0.48	0.32	0.35	2.29	0.84	0.68	1.16
SV	DF	F - Values							
Replication	2	3.49 ns	0.68 ns	5.43 *	5.95 *	1.29 ns	1.71 ns	1.68 ns	1.53 ns
Treatment	4	1.03 ns	1.49 ns	15.13 **	5.63 *	0.92 ns	4.41 *	16.04 **	3.85 **
Rep x Trt	8	1.85 ns	1.22 ns	11.90 **	5.73 **	1.04 ns	3.51 ns	11.25 **	3.08 ns

In a column, means having a common letter are not significantly different at 5% level by DMRT.

** - Significant at 1%

* - Significant at 5%

ns - not significant

Table 2. Plant height and productive plants of maize (Pioneer hybrid #3014) as influenced by different natural vegetative filter strips (NVS) density in an acid upland soil. Claveria, Misamis Oriental, Philippines.

Treatments	Plant height (cm)				Productive plants (ha-1)			
	1st Crop	2nd Crop	3rd Crop	Mean	1st Crop	2nd Crop	3rd Crop	Mean
T1	235.00 a	209.50 a	218.53 a	221.00 a	18594 ab	24415 a	28931.0 a	23980 ab
T2	224.13 b	220.50 a	204.03 bc	216.20 ab	18889 ab	24530 a	29382.3 a	24267 a
T3	224.40 b	216.23 a	208.17 b	216.33 ab	18854 ab	23747 a	29314.0 a	23971 ab
T4	227.13 ab	204.50 a	201.50 c	211.07 b	23082 a	23832 a	26246.3 b	24386 a
T5	224.20 b	216.27 a	202.43 bc	214.30 ab	17533 b	23282 a	24088.0 c	21634 b
Mean	226.97	213.40	206.93	215.87	19390.47	23961.07	27592.33	23647.8
R2	0.67	0.50	0.87	0.50	0.54	0.07	0.90	0.63
CV %	2.39	4.50	1.62	2.12	15.18	10.03	3.79	5.44
LSD	10.22	18.07	6.33	8.60	5541.40	4525.7	1967.5	2422.9

SV	DF	F - Values							
Replication	2	3.86 ns	1.29 ns	0.70 ns	0.32 ns	1.44 ns	0.01 ns	4.23 ns	2.10 ns
Treatment	4	2.21 ns	1.31 ns	12.91 **	1.87 ns	1.58 ns	0.14 ns	15.15 **	2.35 ns
Rep x Trt	8	2.76 ns	1.30 ns	8.84 **	1.35 ns	1.53 ns	0.10 ns	11.51 **	2.27 ns

In a column, means having a common letter are not significantly different at 5% level by DMRT.

** - Significant at 1%

* - Significant at 5%

ns - Not significant

Table 3. Harvest index and number of unproductive plants of maize (Pioneer hybrid #3014) as influenced by different natural vegetative filter strips (NVS) density in an acid upland soil. Claveria, Misamis Oriental, Philippines.

Treatments	DF	------------ Harvest index			---------------	-------------- Unproductive plants (ha-1) ------			
		1st Crop	2nd Crop	3rd Crop	Mean	1st Crop	2nd Crop	3rd Crop	Mean
T1		41.33 a	48.33 a	50.67 b	46.67 ab	1389.3 a	1007.3 a	830.7 a	1012.0 b
T2		41.33 a	49.00 a	51.00 ab	47.33 ab	1773.7 a	1444.0 a	1338.0 a	1518.7 a
T3		43.33 a	49.33 a	51.67 ab	48.00 a	1544.0 a	1454.3 a	590.0 a	1196.0 ab
T4		45.00 a	49.00 a	54.67 a	49.67 b	1296.7 a	1475.0 a	1093.0 a	1288.0 ab
T5		40.67 a	44.67 a	51.67 ab	45.67 b	1667.0 a	815.7 a	571.0 a	1082.0 b
Mean		42.33	48.07	51.93	47.47	1534.13	1239.27	884.53	1219.33
R2		0.55	0.37	0.68	0.69	0.26	0.56	0.50	0.57
CV %		8.22	6.59	3.84	3.41	33.69	32.05	46.20	17.74
LSD		6.55	5.96	3.75	3.05	973.04	747.77	769.48	407.24
SV	DF	-------------------------------------			F - Value	---			
Replication	2	3.37 ns	0.09 ns	4.66 *	3.77 ns	0.54 ns	1.44 ns	0.08 ns	0.18 ns
Treatment	4	0.80 ns	1.12 ns	1.91 ns	2.59 ns	0.43 ns	1.79 ns	1.96 ns	2.51 ns
Rep x Trt		1.66 ns	0.78 ns	2.82 ns	2.98 ns	0.47 ns	1.68 ns	1.33 ns	1.73 ns

In a column, means having a common letter are not significantly different at 5% level by DMRT.

** - Significant at 1%

* - Significant at 5%

ns - Not significant

Table 4. Pooled analyses of grain yield and other agronomic characters of maize (Pioneer hybrid #3014) as influenced by natural vegetative filter strips (NVS) density in an acid upland soil. Claveria, Misamis Oriental, Philippines.

Treatments		Plant height height (cm)	Harvest index	Total dry atter yield (tha-1)	Grain yield yield (tha-1)	Productive plants plants (ha-1)	Unproductive plants (ha-1)	Number of Cobs (ha-1)
T1		221.01 a	46.75 bc	7.50 a	3.46 a	23979.9 a	1011.9 b	24465.0 a
T2		216.22 ab	47.17 bc	6.70 b	3.11 b	24267.0 a	1518.6 a	24568.1 a
T3		216.27 ab	48.08 ab	6.65 b	3.15 b	23971.7 a	1196.1 ab	24362.7 a
T4		211.04 c	49.58 a	6.18 b	3.01 b	24386.5 a	1288.2 ab	24661.7 a
T5		214.30 bc	45.67 c	6.10 b	2.75 c	21634.4 b	1081.8 b	22078.8 b
Mean		215.77	47.45	6.63	3.09	23647.92	1219.32	24027.28
R2		0.81	0.81	0.86	0.84	0.83	0.59	0.86
CV %		2.87	5.65	11.28	9.87	8.77	32.77	8.68
LSD		5.16	2.23	0.62	0.25	1723.8	332.27	1735.2
SV	DF			F - Values				
Cropping (CRP)	3	27.22 **	32.48 **	52.70 **	32.34 **	39.31 **	6.63 **	50.10 **
CRP (Rep)	8	1.61 ns	2.44 *	1.23 ns	3.38 **	1.20 ns	0.62 ns	1.05 ns
Treatment (Trt)	4	4.08 **	3.63 ns	6.72 **	8.41 **	3.63 *	2.95 *	3.30 *
CRP x Trt	12	1.85 ns	0.42 ns	0.64 ns	0.67 ns	1.50 ns	0.78 ns	1.54 ns
CRP xTrt x Rep		4.93 **	5.06 **	7.50 **	6.14 **	5.93 **	1.70 ns	7.05 **

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Table 5. Maize row spacing, hedgerow spacing, and pruning labor required as influenced by different natural vegetative filter strips (NVS) density in an acid upland soil. Claveria, Misamis Oriental, Philippines.

Treatments	Maize row spacing (cm)	Crop area loss (%)	Alley width (m)	Vertical drop (m)	Pruning labor (mandays ha^{-1} $cropping^{-1}$)
T1 - no NVS	69		-	-	-
T2 - one NVS at the middle of the slope	73	5.80	23.92	8	3.5
T3 -Three NVS	75	8.69	11.92	4	107
T4 - Seven NVS	77	11.59	5.98	2	15
T5 - Fifteen NVS	81	17.39	3.00	1	29

Table 6. Soil loss as affected by different natural vegetative filter strips (NVS) density in an acid upland soil. Claveria, Misamis Oriental. Philippines.

Treatments	Vertical drop (m)	Soil loss ($kgha^{-1}$) Year 1	Year 2	Average
T1 - no NVS	-	23277 a	53832 a	38555 a
T2 - one NVS at the middle of the slope	8	7825 b	21924 b	14875 b
T3 -Three NVS	4	6035 b	17810 b	11922 b
T4 - Seven NVS	2	5282 b	8298 b	6790 b
T5 - Fifteen NVS	1	3180 b	2254 b	2717 b
Mean		9120	20824	14972
R2		0.64	0.71	0.66
CV (%)		82.94	78.32	78.33
MSE		7564	16308	11727
SV	df			
Replication	2	0.37 ns	0.77 ns	0.60 ns
Treatment	4	3.43 *	4.52 *	4.27 *
Rep x Trt	8	2.41 ns	3.27 *	3.05 ns

In a columns, means having a common letters are not significantly different by DMRT at 5% level.

ns - not significant

* - significant at 5% level

Year 1 - data taken from May 14, 1995 to May 8 1996

Year 2 - data taken from March 23, 1996 to March 31, 1997.

Mean slope lenght = 48 meters

Mean slope = 45 percent

Table 7. Hedgerow pruning parameters as influenced by different natural vegetative strip desity (NVS) in an acid upland soil. Claveria Misamis Oriental, Philippines.

Hedgerow species	Nutrient content (gkg^{-1})		
	N	P	K
Chromolaena odorata	26.36	0.096	20.10
Imperata cylindrica	11.00	0.060	10.70
Rottboellia cochinchinensis	14.40	0.050	10.50
Ageratum conyzoides	10.09	0.047	13.00
Others	19.68	0.056	24.70
Mean	16.31	0.062	15.800

Pruning biomass and N contribution (gha^{-1})

Hedgerow species	T2		T3		T4		T5	
	Biomass $Kg\ ha^{-1}$	N yield $g\ ha^{-1}$	Biomass $Kg\ ha^{-1}$	N yield $g\ ha^{-1}$	Biomass $Kg\ ha^{-1}$	N yield $g\ ha^{-1}$	Biomass $Kg\ ha^{-1}$	N yield $g\ ha^{-1}$
Chromolaena odorata	60.08	1575	117.66	3085	206.99	5383	374.25	9719
Imperata cylindrica	19.43	199	39.72	407	82.16	855	138.12	1417
Rottboellia cochinchinensis	-	-	-	-	0.25	3.8	0.3	6
Ageratum conyzoides	-	-	0.03	0.2	2.40	24	2.72	27
Others	24.08	510	47.16	998	89.65	1898.0	163.7	3464
Total	103.59	2284	204.57	4490.2	381.45	8163.8	679.09	14633

P K contribution (gha^{-1})

Hedgerow species	T2			T3		T4		T5	
	P	K		P	K	P	K	P	K
Chromolaena odorata	5.76	1183.59		11.27	1832.45	19.76	3931.59	35.700	7066.04
Imperata cylindrica	1.24	107.37		2.52	229.65	5.16	555.22	8.770	798.68
Rottboellia cochinchinensis	-	-		-	-	0.009	2.92	0.016	5.89
Ageratum conyzoides	-	-		-	-	-	-	-	-
Others	1.30	681.06		2.64	1333.00	5.02	2535.74	9.170	4628.03
Total	8.30	1972.02	0.00	16.43	3395.10	29.95	7025.47	53.66	12498.64

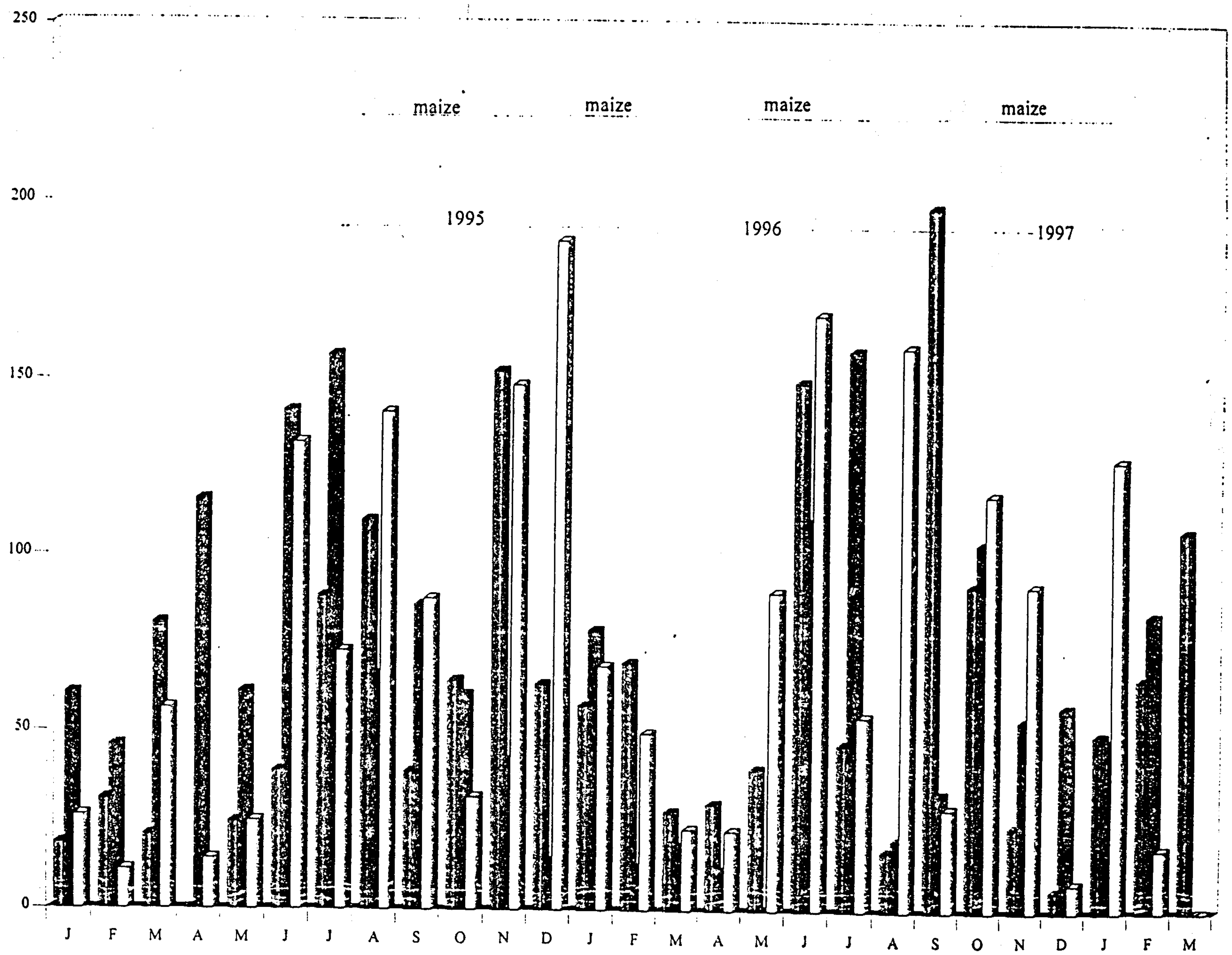

Figure 1. Rainfall by decade (mm) and crop phenology
Lupoc, Claveria, Misamis Oriental, Philippines