

Sod-based rotations

New system could increase profits, reduce risk, and conserve resources



Sod-based rotations have shown promise in research at the University of Florida and elsewhere in increasing profits, reducing risk, conserving water, and building the soil. Unlike annual cover crops, which have most of their biomass aboveground, sod-based rotations incorporate a perennial grass into the rotation, with most of its biomass underground. And unlike pastures, the perennial grasses are rotated into the same fields that are used for row crops. This can have a big effect on soil quality characteristics and ultimately a producer's bottom line.

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Across Florida's Suwannee County, brothers Ryan and Reed Moore are known for being early adopters of best management practices. They perform nutrient management planning and retrofitted the irrigation system for their 1,200-acre cattle and peanut farm with the latest water-saving features. Their use of "cutting-edge" techniques even earned them Conservation Farmer of the Year honors from the county's conservation district in 2009.

Yet one of their most important practices isn't new at all. When their grandfather, R.F. Moore, started his 40-acre livestock and tobacco operation in the 1920s, he established a rotation that involved planting a perennial grass for five or six years, sowing tobacco or peanuts into the same fields for two more, and then going back to sod. Nothing knocked down nematodes or built

up soil organic matter quite like it, Ryan Moore explains, plus peanuts, corn, and tobacco "all love to follow grass." He and his brother have been keeping up their grandfather's practice ever since taking over the farm in the late 1970s. "He always believed strongly in this rotation," Moore says.

Another firm believer in sod rotation is University of Florida's David Wright, who for the past 12 years has been documenting scientifically what the Moores understand intuitively about its benefits. An agronomy professor and extension specialist with the North Florida Research and Education Center, Wright has recorded bumps in peanut yields of 25 to 40% after just two years of sod. He has seen 30 to 40% increases in the total root mass of cotton and peanuts and dramatic drops in nematodes. His economic calculations also suggest

sod rotation can boost farm profitability two- to seven-fold.

In addition to Wright's work in Florida, those data have now sparked research and demonstration projects in Alabama, Georgia, Virginia, Pennsylvania, and even as far away as Columbia, South America. Still, while Wright believes the rotation can help growers most anywhere, his focus remains on those in the Southeast, particularly young people trying to enter agriculture for the first time. Sod rotation reduces the considerable risk southern farmers face from extreme weather (droughts to hurricanes) and the region's droughty, compacted, and infertile soils, he contends. Many growers are also just breaking even, meaning that even small increases in yields can produce significant net returns.

Add in the rotation's capacity to reduce irrigation needs and build the

soil, and it's able to meet agriculture's three most fundamental goals: profitability, risk management, and natural resource conservation. Unfortunately, as more farmland has been rented over time and put into annual row crops for short-term profits, farmers like the Moores who use sod rotation are becoming a rare breed. Raising awareness of

the soil. But cover crops are usually annual species, with two-thirds of their biomass aboveground, explains University of Florida plant pathology professor Jim Marois, a close collaborator of Wright's. "The key with sod-based rotation is to get a perennial grass into your cropping system," he says, where two-thirds of the biomass is below ground,

bringing back what the Midwest had to start with."

He's referring to native prairie plants, whose massive root systems built the Midwest's rich soils in the centuries before white settlers arrived. Long-term agronomic studies, such as the Morrow plots in Illinois, now show that soil organic matter has dropped significantly as farmers have taken land out of perennial sod and planted annual crops: from 3.5 to 4% in the late 1800s to 1 to 2% in 2010. "So that was some of the premise of our work," Wright says: to add organic matter back in.

The sod rotation he promotes in Florida involves planting bahiagrass for two years, rotating to peanut for one year, planting cotton for another, and then returning to grass. Conservation tillage is also critical to the system, Wright says. In addition to protecting against erosion and potentially boosting profits, no-tillage and strip-tillage are known to reduce the incidence of disease in cotton and peanut, conserve soil moisture, and help root and foliar development in these crops.

However, bahiagrass can pose problems in reduced-tillage systems because it produces large amounts of residue that can make planting peanut difficult unless the residue is plowed and disked under. To address this, Wright suggests killing bahiagrass with herbicide in the fall of the second year, giving the residue time to decompose before peanuts are planted in spring. A cover crop can be sown in the interim, and Wright also recommends sowing one between peanut and cotton: No-till drill oats or rye, for example.

The rotation's last component is cattle. Cattle can utilize the grass, of course, and they control weeds. And if row crops can't be sold because they've been damaged by hail, floods, or drought, farmers can still salvage some value from them



David Wright, left, and Jim Marois, professors with the University of Florida's Institute of Food and Agricultural Sciences (UF-IFAS), examine a harvested cotton field at UF's North Florida Research and Education Center in Quincy. To help Southeastern peanut and cotton farmers stay in business, UF and other institutions are developing a crop rotation system that includes bahiagrass, which could significantly improve peanut and cotton yields. AP photo: UF-IFAS/Milt Putnam.

the practice's environmental and economic benefits, and convincing farmers to adopt it anew, have thus become Wright's goals.

What's new with this system?

Raising awareness isn't trivial because at first glance, it may not be obvious what's different here. Many farms have pastures, of course, and conservation tillage already includes cover cropping to protect and build

in roots. In the Southeast, farmers often plant the warm-season grass bahiagrass because it grows on all soil types and resists drought while fescue and orchardgrass are popular cool-season grasses in the north.

The other distinction is that perennial grasses are rotated into the same fields that are used for row crops. "That's different from what most people are doing," Wright says. "Most people have their pastures in one part of the farm and the row crop land in another. So, we're

by using them as cattle feed. But the biggest benefit they offer is nutrient recycling. When farmers spread large quantities of stored manure on fields once a year, substantial amounts of ammonia nitrogen are lost through volatilization, and unincorporated nutrients can runoff into nearby waterways. Livestock, on the other hand, deposit manure continuously in small amounts that improve the soil rather than overwhelming it. Wright and Marois estimate that cattle can recycle nearly 50% of crop needs, reducing the need for commercial fertilizer inputs. When cattle graze on winter cover crops sown after peanuts in sod rotation, the researchers have also seen yield increases of 25 to 30% in subsequent cotton crops.

Higher organic matter, better pest control

Still, farmers who don't own cattle can also reap benefits from sod, Wright says. So what are those benefits? Since roots form the bulk of perennial plant biomass, most of the advantages stem from them. The root mass of bahiagrass can reach 20,000 lb/ac compared with 3,000 to 4,000 for oat and rye cover crops, and Wright and Marois have found that the grass increases soil organic matter by 0.1% per year. Although this may seem negligible, it adds up over 10 years to 1%. "In the Southeast that's pretty much doubling your organic matter," Marois says. "And that means you're farming a lot easier than you were before."

Indeed, he and Wright believe that higher soil organic matter is a critical reason why peanut yields are 25 to 40% higher after two years of bahiagrass than in a conventional rotation with cover crops. Another likely cause of the bump is better pest and disease control, especially of nematodes. As Florida farmers like the Moores know, nematode



Clockwise: Earthworm hole or root channel with cotton roots growing through compaction layer following bahiagrass. Photo courtesy of David Wright. Bahiagrass roots. Photo by Richard Old, XID Services, Inc., Bugwood.org. A distinguishing trait of bahiagrass is its V-shaped seed head (or inflorescence). Photo by Stephen Ausmus (USDA-ARS).

loads plummet after sod—so much so that nematicides often aren't needed to grow cotton or peanuts. This saves money, and it solves pest problems at a time when farmers are losing the option to use nematicides like Temik, due to changing regulations, Wright says. The pressure from other diseases and pests can drop, as well; for example, sprays for leaf spot can often be reduced from six to eight per season to two to four.

Perennial roots also hold soil at the surface and penetrate the compaction layer below. Southeast Coastal Plain soils have a natural hardpan layer that begins six to nine inches below the surface and continues to 16 inches, confining annual plant roots to a shallow

soil volume. But bahiagrass roots penetrate this layer, leaving behind channels that row crop roots can follow. Both the rooting depth and total root mass of cover crops, peanuts, and cotton are 30 to 40% higher following grass than in a conventional rotation, Wright says. "So, not only are we exploiting more soil for nutrients, but we have the water impacts there, too."

Cotton grown after bahiagrass, for example, is known to exhibit less stress during dry conditions and take up more nitrogen, and this has caught the eye of Joel Love, environmental specialist with the Florida Department of Agriculture, and Mace Bauer, best management practices team leader with the University



Left: Conventional system of cotton grown for two years after peanut. **Right:** Sod-based systems with cotton grown after peanut, which was preceded by two years of bahiagrass. Cover crops are grown after peanut/cotton each year, and bahiagrass is planted into the winter cover after cotton in the sod rotation and after the second year of cotton in the conventional rotation. Differences in growth may be attributed to higher organic matter in the sod system and the larger root system of the crops following perennial grasses. Photos courtesy of David Wright.

of Florida's Institute of Food and Agricultural Sciences. Florida's agriculture department already promotes sod rotation as an "advanced" best management practice to farmers, Love says. But he and Bauer also hope to demonstrate its advantages in a study, particularly its ability to reduce nitrate levels in groundwater and surface water by facilitating better nutrient use by crops such as corn, cotton, and vegetables.

Their other key hypothesis is that sod rotation will reduce the irrigation needs of row crops. In northern Florida, irrigation depends on groundwater supplies—the same supplies that cities like Jacksonville tap for drinking water. There's a growing water shortage in the area as a result, Love says. "We're thinking that [this rotation] is the only thing that will, on a large landscape, substantially reduce water use by agriculture,"—up to 30%, he estimates.

Marois adds that when row crops follow sod in non-irrigated areas, he and Wright often see yields that

equal or exceed those that farmers achieve by irrigating—which in drought years like 2011 can consume up to two inches of water per week.

"What we're trying to get growers to think about with this rotation is that irrigation would be used [only] to get a stand established or to dig the peanuts," Marois says. "So, the water is useful, has value. But it's to be used at critical crop points, rather than as the way to grow the crop during the entire season."

The potential to cut water use has caught the attention of the USEPA, which awarded a grant to Marois, Wright, and collaborators at the Nature Conservancy a few years ago to establish sod rotation on farms in southwest Georgia. The USDA-NRCS, too, is interested in the rotation, especially since farmers would likely need money for just one or two years to establish bahiagrass. "It's kind of an ideal situation for an organization like NRCS," Marois says. "They can come in, get the

farmer on the system, and then they can get out, and the good perpetuates."

Hurdles to Adoption of the Practice

Getting farmers on board seems to be the larger hurdle. Bahiagrass excels at rejuvenating worn out, infertile soils or those infested with pests, and Wright hears constantly from growers who solved an intractable problem on their farms by switching to sod. But in general, Bauer says, "It's not a widespread practice. It's very limited and very specialty-crop focused right now."

One of the biggest obstacles to adoption is the livestock factor. Having cattle definitely makes the rotation more profitable, especially since they're so good at recycling nutrients, Wright says. But livestock also require more work and expense, and many row crop farmers aren't up to keeping them. That's why in their initial attempts to promote the rotation, Marois and Wright have been targeting farmers who already own cattle. Estimates are that about 35% of Alabama row crop farmers raise livestock while in Florida and Georgia, the percentage is 25 to 30%.

Another issue is the scarcity of cheap farmland today, which makes it harder to justify keeping

Sod rotation in the Northeast

Most people think of organic agriculture in terms of the food it produces, but it's really about building the soil, says Jeff Moyer of the Pennsylvania-based Rodale Institute, a pioneer in the study and dissemination of organic farming practices. And after 40 years of organic management at Rodale's experimental farm, "we've improved the soil tremendously," he adds.

Still, as Rodale's farm director, Moyer thinks the soil can be improved even more, and he's now turning to livestock and sod rotation as the means to get there. Last fall, the institute's farm planted pastures in perennial orchardgrass, ryegrass, and other species, adding to its existing alfalfa fields. Dairy cows from a neighboring farm began grazing the fields this spring, and over the next several years, the pastures will be tilled under and planted to corn, soybean, oats, and wheat.

It is, in other words, the same sod rotation that University of Florida agronomy professor David Wright promotes in the Southeast, only with different plants, animals, and farming practices. Like their southern counterparts, most farmers in the Northeast who grow row crops and raise livestock put their pastures on certain soils—often the poorest ones—and their crops on others. "What we're envisioning instead is a system where every field on our farm is potentially a pasture, and every field can potentially produce a cash crop," Moyer says, who has been discussing sod rotation with Wright for about 10 years now.

Moyer is also envisioning a number of benefits. Water movement through the soil should increase,

leading to better infiltration and less runoff. He and colleagues also expect to sequester carbon in larger amounts and at greater depths and see better yields of cash crops. By continuously and uniformly depositing manure in fields, the cows are also expected to improve soil health. Even hoof traffic can benefit the soil, Moyer says, as long as grazing is managed well.

But the transition to livestock isn't the only change happening here: The dairy cows participating in the experiment belong to Rodale's next door neighbors, who are converting their conventional, 65-cow operation to organic production. They've struggled ever since milk prices dropped in 2009, Moyer says, and they see organic, pasture-based dairying as the road to increased profitability. Thus the partnership with Rodale: The couple brings their cows onto the institute's farm every day to graze certified organic forage as they move their own fields into organic production. Meanwhile, Rodale gets the benefits of the cows, without incurring the costs of keeping them.

The farmers can charge a premium for organic milk, of course, but that's not the main reason they're making the switch, Moyer says. Rather, they believe it will give them

more control over their farm because success will depend not so much on the fertilizers, chemicals, and other products they buy from others, but on their own mastery of topics such as pasture management, grazing strategies, and even cow psychology.

There's an awful lot to learn. But Moyer also thinks that investing in brainpower is an excellent strategy for small dairy farmers with limited resources.



Photo originally submitted with the *Agronomy Journal* article "Dairy Cattle Grazing Preference among Six Cultivars of Perennial Ryegrass," by Smit et al. (98:1213–1220).



Clockwise: Inspecting peanuts at the University of Florida's North Florida Research and Education Center in Marianna. Photo by Eric Zamora and courtesy of the University of Florida Institute of Food and Agricultural Sciences (UF-IFAS). A University of Florida extension agent discusses a cotton crop with a grower. Photo by Josh Wickham and courtesy of UF-IFAS. Plowing up twin-row peanuts that were strip-till planted in bermudagrass sod. Photo courtesy of Joel Love.

acreage in sod, especially for long periods, Love says. Plus, up to 80% of Florida farmland is rented now under annual contracts, Wright adds. As a result, growers tend to focus on short-term profits: If they rent land for, say, \$80 per acre, it's very tempting to sow row crops every season since bahiagrass doesn't net any cash directly (although a small market does exist for bahiagrass seed, Wright says). Moreover, when a rent-paying farmer puts acreage in bahiagrass, he risks being outbid in subsequent years by farmers who are willing to pay more in rent because they know they'll enjoy higher peanut yields. Growing bahiagrass, in other words, could

unintentionally drive up rents across the region.

Even with all the potential pitfalls, though, Wright is encouraged to see that farmers are still interested in planting sod; they just don't know how they can do it profitably, he says. To help them, he and Marois have developed an interactive business model (http://nfrec.ifas.ufl.edu/programs/sod_rotation.shtml) that evaluates the economic feasibility of a four-year livestock-peanut-cotton-sod rotation. It's based on replicated, small-plot trials, in which the bahiagrass system was compared with a conventional peanut-cotton rotation.

Farmers can enter values for their own operations, but, as an example, the model opens with data for a 200-acre farm with 80 head of cattle (cow-calf pairs). What it shows is that net profits after four years can be two to seven times higher with sod rotation and cattle than in a conventional system. And the biggest boost to profits comes not from having livestock, but from higher peanut and cotton yields, suggesting that sod rotation is likely to be more profitable even when growers don't own cattle.

There's something else to note here: the relatively small size of the farm. The norm these days of farming more and more acres on smaller profit margins comes with greater debt and risk due to weather, especially in the South, Wright says. It also sets up a barrier to young farmers, who may have a hard time acquiring large amounts of land or purchasing needed equipment, which can run in the hundreds of thousands of dollars.

Wright is certain sod-based rotations can help reverse this trend, ultimately making farming more sustainable both for the environment and for rural communities. On up to 20% of their farmland, he adds, most growers only recoup their variable costs, such as seed, chemicals, and fertilizers, with no net profit for their land, equipment, and labor.

"This is a high-risk area of their farm that should go into bahiagrass for two years to reduce risks. It also has excellent potential for profits when it comes out of bahiagrass," Wright says. He thinks what's needed now to convince people is simply time; after all, it took 20 years for farmers to embrace conservation tillage in the South. And from everything he's seen, sod rotation is even better. "It really is a system that can and does work," he says. 🐾