Hedgerows in Agroforestry

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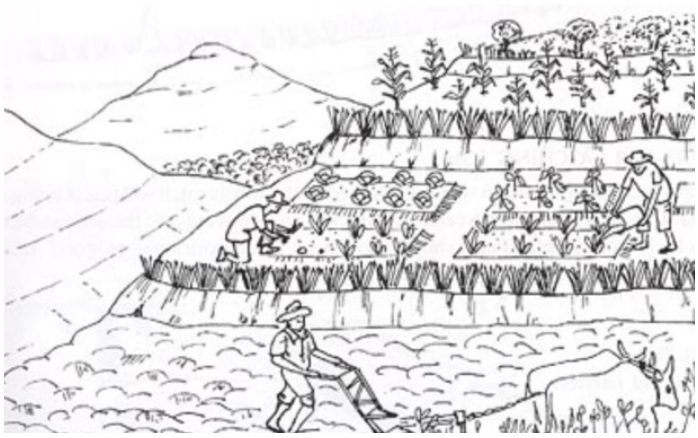
Farmers in the Pacific islands face a number of challenges in raising their crops. Crop damage and soil erosion from strong winds and rain are one such challenge. Soils that are lacking in organic material, which helps retain water and necessary nutrients, is another challenge. Fortunately, there are sustainable agricultural conservation practices that can help overcome these problems. In this publication, we will take a closer look at hedgerows and associated practices for reducing the harmful effects of wind, controlling erosion, providing organic matter, and other benefits.

Hedgerows are typically woody bushes, shrubs, or trees that serve as a living barrier, border, or buffer. In agroforestry, hedgerows are grown around edges, borders, or perimeters of crop fields to promote soil and water conservation. Hedgerows are rows of tree or shrub species that are managed as hedges and can help to improve soil quality and maintain soil quantity. Proper use and design of these systems can provide nitrogen and other nutrients to crops, as well as moisture-conserving mulch.

Hedgerow Associated Practices

Contour Hedgerows

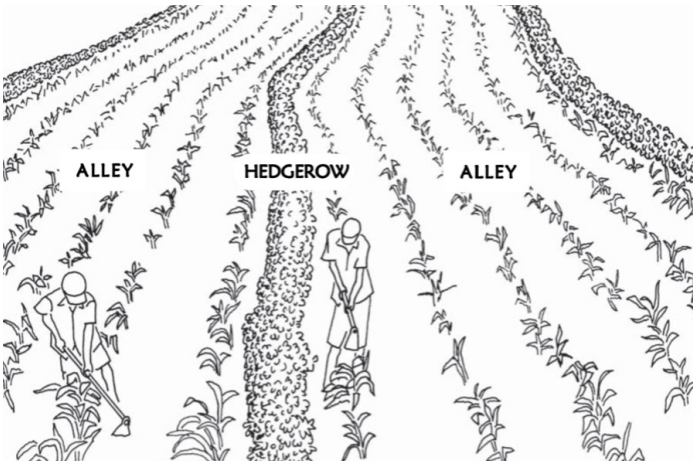
When hedgerows are planted densely with the contour of the land, they can significantly reduce soil erosion. This is a practice known as vegetative contour barriers or contour hedgerows, a viable alternative farming system to expensive terracing.



Alley Cropping with Hedgerows

Trees and shrubs are planted along the contour or on flat land of a farm or crop area. They are planted in rows with selected crops planted between them. This practice allows farmers to produce a variety of products, as well as their main crops, while practicing soil and water conservation (Castro, 2007). Rows of trees and shrubs are called *hedgerows* and the space between where crops are grown is called an *alley* (Figure 3).

Alley cropping can be used in short-term crop production or in agroforestry systems with fruit trees. When used in the production of short-term crops, the pruned plant material is spread over the whole crop area. When used with fruit trees, the pruned material is concentrated under the tree canopy. Hedgerows also provide protection from wind to the alleys, providing a favorable microclimate for crops.



Nitrogen Fixing Tree (NFT) Hedgerows

Nitrogen fixing trees and shrubs use atmospheric nitrogen (N_2) not available to other trees and incorporate it with soil bacteria called **Rhizobia* for plant growth. Using NFT's provide on-site resources for nitrogen fertilizer or organic matter for mulch. They aid in improving soil fertility decomposition of leaves and nutrients available from other plants (Marutani and Sablan, 2006). They also prevent wind damage and soil erosion through farming techniques like intercropping and alley cropping. Sterile varieties of *Leucaena leucocephala* (tangantangan) (Figure 4) and *Gliricidia sepium* (Figure 5) are examples of nitrogen fixing species that benefit Guam farmers and crops.

Nitrogen-fixing trees are gaining recognition as a renewable source of nutrient-rich organic material. When the leaves and branches of these trees drop off or are harvested, the nitrogen becomes available to other plants. Many nitrogen-fixing trees are able to establish themselves on poor or degraded sites. The trees are also able to grow rapidly and produce large amounts of nitrogen-rich green foliage in harsh environments. Many nitrogen-fixing trees can be pruned as often as four times a year. The trimmed leaves and branches are used as nutrient-rich mulch and fodder.

**Rhizobia* are bacteria that live within the native range of the soil of specific legume species. They are housed in root structures called nodules and share a symbiotic relationship with plants they live in. Energy from the plant is used to feed the bacteria, which aids the process of nitrogen fixation. This process allows the plant to receive the nitrogen needed for plant growth. It is important to know that for this process to be effective, the proper species of nitrogen-fixing trees need to be selected to match the strain of *Rhizobia.*

Windbreaks

Windbreaks or "shelter belts" use rows of trees and shrubs or structural barriers to filter or redirect potentially damaging winds that could affect crop and livestock production. Windbreaks are used to improve the quality of farming areas, intercept dust and chemical drift, and reduce erosion (Acosta et al., 2017). Contact the College of Natural & Applied Sciences' Extension and Outreach at 735-2080 for help or more information. Additional publication on windbreaks can be found on our website: ***https://cdn.sare.org/wp-content/uploads/20190421203523/Windbreaks_.pdf.***

Benefits of Hedgerows

Hedgerows can provide many advantages to farmers in the Pacific region such as controlling soil erosion, minimizing crop damage, and reducing moisture loss, they also can provide nutrients and mulch. Hedgerow plants can also be used as fruit and fodder crops.

Erosion Control
Hedgerow plantings provide water regulation through their root systems. Applying hedgerows assist in controlling and preventing soil erosion and water runoff from agriculture fields and can also reduce nutrient, pesticide, and sediment buildup that can flow from agriculture land to waterways. Hedgerows can also increase surface water that becomes infiltrated which allows soil structure to improve around the root zone (Earnshaw, 2004). Reducing erosion also promotes ideal water quality, as hedgerows can trap debris.

Natural Filter of Sediment and Excess Nutrients
As mentioned, hedgerows can assist with controlling water runoff. Hedgerows act as a natural filter of sediment and excess nutrients that can flow from agricultural land to waterways. By trapping sediments and excess nutrients, this can improve water quality.

Wind Protection
Using plants with various heights provides protection and wind control. Reduced drying effects on soil, increased yields, and carbon storage are some of the advantages promoted by hedgerows. Native and non-native trees can be used singly or in combination with shrubs and grasses for effective windbreaks (Earnshaw, 2018).

Intercepts Chemical Drift or Odor Movement
Hedgerows can act as protection against chemical or odor movement that may drift from neighboring fields or factories. Hedgerows can alter wind movement by trapping or intercepting dust particles, pathogens, and odor. Planting your hedgerows upwind from odor or chemical producing areas can help with intercepting and absorbing movement.

Reduces evapotranspiration
Hedgerows play an important role in reducing evapotranspiration through mulch application. Mulches can be organic or inorganic. Organic mulch consists of grass clippings, compost, wood chips, chopped leaves, or even paper. Inorganic mulch includes black plastic, landscape fabrics, or crushed rock. Applying mulch prior to hedgerow production will assist with water conservation, while feeding plants the nutrients necessary for plant growth and development. It also helps protect soils from high temperatures caused by constant exposure to the hot sun and dry out from winds. When mulch is applied, this allows soils to optimum soil temperature and less water evaporation, which in turn allows plants to grow evenly and successfully (Martin Anderson, n.d.).

Pollinators
Hedgerows provide an available habitat for bees and other pollinators in order to sustain and promote food production in diverse agriculture systems (California Agriculture, 2017). It increases pollen and nectar sources, which promotes a natural pest control against natural enemies and predators. These natural enemies also use hedgerows as a source to find insect hosts, for shelter, and to feed and use vegetation as sites for reproduction.

Wildlife Habitat
Incorporating native plants to hedgerow practices provides a habitat for natural enemies, pollinators, insect-eating birds, rodent predators; as well as a habitat for groundwater recharge and wind modification (Earnshaw, 2018). Planting hedgerows attracts a wide variety of wildlife between natural and farming areas. Increasing biodiversity helps the habitat become resilient to environmental changes and events. Biodiversity encourages an overall healthy ecosystem service for local and regional plants and animals.

Source for Soil Amendment
Hedgerows improve the nature's physical quality of the soil's environment. Hedgerow plantings, pruning remains, organic matter, and mulch help amend the soil, which increases crop performance and yield. Mulch serves as a nutrient bank, storing the nutrients and the organic matter and slowly releasing them to the plants as the mulch breaks down. Mulching plants improves nutrient- and water-retention in the soil, suppresses weed growth, and encourages favorable soil microbial activity. Using these techniques can regulate soil temperatures, reduce evaporation, and improve soil fauna activity (Kang and Gutteridge, 1994).

Disadvantages of Hedgerows

Hedgerows could also present some disadvantages to farmers in the Pacific region such as cost of hedgerow production, competition, and reduction of crop space. They also pose a risk of plant disease, pest infestation, and damage from wildlife.

Costs
It is important to plan before beginning hedgerow production. Planting hedgerows can become costly because of additional labor, equipment, and materials needed for planting. Cost of site preparation, irrigation installation, soil amendments, plant installation, and pest control are some important factors to consider when planning.

Competition
The extended roots of hedgerow plants can compete with crops for water and nutrients if not spaced properly. The hedgerows can also compete for sunlight if not pruned in a timely manner.

Reduction of Crop Space
Many farms in Guam are small and space used for conservation practices will reduce the total cropping area. Hedgerow plants need the extra space as they are grown around edges, borders, or perimeters for crop fields. The amount of plant species needed for hedgerows will determine the allotted space needed for crop production.

Risk of Plant Disease
Introducing hedgerow practices can pose a risk for potential plant disease. To prevent plant disease from spreading, careful monitoring is essential for hedgerow production and success. To control issues from arising, special management techniques like limiting or eliminating certain species, using certified disease-free material, or pruning affected areas of plants can be applied. Using a diversity of plant species or native plants can also help reduce problems, which is an advantage for farmers (Earnshaw, 2018).

Risk of Pest and Animal Infestation
Insect pests can be detrimental as some are likely attracted to hedgerow plants. The type of species you apply for hedgerows will determine if the plants are likely to harbor pests that are susceptible to your species. Pest infestation can bring parasites and predators that may harm your hedgerow production. Hedgerows are likely to shelter animals that can cause damage to hedgerow plantings and crops. Like pests, the type of species used for hedgerows and the plant management techniques can bring animal infestations. Local animals to lookout for include pigs, deer, chickens, and snakes. Insects and animals are likely to damage or destroy conservation planting if not monitored and controlled properly.

If you are unable to identify a pest or disease, contact the College of Natural & Applied Sciences' Extension & Outreach Office at the University of Guam. Additional publications can be found on our website at: ***uog.edu/extension/publications*** under the Publications tab.

Factors to Consider

Selection of the best species to use for your hedgerows should receive careful consideration. Probably the most important considerations are the environmental tolerances of the tree. Is it appropriate for the rainfall, temperature and soil type of your site? Other factors to consider include nitrogen-fixing ability, shape, growth rate, weediness, ease of establishment, and its benefit to your farming system.

The plant growth rate, habit, and canopy shape will determine the amount of biomass the plant can produce. Hedgerow plants with vigorous growth, multi-branching and large canopies can produce greater quantities of mulching materials. But species with a higher growth rate will produce more mulch, but it will also require more frequent pruning. Hedgerow plants with a deep taproot system will take up nutrients that are not available to shallow-rooted crops. Plants with a deep taproot are less likely to compete with the crop plants for surface nutrients and water.

Recommended plant species and spacings
Plant selection for hedgerows is important for production because you need species that are suitable to the soil environment and the region's climate. Refer to Table 1 for species selection, Table 2 for recommended spacing, and Table 3 for basic information on some of Guam's common soil-types. Please see your local extension agent for more information on recommended plant species and spacing.

Table 1. Recommended species selection for hedgerow production in the Pacific region.

Type of Species	Common Name	Average Height	Soil Type	Uses
Cajanus cajan	Pigeon pea	~ 13 feet tall (Small tree)	Soils with pH of 7	• Source of nitrogen fertilizer • Hedges for erosion control • Fodder • Windbreak • Improvement of soil fertility
Calliandra inaequilatera	Calliandra, Powder puff tree	8-12 feet tall (Small shrub)	Slightly acidic soils	• Source of nitrogen fertilizer • Hedges for erosion control • Reforestation • Windbreak • Fallow improvement • Organic matter, mulch
Flemingia macrophylla	Large-leaf flemingia	~ 9 feet tall (Small deciduous shrub)	Various soil conditions	• Source of nitrogen fertilizer • Hedges for erosion control • Animal fodder • Organic matter, mulch
Gliricidia sepium	Gliricidia	6-49 feet tall (Large deciduous tree in dry seasons, evergreen tree in humid areas)	Grows well in almost any soil environment	• Source of nitrogen fertilizer • Hedges for erosion control • Windbreak • Organic matter, mulch • Reforestation • Tolerant to salt spray, water-logging & drought
Sesbania grandiflora	Sesbania, Vegetable hummingbird	~ 49 feet tall (Large deciduous tree)	Grows well in Alkaline soils and slightly acidic soils	• Source of nitrogen fertilizer • Hedges for erosion control • Animal fodder • Windbreak • Organic matter, mulch
Leucaena leucocephala	River tamarind, tangan-tångan (sterile)	~ 66 feet tall (Large deciduous shrub or tree)	Grows well in slightly acidic soil, slightly alkaline	• Source of nitrogen fertilizer • Hedges for erosion control • Windbreak • Protection from salt-spray

Table 2. Recommended spacing of trees and shrubs within and between rows.

Plant Type	Spacing (feet) Within Rows		Spacing (feet) Between Rows
	Single Row	Multiple Rows	
Small Shrubs (4-12 feet tall)	2-4	4-6	10-15
Large Shrubs and Small Deciduous Trees (12-30 feet tall)	6-8	8-10	10-20
Large Deciduous Trees (more than 30 feet tall)	10-12	12-14	15-20
Evergreen Trees (columnar form)	6-8	8-10	10-20
Evergreen Trees (conical and broad forms)	8-10	10-14	15-20

Source: https://agriculture.delaware.gov/wp-content/uploads sites/108/2017/12/Trees-Shrubs-Fact-Sheet-422.pdf

Table 3. Soil types to consider for Guam.

Soil Type	Characteristics	pH Level
Yigo-Northern Guam	• Limestone uplands (61%) • Very shallow soil • Fast draining • Guam series	6.5 - 8.0 (acidic - slightly alkaline)
Barrigada - Central Guam	• Bottom lands (4%) • Deep, level, poor drainage • Pulantat series	6.0 - 7.5 (acidic)
Ija - Southern Guam	• Volcanic uplands (35%) • Very clayey, poor drainage, limits cultivation during rainy season • Akina series	4.5 - 6.3 (very acidic)

Where to apply
Hedgerows practices can be used in areas that are non-cropped and available to surround crop fields. These areas are usually suitable along roads and fences or where there is existing vegetation. Hedgerows should be planted in areas that will not inhibit existing or planned infrastructure below and above ground, to include water and drainpipes or power lines (Acosta, et al., 2017). Contour hedgerows are often planted with the contour of land to help reduce erosion. Alley cropping with hedgerows presents a similar planting technique; however, this is done along the slope of the contour or on flat lands of crop areas.

Where not to apply
It is not suitable for hedgerows to be planted in areas that lack access to water or equipment, uncontrollable weeds, or interfere with crop production (Earnshaw, 2018). Sites that have significant uneven lumps in the land, lack of drainage, and areas that are cultural land preserves are factors that limit hedgerow production.

Type of Soil
Hedgerows thrive in well-drained, fertile soil as most plants prefer these conditions. Incorporating good, quality compost, organic matter, or mulch weeks prior to hedgerow application will allow the soil to settle and can preserve soil moisture to make it more workable for hedgerow application. Nitrogen-Fixing Trees are pioneer species that can be used in places with low fertility to add organic matter and build the soil.

Maintenance
These systems should be carefully considered, with thought given to design and routine maintenance in order to maximize production and protection. Hedgerows need regular management to be effective. Keep in mind the primary objectives and determine the secondary benefits that may be derived from the hedgerow. Different management tasks include proper pruning, irrigation, weed management, fertilization, and pests and disease control.

Pruning
Proper pruning management is important for the health and success of hedgerows. Over-management or neglect of hedgerows plays an important role in its maintenance as it can be more threatening than beneficial. Dead and diseased parts of the hedgerow can be detrimental to hedgerow production and a safety risk to surrounding environments if not controlled. Pruning hedgerows allows room for new healthier growth of plant parts and assists with deterring pest and disease pressures that may occur. It is important to understand that hedgerows need to be pruned in a timely manner and need time "to breathe." Over-maintenance can cause stress to hedgerows, which in turn, will enable stems to die out faster.

Irrigation
Irrigate frequently to ensure sufficient soil moisture and avoid oversaturation, particularly with new plantings. If plants are adapted and well-established on site, irrigation requirements may decrease depending on the age and species. Irrigation is critical for the survival and success of hedgerow production. Examples of irrigation systems recommended for hedgerow production are micro-irrigation systems, sprinkler systems, and simple garden hose systems especially during the dry season.

Drip irrigation is a recommended practice for hedgerow production as they help with water control in a timely manner, enhancing plant growth and development, and reducing plant stress. They also assist with weed management and promote water conservation. If using a drip irrigation system, emitters should be checked and cleaned thoroughly to prevent clogging and water surfacing.

Weed Management
Weed control is key upon establishment of hedgerows to reduce competition for water and plant nutrients. Recommended practices such as mulching and sheet mulching will minimize labor and conserve soil moisture. If herbicides are to be used, follow the directions on the label. Do not use bush cutters near plants as they may damage your hedgerow plants and crops.

Fertilizer
Fertilizing hedgerows depends on the plant species. General recommendations for hedgerow plants is to fertilize with a complete fertilizer. Fertilizer application should be done every three to four months.

Fertilizer facts are available at http://cnas-re.uog.edu/wp-content/uploads/2016/06/Fertilizer-Facts.pdf.

Controlling Pest and Disease
If possible, identify pests and/or diseases associated with infested plant species. If you are unable to identify a pest or disease, submit a sample of the pest with the affected plant to the CNAS Extension and Outreach Office at UOG. If pesticide are to be applied, ensure that the plant species as indicated on pesticide labels. Ensure appropriate pesticides are used for targeted pests and diseases.

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