# Section 3: Alley Cropping

**In this chapter:**

- **Defining Alley Cropping**
- **General Benefits of Alley Cropping**
- **Potential Functions of Alley Cropping**
- **Alley Cropping Design Considerations**

*In this alley cropping example, soybeans are planted in the alleyways between nut trees for short-term income and a possible long-term timber harvest.*

## Alley Cropping

Alley cropping is broadly defined as the planting of two or more sets of single or multiple rows of trees or shrubs at wide spacings, creating alleyways within which agricultural, horticultural, or forage crops are cultivated. The trees may include valuable hardwood species, such as nut trees, or trees desirable for wood products. This approach is sometimes called intercropping and multi-cropping. Currently most of the emphasis and research focuses on pecan and black walnut alley cropping or intercropping applications. However, there are numerous other potential tree, shrub, and crop combinations.

### *Role on the Farm*

Alley cropping provides the opportunity to grow wood or other tree products such as nuts or fruit, while providing an annual income through the production of companion crops.

**Benefits of Alley Cropping**

- *Diversify farm enterprise*
- *Reduce erosion*
- *Improve water quality*
- *Protect crops*
- *Enhance wildlife*
- *Improve aesthetics*

### *Diversifying farm products and supplementing income:*

Alley cropping diversifies farm enterprises by providing short-term cash flow from annual crops while also providing medium to long-term products from the trees. Timber and non-timber products may contribute to income generation from the farm. In addition to the potential for producing nuts, berries, and fruits, well-managed timber can provide a long-term investment.

### *Reducing soil erosion from wind and water:*

Soils with a high erodibility index (>8 ) are highly susceptible to damage and are difficult to protect when used as crop land. The soil erodibility index provides a numerical expression of the potential for a soil to erode considering the physical and chemical properties of the soil and the climatic conditions where it is located. The higher the index, the greater the investment needed to maintain the sustainability of the soil resource base if intensively cropped.

Alley cropping protects fragile soils through a network of roots produced by the trees and supplemental ground-cover resulting from fallen leaves and the companion crop. Rows of trees, shrubs, and/or grasses planted on the contour of a slope will also serve to reduce soil movement down the slope.

***Reducing water erosion on sloping cropland:***
The interception of rainfall by the tree canopy and increased infiltration due to tree and herbaceous roots protects the soil; water quality is improved due to interception of sediment by herbaceous cover in tree rows and interception, sequestration, and decomposition of agricultural chemicals by tree and herbaceous root environment.

***Reducing erosion:***
Trees and shrubs improve crop production by slowing wind speed and reducing wind erosion, modifying the crop microclimate with similar effects to that of windbreaks (see section #6 on windbreaks). Alley cropping can reduce crop evapotranspiration by 15-30 percent and increase water content in the tillage layer by 5-15 percent. Deep tree roots transport soil nutrients to leaves. Leaves contribute organic matter to soil and release nutrients as they decompose.

***Protecting crops:***
Alley cropping protects crops from insect pests by reducing crop visibility, diluting pest hosts due to plant diversity, interfering with pest movement, and creating environments less favorable to pests and more favorable to beneficial insects.

***Enhancing wildlife habitat and aesthetics:***
Linear plantings of trees and/or shrubs in an agricultural landscape increases the habitat diversity for wildlife, both through increased amount of edge and/or as a result of the increased diversity (vertical and horizontal) of vegetative types. Increased vertical complexity has been correlated with increased bird numbers. These areas can also serve as protective corridors for wildlife movement and provide a food source.

## Limitations to Alley Cropping:

Alley cropping, as with other forms of multi-cropping, requires more intensive technical management skill and marketing knowledge. The following limitations should be considered:

- *Requires a more intensive management system including specialized equipment for the tree management and additional managerial skills and training to manage multiple crops on a given site*
- *Removes land from annual crop production and may not provide a financial return from the trees for several years*
- *Requires a marketing infrastructure for the tree products that may not be present in the local area*
- *Trees may be an obstacle to crop cultivation if not carefully planned and designed*
- *Trees compete with companion crops for sun, moisture and nutrients*
- *Companion crops may compete with trees for moisture and nutrients*
- *Herbicide drift from crops may damage trees*

## Alley Cropping Functions

There are numerous mechanisms in which alley cropping impacts the landscapes to which it is applied, including water management, nutrient cycling, soil quality, microclimate modification and pest management.

- Alley cropping impacts water management by altering the hydrologic cycle through increased water infiltration via disruption of overland flow by the tree/grass strip. Water cycled through the system is more thoroughly filtered and any excess is gradually released.

- Nutrient cycling and soil quality are impacted as deeply rooted trees exploit lower soil horizons and cycle the nutrients to the surface through litterfall. Additional nitrogen is added to the nutrient pool if a nitrogen-fixing tree or shrub is used. Reduced soil erosion by wind and water help maintain soil quality. Additional moisture is added to the site through interception of rainfall by the tree canopy.

- Microclimates are modified due to reductions in wind velocity which reduces air temperatures and evapotranspiration of intercropped plants and soil.

- Pest management can be strengthened through the structural diversity in the landscape de-

veloped by the intentional association of trees and crops. Alley cropping creates habitat to build up biodiversity and associated populations of natural enemies of insects, diseases, or weed pests and can interrupt pest cycles.

- Similar to the function of riparian forest buffers, alley cropping practices may help intercept, fix and biodegrade sediments, nutrients, pesticides, and other biological pollutants present on the site.

- Similar to the establishment of windbreaks, alley cropping may improve wildlife habitat by providing food, cover, nesting sites, and travel lanes for a variety of wildlife species.

- Incorporation of trees and shrubs add opportunity for additional products which are derived from the tree/shrub component (wood, nuts, fruit, foliage) as well as the option to plant sensitive crops which can be grown due to the protection from the trees.

Not all of these functions may exist with each application of alley cropping. The function is dependent upon the way the plant components are manipulated in the design process. There is also a lack of understanding of all the different interactions that can occur with the different combinations of tree/shrub/herbaceous (annual and perennial) plants. For example, we do not have enough information to evaluate all the different pest interactions to positively say that beneficial insects will be favored and the negative pests will be reduced, although there are examples of this.

## Designs Unique to Each Landowner

Each alley cropping practice can be uniquely designed to reflect landowner needs and site potential. However, there are physical interactions between the rows of woody species and the companion crop that should be understood and reflected in plans for the alley cropping practice design.

***Physical growth traits of individual trees and how these influence the crop, are based on three factors:***

***A. Light Competition***
***B. Root Competition***
***C. Allelopathy***

### *A) Light Competition (above ground)*

A tree species should be selected that best accommodates the sunlight requirements of a specific crop. Some tree species have small leaves and feathery foliage casting a light shade and lend themselves well to alley cropping. When considering a tree species for an alley cropping practice, small leaves and light shade is preferable to heavy shade.

***In what ways can light competition be reduced?***

- *Spacing*

When the distance between rows of trees is increased, the years an alleyway may be cropped with minimal competition from the trees is also increased.

- *Row Orientation*

An East-West orientation of tree rows will maximize the sunlight received by an alley crop, provided the topography permits this arrangement. Trees may have to be planted on the contour if erosion is a consideration. Trees may be planted in other orientations if prevailing winds have a negative influence on crop yields.

- *Maximizing available light*

Trees with small fine leaves will allow more light through the canopy. These leaves decompose rapidly and allow nutrients to be recycled into the soil faster. As decomposed materials contribute organic matter to the soil, the soil moisture-holding capacity is increased. Increased organic matter enhances soil microbe and earthworm activity. Taken together, this also improves soil tilth and health.

- *Understanding crown and foliage characteristics - phenology*

Utilize trees that leaf-out late in the spring and/or drop leaves early in the fall. If the agronomic crop component matures in the early spring, such

as winter wheat (*Triticum aestivum L.*) does, or heads out in the late fall, such as milo does,, a tree species should be incorporated that best accommodates the light needs of that specific crop (e.g., a tree species that breaks dormancy late for winter wheat or a species that drops its leaves early for milo - a good example of a tree that satisfies both needs is black walnut).

- *Timely Thinning and Pruning*

Properly thinning trees within rows can maintain semi-open crown conditions. Maintained through regular thinning, these openings can help continue the vigorous growth of shade intolerant companion crops. Pruning basal branches before they reach 1" in diameter improves future wood quality and thins the depth of the canopy permitting more sunlight to reach companion crops.

### *B) Root Competition (below ground)*

Competition for water and nutrients between the tree and the intercropped species not only affects the yields of the companion crop but also the growth of the trees.

#### *What ways can root competition be reduced?*

- *Understanding rooting zones*

Vertical distribution of root systems varies among species. Deep-rooted species have a reduced volume of roots near the surface (good for minimizing competition with adjacent crops). Erosion can be addressed through ground cover establishment and management.

- *Which trees have deep roots?*

Species have different site requirements. For instance, as a rule, wetland species tend to be shallow rooted. While a potential species list has been included in the appendices, it is always useful to consult your local forester for assistance in determining species suitable to your planting site.

- *What can be done if the trees are more shallow rooted?*

Through the use of a Ripper, Coulter, or Chisel Plow, roots can be severed (the addition of subsurface knifes may also be used to sever more roots outside the rip).

Trenching trials strongly suggest that even during the early years of tree development, competition for water and/or nutrients is the major reason for reduced crop yields. By early (beginning with young trees) and repeated (every couple of years) severing of shallow lateral roots, the number of tree roots can be significantly decreased in the plow zone. The remaining roots will remain active deeper in the soil profile.

### *C) Allelopathy (Chemical Interactions)*

Traditionally, the term allelopathy denotes the negative biochemical influence exerted by one plant on the growth of nearby plants. For example, pine needles may produce acids that inhibit growth of plants on the forest floor, while roots of black walnut trees produce a compound called juglone, which also inhibits the growth of other plants.

A broader definition would also include positive influences. For example, some plants (e.g., legumes, European black alder, black locust) fix nitrogen that can benefit nearby plants.

Chemical interactions can be controlled by choosing plant combinations that work together. Juglone, for instance, does not affect all plants. Conversely, nitrogen-fixing plants are only useful to neighboring plants that require extra nitrogen.

## Tree arrangement on the land

### *Layout*

The tree and/or shrub row(s) are placed at intervals across the crop field, depending on the purpose, either on the contour or perhaps even perpendicular to prevailing troublesome winds. Several factors are used to determine the interval between the row(s) of trees or shrubs including slope length, field width, crop light requirements and equipment width.

As mentioned earlier, landowner objectives will determine the products to be harvested from the alley cropping practice. These objectives also determine the arrangement of trees and crops and

the set of management practices needed to obtain those products. Alley cropping practices are highly diverse and range from simple to complex. Plantings can consists of a single tree species or a number of species. Similarly, single tree rows or multiple rows may be used.

There are several key factors to consider when planning and establishing the practice on a given site:

**Layout - Tree Arrangement**

- Single or mixed species
- Number of tree rows - single vs. multiple
- Alley width: Between row spacing
- Within row spacing

With a conservation perspective in mind, slope length relates to the spacing needed to reduce water erosion. The light requirement for the crop or forage to be grown in the alleyway must be considered prior to tree establishment. Finally, alley width must be set as multiples of the widest field equipment width.

***Single vs. Mixed Species -*** The row(s) of trees can have either a single species in the row or mixed species. A single species is the easiest to plant but a mixed species planting with similar growth rates and site requirements may provide greater economic and environmental diversity. Factors to consider when deciding how many rows to establish and the arrangement of the trees within the rows may be based on a number of potential benefits including:

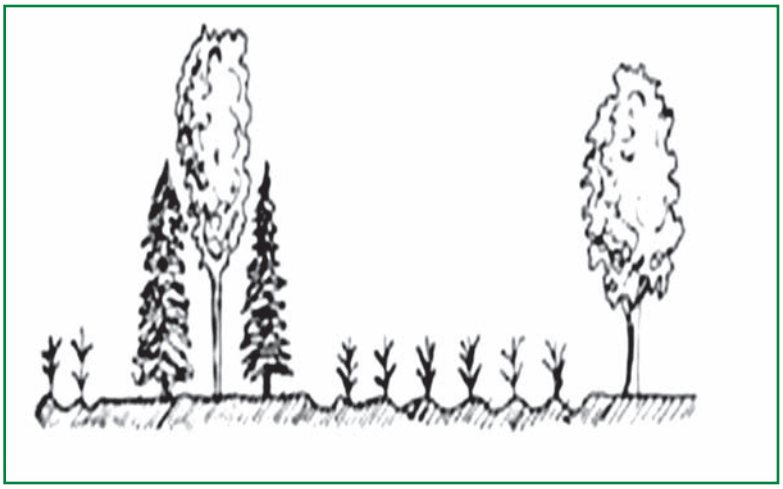
- *Annual crop being produced and area removed from production by tree/shrub rows*
- *Desired tree/shrub crops and management needed to enhance production (such as weed control and pruning)*
- *Erosion concerns that multiple rows and combinations of trees/shrubs/grasses can better address*
- *Wildlife habitat created through multiple rows of combined trees/shrubs/grasses*

***Single vs. Multiple Row Sets of Trees -*** The single row takes up the least amount of space but the trees will probably require pruning to enhance the quality of the future wood product. Multiple rows, however, will result in self pruning of the interior row(s). Conifers are a good choice as the "trainer" trees in the outside rows since hardwood species will tend to bend toward the light in the alleyway thus reducing their wood value except for chips. Nitrogen-fixing "nurse trees" can also be used.

***Advantages to single rows:***

- *Environment maintained*
- *Less tree to tree competition*
- *Reduced competition*
- *Wildlife habitat*
- *Plant-Insect relationships*
- *Economics*

Excellent environment for nut trees to develop full crowns. Trees in single rows which are spaced further apart develop wider, more branched crowns. Conversely, if high value tree form is important, then closely spaced trees may encourage self pruning and straight bole development. Trees are open on at least two sides, and therefore have less competition between trees within each row, when compared to multiple row configurations. Single tree rows add diversity to a typical row



*Top: Triple row of trees using conifers to train high-value hardwoods. A single-row tree strip is also shown. Bottom: aerial view of single, double and triple row configurations for alley cropping at the Horticulture and Agroforestry Research Center, New Franklin, Mo.*

crop field. Researchers think the greatest value to wildlife of woody-herbaceous buffers are the benefits created through breaking-up the traditional mono-culture setting associated with agriculture. Vegetation change and structural diversity is an important tool in controlling agricultural pests. Products coming from the farm are diversified through the addition of trees and their products.

***Advantages to double rows:***

- *Environment maintained*
- *Reduced competition*
- *Wildlife habitat*
- *Economics*

When rows are offset, double rows of trees maintain similar advantages to that of single row plantings while improving the potential to realize environmental benefits, such as soil and water protection. Compared to rectangular grid patterns of tree planting, double rows allow maximum utilization of space for companion crops.

Competition for light between trees can be reduced through offset row configurations.*
Multiple rows of trees planted in offset configurations maintain exposure of a majority of each trees crown/canopy to sunlight. Double rows provide the same benefits as a single row alley crop setting, but allow structure (vertical and horizontal vegetative layering and density components) and diversity (variety of species planted) to be increased. This creates an environment for greater utilization of the tree row by increased numbers of wildlife species. Finally, products coming from the farm are further diversified. It is also possible that thinned trees can provide early economic gain (prior to final crop tree maturation).

[*As mentioned, caution should be observed since deciduous hardwood trees will exhibit a tendency to grow towards light. If an environment of unequal lighting is created (more light to one side of a trees' crown), most hardwood species will grow towards sunlight, and away from competition. This can cause devaluing of the tree for wood products due to sweep (stem curvature). ]

### *Advantages to multiple rows:*

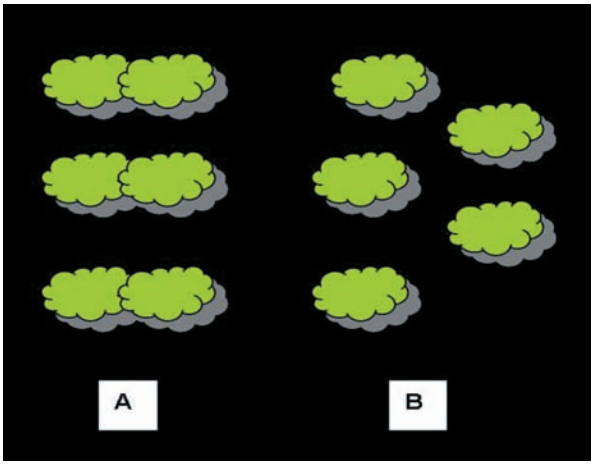
- *Benefit from competition between tree rows*
- *Wildlife habitat*
- *Plant-Insect relationships*
- *Economics*

Certain trees will benefit from some light competition. For high value wood, it is desirable to grow a single, straight stem. Trees and /or shrubs planted on either side of a high value tree species, can be used to train the stem of that tree. By using 'trainer' trees on either side of the high value tree, natural pruning and straight stem growth can be encouraged. Ultimately, this starts the process (may also require pruning) of producing a straight, clear (small or no knots) log of higher quality than might be grown in an open setting. However, choosing the correct 'trainer' species is important because you do not want the outside trees to outgrow your center tree. If they do, they will provide too much shade.

Wildlife habitat potential increases greatly with a wider row of trees. Increased numbers of animals will use this area for travel lanes and the interior creates protective cover opportunities for birds and small mammals.

Plant-insect benefits are the same for single and double row configurations, though some additional advantages may be realized by diversifying the species planted.

Economic benefits are similar to double row configurations. As with double rows, additional trees per acre in multiple row configurations may also qualify these plantings for cost-share assistance and create opportunities for medium-term tree crops to be removed for cash flow (e.g., trees grown for landscaping).

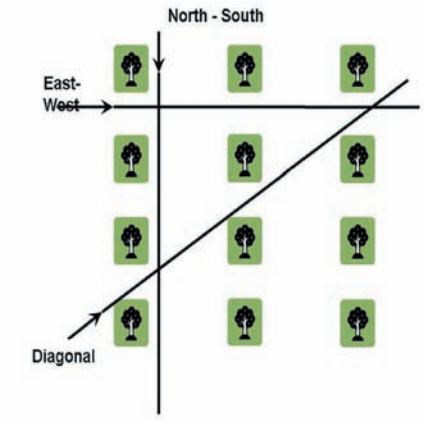



*Crown competition between adjacent trees (A) as compared to the increased growing space available to individual trees when planting in an offset configuration (B). Double or triple rows of long-needled hard pines (e.g., cold tolerant loblolly or pitch x loblolly hybrids) can be grown either as (A) or (B). A byproduct of a double or triple planting is the potential for pine straw production within tree rows.*

## *Tree and shrub arrangement*

To enhance the growth of trees in multiple-row plantings, staggering the trees between adjacent rows will permit maximum crown development. Staggered spacing provides more room to grow.

***Alley Width: between tree row/set spacing:*** If wood production is of primary importance, closer row spacing is desirable. Wider row spacing is preferred when nut production is desired.




*Equipment Travel Lanes: The use of trees planted in rows can allow equipment passage in any number of directions.*

The spacing should also be adjusted based on multiples of the widest farm equipment to be used in the alley way. Spacing to accommodate equipment is particularly important in nut production when early crown development is desirable. Plan alleys such that full, or multiple, passes of the equipment are utilized. For example, if using a 13-foot wide disk it may be desirable to have an alleyway 60 feet wide. This allows for 4 passes with the disk (52 feet) and a buffer (to ensure damage is not done to the base of the tree) of 4 feet adjacent to each tree row (8 feet; 4 feet on either side of the cropped alley).

***The number of years that light-demanding crops are to be grown in the alleyways is another consideration:***

- *60 feet spacing will generally allow crop production (e.g. corn, soybeans, cereals, etc.) for 5-10 years*
- *80-120 foott spacing will allow production for up to 20 years or more*
- *As the shade increases over the life of the trees, it may be necessary to change the companion crop being grown in the alleyway (see plant material section).*

***Within Tree Row Spacing:*** The primary objective for the trees, and the cost of the planting stock, will help determine the within-row spacing. If erosion control is desired, a closer spacing would give better results. If the tree stock is of unknown origin and quality, a closer spacing would also be desirable to give more opportunities to select the best quality trees during succeeding thinnings. Closer spacing may also be required if minimum numbers of trees per acre are required to meet government cost share requirements. However, if expensive grafted tree stock is used for nut production, a wider spacing may be used to reduce cost.

For example, trees that are grown tightly spaced will have a tendency to grow up, towards the light. This growth trait is highly desirable when growing trees for quality wood production. Additionally, as these tightly spaced trees begin to shade one another, each of their branches in the shade will begin to die and eventually fall off. This is called self-pruning, and is again desirable when trying to grow high quality wood in timber production.

## Tree and Shrub Selection: Desirable Characteristics

There are a number of desirable characteristics for trees or shrubs that will be grown in an alley cropping system. It is not necessary (probably not possible) that all the following characteristics be exhibited by one tree species:

- *Produces a commercially valuable product or multiple products (i.e., timber, nuts) that has an acceptable local market.*
- *Relatively fast growing (medium growth rate on high value trees is acceptable) or highly valued for production or conservation benefits*
- *Produces appropriate shade for the companion crop*
- *Be adapted to a variety of sites and soils*
- *Deep-rooted with minimal roots at the soil surface to minimize competition with crops in the alleyway.*
- *Have foliage with minimal acid-generating potential if companion crops prefer a pH neutral soil. Conifers acidify soil, combine well with acid loving crops.*
- *Does not produce growth inhibitory chemicals (allelochemicals) that would prevent some crops from growing near them (e.g., black walnut)*
- *Have a growing season that complements the companion crop*
- *Produces wildlife benefits*

### *Selecting companion crops*

Companion crops are planted in the alleys between the tree rows. The choice of companion crop will vary depending on the types of trees selected and the crop(s) desired by the grower. There are three major groups of crops which can be grown in an alley cropping practice: 1) Row/cereal and forage crops; 2) Fruits and other specialty crops; and 3) biomass producing crops.

Initially, the growing environment in the alley will

be favorable to row crops requiring full sun (corn, soybeans, wheat) or forages. Potential companion crops include row/cereal crops, forages, fruits and other specialty crops, biomass producing crops.

As trees grow taller and develop larger crowns, they will exert greater influence on the growing environment in the alley with increased shade, water and nutrient competition and humidity levels, along with decreased temperatures and decreased wind movement.

| Plant Materials - Trees for Alley Cropping |
|---|
| **Black walnut:** Outstanding markets available for wood. Opportunities exist for the sale of wild nuts, cultivars provide a higher return. Produces light shade, has a short foliage period, and is deep rooted. The juglone allelochemical limits companion crop choices somewhat. |
| **Pecan:** Markets available for both wood and nuts. Markets exist for nuts from native wild pecans and for cultivars. Nuts more valuable than the wood. More shade produced than with walnut but no allelochemicals. |
| **Oaks:** The wood has a high value and the acorns are good wildlife food. The oaks are relatively slow growing and produce fairly dense shade. |
| **Chestnuts:** Chinese chestnut produce valuable nuts at an early age, are blight resistant and adapted to the climate of the eastern US. Markets are growing for domestic producers. |
| **Ash:** The wood is high value but there are no other potential products. They are relatively fast growing and produce a light shade. |
| **Nut or fruit bearing shrubs:** The hazelnut, pawpaw, blueberries, etc. could be used as stand-alone hedgerows or in combination with other taller tree species. |

While availability of sunlight is a primary factor that determines how well row crops or forages perform in the alley, water and nutrient competition is even more significant. The tree canopy density will be partially determined by the spacing of the trees within a row and the width between tree rows. This spacing will also influence below ground competition.

***Tree/Shrub selection for row crops -*** - Corn, soybeans, wheat, milo, barley, oats, potatoes, pumpkins, lettuce, peas, etc. have demonstrated success in alley cropping. Most of these crops have high light demands. Using corn in the first few years speeds tree growth by creating a greenhouse effect for the tree rows. In an alleyway 60 feet wide, shade will limit their use after 5-10 years depending on the tree species.

***Selection of forage crops -*** In an alley cropping practice, forage crops such as fescue, orchard grass, bluegrass, or alfalfa, are grown for hay production between rows of planted trees, but are not grazed. This distinguishes the alley cropping practice from a silvopasture practice.

Kentucky 31 tall fescue and orchardgrass tolerate considerable shade and are very productive cool-season grasses. Other potential forages that show shade tolerance include Kentucky bluegrass, ryegrass, smooth brome, timothy and white clover. Winter annuals such as cereal grains, crimson clover, and hairy vetch must be reseeded every year and only provide one cutting of hay, but do not compete with the trees and provide good erosion control.

*Bluegrass hay is harvested between rows of pecan trees in this alley cropping example.*

## Cool vs. warm-season forages

It is also necessary to consider whether a cool or warm season crop and/or forage may be more appropriate for the site conditions and objectives. Studies conducted by the University of Missouri have found that many cool-season legumes and grasses produce greater biomass when grown under partial shade as compared to full sun. Some warm-season grasses showed similar responses, but most were southern temperate zone species.

- **Advantages and Disadvantages of Cool Season Forages**

  Cool-season perennial species are most productive in the spring when temperatures are typically cool and moisture plentiful. They grow less or become dormant during the hot summer months when moisture is often limiting, then increase growth in the fall.

  Cool-season forages can be highly competitive with tree crops for moisture and nutrients, especially in the spring as trees break dormancy. As young trees are becoming established, it is desirable that no vegetation grow within a 3-foot radius. To maximize the growth of older trees, vegetation should be controlled in a diameter approximately equal to the crown diameter size. However, this may or may not result in the greatest economic gain.

### Warm-season forages

Warm-season perennial species grow most during the summer months. Though warm-season forages have a shorter growing season, they are still very productive.

Eastern gamagrass, bermuda grass, Switchgrass, Indiangrass, and big bluestem are examples of warm-season perennial grasses identified for use in Missouri. Southern climates may use bahiagrass or bermudagrass.

- **Advantages and Disadvantages of Warm-Season Forages**

  The root systems associated with warm-season forages are typically deeper than cool-season grasses. This makes them an excellent choice for controlling erosion and protecting sub-surface water from leached pesticides and nutrients. These forages will likely be less competitive in the early spring when many trees are beginning their annual growth. Warm season "clump" grasses provide excellent habitat for quail in combination with woody shrubs.

  Warm-season forages grow vigorously in the hot summer months. Therefore, a consideration is that this may put them in competition with trees and other woody vegetation at a time of the year when water is quite possibly the most limited resource. On the other hand, if a tree species puts on its growth in late spring, in certain instances a warm-season forage can make a good companion crop.

  The point is that compatibility, even seasonal compatibility, must be considered when selecting trees, shrubs, grasses, and crops for an alley cropping practice.

## Integrating Specialty Crops into an Alley Cropping Practice

Most often associated with the forest farming practice, specialty crops also have potential for integration into alley cropping practices. Landscaping plants, Christmas trees, small fruit trees or shrubs and berries can be grown either temporarily between the permanent in-row crop trees or in the alleyways. As the alleyways become more shaded, shade tolerant species such as redbud, dogwood and spruce could be grown for landscaping if there is a nearby market. Plants which can be marketed for their medicinal, ornamental, or food values (including St. John's Wort, wildflowers for seed, pumpkins, etc.) also provide unique opportunities for alley cropping. Species that are light demanding can be established in the alleyways while those requiring some shade can be planted within the tree rows as shade develops.

**Specialty crops that can be produced in full sun include:**

- *Horticultural plants, such as tomatoes, pumpkins and blackberries*
- *Forages, grains and oilseeds*
- *Tree crops, such as nuts*
- *Seed production, such as wildflower or select grasses*
- *Christmas trees*
- *Shrubs and other landscaping plants*
- *Trees for lumber and wood fiber products*

## *Biomass Crops*

Both woody and herbaceous plants for biomass production could be an option for the alleyways. Soft hardwood species such as cottonwood, hybrid poplars, willow, sycamore and silver maple could be grown for pulp, paper or oriented strand board if markets are available. Herbaceous biomass crops (e.g. switchgrass) could be another alternative.

## Operation and Maintenance:

***Pest management:*** Periodic inspection of the crops and trees is recommended to detect and identify possible pests. Insects and diseases can be significant factors in reducing the health and vigor of both the tree crop and the intercrop. The corrective actions should minimize the impacts on beneficial insects.

***Fertilization and nutrient management:*** A normal fertility program should be applied for the intercrop in the alleyway. Generally, fertilization of the tree crop is not needed, but fertilizing the intercrop may also benefit the trees. Competition for nutrients can be minimized by root pruning or by adding more nutrients. Nutrients can be added in the form of chemical fertilizer, animal manure or a wide range of other materials. This may also include the use of living mulches or green manures.

***Canopy management (Pruning):***

If there is too much shade under an existing stand of trees, the canopy can be pruned to allow more light to reach the understory plants. You may be able to accomplish this by clear-stem pruning for improved timber production. This involves the removal of branches low on the stem of a tree in order to raise the height at which the canopy begins. This allows more light to enter the understory from side angles while also creating adequate space for operating equipment. Remember, removing more than 40% of the trees foliage will significantly reduce the growth of the tree. It is best to always have 40-50% of a tree's height in crown or foliage.

***Top:*** *Lettuce intercropped until mid-June followed immediately by a pumpkin intercrop until October. Vineland, Ontario.* ***Bottom:*** *Grain is alley-cropped in a young pecan orchard, Georgia, U.S.*

***Alley cropping example:*** *Paulownia and winter wheat in China-- Through careful pruning, the proper shade canopy can be developed and light levels can be manipulated in an alley cropping practice. Often, the alley cropping practice will transition to more shade tolerant crops, or extensive tree removal by thinning will be needed in order to maintain light levels.*

***Periodic root "training" will improve crop yields:***
Based on research into tree and crop interactions it has been shown that even during the early years of tree development, competition for water and/or nutrients is the major reason for reduced crop yields. By early (beginning with young trees) and repeated (every couple of years) severing of lateral roots, the number of tree roots can be significantly decreased in the plow zone. Row crops will continue to produce commercial yields even as shade levels increase.

***Weed Control:***
Weed control for an alley cropping includes both the rows of trees and the intercrop. For the tree row(s), weeds need to be minimized usually for the first three to five years in a band about three feet on each side of the trees. Weed removal can be done in a number of different ways, from herbicides and cutting to cultivation. An additional consideration for use in controlling weeds adjacent to trees may include mulch, fabric barriers or living mulches. Nothing will improve the growth of trees and shrubs like the control of competing grasses.

***Maintenance tasks specific to trees:***

- *Replanting: Replant all trees or shrubs that have failed for the first 3 years.*
- *Branch Pruning: Pruning of the trees may be necessary to improve wood quality, the micro-environment for the companion crop, allow equipment access, or correct storm damage.*
- *Root Pruning: Pruning tree roots (up to 24 inches deep) projecting into the companion crop area may reduce competition. Do not prune both sides of the trees the same year. Allow a 3-year interval before pruning the other side. Pruning will need to be repeated on a 5- to 8-year interval.*
- *Thinning: The tree rows will normally need to be thinned to increase light in the alleyways and speed production of high value crop trees.*

***To achieve the objective of maximum tree growth rates throughout the timber rotation, growers must be willing to periodically thin out trees. Failure to do so dramatically and adversely impacts future tree growth rates and rotation length.***

## Economic incentives for alley cropping:

There are many agencies offering programs that can be used to establish and maintain agroforestry practices on private land. One of the most significant of these agencies is the USDA Natural Resource Conservation Service (NRCS), which offers the Environmental Quality Incentive Program (EQIP) that may be utilized toward agroforestry practices like alley cropping.

The EQIP program is designated for environmental concerns associated with livestock production. Landowners engaged in livestock or agricultural production can apply for 1-to 10-year contracts through a competitive application process based on environmental benefits. Eligible lands include cropland, rangeland, pasture, forestland, and other farm and ranch lands. Conservation practices are designed with the help of USDA/NRCS and other agencies to address the locally-identified priority resource concerns. EQIP contracts provide cost-

share payments up to 50 percent of the establishment cost for conservation practices and various incentive payments. For alley cropping practices, EQIP will pay $50 per acre for first 3 years on land planted in trees and the grass strip adjacent to trees. No more than 50% of the cropland can be enrolled.

NRCS Standard 311 identifies the guidelines for establishing an alley cropping practice for EQIP. For more information, contact your local USDA/NRCS office.

Additional USDA programs to establish and maintain an alley cropping practice are offered through the Forest Service (FS) and the Sustainable Agriculture Research and Education (SARE) program. See chart below for a listing of incentives offered by these federal agencies or consult the UMCA publication "Funding Incentives for Agroforestry in Missouri."

**Funding incentive for Alley Cropping through EQIP:**

$50 payment per acre for first 3 years on land in trees and grass strip adjacent to trees. No more than 50% of the cropland can be enrolled.

### *Cost Share Opportunities:*

Alley cropping is the tree or shrub component of an overall conservation management system for cropland or hayland. To be an effective conservation management system, several other conservation practices need to be considered for inclusion in the system depending on the objectives to be achieved.

- Conservation Crop Rotation (328)
- Crop Residue Management (329, 344)
- Contour Farming (330)
- Contour Buffer Strips (332)
- Contour Orchard & Other Fruit Area (331)
- Filter Strip (393)
- Forage Harvest Management (511)
- Grassed Waterway (412)
- Stripcropping, Contour (585)

| Federal Agency and Programs Offered | Programs available for Alley Cropping | Key to programs |
|---|---|---|
| USDA/NRCS | | • CS = Cost Share (ranges from 50% to 90%, based on a predetermined expected cost structure)<br>• LE = Land Easement (Rental payments based on an average rental rate per land use type; easements are typically 5, 10, 15, 30 years or permanent)<br>• M = Annual maintenance payments (range from $5 - $10 per acre)<br>• IP = Additional incentive payments (payments could include sign-up bonuses, additional cost-share, and/or increased land easement rates)<br>• G = Grants |
| Environmental Quality Incentive Program (EQIP) | IP | |
| Conservation Security Program (CSP) | CS,LE | |
| USDA/FS | | |
| Forest Land Enhancement Program (FLEP) | CS | |
| SARE | | |
| Producer Grants | G | |

- Terrace (600)
- Pasture and Hayland Planting (512)
- Nutrient Management (590)
- Pest Management (595)
- Wildlife Upland Habitat Management (645)

## Summary

Alley cropping needs to be part of an overall management system including crop rotation, crop residue management, combinations of buffer practices, pest management and nutrient management. Alley Cropping can help diversify farm enterprises, protect soil, improve air and water quality, enhance fish and wildlife habitat, conserve biodiversity, and beautify the landscape.

## Success Stories:

### Paul Smith

***20-acre alley cropping practice***
***Northwest Missouri, near Claremont***

"I guess I was a little hesitant at first to plant trees. I wondered at times what some of my farmer friends and neighbors would think of covering good bottomland with trees. My wife reminded me that her father had spent his lifetime clearing this off and now we're planting it back in trees.

In 1999 we seeded this field to orchard grass, and alfalfa. The first cutting that year produced about 3 tons per acre, and I feel that we benefit from the alley cropping because we have a short-term benefit of the crops between the tree rows -- and eventually, my family or someone else will benefit from the tree crop."

### Dan Shepherd

***Shepherd Farms - Bluegrass hay and pecan alley cropping practice; buffalo ranch and agritourism business, Clifton Hill, Mo.***

Dan Shepherd raises buffalo for processing into lean, high-quality meats and jerky, in addition to his pecan and bluegrass hay alley cropping practice. Shepherd Farms is also a nationwide leader in production, wholesale and retail distribution of Eastern Gamagrass seed.

"Alley cropping is ideal for achieving both our production and conservation benefits," said Shepherd. "We earn an annual income off the ground, while the trees are being established. We also enjoy an abundance of wildlife in the habitat created by alley cropping. While the crops are growing we see deer, turkey and quail utilizing this ground and the trees."

## Additional Resources

***National Agroforestry Center:***
http://www.unl.edu/nac/alley-cropping.html

***UMCA DVD:***
Visit www.centerforagroforestry.org or the University of Missouri Extension web page at http://extension.missouri.edu/explore/agguides/agroforestry/index.htm to purchase.

***In Print:***
Garrett, H.E., W.J. Rietveld and R.F. Fisher (eds.) 2000. *North American Agroforestry: An Integrated Science and Practice*. American Society of Agronomy. pp. 149-188. (Chapter 6)

***UMCA Research Publications:***
http://www.centerforagroforestry.org/research/pubs.asp

***From the United Kingdom:***
http://www.agroforestry.co.uk/silvoar.html

***From the Association For Temperate Agroforestry (AFTA):***
http://www.aftaweb.org/entserv1.php?page=1

***From the University of Florida:***
http://cstaf.ifas.ufl.edu/research2.htm

***From Australia:***
http://www.rirdc.gov.au/pub/shortreps/sr8.html

***For additional information on the characteristics of individual forage species:***
*Forages Vol. 1: An Introduction to Grassland Agriculture* by Barnes, Miller, & Nelson, 1995, Iowa State University Press.

*Southern Forages* by Ball, Hoveland, & Lacefield, 1991, Potash and Phosphate Institute

*Pasture Management Guide for Northern Missouri* by USDA NRCS, Ingalls, John J., 1998.

***From USDA SARE:***
Manage Insects on Your Farm. http://www.sare.org/publications/insect.htm

## EXERCISE: REVIEW OF ALLEY CROPPING

*1. What factors affect the width between your rows?*

*2. What are some of the advantages and disadvantages to alley cropping?*

*3. What are advantages and drawbacks of utilizing narrow vs. wide alleyways?*

*4. Identify two management practices that are critical to maintaining tree growth over time.*

*5. Why is root pruning performed on tree/shrub species in alley cropping?*

*6. Removing what percent or more of the tree's foliage can have a serious impact on the growth of the tree?*

*7. How do you determine how far apart to plant trees in a tree line and how far apart to plant the tree rows? Is there such a thing as a wrong distance, such as too far apart or too close together?*

## EXERCISE KEY

***1. What factors affect the width between your rows?***

Landowner goals and objectives, desired crops, uses for trees, and width of existing crop production equipment all impact between and within row widths.

***2. What are some of the advantages and disadvantages to alley cropping?***

Advantages: Short-term cash flow, trees benefit from crop fertilization, sun crops compete with weeds, reduce runoff, form of windbreaks, provide increased economic diversity and long-term payoff. Disadvantages- Tree rows are obstacles for cultivation, provide competition for sunlight, moisture, and nutrients, and require more intensive management. Herbicide drift from crops may damage trees. Sun crops will need to be exchanged for more shade tolerant crops over time.

***3. What are advantages and drawbacks of utilizing narrow vs. wide alleyways?***

Narrow alleys with more tree rows permit greater production of trees and shrubs per acre of land putting an emphasis on the value of the woody crop. Narrower alleys will also become shaded within just a few years forcing a shift from sun to shade loving crops. Wide alleys permit sun loving crops to be grown for many years and are often more compatible with farm equipment

***4. Identify two management practices that are critical to maintaining tree growth over time.***

Ongoing weed control around the base of the trees, using herbicides, mulch, fabric barriers or living mulches is absolutely essential for rapid tree growth and establishment. As the trees age and grow, thinning out crowded trees within the row will enable the trees to maintain maximum growth rates over the long haul.

***5. Why is root pruning performed on tree/shrub species in alley cropping?***

Tree roots can be pruned (severed) or "trained" to reduce competition for water and nutrients.

***6. Removing what percent or more of the tree's foliage can have a serious impact on the growth of the tree?***

Removing over 40% of the crown of the tree will reduce its growth.

***7. How do you determine how far apart to plant trees in a tree line and how far apart to plant the tree rows? Is their such a thing as a wrong distance, such as too far apart or too close together?*** (see question #1) Depending on the emphasis of nut or wood production, and what kinds of crops are planned on, the width of the alleys must be adjusted to meet these plans. Wood production is compatible with narrow rows and multiple rows, nut production requires single rows and wide spacing between trees.

A "wrong" distance would be any planting configuration that does not meet the landowners short-, medium- and long-term objectives resulting is lower production from desired crops or reduced tree growth or poor tree form. Row-to-row distance also must match with existing equipment.

# UMCA Research: Shade Tolerance of Forage Crops

*Since 2001, UMCA has been supported by and managed three significant USDA - ARS programs, representing more than 50 individual projects. The Center seeks to develop the scientific basis for designing and prescribing agroforestry practices within a "systems context," which allows technology to be used most effectively.*

**Project Team:** Jerry Van Sambeek, Gene Garrett, Bob McGraw, Nadia Navarrete-Tindall

When utilizing agroforestry practices for short- and long-term income, especially in an alley cropping, silvopasture or forest farming setting, the management of ground cover under decreasing amounts of light as the tree canopy develops is critical. The landowner must understand how different plant species will respond when grown under the shade of trees.

UMCA's shade tolerance research project is conducted in a specially designed shade laboratory at the Horticulture and Agroforestry Research Center to evaluate these factors. The laboratory allows researchers the opportunity to evaluate forage yield and quality of grasses and legumes with light as the only limiting factor. The goal of the project is to identify which species or cultivars should be further tested in field trials for optimizing their success in agroforestry practices.

*UMCA shade tolerance laboratory, Horticulture and Agroforestry Research Center, New Franklin, MO.*

Within the shade tolerance laboratory, 20 to 27 grasses and legumes are simultaneously grown under 20, 45, and 100 percent of full sunlight and periodically harvested to determine yield and forage quality as percent crude protein, neutral detergent fiber (NDF), and acid digestible fiber (ADF). Through multiple screening trials, researchers have determined a ranking of the shade tolerance of grasses and legumes.

**The following species have performed well under moderate to heavy shade in multiple studies (ranked from very shade tolerant to moderately shade tolerant):**

**Very Shade Tolerant**

| | |
|---|---|
|  | Hoary tick clover (*Desmodium canescens*) |
| | Kura clover (*Trifolium ambiguum*) |
| | Crownvetch *(Coronilla varia)* |
| | Crimson clover *(Trifolium incarnatum)* |
| | Cluster fescue *(Festuca paradoxa)* |
| | Paniculated tick clover *(Desmodium paniculatum)* |
| | Reed canarygrass *(Phalaris arundinacea)* |
| | Kentucky bluegrass *(Poa pratensis)* |
| | Red clover *(Trifolium pretense)* |
| | Subterranean clover *(Trifolium subterraneum)* |
|  | Kentucky 31 tall fescue *(Festuca arundinacea)* |

**Moderately Shade Tolerant**

**Top:** Shade tolerance laboratory in full sun.
**Bottom:** Shade tolerance laboratory covered with 55% shade cloth.

# Notes