CROP PRODUCTIVITY USING FORAGE LEGUMES AND GRASSES AS CONTOUR HEDGEROW SPECIES IN AN ACID UPLAND SOIL[1]

Agustin R. Mercado, Jr.[2*], Nestor Sanchez[2] and Dennis P. Garrity[3]

Abstract

Contour hedgerow systems have been viewed as an important technology to sustain crop production in the sloping uplands by reducing soil erosion and provide organic fertilizer for crop production. A collaborative study between the International Centre for Research in Agroforestry (ICRAF) and Misamis Oriental State College of Agriculture and Technology (MOSCAT) compared several forage legumes and grasses as contour hedgerow species. The trial focused on how the species compared in reducing soil erosion, influencing annual crop yields, and their relative competition with the associated crops. A 5 x 3 factorial experiment was laid out in a strip-plot design in randomized complete blocks. The five hedgerow species of *Flemingia congesta*, *Stylosantes scabra*, *Panicum maximum* and *Vetiveria zizanoides*, and an open-field control were the vertical factor. The three pruning management practices of prunings removed, uniform application, and skewed application across the alleyway (2/3, 1/3, 0, and 0 on the four inter-alley zones from highest to lowest elevation) were the horizontal factors. The annual double-crop system was upland rice followed by maize in the alleyways. The hedgerow systems reduced soil erosion between 67 and 95%, with the grass species tending to be most superior alternatives for soil conservation. *F. mycrophylla* provided the highest annual pruning biomass (7.22 t/ha). Grain yields and total dry matter of upland rice and maize in the hedgerow systems did not differ consistently from those observed in the open field control. *P. maximum* reduced yields significantly, due to severe competitiveness. The hedgerow species rankings from lowest to highest in competitiveness were *S. scabra*, *V. zizanoides*, *F. congesta*, and *P. maximum*. Skewed application of pruning biomass and crop residues to the upper alleyways to ameliorate upper-alley scouring showed no superiority compared with a uniform application.

---

[1]Paper presented during the Roving Workshop on Conservation Farming on Sloping Lands on November 1-9, 1998 at Southwinds Hotel, Cagayan de Oro City.

[2] Associate Research Officer and Field Assistant, respectively, International Centre for Research in Agroforestry, Claveria Research Site, MOSCAT Campus, Claveria, Misamis Oriental 9004, Philippines.

[3]Systems Agronomist and Coordinator, Southeast Asian Regional Research Programme, ICRAF, P.O. Box 161, Bogor 16001, Indonesia.

Introduction

Contour hedgerow systems are an important technology to reduce soil loss due to water erosion (Garrity et al., 1995; Fujisaka, 1993; Soriano, 1993; Paningbatan and Maglinao, 1993). They may ameliorate soil fertility from the loppings of leguminous trees used as hedgerows (Kang and Wilson, 1987, Kent 1985, PCARRD 1992, O'Sullivan 1985). Tree hedgerow technology has been most successful on calcareous and relatively favorable upland soils (Watson and Laquihon, 1987; Lasco and Suson, 1989; Sanchez, 1995) where P and K were not the limiting nutrients.

Adoption rates of tree legume hedgerows, even in these areas, have been disappointing. Limited diffusion can be attributed to: 1) high labor requirements to establish and maintain tree legume hedgerows, 2) lack of planting materials, 3) poor adaptation of some tree legumes (eg *Leucaena leucocephala*) in acid infertile soils, and 4) tree-crop competition for light, water and nutrients. Farmers and researchers have been searching for alternative hedgerow species that are adapted to unfavorable growing environments e.g. on acid upland soils. Ideal species for hedgerows would be effective in eliminating soil erosion by water, require less labor to establish and maintain, be less competitive to associated food crops, and have multiple uses, eg. as fodder or as organic fertilizer.

Forage legumes and grasses are prospective alternative hedgerows species to trees because of their multiple uses as fodder, erosion control and organic fertilizer. Fujisaka (1990) observed that farmers more readily adopted grass strips hedgerows, and used them as a source of fodder during dry seasons. When there is over-production of fodder beyond the needs of animal population in a household, the excess may be used as organic fertilizer.

Fodder grasses and legumes are easy to establish and maintain. Since they are short- statured, they can be planted densely, which makes them very effective in controlling soil erosion. More knowledge is needed of the direct comparison in performance between different trees, grasses, and forage legumes as hedgerow species.

This is urgent because contour hedgerows are widely recommended as a sloping-land conservation farming practice, but little empirical evidence is yet available to guide the appropriate choice of species.

As terraces develop in contour hedgerow systems, the upper part of the alleyway is scoured due to the movements of soil from the upper zone towards the lower zone. The re-distributed soil accumulates in the lower zone of the alleyway and under the hedgerow. A soil fertility gradient develops across the alleyway. This is exhibited by a linear trend of low to high nutrient levels from the upper alleyway zone to the lower alleyway; crop productivity also follows the same trend (Garrity et al., 1995; Basri et al., 1990, Mercado et al., 1992). This scouring is mainly the result of frequent animal tillage (plowing and harrowing). Soil erosion by water within the alley may also contribute.

Upper-alleyway soil scouring has drawn the concern of farmers and researchers. Practices must be found to avoid or alleviate this decline in soil fertility so as not to endanger the sustained yields of these naturally-developed terrace systems. One of the prospective ways of approaching the problem is to apply all or most of the hedgerow prunings, crop residues, or fertilizers, on the upper zones of the alleyway, and lesser amounts on the lower zones. This experiment included treatments to compare some alternative ways of avoiding or alleviating the scouring problem. The inclusion of both species comparison and hedgerow pruning management issues within one experiment enabled us to explore the interaction between choosing the right species, and managing it in such a way that the system reduces scouring and hedgerow-crop competition.

The objectives of the study were: 1) to compare the long-term productivity of upland rice and maize in sequence when associated with a range of different tree, forage legume, and grass hedgerow species, 2) to quantify the effectiveness of these different species in controlling soil erosion, 3) and to determine the response of the associated food crops to different ways of managing the soil so as to ameliorate scouring.

Materials and Methods

Treatment and layout

Four hedgerows species were compared, along with a control treatment (open field cultivation without hedgerows). The species were 1) *Flemingia congesta* (forage legume) 2) *Stylosanthes scabra* (forage legume), 3) *Panicum maximum* (forage grass), 4) *Vetiveria zizanoides (non-forage erosion control grass).* The species were arranged in a randomized complete block design (RCBD) replicated twice in each of 2 locations (total of four replications): The experimental farm of the Misamis Oriental State College of Agriculture and Technology (MOSCAT); and a farmer's field in Cabacungan village. Both sites were located in the municipality of Claveria, Misamis Oriental, Philippines. The MOSCAT site had a 24% slope while Cabacungan site had a slope of 18%. Each hedgerow species was laid out in contour strips with 8-9 meter-wide alleyways. Each species plot was 8 meters wide perpendicular to the slope, and 24 meters long downslope. There were 3 alleyways and 5 hedgerow strips for each species.

Three pruning/crop residue management treatments were applied to test different methods to ameliorate upper alley scouring: 1) prunings and crop residues applied uniformly across the alleyway; 2) prunings and crop residue application skewed to higher amounts on the upper alleyway (amounts were 2/3, ½, 0,0) in four equal-width zones (zone 1 was nearest the hedgerow on the uppermost part of the alley, zone 4 near the hedgerow on the lower side); 3) prunings were removed and the crop residues were applied uniformly across the alleyways. In treatment 3 the hedgerow prunings were taken from the field to simulate a cut-and-carry animal production system. These 3 management schemes were applied in 3 alleys as subplots.

Land preparation and crop establishment

During the dry season in March the field was plowed using a moldboard plow drawn by draft animal (cow) 2-3 times. The field was harrowed between plowings. Before the last plowing the hedgerows were pruned and the prunings were spread in the alleyways, and plowed under. There was no harrowing after the last plowing so as not to disturb the distribution of crop residues and prunings. After the onset of rainfall (50 mm total rainfall) the field was furrowed, using the lithao, a 5-bladed furrower drawn by animal, with tines spaced 30 cm apart. Phosphorus (P), potassium (K), and Furadan 3G insecticide at the rate of 20, 20 and 18 kilograms (kg) per hectare, respectively, were applied basally in the furrows before the upland rice seeds (IR30716-B-1-B-1-2, a superior IRRI upland rice cultivar) were drilled at the rate of 100-kg per hectare. The seeds were covered with soil by foot. The upland rice germinated 7 days after planting (hypocotyl appeared above the soil surface). Fifteen days after emergence (DAE) interrow cultivation with a light hoe controlled the weed seedlings emerging between the rows. At thirty DAE 30 kg nitrogen per hectare was side dressed and another inter-row cultivation was done using the lithao. Spot weeding was done at 40 DAE to remove any remaining weeds. Another 30 kg N per hectare was applied at 55 DAE (approximately 7 days before panicle initiation (DBPI) of this early maturing upland rice cultivar). Insecticides (Decis, 2.5% Deltamithrin) at the rate of 30 ml per 16 liters of water were sprayed at the milking stage to control rice bugs. The upland rice was harvested 110 DAE. Stalks were cut at ground level.

After the upland rice harvest, the crop residues were collected and weighed, and were re-applied to the alleyways based on the treatments. The field was plowed twice or thrice for the subsequent crop of corn. The 2nd or 3rd plowing incorporated the hedgerow prunings. No harrowing was done so as not to disturb the distribution of prunings and crop residues. The field was furrowed with rows 60 cm apart by animal-drawn moldboard plow. Phosphorus, K and Furadan 3G were drilled on the furrows at the rate of 30, 30 and 18 kg per hectare, respectively. Pioneer hybrid #3274 maize was planted in the furrows with hills spaced 25 cm apart, producing a population of 67,000 plants per hectare. Corn seeds germinated 5 days after planting. The first inter-row cultivation was at 14 DAE using a single moldboard plow. Before the first inter-row cultivation 40 kg N per ha was sidedressed at the base of the plants. The other equal split of 40 kg N per ha was applied at 30 DAE, just before the 2nd interow cultivation, using a double moldboard plow for hilling up. Spot weeding was done at 45 DAE. The maize was ready for harvest at 105 DAE. The plants were cut at ground level.

Hedgerow establishment and prunings

The hedgerows were established in 1990. *Flemingia* and *Stylosanthes* were established by seeds drilled 10-15 cm apart in two parallel furrows spaced 50-cm apart and parallel to the contour line. Two weeks after emergence the population was thinned to 10-15 plants per linear meter. *Panicum* and *Vetiveria* were established in two parallel furrows using tillers. The hedgerows were allowed to establish for 6 months before pruning commenced. There were 4-5 prunings per year: 3 during the first crop (upland rice), and 2 during the second crop (maize). Prunings were done prior to each cropping and 1-2 prunings during the growing season. The forage legumes and grasses were cut 10-15 cm above the plant base. Prunings were spread on the alleyways according to the respective treatments, and were later plowed under.

Erosion and raingauge measurements

Soil sediment traps were constructed at the downslope base of each plot in the experiment composed of trenches lined with either split bamboo or galvanized iron (GI). The trenches were 50 cm wide and 50 cm deep and stretched 6 meters along the base of the plots. The field area from which the sediment was collected was 6 meters along the contour and 24 meters running downslope across the three alleyway/hedgerow units. They were bordered with earthen bunds to define the plots, and to avoid water from entering or exiting the erosion plots. Soil collected in the trenches was weighed every month. After weighing the soil was subsampled for water content determination. Raingauges were installed at each site and monitored daily.

Data collection and statistical analyses

The agronomic data collected on the upland rice and maize included plant height, grain yield, total dry matter yield, number of productive plants, number of unproductive plants, and number of tillers. These data were computed in 3 ways: 1) field area basis, ie. yields were based on the full area of the system including that occupied by the hedgerows; 2) full alley basis, ie. yields were based on the area cropped with the area occupied by the hedgerows excluded; and 3) row-by-row or zonal basis, with the alleyways divided by individual rows, or into four zones. Row-by-row and zonal analyses were used to examine the relative competitiveness of different hedgerow species.

Plant height was taken by measuring 10 plants per row, from the base of the plant to the tip of panicle (for rice) or tassel (for corn). Productive plants and tillers were counted in 1 linear meter per row from the top to the bottom of the alley. Total dry matter yields were taken by cutting the plants at ground level in a 4 linear-meter length of row across the entire alleyway. The sample was weighed fresh, and subsamples were taken for oven-drying and moisture content determination. Grain yield is expressed at 14% moisture content.

Plant height of the hedgerows was observed at each pruning. Total fresh weight of the pruning samples was determined, and the biomass subsampled for moisture content determination. The pruning yield data was computed on a field area basis (ie. the area occupied by the alleys was included).

The datasets were statistically analyzed using the Statistical Analyses Systems (SAS Institute, 1988). The hedgerow pruning data and soil loss data were analyzed using an RCBD design. The crop data , both upland rice and maize, were analyzed using the strip- plot in RCBD. The hedgerows species were the vertical factor, and pruning and crop residue management treatment (which were applied in strips across the different hedgerow species) were the horizontal factors.

Results and Discussion

The Crop Environment. The results presented are from crop years 1993-1994 and 1994-1995, a total of 4 croppings which included two crops of upland rice and 2 corps of maize. During both crop seasons in 1993-94 moisture was sufficient as the result of good distribution of rainfall (Figure 1). In 1994-95 at MOSCAT, rainfall was evenly distributed during the upland rice crop, except for a short dry spell in late July which did not affect the rice because it was at maturity (Figure 2). During the maize crop there was a dry spell during the vegetative stage, but it recovered upon resumption of rain, and produced well. In Cabacungan (Figure 3) there was a good distribution of rainfall except for a short dry spell in late July to early August. This dry spell affected the growth of the rice, but it was able to recover upon resumption of rain in mid-August. During the maize crop, although there was no heavy rains, the precipitation was evenly distributed throughout the growing period.

Hedgerow performance. The pruning biomass of the different contour hedgerow species is compared in Table 1. The annual pruning biomass of *Flemingia congesta* (6.78 tons per hectare) was the highest among species, but was not statistically different than the 4.30 t/ha produced by *Vetiveria zizanoides*. The high biomass production of *Flemingia* is attributed to its accumulated growth during the dry season in which hedgerows were allowed to grow as fallow species. *Stylosanthes scabra* had the lowest biomass among the hedgerow species (0.79 t/ha) because of a gradual dieback in this species which reduced its plant population.

Table 2a compares the amount of prunings applied to the alleyways. This was computed on a crop-area or full-alley basis, which accounts for the higher biomass values in this table compared to Table 1 and the amounts of pruning biomass applied in the treatment with uniform distribution. Table 2a shows the amounts of pruning biomass applied in the treatment in which it was applied in a skewed distribution toward the upper alleyways.

The hedgerows were managed uniformly in this experiment. They were pruned at the same time so as to avoid differential pruning frequency as an experimental variable. Table 4 compares the herbage yield and plant height of the hedgerow species in 1994-95. There were a total of 5 prunings that year. *Flemingia* again produced the highest biomass at both locations (6.29 t/ha at MOSCAT; 8.59 t/ha at Cabacungan). *Panicum maximum* and *Vetiveria zizanoides* had consistently high biomass at both sites. *Stylosanthes* yielded well at Cabacungan (6.23 t/ha) but poorly at MOSCAT (1.22 t/ha) due to the dieback condition referred to above.

The pooled analyses of the 2 sites is presented in Table 3. There was a significant location effect, indicating that the species responded differently across sites. *P. maximum* and *V. zizanoides* yielded best in MOSCAT, but the highest yields of Stylo and Flemingia were observed in Cabacungan. Pruning schedules affected hedgerow yields and plant heights. Species differed significantly in herbage yields. The interaction between hedgerow species, pruning schedule and location was also highly significant.

Soil loss. The control treatment (open field cultivation on the contour) registered an annual rate of soil loss of 39.88 tons per hectare in 1993-94. All of the hedgerows treatments were effective in dramatically reducing soil loss compared to this value (Table 5). The percentage reduction in soil loss due to hedgerows varied from 67% to 95%. Numerically, the two grasses showed the greatest effectivity in controlling erosion. Only 2.18-2.19 t/ha were lost with either species. Stylo had the greatest soil loss among the hedgerows (9.18 t/ha), presumably due to the loss of cover in the hedgerows as a result of the plant dieback.

The soil loss data for 1994-95 were very similar to those for 1993-94. The results indicate that all hedgerow species were effective barriers to soil loss. The grasses, however, would appear to be the most effective among the alternatives tested. They reduced soil losses to insignificant levels, even on slopes of 18 to 24%.

Upland rice response

Full alley analyses. The crop data consists of 4 croppings over 2 years, two each of upland rice and maize. The pooled data for rice grain yield, total dry matter yield and plant height for the cropping years 1993-1994 and 1994-1995 are shown in Table 6. Yields did not differ among hedgerow species in 1993, but *F. congesta* hedgerows produced the highest rice dry matter. In 1994-95 Flemingia hedgerows produced the lowest rice grain yields. This contrasted with the results of the previous year in which it was evidently the superior species. The rice yield reduction in 1994-95 with Flemingia was caused by a severe infestation of leaf folder (*Cnaphalocrocis medinales*) during the late vegetative to reproductive stage. The infestation was localized in the *F. congesta* plots. The upland rice was showing superior growth in these plots at an early stage, compared with other hedgerow species. The insect damage affected grain yield, and also eliminated the advantage in total dry matter. This was an illustrative case of differential pest infestation caused by the micro-environmental and soil fertility differences produced by different hedgerow species. As a consequence of the contrasting responses of the two growing seasons, mean grain yields for the two years were nearly identical among all hedgerow treatments. Likewise, total dry matter yields were similar and not statistically significant.

Table 6 also shows the results of the variation in pruning applications. In the first year (1993-94), uniform application of prunings and crop residues (T1) produced significantly higher rice yields (2.32 t/ha) than if they were removed (T3) (1.81 t/ha). Upland rice total dry matter did not differ significantly among pruning application treatments. In the second year (1994-95) there were no significant differences among pruning management treatments in either rice yields or biomass. Thus, applying the prunings in the upper alleyway (T2) did not show any advantage compared to uniform application. . However, applying the prunings (T1 and T2) produced taller plants. Such a change in pruning management may require a number of years to cause yield effects that are significant.

Field area analyses. Yields on a field area basis consider the total area occupied by the system, including the area of the alleys and the hedgerows. Factors that contribute to area loss by the hedgerows include: steepness of the slope, the species used, the alley crop used, and the hedgerow management. The steeper the slope the bigger the area loss. Fast-growing and creeping hedgerow species are likely to cause a bigger loss of crop area. Plowing closely to the hedgerow reduces the spread of the hedges toward the alley. Upland rice has more area loss compared to maize, due to the loss of more rice rows. The percent area loss of different hedgerow species for the MOSCAT site (24% slope) were: *F. congesta* = 17%, *P. maximum* = 19%, *S. scabra* = 17%, *V. zizanoides* = 17%. On the 18% slope Cabacungan *F. congesta* = 14%, *P. maximum* = 14%, *S. scabra* = 12%, *V. zizanoides* = 13%.

Field area analyses of upland rice in the 1993-1994 cropping are presented in Tables 7 and 8. The results were quite similar to those with calculations on a full-alley or cropped-area basis (Table 6). However, the hedgerow treatment yields were slightly lower in relation to the control treatment, because they were deflated for the area occupied by the hedgerows. Thus, in 1994-95 rice yields and total dry matter in the control were significantly higher than with all hedgerow treatments. This suggests that the hedgerows did not demonstrate a yield advantage compared to open-field cultivation during the two-year period.

Row by row analysis. Figure 4 compares the row-by-row response upland rice across the alleyway. All hedgerow species caused a depression in grain yield on both sides of the alley, suggesting the existence of hedgerow-crop competition. The most competitive species was guinea grass (*P. maximum).* Although, *F. congesta* was the tallest, and produced the highest pruning biomass among the species evaluated, it was not quite as competitive as *P. maximum. Stylo* was least competitive with rice. Vetiver (*V. zizanoides)* was intermediate in competitiveness. These two species produced a similar amount of pruning biomass as did guinea grass.

Vetiver has been recommended as a relatively less competitive hedgerow alternative, presumably because its roots presumably tend to grow more vertically into the soil rather than into the adjacent alleyway. This presumed advantage was not substantive in this trial.

There was a depression in rice yield in the first 2 rows on both sides of the alley across all species. This was compensated by an increase in yield in the middle rows, which tended to make up for the depression of yield in the outer rows. If good contour hedgerow management can reduce the reduction of crop yield in these outer rows by reducing or eliminating hedgerow-alleycrop competition, the system would more dramatically improve crop productivity, even if a percentage of cropped area due to the hedgerows. Eliminating the competitive effect may, however, be impractical.

Zonal analyses. Figure 5 shows the performance of rice grain yields by alleyway zone in cropping year 1994-1995. Grain yields were depressed in zones 1 and 4 for all hedgerow species except stylo (*S. scabra*), which had maximum yields in the lowest zone. *S. scabra* had the lowest pruning biomass and had a relatively short stature. The yield depression in the upper zone was least with this species.

The yield depréssion was most severe in the first zone for all hedgerow species except guinea grass: This is expected since the upper part of the alley experiences both competition and soil scouring. However, in *P. maximum* the depression was more severe in the lower zone. This zone has more fertile soil than in other parts of the alley because of soil accumulation as the terracing developed. *P. maximum* is a very competitive species, and as shown earlier by Solera (1993), the effect of scouring was outweighed by strong root competition in that zone. show any significant depression of yield in both outer zones. *V. zizanoides* caused a depression in rice yield in both outer zones, further evidence that it also has a strong tendency to compete with an associated annual crop. Figure 6 illustrates the total dry matter yield of upland rice by zone. The trends for total dry matter were very similar to those for grain yield.

Maize response

Full alley analyses. Maize treatment responses on a cropped area basis for both years are shown in Table 9. The tree legume (Flemingia), the forage legume (stylo), and the less-competitive grass (vetiver) had the greatest positive response on maize yields and dry matter, and effects similar to each other. Maize yield and dry matter in association with Guinea grass produced lower yields; these were similar to the control. The two-years' data suggest that the former three hedgerows had a stimulatory effect on maize, per unit area of maize planted. In contrast, *Panicum* so strongly competed with maize that it reduced its yield potential. This was most evident in the grain yield data of 1994-95.

There were no differences in the effect of pruning and crop residue management treatment on all maize attributes, except for plant height. Taller plants were observed in the pruning application treatments, whether the prunings were applied uniformly or on the upper alley only. Application of prunings, either uniformly (T1) or concentrated in the upper alley (T2) improved crop growth compared to the practice of removing the prunings from the field (T3). However, the effect was not dramatic at this time. T1 and

T2 had higher grain yields (3.97 and 4.16 tons per hectare, respectively) compared to T3. The total dry matter yield were also higher in these treatments, although the effects were not statistically significant.

Field area analyses. The area lost from maize production at MOSCAT (24% slope), as influenced by different hedgerow species, was *F. congesta* = 19%, *P. maximum* = 20%, *S. scabra* = 16%, *V. zizanoides* = 17%. At the Cabacungan site (18% slope): *F. congesta* = 10%, *P. maximum* = 10%, *S. scabra* = 6%, *V. zizanoides* = 8%. In 1993-94 maize yield and dry matter (Table 10) were similar among all hedgerow treatments and the control, except for Panicum. Both yields and dry matter were reduced in association with this species. This was related to a much lower number of productive plants per hectare (Table 10), evidence of direct competition between the grass and the crop for growth resources.

The 1994-1995 cropping year field-area analyses is presented in Table 11. Grain and total dry matter yields were not statistically different among treatments. parameters observed.

Row by row analyses. The response of maize across the alleyways was quite different than that for rice (Figure 7). Maize in the rows adjacent to the hedgerows of Flemingia, stylo, and vetiver did not show any yield depression. The row-by-row performance was linear across the alleyway. The exception was *Panicum*. Plants in the rows adjacent to Panicum hedgerows displayed a severe yield reduction (Figure 7). The control showed no spatial variability in grain yield, as expected. But the productivity of the control was much lower compared with the productivity of the different hedgerow species.

Zonal analysis. Figure 8 illustrates the zonal analysis of maize in cropping year 1994-1995. In this year, contrary to the previous one (results shown in Figure 7) competition in the zones adjacent to the hedgerows was more evident. Yields were depressed with all four of the hedgerow species, particularly in the upper alleyways. Panicum depressed yields about equally in the upper and lower zones. But the lower-zone depression was minor for stylo, Flemingia, and vetiver. The results for maize total dry matter by zone (Figure 9) were almost identical with those for grain yield.

Conclusions

Hedgerows of *Flemingia congesta, Vetiver zizanoides, Stylosanthes scabra, and Panicum maximum* were all very effective in reducing off-field soil losses. The two grass species controlled erosion most effectively (about 95% reduction compared with the open-field control). However, the tree legume and the forage legume also depressed soil losses dramatically (greater than 65% reduction). Thus, it is evident that the use of any of these species as the contour hedgerow component will dramatically alleviate the tendency for the soil resources of a steeply sloping field (18 to 24%) to degrade, and will thereby enhance the prospects to sustain annual cropping, assuming that soil fertility is managed through appropriate nutrient inputs.

The hedgerow alternatives that were tested had contrasting implications concerning soil fertility maintenance. The prunings supplied abundant biomass. And the yields of rice and maize were stimulated significantly on a cropped-area basis, suggesting that the hedgerow biomass did improve short-term soil fertility. However, yields calculated on a field-area basis did not differ among the hedgerow treatments and the open-field control. Thus, the soil fertility enhancement provided by the prunings was negated by the additional non-cropped area occupied by the hedgerows.

One of the hedgerow species, napier grass (*Panicum maximum*), exhibited severe competitive effects on the associated annual crops. Crop yields and dry matter were reduced compared to the other hedgerow species and the control. Napier is a highly productive fodder grass. However, use of this particular species as a hedgerow component must be questioned because of its strongly negative interaction with food crop production.

Spatial analysis of crop yields across the alleyways suggests that upland rice is more sensitive than maize to hedgerow competition. However, maize was also affected in one of the two years. Yields of both crops tended to be more negatively affected in the upper alleyway zone than in the lower alleyway. This is due to the compounding effects of degraded soil fertility, both chemical and physical, due to scouring in the upper alley, in addition to direct hedgerow competition for growth resources. The data suggest that the ranking of hedgerow species from least to greatest in relative competitiveness is stylo, vetiver, flemingia, and napier. The legumes were not distinctly superior to vetiver in stimulating yields or in reduced competition, as might have been expected. On the other hand, vetiver exhibited crop competition, contrary to some claims that it tends to be vertically rooted and is non-competitive.

Biasing the application of prunings and crop residues to the upper alleyways was hypothesized to be useful in maintaining soil fertility in upper alleyways. Crop yields did not differ between skewed application toward the upper alleyways compared to uniform application. A longer time period may well be necessary in order to observe a yield benefit from skewed pruning applications. It is also not known whether the degree to which the prunings and residues were biased to the upper alleyways may have too extreme in favor of the upper alleys. Further research will be necessary to elucidate this response more confidently.

References Cited

Basri, I. Mercado, A.R. and Garrity, D.P. 1990. *Upland rice cultivation using leguminous tree hedgerows on strongly acid soils.* Paper presented at the American Society of Agronomy, San Antonio, TX, October 21-26, 1990.

Fujisaka, Samuel. 1990. *Trees, grasses, and weeds: species choices in farmers' - developed contour hedgerow.* Unpublished paper. Social Division, International Rice Research Institute, P. O. Box 933, Manila, Philippines.

Fujisaka, Samuel. 1993. A case of farmer adaptation and adoption of contour hedgerow for soil conservation, Expl Agric., pp. 97-105.

Garrity, D. P. Mercado, A. and Solera, C. 1995. *Species interference and soil changes in contour hedgerows on sloping acidic soils. In:* Kang, B T, Osiname, A O, and Larbi, A. (eds) Alley Farming Research and Development, IITA, Ibadan, Nigeria, pp. 351-365.

Kang, B.T. and Wilson, G.F. 1987. *The development of alley cropping as a promising agroforestry technology.* In: Steppler, H.A and Nair, P.K. (Eds). Agroforestry -a decade of development, International Council for Research in Agroforestry, Nairobi, Kenya.

Kent, T. 1985. *Development and extension of the agroforestry/hillside farming programme in Zamboanga del Sur,* AIDAB, Melbourne, Australia.

Lasco, R.D. and Suson, P. D. 1993. *On farm evaluation of the Naalad indigenous agroforestry system: preliminary findings.* Paper presented to the National

Symposium on Multipurpose Tree Species (MPTS) for Rural Livelihood on May 3-6, 1993, Holiday Inn, Manila, Philippines.

Mercado, A.R. Jr., A. Montecalvo. D.P. Garrity and I. Basri. 1992. *Upland rice and maize response in a contour hedgerow systems in sloping upland soils.* Paper presented at the 5th Annual Scientific Meeting of the Federation of Crop Science Society of the Philippines held at Western Mindanao State University, Zamboanga City on May 24-29, 1992.

O'Sullivan, T. 1985. *Farming systems and soil management: the Philippine/Australian Development Assistance Program experience.* In: Craswell, E.T. Remenyi, J.V. and Nallana, L.G. (Eds), soil erosion management, Proceedings of a workshop held at PCARRD, Los Baños, Laguna on December 3-5, 1984. ACIAR Proceedings Series No. 6, ACIAR, Canberra, Australia.

Paningbatan, E.P. and Guinto, D.F. 1989. *Use of barriers, alleycropping and agroforestry for sustainable agriculture,* PACIFICLAND workshop on the establishment of soil management experiments on sloping lands. Paper and reports of a training workshop held at Aiyura, Papua New Guinea on September 22- October 2, 1989, IBSRAM Technical Notes, No. 4

Paningbatan, E.P. and Maglinao, A.R. 1993. *Management and Rehabilitation of degraded hillyland in the Philippines.* International Board of Soil Conservation and Management (IBSRAM) network on management of sloping lands for sustainable agriculture held at Guiyang, Guizhou, China, September 1-7, 1993.

Philippine Council of Agricultural Research and Resources Development. 1992. *Management and rehabilitation of degraded hilly lands: A terminal report.* PCARRD/IBSRAM Project, Los Baños, Laguna, Philippines.

Sanchez, P.A. 1995. *Science in agroforestry.* Agroforestry Systems 30:5-55.

SAS Institute Inc., SAS/STAT[R] User's Guide, Release 6.03 Edition,Cary, NC: SAS Institute, Inc., 1988.

Solera, C. 1993. *Determinants competition between hedgerow and species in a contour hedgerow intercropping system.* PhD thesis. University of the Philippines. (UPLB). 121 p.

Soriano, H. M. 1993. *Soil fertility and corn (Zea mays L.) yield under alley cropping agroforestry scheme involving selected MPTS as hedgerows.* Paper presented to the National Symposium on Multipurpose Tree Species (MPTS) for Rural Livelihood on May 3-6, 1993 at the Holiday Inn, Manila, Philippines.

Watson, Harold and Laquihon Warlito. 1987. *Sloping agricultural land technology (SALT)* In: Vergara, NT. and Briones, N.D. (Eds), Agroforestry in the humid tropics - its protective and ameliorative roles to enhance productivity and sustainability. Environment, and policy Institute, East-West Center, Honolulu and Southeast Asian Regional Center for Graduate Studies and Research in Agriculture (SEARCA), Los Baños, Laguna.

Table 1. Annual pruning biomass in dry weight (tons/hectare) of different contour hedgerow species on an acid upland soils. Claveria, Misamis Oriental. The Philippines

Species	Year 1			Year 2			Year 3		
	First Cropping	Second Cropping	Annual Production	First Cropping	Second Cropping	Annual Production	First Cropping	Second Cropping	Annual Production
Flemingia congesta	5.08 a	1.71 b	6.78 a	5.57 a	1.64 a	7.22 a	1.85 a	1.63 a	3.48
Panicum maximum	1.52 b	2.26 a	3.78 ab	2.08 c	1.94 a	4.02 b	0.84 c	0.47 bc	1.31
Stylosanthes scabra	0.55 b	0.24 c	0.79 b	1.84 c	1.20 a	3.05 b	0.47 d	0.59 c	1.06
Vetiveria zizanoides	2.92 ab	1.39 b	4.305 a	3.91 b	1.52 a	5.48 ab	1.42 b	1.27 ab	2.69
Mean	2.52	1.40	3.91	3.25	1.59	4.94	1.14	1.11	2.25
R2	0.92	0.99	0.93	0.84	0.22	0.71	0.64	0.44	0.76
CV (%)	32.77	9.82	24.47	30.13	46.57	31.95	41.12	50.85	45.98
Sources of Variations	---------- F - Values ----------								
Replication	1.04 ns	4.79 ns	1.42 ns	3.81 *	0.16 ns	1.98 ns	9.82 **	7.43 **	8.63
Species	11.38 *	77.06 **	13.20 *	11.95 **	0.68 ns	5.31 *	23.87**	7.5 **	15.69
Rep x Species	8.80 *	58.99 **	10.26 *	7.88 **	0.42 ns	3.64 *	1.86 ns	0.32 ns	1.09

Year 1 - 1993 - 1994 cropping year

Year 2 - 1994 - 1995 cropping year

ns= Not significant

* = significant at 5 % level

** = Significant at 1 % level

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

Data computed on a field area basis. (area occupied by the hedgerow is accounted for).

Table 2a. Pruning biomass in dry weight (tons/hectare) of different contour hedgerow species on an acid upland soils. Claveria, Misamis Oriental. Crop year 1994-1995.

Species	First Cropping	Second Cropping	Annual application
Flemingia congesta	5.57 a	1.64 a	7.22 a
Panicum maximum	2.08 c	1.94 a	4.02 b
Stylosanthes scabra	1.84 c	1.20 a	3.05 b
Vetiveria zizanoides	3.91 b	1.52 a	5.48 ab
Mean	3.25	1.59	4.94
R2	0.84	0.22	0.71
CV (%)	30.13	46.57	31.95
Sources of Variations	----------------	F - Value	-------------
Replication	3.81 *	0.16 ns	1.98 ns
Species	11.95 **	0.68 ns	5.31 *
Rep x Species	7.88 **	0.42 ns	3.64 *

ns= Not significant

* = significant at 5 % level

** = significant at 1 % level

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

Data computed on full alley basis (area occupied by hedgerows are not accounted for).

Table 2b. Amount of pruning biomass (tons/hectare) applied in Treatment 2 (2/3, 1/3, 0, 0) of different contour hedgerow species on an acid upland soils. Claveria, Misamis Oriental. Crop Year 1993-1994. Crop Year 1993-1994.

Species	First Cropping			
	Zone 1	Zone 2	Zone 3	Zone 4
Flemingia congesta	7.43	3.71	0	0
Panicum maximum	2.77	1.39	0	0
Stylosanthes scabra	2.45	1.23	0	0
Vetiveria zizanoides	5.21	2.61	0	0
Mean	4.46	2.24	0	0

Species	Second Cropping			
	Zone 1	Zone 2	Zone 3	Zone 4
Flemingia congesta	2.19	1.09	0	0
Panicum maximum	2.59	1.29	0	0
Stylosanthes scabra	1.60	0.8	0	0
Vetiveria zizanoides	2.03	1.01	0	0
Mean	2.10	1.05	0	0

Species	Annual Application			
	Zone 1	Zone 2	Zone 3	Zone 4
Flemingia congesta	9.63	4.81	0	0
Panicum maximum	536	2.68	0	0
Stylosanthes scabra	4.07	2.03	0	0
Vetiveria zizanoides	7.31	3.65	0	0
Mean	6.59	3.29	0	0

Table 3. Dry herbage (0% moisture) and plant height (cm) of different hedgerow species in an acid upland soil. Claveria, Misamis Oriental. Philippines. 1994-1995 cropping year.

Dry herbage (kg/ha)

Species (V)	Pruning schedules											
	Cabacungan						MOSCAT					
	1	2	3	4	5	Total	1	2	3	4	5	Total
Panicum maximum	969.0 bc	890.8 b	1194.2 b	443.6 c	797.0 b	4294.6	908.0 ab	1183.4 a	1900.5 a	1197.8 a	795.5 a	5985.2
Flamingia congesta	1381.4 a	1434.5 a	2611.0 a	1137.4 a	2028 a	8591.9	1711.3 a	801.5 b	1818.3 a	989.9 a	976.4 a	6297.4
Stylosanthes scabra	1283.5 ab	1195.9 ab	2692.4 a	398.0 c	666.7 b	6236.5	189.5 b	93.4 c	568.0 b	157.2 b	217.9 b	1226.0
Vetiveria zizanoides	833.2 c	1162.2 ab	1643.3 b	771.2 b	957.0 b	5366.9	1208.2 ab	881.6 b	1761.5 ab	988.4 a	1123.7 a	5963.4
Mean	1116.8	1170.9	2035.2	687.6	1112.4	6122.9	1004.3	740.0	1512.1	833.3	778.38	
CV (%)	10.26	9.06	8.38	8.58	12.56		36.7	8.69	25.75	22.53	20.52	
R2	0.95	0.93	0.98	0.99	0.98		0.86	0.99	0.85	0.93	0.94	

Plant height

Species (V)	Pruning schedules											
	Cabacungan						MOSCAT					
	1	2	3	4	5	Mean	1	2	3	4	5	Mean
Panicum maximum	133.4 b	149.4 a	236.4 a	139.6 a	132.3 a	158.2	116.9 b	142.5 a	174.0 ab	126.5 a	97.9 b	131.6
Flamingia congesta	166.6 a	156.4 a	235.8 a	153.3 a	181.8 a	178.8	160.2 a	117.8 a	180.2 a	124.8 a	132.1 a	143.02
Stylosanthes scabra	99.9 c	89.1 c	143.8 b	82.6 b	86.2 a	100.3	58.5 c	54.8 b	105.75 c	68.4 b	66.1 c	70.7
Vetiveria zizanoides	127.0 b	138.1 b	146.4 b	124.6 a	76.45 a	122.5	109.4 b	120.2 a	120.4 bc	116.8 a	115.8 ab	116.5
Mean	131.8	133.2	190.6	125.0	119.19		111.2	108.8	145.1	109.1	103.0	
CV (%)	4.01	2.53	1.97	7.43	38.86		8.66	11.26	12.75	6.44	5.61	
R2	0.98	0.93	1.0	0.96	0.70		0.97	0.95	0.89	0.97	0.98	

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

Pruning 1,2 & 3 were done during the first cropping of upland rice.

Pruning 4 & 5 were done the second cropping of maize.

Table 4. Sources of variations, degrees of freedom and computed F-values of dry herbage, plant height and pruning schedules ofdifferent hedgerow species in acid upland soil. Claveria, Misamis Oriental. Philippines. 1994-1995 cropping year.

Sources of variations	Degrees of freedom	F - Values	
		Dry herbage	Plant height
Location (Loc)	1	29.39 **	40.74 **
Replication (Rep)(Loc)	2	12.36 **	0.63 ns
Pruning schedlues (Ps)	4	57.45 **	28.26 **
Loc x Ps	4	6.77 **	2.06 ns
Ps x Loc x Rep	8	1.00 ns	0.44 ns
Species (Sp)	3	44.00 **	68.29 **
Sp x Ps	12	2.23 *	4.97 **
Sp x Loc	3	42.46 **	1.62 ns
Sp x Ps x Loc	12	5.91 **	0.98 ns
Residuals	49	13.80 **	9.14 **

ns - not significant

* - significant at 5% level

** - significant at 1% level

Table 5. Soil loss tons per hectare per year as influenced by different contour hedgerow species on an acid upland soils. Claveria, Misamis Oriental. April 1993 - January 1996

Species		---------- Soil loss (t/ha) -------------			
		Year 1	Year 2	Year 3	Mean
Control		39.88 a	37.61 a	25.05 a	34.18
Panicum maximum		2.18 b	1.89 b	0.87 b	1.65
Vetiveria zizanoides		2.19 b	1.84 b	1.04 b	1.69
Flamingia congesta		5.70 b	5.34 b	2.76 b	4.60
Stylosanthes guyanensis		9.18 b	5.49 b	6.79 a	7.15
Mean		11.83	10.43	7.29	2.43
CV (%)		61.07	91.87	143.8	47.93
R2		0.84	0.80	0.65	0.22
Sources of Variations	df	----	F - Values	----	
Replication (Rep)	3	5.95 **	2.45 ns	2.32 ns	
Species (Sp)	4	39.00 **	10.11 **	3.79 **	
Rep X Sp	11	24.84 **	6.87 *	3.16 *	

Year 1: April 1993 - March 1994
Year 2: February 1994 - January 1995
Year 3: February 1995 - January 1996
** - Significant at 1% level.
In columns, means having a common letters are not significantly different by DMRT at 5% level

Table 7. Field area analysis of upland rice (IR30716-B-1-B-1-2) grain yield and other agronomic characters as influenced by different hedgerow species and crop residues and pruning managements in an acid upland soil. Claveria, Misamis Oriental, Philippines. 1993 Wet Season

Hedgerow species (V)		Grain yield Yield (t/ha)	Total Dry Matter Yield (t/ha)	Plant Height (cm)	Number of plants (m2) Productive	Unproductive	Tiller Number
Control		1.93 ab	5.26 ab	86 ab	177 a	21 a	238 a
Flamingia congesta		2.00 a	6.07 a	88 a	174 a	20 a	251 a
Panicum maximum		1.74 ab	4.64 b	83 b	163 ab	19 a	227 a
Stylosanthes scabra		1.81 ab	5.03 ab	88 a	153 ab	18 a	221 a
Vetiveria zizanoides		1.67 b	4.43 b	87 a	141 b	16 a	204 a
Mean		1.83	5.09	87	162	19	228
R2		0.81	0.65	0.98	0.58	0.77	0.54
CV(%)		28.37	29.01	3.13	32.62	49.76	34.72
nd crop residues managements (H)							
T1		2.00 a	5.63 a	88.15 a	168.70 a	21.40 a	244.05 a
T2		1.91 a	5.24 ab	88.37 a	162.15 a	17.95 a	227.00 a
T3		1.58 a	4.38 b	83.16 b	154.45 a	17.50 a	213.75 a
Mean		1.83	5.08	86.56	161.77	18.95	228.27
Source of variations	Df	----------	----------	F - Values	----------	-------------	
Replication (Rep)	3	24.05 **	1.84 ns	80.97 **	1.77 ns	13.75 **	181 ns
H	2	3.62 *	3.75 *	23.62 **	0.37 ns	1.02 ns	0.73 ns
H x Rep	6	1.16 ns	0.71 ns	2.44 *	1.42 ns	0.57 ns	0.55 ns
V	4	0.78 ns	2.25 ns	6.36 **	0.97 ns	0.51 ns	0.59 ns
V x Rep	12	0.41 ns	0.77 ns	2.24 *	0.31 ns	1.39 ns	0.44 ns
V x H	8	1.28 ns	1.09 ns	2.12 ns	1.28 ns	1.85 ns	1.24 ns
Residuals	24	2.99 **	1.26 ns	10.69 **	0.93 ns	2.29 **	0.80 ns

T - 1 Hedgerow pruning and crop residues applied uniformly.
T - 2 Hedgerow pruning and crop residues applied on the upper alley (2/3, 1/3, 0, 0)
T - 3 Hedgerow pruning removed; crop residues applied uniformly
ns - not significant
* - significant at 5% level.
** - significant at 1% level

Table 6. Grain yield, total dry matter yield and plant height of upland rice (cv IR30716-B-1-B-1-2) as influenced by different hedgerow species and different pruning and crop residues managements in an acid upland soils. Claveria, Misamis Oriental. Philippines. Wet season 1993, 1994, 1995 and 1996.

Hedgerow species (V)		Grain yield (t/ha)					Total dry matter yield (t/ha)					Plant height (cm)				
		1993	1994	1995	1996	Mean	1993	1994	1995	1996	Mean	1993	1994	1995	1996	Mean
Control		1.93	2.44 a	3.52 a	1.93 a	2.46	5.26 b	6.72	7.84 a	5.64 a	6.37	86.01 ab	82.18 a	89.73 a	80.40 ab	84.58
Panicum maximum		2.06	2.22 ab	2.99 b	1.69 b	2.24	5.56 b	6.28	6.24 c	4.41 b	5.62	83.37 ab	77.15 b	76.22 c	76.22 c	82.77
Flemingia congesta		2.38	1.99 b	3.16 ab	1.96 a	2.37	7.23 a	6.53	6.71 bc	5.38 a	6.46	88.21 a	81.87 a	82.31 ab	82.31 a	82.17
Stylosanthes scabra		2.12	2.30 ab	3.40 a	2.06 a	2.47	5.88 ab	6.45	7.50 ab	5.67 a	6.38	87.95 a	81.65 a	88.41 a	80.78 ab	84.70
Vetiveria zizanoides		2.00	2.15 ab	2.94 b	1.81 ab	2.23	5.24 b	7.32	6.36 c	5.12 ab	6.01	87.25 a	80.71 a	86.80 a	77.96 bc	83.18
Mean		2.10	2.22	3.20	1.89	1.27	5.83	6.66	6.93	5.24	3.04	86.56	80.71	87.11	79.53	41.66
GV (%)		28.35	9.42	11.79	7.36	4.79	31.70	25.59	13.63	16.25	7.47			4.8	7.36	6.08
R2		0.78	0.99	0.97	0.97	0.49	0.52	0.95	0.96	0.96	0.48			0.93	0.96	0.95
Hedgerow prunings and crop residues managements (H)																
T1		2.32 a	2.22	3.17 a	1.94 a	2.41	6.50 a	6.50	6.86 a	5.15 a	6.50	88.14 a	81.53 a	88.52 a	80.58 a	84.84
T2		2.18 ab	2.38	3.23 a	1.93 ab	2.43	5.97 a	7.02	7.21 a	5.36 a	6.49	88.37 a	82.26 a	88.29 a	80.77a	85.32
T3		1.81 b	2.21	3.21 a	1.81 b	2.26	5.03 b	6.46	6.73 a	5.22 a	5.74	83.16 b	78.35 b	84.54 b	77.25 b	80.76
Mean		2.10	2.27	3.20	1.89	2.37	5.83	6.66	6.93	5.24	3.04	86.56	80.71	87.12	79.53	41.66
Sources of Variations	df	F - Values														
Replication (Rep)	3	39.56 **	79.66 **	59.04 **	36.92 **		1.07 ns	36.14 **	959.9 **	96.92 **		80.78 **	25.45 **	89.45 **	58.04 **	
H	2	3.84 *	0.09 ns	0.53 ns	2.43 ns		3.24 *	0.67 ns	5.45 **	1.36 ns		16.14 **	6.64 **	22.79 **	9.12 **	
H X Rep	6	0.62 ns	0.98 ns	0.80 ns	1.05 ns		0.93 ns	0.71 ns	1.36 ns	1.12 ns		0.90 ns	0.67 ns	0.58 ns	0.75 ns	
V	4	1.00 ns	7.38 **	21.73 **	5.53 **		2.37 *	0.67 ns	26.86 **	17.93 **		4.35 **	3.94 **	22.04 **	8.24 **	
V X Rep	12	0.60 ns	2.50 *	4.59 **	3.46 **		0.50 ns	0.68 ns	5.81 **	5.56 **		1.84 ns	0.67 ns	2.74 **	1.41 ns	
V X H	8	1.33 ns	1.43 ns	4.69 **	0.92 ns		0.96 ns	0.95 ns	6.88 **	7.05 **		1.45 ns	2.93 **	3.14 **	3.30 **	
V X H X Rep	24	3.88 **	63.31 **	1.32 ns	0.46 ns		1.20 ns	12.35 **	.62 ns	0.37 ns		8.61 **	21.17 **	1.22 ns	0.44 ns	

T-1 = Pruning and crop residues applied uniformly
T-2 = Pruning and crop residues applied on the upper alley (2/3, 1/3, 0, 0)
T-3 = Pruning removed (simulated as animal fodder) and crop residues applied uniformly
ns = Not significant
* = Significant by DMRT at 5% level
** = Significant by DMRT at 1% level
In rows, means having a common letters are significantly different by DMRT at 5% level

Table 8. Field area analysis of upland rice (IR30716-B-1-B-1-2) grain yield and other agronomic character as influenced by different hedgerow species and crop residues and pruning managements in an acid upland soil. Claveria, Misamis Oriental, Philippines. 1994 Wet Season

Hedgerow species (V)		Grain yield Yield (t/ha)	Total Dry Matter Yield (t/ha)	Plant Height (cm)	Number of plants (per ha)		Tiller Number
					Productive	Unproductive	
Control		2.44 a	6.72 a	82.2 a	331628 a	134263 a	582406 a
Flamingia congesta		1.65 b	5.43 b	81.9 a	255003 b	117813 a	493921 b
Panicum maximum		1.80 b	5.12 b	77.2 b	239439 b	117056 a	458281 b
Stylosanthes scabra		1.92 b	5.41 b	81.6 a	268910 b	109485 a	490725 b
Vetiveria zizanoides		1.78 b	6.10 ab	80.7 a	255596 b	102370 a	472688 b
Mean		1.92	5.76	80.7	270115.38	116197	499604
R2		1.0	0.95	0.97	0.99	0.85	0.80
CV(%)		9.41	25.01	4.47	11.71	56.65	15.92
nd crop residues managements (H)							
T1		1.92 a	5.61 a	81.5 a	253957 b	121690 a	503250 a
T2		1.93 a	6.07 a	82.3 a	265585 ab	142755 a	524587 a
T3		1.91 a	5.58 a	78.4 b	290804 a	84147 a	470974 a
Mean		1.92	5.75	80.73	270115	116197	499604
Source of variations	Df	----------	----------	F - Values	----------	-------------	
Replication (Rep)	3	1867.22 **	136.14 **	225.45 **	659.22 **	33.73 **	17.44 **
H	2	0.09 ns	0.74 ns	6.64 **	7.09 **	4.07 *	2.30 ns
H x Rep	6	1.00 ns	0.69 ns	0.67 ns	1.25 ns	2.06 ns	1.75 ns
V	4	34.43 **	2.41 ns	3.94 **	15.48 **	0.39 ns	4.46 **
V x Rep	12	9.70 **	0.75 ns	0.67 ns	1.77 ns	0.32 ns	0.49 ns
V x H	8	1.41 ns	0.92 ns	2.93 **	1.20 ns	1.23 ns	0.90 ns
Residuals	24	167.81 **	12.57 **	21.17 **	59.78 **	3.91 **	2.81 **

T - 1 Hedgerow pruning and crop residues applied uniformly.
T - 2 Hedgerow pruning and crop residues applied on the upper alley (2/3, 1/3, 0, 0)
T - 3 Hedgerow pruning removed; crop residues applied uniformly
ns - not significant
* - significant at 5% level.
** - significant at 1% level

Table 9. Grain yield, total dry matter yield and plant height of maize (Pioneer hybrid #3274) as influenced by different hedgerow species and different pruning and crop residues managements in an acid upland soils. Claveria, Misamis Oriental, Philippines. Second cropping (dry season) 1993-94 and 1994-95.

Species (V)	Grain yield (t/ha)				Total dry matter yield (t/ha)				Plant height (cm)			
	1993	1994	1995	Mean	1993	1994	1995	Mean	1993.00	1994.00	1995.00	Mean
Control	3.64 c	3.62	5.54 a	4.27	8.97 b	6.31	11.69 ab	8.99	173.1 bc	170.6 b	213.65 a	185.78
Panicum maximum	3.67 bc	3.24	5.20 b	4.04	8.58 b	5.74	10.55 b	8.29	170.6 c	163.0 c	207.73 b	180.44
Flamingia congesta	4.14 ab	3.88	6.14 a	4.72	10.17 a	6.60	12.41 a	9.73	179.2 ab	178.7 a	218.96 a	192.29
Stylosanthes scabra	4.18 a	3.66	6.00 ab	4.61	10.32 a	5.82	12.27 a	9.47	177.8 ab	173.71 b	215.79 a	189.10
Vetiveria zizanoides	4.15 ab	3.83	5.59 ab	4.52	10.17 a	6.70	11.98 a	9.62	181.0 a	173.38 b	214.19 a	189.52
Mean	3.96	3.65	5.69	4.43	9.64	6.23	11.78	9.22	176.30	171.87	214.06	187.41
CV (%)	14.63	38.57	16.45	23.22	11.25	34.50	15.31	20.35	4.33	5.36	4.00	4.56
R2	0.69	0.68	0.66	0.69	0.83	0.69	0.71	0.74	0.75	0.70	0.88	0.78
unings and crop residues managements (H)												
T1	3.97 ab	4.01 a	5.86 a	4.61	10.00 a	6.55 a	12.04 a	9.78	178.93 a	174.17 a	215.29 a	189.46
T2	4.16 a	4.07 a	5.88 a	4.70	9.89 a	7.00 a	11.84 a	9.58	179.87 a	176.06 a	217.25 a	191.06
T3	3.76 b	2.85 b	5.33 b	3.98	9.13 b	5.15 b	11.46 a	8.58	170.94 b	165.38 b	209.65 b	181.99
Mean												

Sources of Variations	df	F - Values								
Replication (Rep)	3	39.56**	879.66*	7.35 **	1.07ns	136.14**	3.76 **	80.78**	225.45**	184.77 **
H	2	3.84*	0.09ns	8.99 **	3.24 *	0.67ns	2.14 ns	16.14**	6.64**	17.03 **
H X Rep	6	0.62ns	0.98ns	2.26 *	0.93ns	0.71ns	2.74 *	0.90ns	0.67ns	4.42 **
V	4	1.00ns	7.38**	7.78 **	2.37*	0.67ns	8.08 **	4.35**	3.94**	11.04 **
V X Rep	12	0.60ns	2.50*	3.16 **	0.50ns	0.68ns	2.67 **	1.84ns	0.67ns	2.08 **
V X H	8	1.33ns	1.43ns	1.07 ns	0.96ns	0.95ns	2.63 **	1.45ns	2.93**	0.67 ns
V X H X Rep	24	3.88**	163.31**	0.87 ns	1.20ns	12.35**	1.04 ns	8.61**	21.17**	0.97 ns

T-1 = Pruning and crop residues applied uniformly

T-2 = Pruning and crop residues applied on the upper alley (2/3, 1/3, 0, 0)

T-3 = Pruning removed (simulated as animal fodder) and crop residues applied uniformly

ns = Not significant

* = Significant at 5% level

** = Significant 1% level

In columns, means having a common letters are significantly different by DMRT at 5% level

Table 10. Field area analysis of maize (Pioneer hybrid #3274) grain yield and other agronomic characters as influenced by different hedgerow species and crop residues and pruning managements in an acid upland soil. Claveria, Misamis Oriental, Philippines. 1993-1994 Dry Season (2nd cropping)

Hedgerow species (V)		Grain Yield (t/ha)	Total Dry Matter (t/ha)	Plant Height (cm)	Number of plants (per ha)	
					Productive	Unproductive
Control		3.65 ab	8.97 a	173.9 bc	53873 a	3439 ab
Flamingia congesta		3.58 ab	8.69 a	179.2 ab	49150 b	2003 c
Panicum maximum		3.12 b	7.19 b	170.6 c	45679 c	4147 a
Stylosanthes scabra		3.73 a	9.14 a	177.8 ac	51369 ab	2256 bc
Vetiveria zizanoides		3.64 ab	8.86 a	181.0 a	50950 ab	2080 bc
Mean		3.54	8.57	176.3	50204.08	2785
R2		0.76	0.80	0.75	0.94	0.66
CV(%)		14.75	11.59	4.33	5.79	50.89
and crop residues managements (H)						
T1		3.56 a	8.91 a	178.9 a	49771 a	3023 a
T2		3.72 a	8.78 a	179.9 a	49518 a	2602 a
T3		3.36 a	8.11 a	170.9 b	51193 a	2775 a
Mean		3.55	8.60	176.6	50161	2800
Source of variations	Df	---------------------------		F - Values	-------------------------	
Replication (Rep)	3	9.01 **	8.29 **	3.25 *	94.38 **	1.06 ns
H	2	2.49 ns	3.80 *	8.73 **	2.05 ns	0.42 ns
H x Rep	6	2.05 ns	1.44 ns	0.59 ns	2.43 *	0.95 ns
V	4	2.64 *	7.54 **	3.89 **	13.12 **	5.48 **
V x Rep	12	1.21 ns	1.64 ns	1.10 ns	1.65 ns	1.08 ns
V x H	8	1.03 ns	0.79 ns	1.39 ns	1.37 ns	0.11 ns
Residuals	24	2.22 *	2.78 **	2.02 *	11.00 **	1.30 ns

T - 1 Hedgerow pruning and crop residues applied uniformly.

T - 2 Hedgerow pruning and crop residues applied on the upper alley (2/3, 1/3, 0, 0)

T - 3 Hedgerow pruning removed; crop residues applied uniformly

ns - not significant

* - significant at 5% level.

** - significant at 1% level

Table 11. Field area analysis of maize (Pioneer hybrid #3274) grain yield and other agronomic characters are influenced by different hedgerow species and crop residues and pruning management in an acid upland soil. Claveria, Misamis Oriental, Philippines. 1994-1995 dry season (2nd cropping)

Hedgerow species (V)		Grain yield Yield (t/ha)	Total Dry Matter Yield (t/ha)	Plant Height (cm)	Number of plants (per ha)	
					Productive	Unproductive
Control		3.62 a	6.31 a	170.56 b	43753 a	3484.8 ab
Flamingia congesta		3.28 a	5.58 a	178.68 a	43058 a	2526.8 b
Panicum maximum		2.71 a	4.79 a	163.03 c	42403 a	5001.0 a
Stylosanthes scabra		3.13 a	4.19 a	173.71 b	38786 a	2289.8 b
Vetiveria zizanoides		3..26 a	5.70 a	173.38 b	46536 a	3423.2 ab
Mean		3.20	5.47	171.87	42907.20	3345.08
R2		0.68	0.69	0.70	0.50	0.85
CV(%)		38.57	34.51	5.36	41.00	56.22
nd crop residues managements (H)						
T1		4.01 a	6.55 a	174.71 a	43892 a	2565 a
T2		4.07 a	7.00 a	176.06 a	45860 a	2695 a
T3		2.85 b	5.15 b	165.38 b	38970 a	4775 a
Mean		3.64	6.23	172.05	42907.33	3345
Source of variations	Df	----------	----------	F - Values	----------	-------------
Replication (Rep)	3	5.92 **	9.73 **	1.80 ns	2.89 *	16.36 **
H	2	4.81 *	4.03 *	7.65 **	0.81 ns	8.70 **
H x Rep	6	0.60 ns	0.21 ns	0.22 ns	0.26 ns	4.50 **
V	4	0.39 ns	0.50 ns	4.66 **	0.30 ns	3.86 **
V x Rep	12	0.56 ns	0.42 ns	0.32 ns	0.37 ns	1.20 ns
V x H	8	1.31 ns	10.2 ns	1.36 ns	0.84 ns	1.16 ns
Residuals	24	1.42 ns	1.53 ns	1.58 ns	0.69 ns	3.79 **

T - 1 Hedgerow pruning and crop residues applied uniformly.
T - 2 Hedgerow pruning and crop residues applied on the upper alley (2/3, 1/3, 0, 0)
T - 3 Hedgerow pruning removed; crop residues applied uniformly
ns - not significant
* - significant at 5% level.
** - significant at 1% level

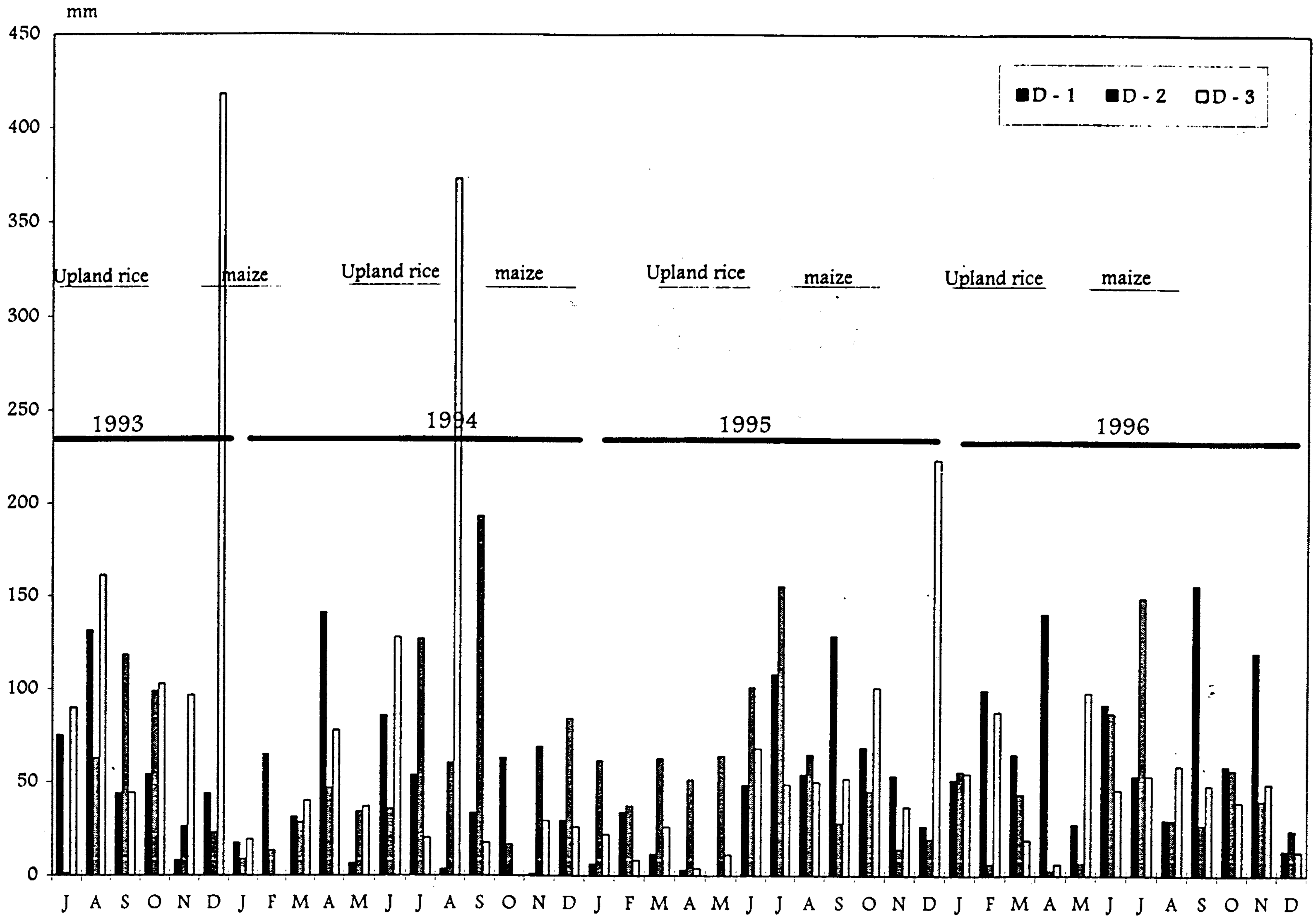

Figure 1. Rainfall by decade and crop phenology.
MOSCAT, Claveria, Misamis Oriental, Philippines.
July 1993 - December 1996

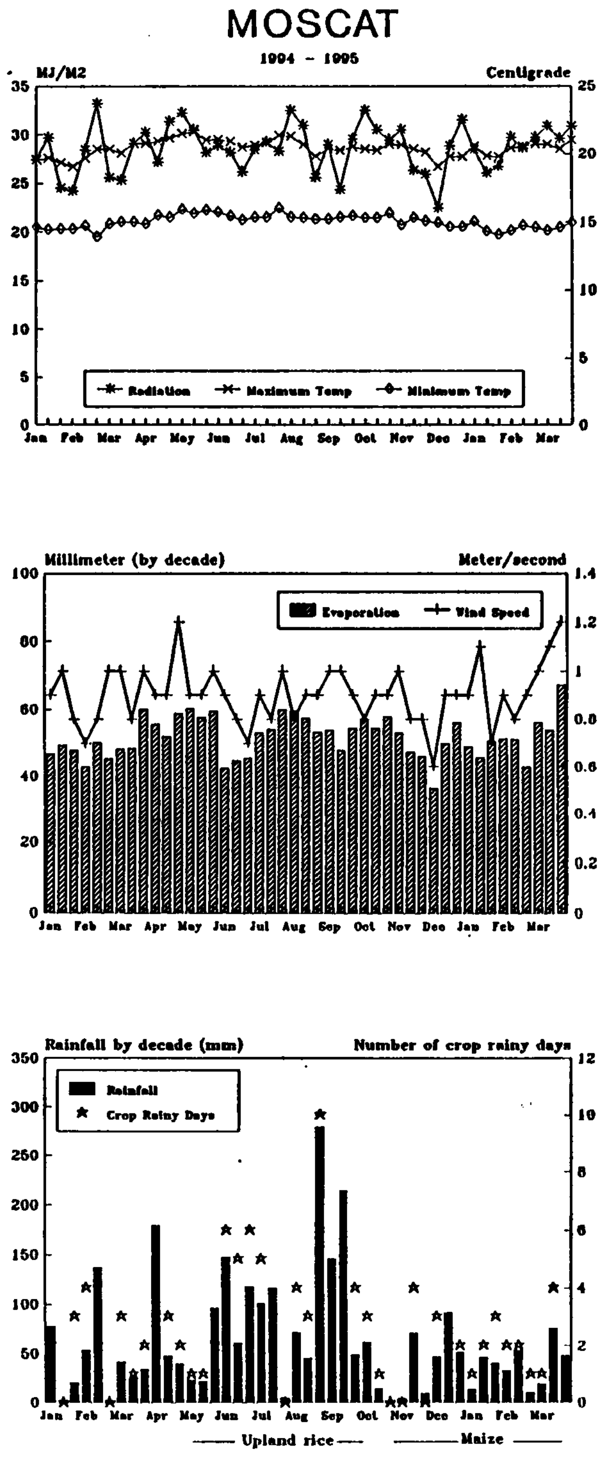

Figure 2. Agroclimatic data by decade (sum of ten days) relative to crop phenology MOSCAT. Claveria, Misamis Oriental.Cropping year 1994-1995.

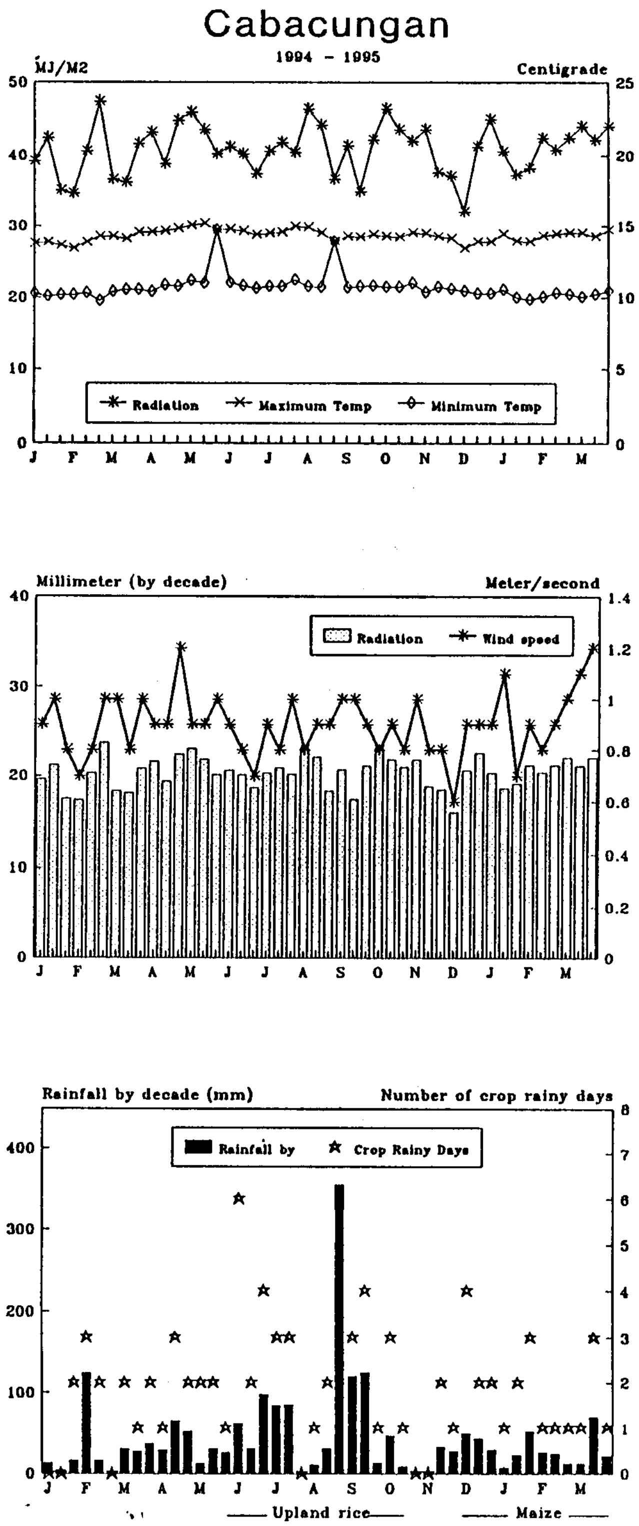

Figure 3. Agroclimatic data by decade (sum of ten days) relative to crop phenology. Cabacungan. Claveria, Misamis Oriental. Cropping year 1994 - 1995.

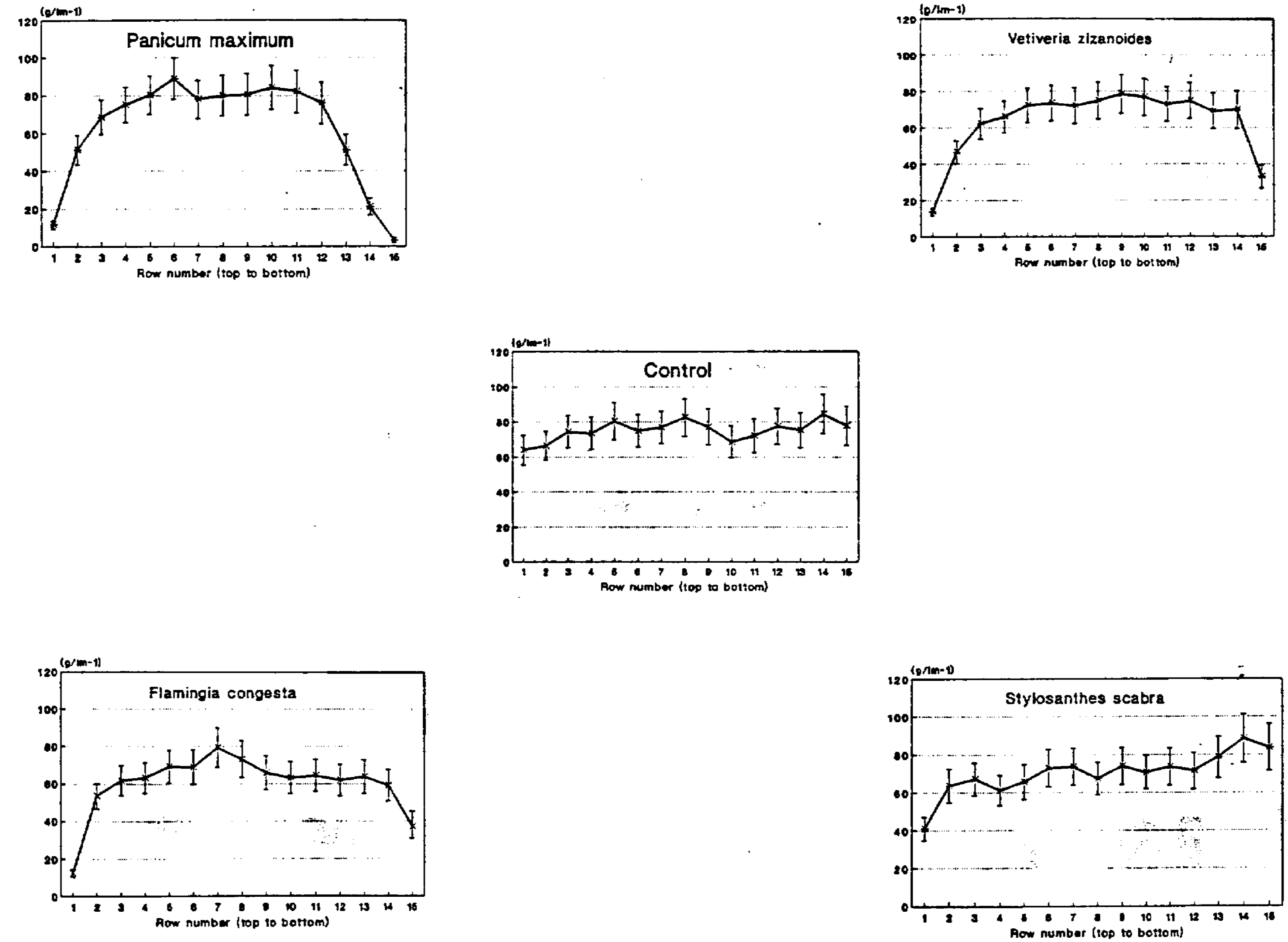

Figure 4. Grain yield of upland rice row-wise across the alley as influenced by different hedgerow species. Claveria, Misamis Oriental, Philippines

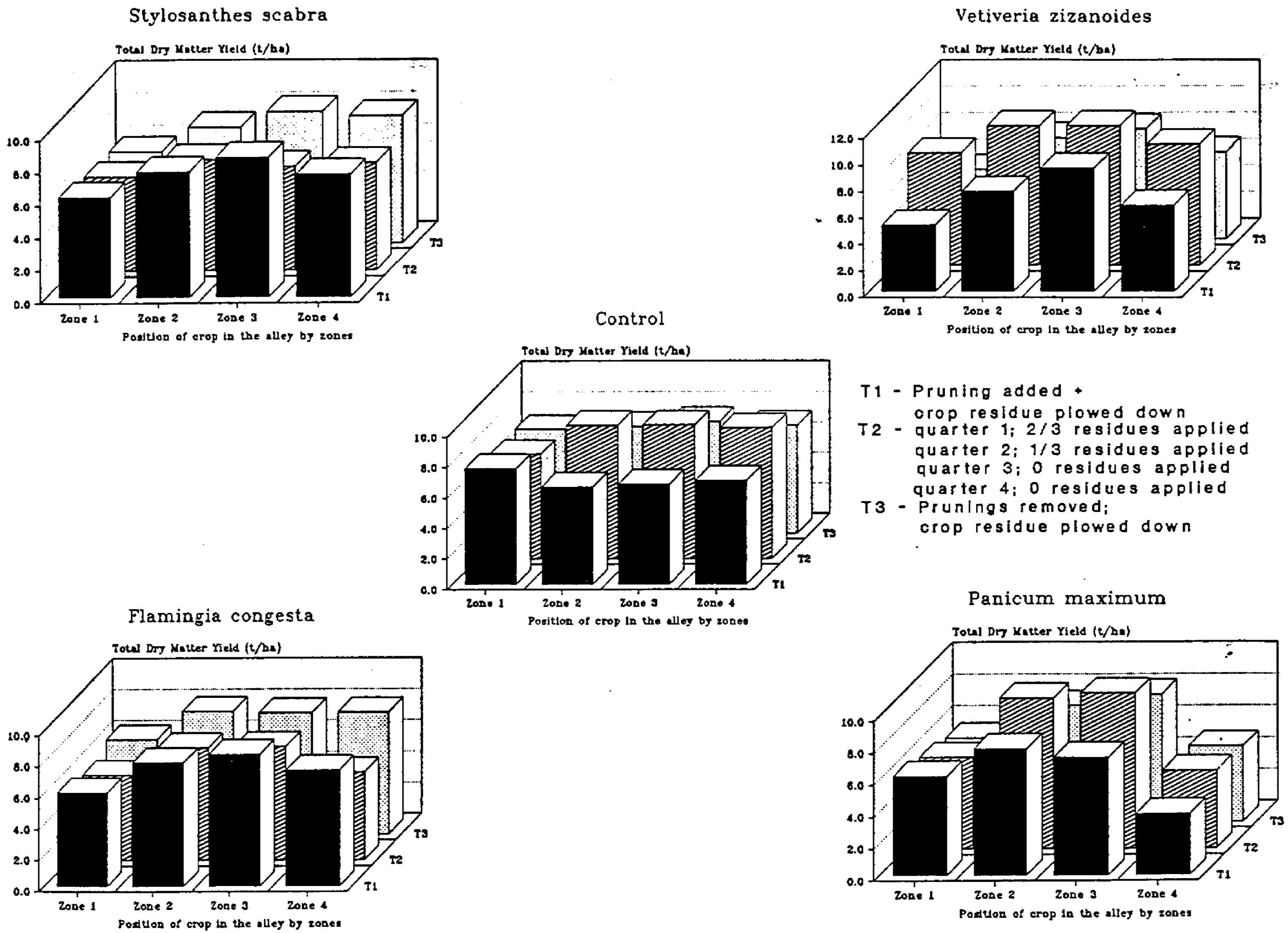

Figure 5. Total dry matter yield of upland rice (IR30716-B--B-1-2) as influenced by different hedgerow species. Claveria, Misamis Oriental. Cropping year 1994-1995.

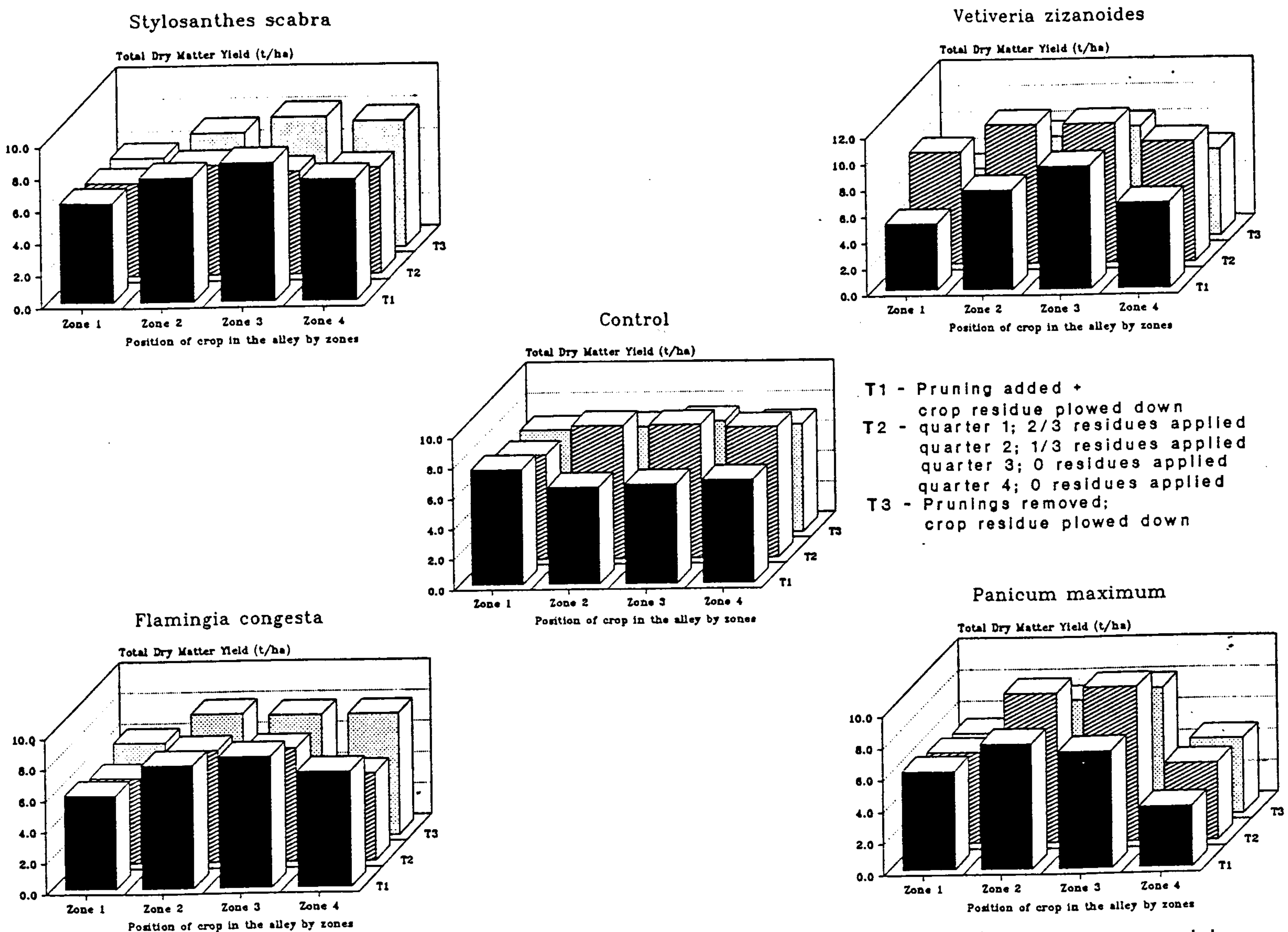

Figure 6. Total dry matter yield of upland rice (IR30716-B-1-B-1-2) as influenced by different hedgerow species. Claveria, Misamis Oriental. Cropping year 1994-1995.

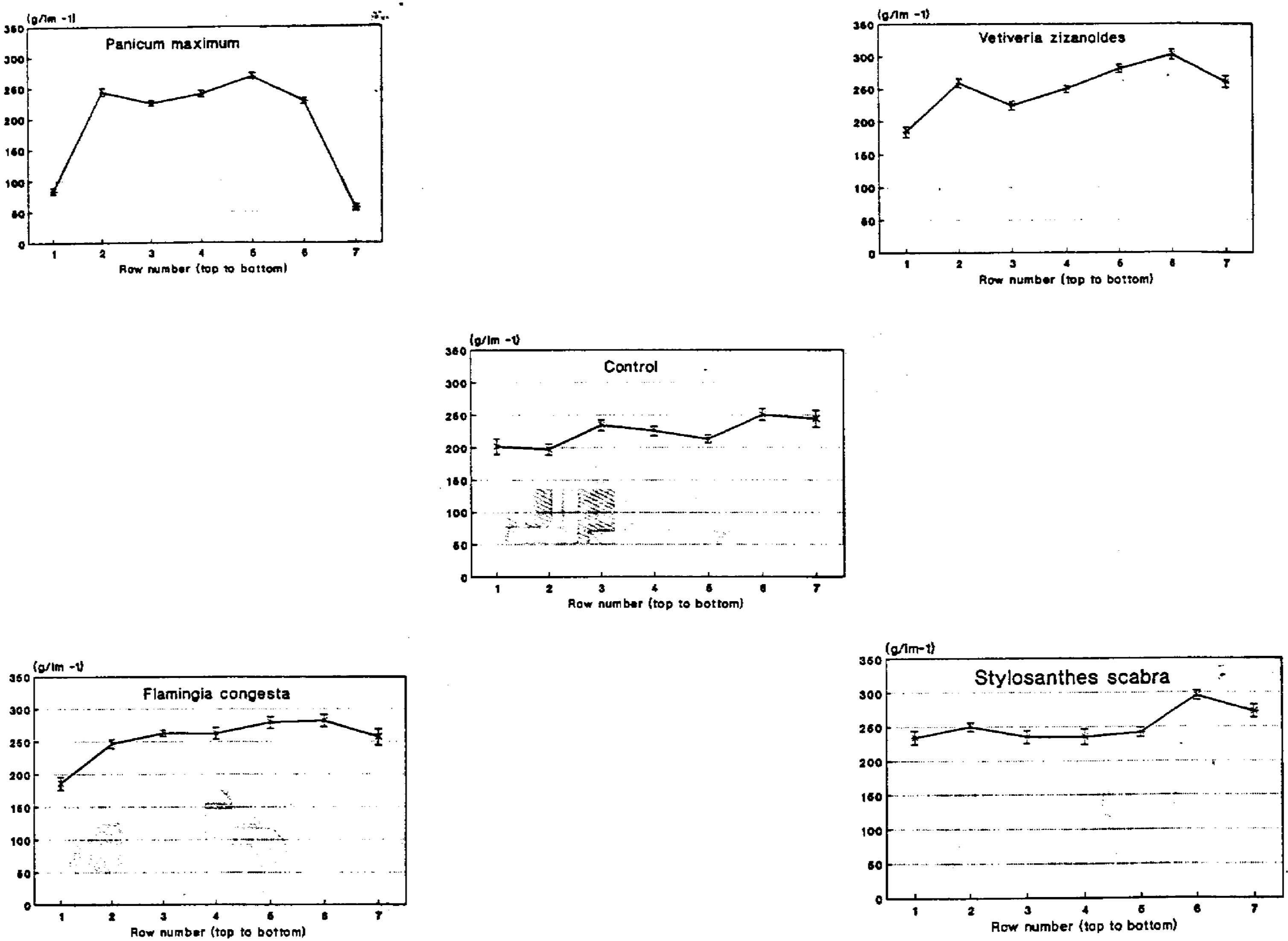

Figure 7. Grain yield of maize row-wise across the alley as influenced by different contour hedgerow species. Claveria, Misamis Oriental, Philippines

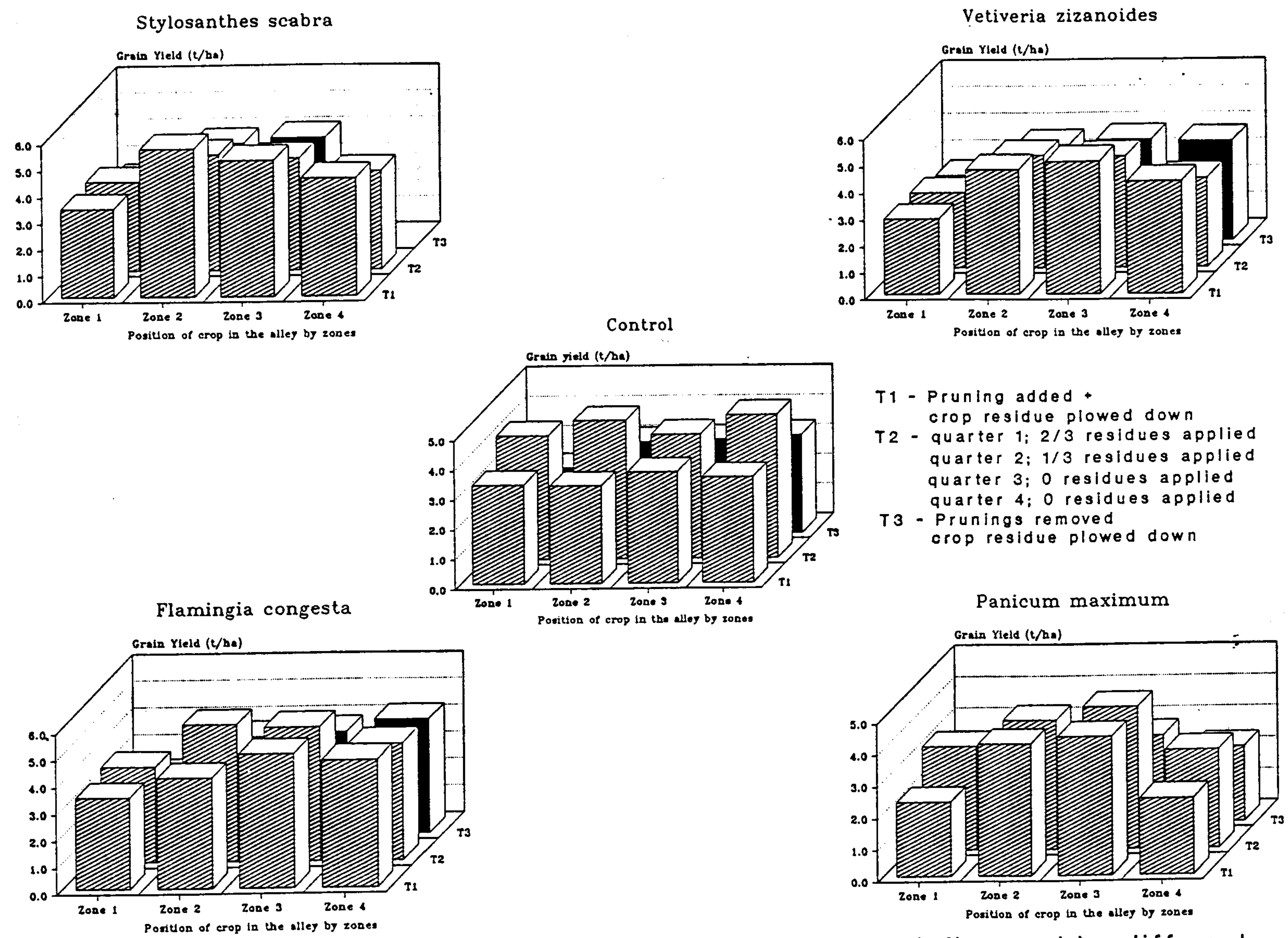

Figure 8. Grain yield of maize (Pioneer hybrid seed # 3274)as influenced by different hedgerow species. Claveria, Misamis Oriental. Cropping year 1994 -1995.

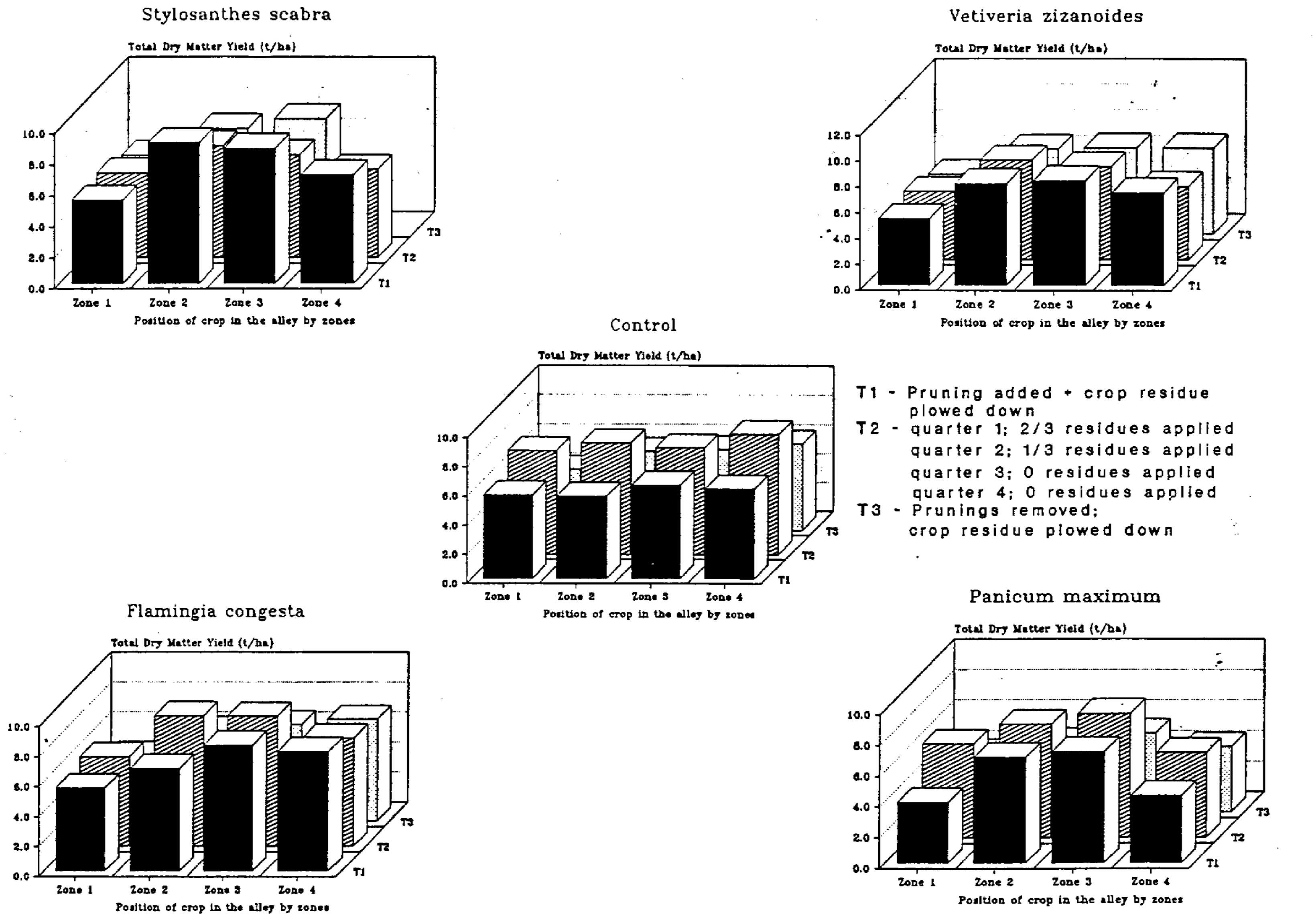

Figure 9. Total dry matter yield of maize (Pioneer hybridseed # 3274) as influenced by different hedgerow species. Claveria, Misamis Oriental. Cropping year 1994 - 1995.