Benefits & Use of Legumes in Pecan Orchards

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A mature pecan orchard consists of two separate, yet interrelated ecosystems. The orchard floor provides a working surface for orchard operations and influences activities in the trees, which produce the crop. Pecan orchards usually consist of sod culture on the orchard floor with a weed-free herbicide strip approximately 6-12' wide along the tree row. Row middles are maintained by mowing. The mowed sod middle improves wet weather passage for spraying, harvesting, and other orchard operations.

An efficient orchard floor cover does not compete heavily with trees for moisture and nutrients and is compatible with orchard insect populations. Weed competition with tree roots is significant throughout the life of the tree. In a newly planted orchard, weed competition can significantly reduce young tree survival and can stunt tree growth. Weed competition can reduce tree growth and yield, as well as promote alternate bearing in mature trees.

Pecan trees have an extensive root system, consisting of a tap root which can penetrate as deep as the soil structure and water table permit, and small feeder roots located near the soil surface. These feeder roots supply the bulk of the pecan's nutritional needs and come into direct competition with vegetation on the orchard floor.

Cool season legumes, such as clover, posses a variety of characteristics that make them compatible with pecan production. Cool season legumes are not especially competitive with trees for soil moisture until mid to late spring. They also serve as an effective source of organically bound nitrogen (N). In addition, cool season legumes stimulate an early increase in beneficial insect populations. The environmental benefits of cool season legumes make their use an especially attractive practice. In addition to the benefits mentioned above, legumes can reduce weed competition, aid in the cycling of nutrients, build soil organic matter, prevent soil erosion and runoff, and serve as an effective source of food and habitat for a variety of beneficial insects.

Pecan Nitrogen Use & Compatibility with Legumes

Of all nutrients applied to pecans, N most commonly limits pecan growth and orchard profitability. This element has a dominant influence on vegetative growth and crop production. In recent years, the rising cost of fuel, and its effect upon synthetic fertilizer production, has led to a need for alternative sources of nitrogen in many orchard and row crops operations. With regard to pecan production, one very efficient source can be found in the planting of leguminous plants, particularly crimson and white clovers, on the orchard floor.

All legumes, including clover, utilize soil-dwelling bacteria that convert nitrogen from the air into a form that can be used by plants. This is termed "nitrogen fixation". Only particular strains of bacteria provide optimum N production for each group of legumes. When the roots of a leguminous plant come into contact with the appropriate bacteria, the root hairs encircle the bacteria to create a nodule which houses the bacteria. These lumps on the root surface may range in size from a BB to a kernel of corn.

Perennial legumes "fix" N during any time of active growth, usually peaking at flowering. With seed formation, N fixation ceases and the nodules slough from the roots. While they are alive, legumes release little to no nitrogen from the soil. As they die and are decomposed by soil micro-organisms, the N in the roots, stalks, leaves, and seeds are converted to a form available to other plants. Residue from a grass/legume mix has a higher C:N ratio than the legume alone, thus the release of N is slow and not as vulnerable to loss.

Mature pecan trees require 75-150 lbs of N annually for optimum production. Nitrogen uptake in the pecan tree is driven by demand. There are two critical periods of nitrogen demand during the season; (1) early foliage growth and (2) kernel filling. The early spring foliage flush is nourished primarily from reserves held within the tree, while the nitrogen demand during the kernel fill stage is usually satisfied from soil uptake. If N is limited at kernel filling, then the tree will mobilize N from the foliage to the kernels.

Studies have suggested that white clover over-winters dependably in the southeastern United States and much of the U.S. pecan belt. Crimson clover is a winter annual plant, yet will re-seed itself for 3-5 years before additional planting is required. Sandy sites will need to be re-seeded sooner than loamy or clay soils, therefore soil type should be taken into consideration when estimating the need for re-establishment. A vigorous stand of crimson clover will contribute between 70-150 lbs of N/acre, an adequate but not excessive amount for pecans. A vigorous stand of white clover can fix 100-150 lbs of N per year depending on soil and growing conditions. When aided by moisture and warm weather to speed up decomposition, up to half the N available from legumes can be released within 7 to 8 weeks. For best results, a combination of white and crimson clover is recommended.

Pecans are an "irregular bearing" crop, meaning that they tend to bear heavy crop loads for 1-2 years, followed by very light crop loads, depending upon various physiological and environmental factors. In the light crop or "off" years, the N supplied by the clover alone, would be adequate for optimum production. Heavy crop or "on" years may require low supplemental N rates in order to bring marketable nuts to maturity and provide a return crop the following year.

Supplemental N should only be applied to orchards utilizing legumes after N fixation by the legumes has ceased (after full bloom). It is important to recognize that the ability of the legume plant to "fix" nitrogen is destroyed by the presence of readily available N in the soil. Little to no fixation occurs when available soil N is present, and legumes will use it in preference to atmospheric N. Fertilizing orchards utilizing legumes at the wrong time can also lead to aggressive growth of grasses and other competitive species, which can lead to shading out of the legume crop.

Enhancement of Pest Management

Conserving and encouraging beneficial organisms is key to achieving sustainable pest management. The blossoms of clover attract various species of bees, which feed readily on the abundant nectar. In addition, blooms may harbor beneficial insects such as the minute pirate bug. Pea aphids and blue alfalfa aphids are commonly associated with crimson clover. Although these species are not pests of pecan, they serve as alternative food sources for beneficial predators such as lady beetles, green lacewings, soldier

beetles, predaceous stink bugs, damsel bugs, and hover flies. As the clover declines with the onset of warm weather in June, these beneficial insects move into the trees to feed on pecan aphids and other insect pests, reducing the need for insecticide application.

In addition to reducing insecticide inputs through enhancing beneficial insect populations, the use of legumes in the orchard can also reduce herbicide use. As clover grows, it forms a thick, living mulch. This helps to smother and shade out more troublesome, competitive weed species. White clover has a creeping growth habit and spreads with rhizomes or "runners". This helps to fill voids in the orchard and is a very effective means of reducing weedy competition.

Soil Building & Sustainability

Legumes can improve orchard soils in a number of ways. Protection against erosion is the most obvious benefit, but providing organic matter is an equally important and more long term goal. Clover can provide habitat and/or food source for important soil organisms, break up compacted soil layers, and help dry out wet soils.

Erosion deprives orchards of topsoil, the most fertile portion of soil with the highest amount of organic matter. When soil particles are dislodged by rainfall, they are more vulnerable to runoff. Cool season legumes can reduce the impact of rainfall on bare ground, slow the action of moving water, increase the soil's ability to absorb and hold water, and help stabilize soil particles. Crimson clover produces more dry matter (5600-6000 lbs/A) than many other legumes and is recommended for soil erosion control because of its high early autumn dry matter production. Grass/clover mixtures combine fibrous surface roots with long tap roots and have been observed to reduce herbicide runoff by 94-100%.

Over-fertilization is common in orchard crops because most growers rely on synthetic fertilizers. The amount of nitrogen removed by the crop in proportion to that applied is often far less with tree crops than with more traditional crops. Therefore, the leaching of nitrates into groundwater may be especially serious in orchard crops. Winter cover crops such as clover grow primarily during a period of tree dormancy, when N uptake by the crop is at a minimum and percolation from rainfall is often the greatest. Although pecan growers have historically had little economic incentive to grow cool season legumes solely to prevent nitrate leaching, it is one of the many benefits they provide.

Perennial legumes break down quickly; however their root systems remain tough and fibrous, contributing to the accumulation of organic matter. The addition of organic matter to soils improves soil structure, increases water holding capacity, increases cation exchange capacity (the ability of the soil to act as a short term storage bank for positively charged plant nutrients), and provides more efficient storage of nutrients.

Legumes help to increase the total number and diversity of soil organisms, which is the key to a healthy, well functioning soil. Legumes are closely associated with beneficial fungi, called mycorrhizae, which produce a water-insoluble protein known as glomalin, which binds and glues together particles of organic matter, plant cells, bacteria, and other fungi. The resulting well aggregated soils are less prone to compaction.

Mycorrhizal fungi also have an efficient method of absorbing phosphorous (P) from the soil, which they pass on to their host. Without this relationship, P builds up in

the soil. Although it is not leached, it can runoff into streams and rivers through soil erosion. The filaments of the mycorrhizal fungi effectively extend the root system and help the plants tap more P from the soil. Keeping P in an organic form is the most efficient way to keep it cycling in the soil.

Wildlife Benefits

Due to the limited availability of suitable nesting areas in the United States for early-successional songbirds, converting a common attribute of the southern agricultural landscape, such as pecan orchards, to a resource for food and reproductive habitat would provides some of the factors necessary to increase survival and nesting success. Increased abundance of birds and beneficial arthropods and higher species richness in agricultural fields have been linked to habitat heterogeneity.

The sod/clover orchard floor mixture along with the pecan overstory allows for an increased landscape heterogeneity. Birds benefit from an increase in prey, an increase in cover for nesting sites and fledgelings, and a reduction in nest loss due to the elimination of mowing during the nesting season. In addition to enhancing the landscape for non-game songbirds, bobwhite quail, wild turkey, and mourning dove will also benefit.

Clover has been shown to be highly effective at attracting high avian and arthropod densities, increasing wildlife and agronomic benefits compared with conventional management of agricultural systems. The reduction of input in the clover system, coupled with its agricultural and environmental benefits, makes this system economically desirable and a good choice for reducing negative impacts on wildlife and surrounding ecosystems.

Establishment & Maintenance

In order to establish an adequate stand, Crimson clover should be drilled at 15-18 lbs/A or broadcast at 20-30 lbs/A. White clover should be drilled at 2-3 lbs per acre. If white clover seed are broadcast, the seeding rate should be increased by 25 percent. Establishment should be completed as soon as possible following pecan harvest, preferably in November-December. If clover is seeded prior to harvest, many seeds are removed from the orchard floor with the sweeping and harvesting process.

Since legumes require the presence of rhizobial bacteria to effectively fix N, it is important to obtain the correct rhizobial inoculant for the legume being grown. Fresh inoculant and a sticking agent should be mixed with the seed. Otherwise, there will be few nodules and N fixation will be low. Soil pH should be maintained at 6.5 because *Rhizobia* bacteria cannot function properly under highly acidic conditions and will die in soils with pH below 5.0.

Many southeastern orchards have well established populations of annual ryegrass. Where this occurs, the ryegrass often competes with and inhibits growth of clover. This can be prevented by the application of a low rate (16 oz/A) of sethoxydim herbicide in February. The rye grass does not have to be eliminated, only stunted by this application in order to release clover from this competition. By foregoing mowing of the orchard until clover has gone to seed, producers can take advantage of its re-seeding ability.

Selecting a Clover Variety for the Orchard Floor

Large or ladino white clovers are later blooming and more upright in growth than the small or intermediate clover types. This may make them unattractive for pecan orchards because they make it difficult to move about in the orchard. In addition, they are not dependable re-seeders and have fewer stolons and leaves close to the ground. Intermediate types reseed more dependably and posses many ground-level stolons.

Durana clover is a white variety with small leaves and many stolons, which allows aggressive spreading and excellent traffic tolerance. It flowers profusely for long periods, making it a dependable re-seeder. During cultivar development, Durana was selected partially on its ability to survive hot, dry conditions. Clover normally requires adequate water, which makes it best suited to solid-set sprinkler irrigated orchards. Durana's drought tolerance makes it better suited to drip or microjet sprinkler irrigated orchards.

Costs & Savings

The approximate cost of clover seed and bacterial inoculum required to produce N-fixing nodules is $40/A. At 2005 N prices of $72/A, this represents a difference of $32/A. Clover can replace from 50-100% of synthetic N applied to pecan orchards, depending on the pecan crop load in a given year. This would save growers approximately $36-$72/A and significantly reduce the grower's reliance on synthetic N. Reduced maintenance and mowing compared to grass covers creates further economic savings and reduces fuel consumption.

Pecan acreage is widely dispersed and hard to track, but reliable estimates indicate that pecans are grown on approximately 550,000 acres in the United States, with Georgia making up about ¼ of the total U.S. acreage. This would indicate a potential savings of approximately $19,800,000-$39,600,000 in N costs, as well as a 41,250 ton reduction in the use of synthetic N nationwide with the use of N-fixing legume culture applied to orchard floor management.

Summary

One of farming's greatest challenges is to keep N in a stable, storable form until needed by the crop. The use of organic N, such as that produced by legumes, is an ideal way to accomplish this. Combining warm season sod culture and cool season legumes is a practical and effective strategy for conserving and supplying nitrogen for orchard crops, as well as enhancing stewardship of the environment through the enhancement of beneficial insects, weed suppression, soil sustainability, and wildlife.

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