POTENTIAL HEDGEROW SPECIES FOR ALLEY CROPPING SYSTEMS IN PHILIPPINE UPLAND FARMS

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Abstract

The search for hedgerow species for alley cropping in upland farms will continuously be done to suit the changing ecological conditions and varying needs of the upland farmers. There is a need for extra effort to make the upland farming systems productive and sustainable.

Vetiver, a tested species in controlling soil erosion, is fast becoming a farmer's choice in alley cropping systems for sustainable production in Philippine upland farms. This could be attributed to the dynamic characteristics of vetiver comparable to if not unfound in other known leguminous and non-leguminous species.

Introduction

The gaunt, highly erodible regions of the Philippines have led scientific experts and planners to evolve a farming technology which can sustain crop production and regenerate soil fertility in the uplands, ways which will ultimately improve the quality of life of some 20 million uplanders (Dalmacio 1996) trapped in extreme poverty. Alley cropping is proposed as an alternative to destructive and unsustainable farming practices.

Alley cropping is the growing of crops, usually food crops, in an alley formed by trees or woody shrubs that are cut back at crop planting and maintained as hedgerows by frequent trimming during cropping (Wilson and Kang 1981). It results in improvements in soil chemical properties and nutrient cycling, erosion control and weed suppression, in addition to providing fodder, stakes and firewood (Kang et al. 1981, 1984, 1985 and 1989). In the country, it is usually referred to as contour strip cropping, contour hedgerow cropping or more popularly as sloping agricultural land technology (SALT).

One vital component of alley cropping is the contour hedgerows which have been proven to be effective in reducing soil erosion and restoring soil fertility. Leaves and twigs of these hedgerows are pruned and utilized either as green manure or as mulch (Kang et al. 1981; Wilson et al. 1986). Hedgerows that are commonly used are leguminous indigenous species. However, the management schemes for using each hedgerow species still vary from site to site.

Identification of hedgerow species that would best conserve soil while enhancing farm productivity remains a challenging research problem that requires continuous testing and experimentation.

This paper attempts to evaluate the potential characteristics of selected hedgerow species which can be adopted in small Philippine upland farms. A lengthy discussion is provided for vetiver *(Vetiveria zizanioides)*, a promising hedgerow species. It also discusses the main factors that must be considered in maintaining hedgerows for alley cropping and raises issues for future research and development efforts.

Criteria for Hedgerow Species Selection

In the selection of hedgerow species for alley cropping, Serrano (1988) considers the following as important criteria for determining whether or not alley crop species are suitable: (1) species survival including pest and disease resistance; (2) nitrogen-fixing capacity; and (3) biomass as well as litter production. However, even if the hedgerow species possess these excellent properties but do not satisfactorily enhance or sustain the productivity of the ecosystem, such species may only be of marginal if not dubious value to alley cropping.

Enhancement of ecosystem productivity is primarily determined among other things by the amount and decomposition characteristics of hedgerow pruning which the food crops may receive from the associated alley crops. Species ability to withstand repeated pruning plays an important role in this respect. Such parameters were included in a study conducted by Szoot et al. (1987). Their results indicate that *Inga edulia* produced 8.7 tons of biomass per hectare per year while *Cajanus cajan* yielded only 1.8 tons of pruning at the same production area and on the same time-rate basis. The low biomass production by *Cajanus* was due to plant senescence. As to decomposition properties, the same researchers found that *Erythrina* sp. pruning can still be observed even after three months. The decomposition rate of *Cajanus* was found to be intermediate between that of *Inga* and that of *Erythrina*.

In an earlier study in Nigeria, (Yamoah et al. 1986), the relative potential of three leguminous shrubs *(Cassia siamea, Flemingia congesta* and *Gliricidia sepium)* were also evaluated; but with respect to changes on some soil properties in an alley cropping system with maize (*Zea mays***)** as the main food crop, soils under *Cassia* yielded the highest content of nitrogen (N), phosphorus (P), potassium (K) and organic carbon after the second maize crop. The increase in these important nutrients is due to the large amount of contribution of *Cassia* pruning coupled with its slow rate of decomposition, which reduces nutrient loss through leaching. Even though maize removed some nutrient, especially N, from the other plots, nutrients taken by the maize was replaced by pruning and fertilizer.

Characteristics of Selected Hedgerow Species

Leguminous Trees

***Leucaena* sp. and *Gliricidia* sp.** *Leucaena* species were once ideal for hedgerow planting in alley cropping systems. *Leucaena*, like many other leguminous species, is preferred for hedgerows as it can bring atmospheric N into the soil system. A well-nodulated *Leucaena*, for instance, can biologically fix about 40 % if its N (Sanginga et al. 1986). Its pruning can likewise yield more than 500 kg N ha^{-1} in a year (Guevarra 1976). However, the efficiency with which associated crops like maize use N from *Leucaena* sp. pruning is usually low, as shown by a study conducted by Mulongoy and van der Meersch (1988). They explained that much of the pruning **N** is probably retained in the soil organic matter or lost through leaching and volatilization.

But with *Leucaena*'s almost zero resistance to psyllid *(Heterropsylla cubana* Crawford) attack, its excellent properties for nitrogen fixing, drought resistance and versatility were at once nullified. The need for other alternative hedgerow species has then necessitated the field evaluation of plant species that may be used in place of *Leucaena*.

Serrano (1988) reported that *Gliricidia sepium* may be used as a substitute for *Leucaena*. *G. sepium* is a leguminous tree that is grown throughout the tropics on frost-free sites with 450-3 500 mm rainfall. Fuel wood, building poles, fodder, live fences, green manure and contour planting to reduce soil erosion and to some extent extraction of medicinal values for skin fungi are among the trees' many uses. These, combined with fast growth and termite resistance, make *Gliricidia* an excellent choice in many areas.

Acacia auriculiformis. The National Academy of Science (NAS 1979) provides an interesting account of *A. auriculiformis* as an important tree legume that can be exploited for hedgerow species planting. According to NAS (1979), the tree is a prolific litter-producing legume, a remarkable characteristic that makes it a potentially desirable species for alley cropping.

A. auriculiformis is, however, not ideal for lumber purposes, as it is branchy and has a crooked bole, although NAS (1979) states that the tree is an excellent source of fuelwood and pulpwood. Since fuelwood is now getting scarcer especially in small farmers' farms, *A. auriculiformis* plantings can be of great economic importance in the production of energy sources for cooking in small farmers' abodes. Trials of these species for hedgerow cropping are then necessary to verify their potential in soil fertility build-up, including their compatibility with the commonly used cash in alley cropping.

Pennisetum purpureum as hedgerow species. Moody et al. (1984) presented the biological description of *P. purpureum* as "an uplight, robust, densely tufted perennial bunchgrass" that grows 2 to 7 m high. It has a large, deep-root system with short creeping rhizomes. It is propagated either by seed or by rhizome.

It is reported that the dry matter yield of *P. purpureum* is 46 tons per hectare removing 800 kg N, 92 kg P and 900 kg K (Wrigley 1961 and Ochse et al. 1961, as cited by Sanchez 1976). As a pasture crop, *P. purpureum* may then be considered to be a high yielder. However, it depletes the soil of large amounts of macronutrient elements, which may be not desirable in an alley crop. For comparative purposes, however, this species was included in this paper.

Promising Introduced Legumes and Grass Species

Recent evaluations have identified promising legumes and grass species such as: (1) stylo (*Stylosanthes guyanesis)*; (2) guinea grass *(Pannicum maxim)*; (3) setaria *(Setaria sphacelata/splendida)*; (4) centro *(Centrosema pubescens)*; (5) Napier and elephant grass *(Pennisetum purpureum)*; (6) Para grass *(Brachiaria mutica)*; and (7) vetiver *(Vetiveria zizanioides).*

The main features of these species included high seasonal yield, good source of fodder, good drought, pest, cold and acid tolerance and, for some, strong persistence.

The use of such improved species in combination with soil amelioration can result in forage yield three to five times higher and growing season three to five months longer than native species (Yang 1989).

Vetiveria zizanioides: *Vetiveria zizanioides* or vetiver is an Asian perennial grass, probably native to a lowland swampy area north of New Delhi. It belongs to the same family as maize, sorghum, sugarcane and lemon grass. It has existed under cultivation for centuries and is widely distributed throughout the tropics. In the Philippines, it is known as *tres-moras, amoras, rimoras* or *rimodas* (Grimshaw 1990).

It has no rhizomes or stolons and is propagated by root division or slips. Both a xerophyte and a hydrophyte, vetiver can withstand extreme drought, perhaps owing to the high salt content of its leaf sap, as well as long periods of inundation (up to 45 days) as has been established in the field (Grimshaw 1990).

Although other grasses and trees have been used as vegetative barriers for soil conservation, vetiver seems to combine several characteristics that make it special.

1. It reduces erosion when in a hedge just one-plant wide. (Few, if any, other grasses seem to hold back soil or moisture when planted in such a thin line.)
2. Certain types appear to bear infertile seeds and produce no spreading stolons or rhizomes, so they remain where they are planted.
3. It is able to survive drought, windstorm, fire, grazing animals and other forces of nature, except freezing.
4. It has a strong, fibrous and deep-penetrating root system that binds the soil to a depth of up to 3 m.
5. It does not appear to compete seriously with neighbouring crops for moisture or nutrients in the soil. Yield increases of 25 to 60 % have in fact been recorded for contour farming of cotton, sorghum and other crops in India. Vetiver is cheap and usually easy to establish as a hedge and easy to maintain, therefore it can be adopted by small upland farmers very easily and conveniently.
6. It is (at least so far) largely free of insects and diseases and does not appear to be a host for any serious pests or pathogens that attack crops.
7. It grows in all types of soil regardless of fertility, pH or salinity. This includes sands, gravels, shale and even soils with maximum toxicity. In Sri Lanka, for instance, some vetiver grows in bauxite, a material toxic to almost every plant species.
8. It is capable of growing in a wide range of climates: for example, where rainfall ranges from 300 mm (very dry) to 3 000 mm (very wet) or where temperature ranges from slightly below 0^{o}C to somewhere above 50^{o}C. In India, for example, it is found in the rainforest of Kerala, the deserts of Rojas and the first zones of the Himalaya foothills (NCR 1993; Grimshaw 1990).

Apart from its use for controlling soil erosion, vetiver yields several products. Its stems and leaves can be used for making ropes, hats, brushes, thatch, mats, and fuel. They also make excellent mulch and litter. Young vetiver leaves are palatable to livestock and thus can be used as feed.

As with any hedgerow species, however, vetiver has also some demerits. Although it eventually needs little or no care, sometimes the plant has to be helped to form a hedge, especially at the establishment phase. In addition, it may not be effective on very shallow soils where it is difficult to anchor its roots deeply; rushing runoff might undermine the vetiver and wash it away. It should also be noted that although some hedges can be formed within a few months of planting, in many sites they may take three years or more to form. The establishment time depends on the site, climate and number or size of the plants employed.

All in all, however, vetiver has broad adaptability and great potential as a hedgerow species. Despite this, it is not widely used in the country and much has yet to be done to promote its use for soil stabilization and moisture conservation in sloping uplands. Of immediate need is the conduct of on-farm trials that will test its ecological effects as hedgerows for alley cropping.

Napier grass *(Pennisetum purpureum)* is native to tropical Africa but is now growing throughout the tropics. It is a tall, clumped perennial that in some places is planted on bunds to serve as windbreak and to conserve the soil. Although the dry stems or canes are used for fencing and for house walls and ceilings, it is primarily grown for fodder.

Despite the fact that it is useful for erosion control, Napier grass (also known as elephant grass) cannot be used in a single line like vetiver. Its stalks are too weak and the gaps between them too wide for it to stop the onrush of soil and water after tropical deluges. Moreover, its shallow spreading roots compete with any nearby crops.

It is likely, however, that certain genotypes (possibly those rejected by the forage developers because of coarseness, woodiness and lack of palatability) might prove to be good erosion-hedge species. Also, there is a sterile dwarf form that might prove applicable.

Napier grass has been crossed with a wild relative *(P. typhoides)* to give a sterile triploid. This is said to provide more fodder than its parents, but it might be even more useful as a hedge for erosion control (NRC 1993).

Factors to Consider in Hedgerow Use and Maintenance

Use of Grass *versus* Trees/Shrubs or Their Combination

Using trees as hedgerows has several advantages. They have deep roots which enable them to survive the dry season and to restore mineral nutrients to the surface soil. In addition, they provide a favourable environment for beneficial soil organisms, notably earthworms, through shading, which reduces soil temperature and evaporation. Observation at the International Institute of Tropical Agriculture reveals that earthworm activities are higher under the shade of trees than in soils that are not shaded (Wilson, Kang and Mulongoy 1986).

Farmers in tropical countries like the Philippines, however, find tree legumes for hedgerows more difficult to maintain due to the lack of available farm labour and their inability to efficiently control erosion on steep-slope (more than 20 %) farms. Thus, they would prefer to use forage legumes and grasses which not only are effective in erosion control but also provide animal feeds. Likewise, they could be used as green manure or mulch for soil regeneration and are easier to maintain than tree legumes (Garrity et al. no date).

When combined, trees and grasses as hedgerows could be more effective in controlling soil erosion. Such is the practice of farmers in Cebu (World Neighbour project) and in Claveria, Misamis Oriental. In their farms, trees on the top of the ridge of the bunds serve as macro-filter while grasses placed on the riser of the bund serve as micro-filter to supplement erosion control (Garrity et al. undated).

Pruning Frequency, Quantity and Quality

Aside from selecting specific characteristics and type (grass, tree or shrub) of the hedgerow species appropriate in an upland farm, several factors have to be taken into account to produce the best result. These factors include pruning frequency, quantity and quality of the pruning produced by the hedgerows.

Hulugaille and Kang's study (1990) suggests that hedgerow species that frequently produce large quantities of pruning which decompose slowly may be the most desirable for alley cropping systems. They explain that soil physical properties are more likely to improve when a shrub produces either large or small quantities of easily decomposable pruning. This is also what Yamoah et al. (1986) indicated in their study where cassia exhibited greater potential for improving soil properties, which they attributed to large amounts of pruning and a slow rate of decomposition.

Conclusion

The use of hedgerows for alley cropping in upland farms should be further evaluated to suit the changing ecological conditions and varying needs of the upland farmers. Creative ways must be sought to keep upland farming productive and sustainable and make farmers self-reliant. Vetiver along with common leguminous trees/shrubs offers a starting point for exploring a wide range of hedgerow species that can be used for restoring most of the country's degraded uplands. For future R&D activities, it might help to use the effectiveness of our indigenous non-leguminous species rather than introduce new ones.

References

Dalmacio, M.V. 1996. Policy and Institutional Reforms for Grassland Development. *In* Umali, C. G. (ed.) Unifying Various Disciplines and Interests for Grassland Resource Conservation and Development. Proc. 2nd Nat. Grassl. Congr. pp 121-129. ERDB, College, Laguna, Philippines.

Garrity, D. (no date). Effects of Grass and Tree Legume Contour Hedgerow Systems on an Acid Sloping Upland Soil.

Grimshaw, R.G. 1990. Vetiver Grass: The Hedge Against Erosion. 3rd ed. World Bank. Washington, DC.

Guevarra, A.B. 1976. Management of *Leucaena leucocephala* (Lam.) de Wit. for maximum yield and nitrogen contribution to intercropped com. Ph D Thesis. University of Hawaii, Honolulu, HI, USA.

Hulugalle, N.R.; and Kang, B.T. 1990. Effect of hedgerows species in alley cropping systems in surface soil physical of an Oxic Paleustaff in South-Western Nigeria. J. Agric. Sci. Cambridge 14: 301-307.

Kang, B.T. et al. 1961. Alley cropping maize *(Zea mays* L.) and *Leucaena leucocephala* in Southern Nigeria. Plant and Soil 63: 165-179.

______. 1984. Alley Cropping: A Stable Alternative to Shifting Cultivation. IITA, Ibadan, Nigeria.

______. 1985. Alley cropping: Sequentially cropped maize and cowpea with *Leucaena* on a sandy soil in Southern Nigeria. Plant and Soil 85: 267-276.

______.; and Alley, G.B.S. 1989. Cropping as a sustainable crop. Production system. Paper presented at International Workshop on Conservation Farming on Hill Slopes. Taichung, Taiwan. 20-29 March 1989.

Mulongoy, K.; and van der Meersch, M.K. 1988. Nitrogen Contribution by *Leucaena leucocephala* Pruning to Maize in an Alley Cropping System. IITA, Ibadan, Nigeria.

Moody, K.; Monroe, C.E.; Lubigan, R.T.; and Paller, E.C., Jr. 1984. Major Weeds of the Philippines. UPLB, College, Laguna, Philippines.

NAS. 1977. Tropical Legumes. Resources for the Future. National Academy of Science. Washington, DC.

National Research Council. 1993. Vetiver Grass: A Thin Green Line Against Erosion. National Academy Press, Washington, DC.

Omhse, J.J.; Soule, M.J.; Dijkman, M.J.; and Weltbarg, C. 1961. Tropical and Subtropical Agriculture. Macmillan, New York.

Sanchez, P. A. 1976. Properties and Management of Tropical Soils. John Wiley, New York.

Serrano, R. C. 1988. Alternative species other than ipil-ipil for agroforestry. The PCARRD Monitor. 16 (1 & 10): 3.

Wilson, G. F.; Kang, B.T.; and Mulongoy, K. 1986. Alley Cropping: Trees as Sources of Green Manure and Mulch in the Tropics. IITA, Ibadan, Nigeria.

Wringley, G. 1961. Tropical Agriculture. Bastford Londao.

Yamaoh, C.F. et al. 1986. Soil properties as affected by the use of leguminous shrubs for alley cropping with maize. Agriculture, Ecosystems and Environment 18:167-177.

Yang, B. 1989. A study on the potential of developing an herbivorous livestock industry in the subtropical mountainous regions of China. Proc. Workshop Grassl. Sci., pp. 129-132. Scientific Press, Beijing.