

INTEGRATING WALNUT AND OTHER HARDWOODS INTO AGROFORESTRY PRACTICES

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Abstract.—Agroforestry systems have been proposed as alternative, environmentally benign systems for agricultural production in temperate North America. Walnut and other hardwoods have been successfully integrated in most agroforestry practices include alley cropping, silvopastural, windbreaks, and riparian buffers. Because of walnuts relatively thin crowns and nut production, it has been the most frequently used woody species. The biophysical research has revealed that the success of complex hardwood-based agroforestry systems will depend on minimizing the negative interactions, especially above and below ground competition, while enhancing the synergistic interactions between system components. Research has shown that agroforestry systems can provide significant ecosystem services in addition to the direct economic benefits.

Agroforestry systems, the planting of perennial trees and/or shrubs with annual agronomic crops or pasture, have been proposed as more environmentally benign, alternative systems for agricultural production in temperate North America. In addition to environmental pressures, the economic benefits of multiple crops within agroforestry systems have also generated interest in their adoption by farmers (Garrett 2009). Alley cropping, a form of agroforestry in which trees and/or shrubs are established in hedgerows on crop land with agronomic crops or pasture grasses cultivated in the alleys, has been a subject of numerous experiments in the tropics. Interest in diversifying farm income and reducing environmental impacts of agricultural practices has led to the development of alley cropping systems in the temperate region. The crops most often planted in the United States and Canada include corn (*Zea mays* L.), soybean (*Glycine max* L. (Merr.)), wheat (*Triticum* spp.) and oats (*Avena* spp.), combined with trees such as black walnut

(*Juglans nigra* L.), pecan (*Carya illinoensis* (Marsh.) Engl. Graebn), oaks (*Quercus* spp.) and poplars (*Populus* spp.). In the north-central United States, systems combining crops with timber producing trees, especially black walnut, have been established on several sites. Research conducted over the past three decades on the biophysical and socioeconomic aspects of the black walnut-based alley cropping systems has provided encouraging results that should help promote these practices in the Midwest (Idassi 2012).

A number of positive and negative interactions have been postulated for both the tree and crop components of these systems, and the direction and magnitude of these interactions are determined by the patterns of resource sharing and the time scale at which these patterns are measured. Biophysical research has revealed that the success of these complex hardwood-based agroforestry systems will depend on minimizing negative interactions while enhancing the synergistic interactions between system components. The acceptability of black walnut-based alley cropping by landowners would be improved if interactions that exist between trees, crops and/or livestock remain largely beneficial so that productivity per unit area of

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land is increased while reducing environmental risks associated with monocultural systems. While many shade tolerant C₃ crops (most forbs and cool season grasses) perform well in terms of growth and yield under shade in mature walnut agroforestry systems, C₄ crops (corn and other warm season grasses) can suffer greatly if shading exceeds 40 percent. It has also been shown that belowground competition for water and nutrients can be a major determinant of growth whether C₃ or C₄ crops are grown in combination with walnut trees. Since black walnut is known for its allelopathic properties mediated by the phenolic compound juglone, care should be taken to avoid planting juglone-sensitive crops in association with black walnut.

Both the aboveground and belowground competition can be alleviated through management practices. Studies of other tree species have revealed that deep disking of the alleys in early years of establishment can train the roots to go deeper and reduce the competitive stress in the crop rooting zone. Thinning the overstory to allow optimum light levels in the understory or changing to a shade tolerant crop in the understory can prolong the life of a timber-based agroforestry system.

Economic research has shown that walnut alley cropping can be a viable economic alternative to landowners interested in nut production without an income lag as the trees mature. Establishment of grafted, genetically-improved trees can substantially reduce the time it takes to reach commercial production and increase net income to the landowner (Godsey 2012). From a financial perspective, black walnut alley cropping is best suited to marginal cropland that is being transitioned from crops to a more sustainable land use. Planting black walnut can ensure that the land that was once used for marginal crops can still produce a high annual income once the trees reach commercial production level. Landowners that are looking for a potential long term investment can expect rates of return ranging from 4 percent

to 6 percent. In addition to annual income from nut production, black walnut wood is the most valuable timber grown in Missouri. Although grafting and shaking of trees during nut harvesting may have a negative impact on the value of that timber, the timber is still marketable for lumber and would increase the financial returns for the landowner's future generations.

Various ecosystem services and environmental benefits have been reported from hardwood-based agroforestry systems, in addition to direct economic benefits (Jose 2009). Hardwood alley-cropping, for example, has been shown to have higher soil organic matter and soil nitrogen compared to sole cropping systems (Kremer and Kussman 2011). Researchers have also reported higher diversity both above (e.g., arthropod) and belowground (e.g., microbial activity) in hardwood agroforestry systems (Kremer and Kussman 2011, Stamps et al. 2002).

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