Organic Bio-Extensive Management Revisited

INTRODUCTION

BY GEORGE KUEPPER
Horticulture Program Manager (ret.)
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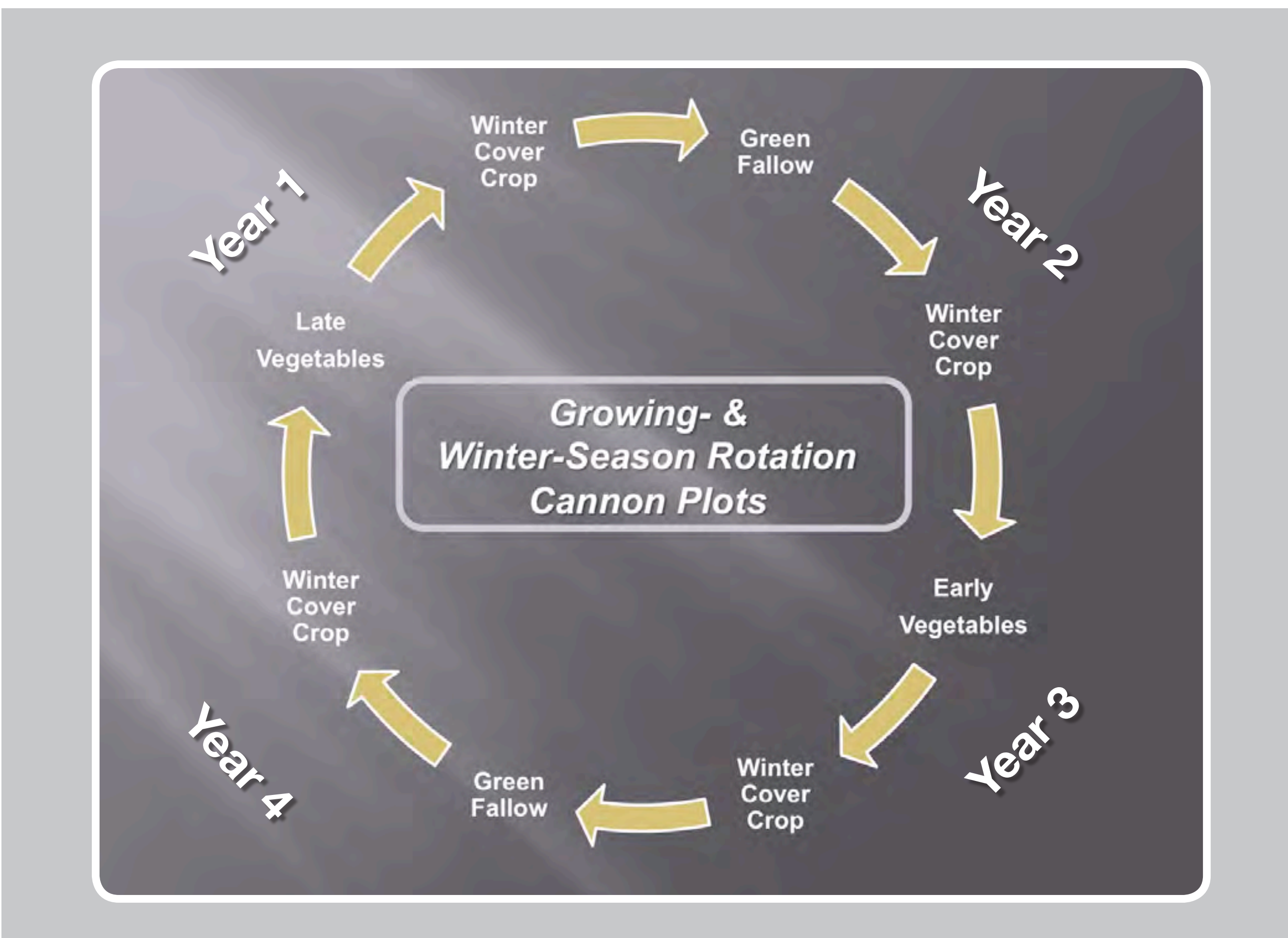
I retired from the Kerr Center in mid-2016 after nine rewarding years of designing and managing an organic bio-extensive system for the Kerr Center's Cannon Horticulture Demonstration.   All of us—staff, interns, and our friends in the horticulture and small farm communities—learned so very much about sustainability, practical horticulture, organic compliance, and the human element in small-scale farming. We captured much of that experience in the 2015 publication *Market Farming with Rotations and Cover Crops: An Organic Bio-Extensive System* (http://kerrcenter.com/publication/market-farming-with-rotations-and-cover-crops-an-organic-bio-extensive-system). We have learned even more since then, and are including it in this follow-up publication.

Briefly, for the reader who is not familiar with bio-extensive management, we characterize this approach through its reliance on planned crop rotations with the generous and creative use of both summer and winter cover crops. (We frequently use the term *green fallow* to describe the summer cover crops.) The cover crops are combined with vegetable crop rotations to protect the soil against erosion, control weeds, suppress soil-borne diseases and insect pests, and provide other benefits. This helps us achieve a high degree of self-sufficiency in nitrogen, and organic matter (biomass), which feeds and sustains a healthy soil food web. Diverse and vital soil food webs are the bases for healthy organic and sustainable cropping. The use of annual green fallow/summer cover crops, specifically, results in resting a significant percentage of land each year and reducing the amount of saleable crop. It is our hypothesis that the agronomic benefits—only some of which we cite here—compensate for lower annual gross income, by reducing expenses and labor and, with time, improving the resilience of the farm operation.

The following diagram helps explain our system by illustrating how we combine cover crops and rotation in the Cannon Demonstration, which does, indeed, feature four half-acre-plus fields, separated by conservation strips. We "grow" most of the needed nitrogen using annual legumes (vetches, clovers, winter peas) in winter cover crop blends, and much of our biomass with summer green fallow crops. The green fallow crops, which commonly feature annual forage sorghums, also smother and control bermudagrass (*Cynodon dactylon*)—our most serious weed threat.



Generating Biomass

As mentioned, one of the many agronomic benefits of a bio-extensive system is the large amount of organic matter or biomass that cover crops produce, especially summer green fallow. This organic material not only serves to stimulate and feed the macro- and micro-organisms and sustain a respectable level of humus, but also provides mulch for our research and demonstrations of organic conservation and no-till culture.

Students and visitors, after seeing the diversity of cover crops growing on the Cannon site, often ask how much biomass they actually produce. The table below features the actual dry matter yields of several Cannon cover crops sampled during the 2015 season by staff member Simon Billy and student intern Jayla Roath. We compare them with standard yield figures provided in the third edition of SARE's *Managing Cover Crops Profitably* (http://www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition). (Note that the air-dried Kerr Center sample yields have been adjusted for moisture content to equate with the SARE estimates, which are based on laboratory determinations of dry matter content.)

Dry Matter (DM) Yields of Summer Cover Crops

Cover Crop	SARE DM Estimates	Kerr 2015 DM Yields
Buckwheat	1-2 t/a	2.2 t/a
Cowpeas	1.25-2.25 t/a	3.3 t/a
Lablab	2.4 t/a	
Sorghum-Sudangrass	4-5 t/a	5.1 t/a

Kerr Center's 2015 yields were quite good, and reflect several years of soil building practices and our experience managing cover crops. Actual yields of dry matter that you and other farmers and gardeners might get will vary with factors including your experience, the cover crop variety, seed quality, planting dates, soil fertility, multiple cuttings (if you use them), and, of course, the vagaries of weather.

Jayla Roath

The Vagaries of Weather and Climate

We believe that bio-extensive management has helped us achieve greater stability and resilience on the Cannon site. While such observations are largely qualitative, we are quite confident after ten years that we've made solid progress. That said, we have also learned, often the hard way, that nature, in the form of inclement weather, can mess things up big time! As the Scots poet Robert Burns once wrote: *"The best-laid plans of mice and men often go astray."*

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ROBERT BURNS

Water, Water, Everywhere...

The Cannon site, while moderately sloped, has very poor internal drainage. As a result, heavy rain produces lots of runoff and erosion if the soil is not covered. It also leaves large portions of the fields waterlogged and very slow to dry.

Cover crops have been essential for preventing soil erosion. It's been especially true in winter and spring, when most of the heavy and prolonged rains occur. We choose our cover crop species carefully. We almost always combine a vigorous winter annual grass, such as grain rye, ryegrass, wheat, triticale, or oats, with slower-growing legumes like crimson or arrowleaf clover. Winter annual grasses cover the soil quickly, protecting against erosion, and ensuring that the more vulnerable clovers can get established. If you desire a pure legume stand the following spring, try hulless oats as a companion. *Most* hulless oat varieties are readily winter-killed, leaving a protective brown mat on the soil surface that clovers, vetches, and winter peas readily grow through. But take note: following one of our milder winters, the hulless oats we planted continued to grow—quite vigorously, in fact—after spring arrived! Apparently eastern Oklahoma winters are not reliably cold enough to ensure a thorough killing of all hulless oat varieties.

To enhance and diversify your winter cover crop further, you might consider adding about two to four pounds per acre of field turnips or tillage radish to winter cover crop blends. These brassicas increase biodiversity and send long taproots into the soil that bring nutrients up into the topsoil. Tap-rooted plants also help break up plow pans, and the canals they leave in the soil allow rainwater to percolate more quickly. They have become part of our strategy to mitigate the problem of waterlogging.

Our soils are always the most vulnerable in between the time we till and before crops and cover crops fully emerge. This is the time that wind and rain can do the most damage. One of those vulnerable time windows is between incorporation of green fallow crops and soil coverage by a winter cover crop. We have experimented by forgoing fall tillage and overseeding the winter cover crop. For example, when establishing a winter cover crop following sudangrass or sorghum-sudangrass, we have overseeded it with small-seeded legumes, like clovers, and with brassicas, which are also small-seeded. We did this somewhat later in fall—taking advantage of sorghum's slowing growth and its frost sensitivity. Annual sorghums are frost-sensitive and readily winter killed, allowing the clovers and brassicas to emerge and thrive. This has worked well where and when we've tried it. We noted, however, that cover crop emergence and growth was aided, considerably, by mowing and shredding the standing residue. You need not wait until frost-kill to mow; do so as soon as the growth of sorghum substantially slows.

Recent winters in southeastern Oklahoma have been exceptionally wet. Whole fields within the Cannon site lost well-established winter cover crops. Fortunately, there was little to no erosion. Dead, but well-rooted, vegetation will still work to stabilize soil. However, losing a winter cover crop has other implications for soil fertility.

As mentioned earlier, the Cannon demonstration relies heavily on winter legume cover crops to supply nitrogen for subsequent crops. When winter cover crops fail, there is little to no nitrogen fixation, and a risk for nitrogen deficiency. The risk is increased by denitrification—the loss of nitrogen when soils become anaerobic due to flooding and waterlogging. When these things occur, the most straightforward action is to supplement the following crop with nitrogen-rich fertilizer. Organic growers can use NOP-compliant compost, heat-processed manure products, seed meals, feather meal, and/or foliar sprays of soluble fish or fish emulsion. Alternatively, one might plant a commercial legume crop, like peas, beans, or cowpeas, which will fix the needed nitrogen. (Remember to inoculate with the proper *Rhizobium* species!)

We mitigated some cover crop drowning by using raised beds and/or ridges. Excessive rain may still flood out cover crop plants in and on the edges of the furrows, but those growing on the bed and ridge tops typically thrive.

And Then, Sometimes, It Gets Hot and Dry…

The past ten years also presented us with several periods of drought and extremely high temperatures. Again, bio-extensive management showed considerable resilience. When coupled with mulching and killed-mulch practices, the system worked to build organic matter in the soil, thus improving water retention. Also, keeping the soil covered reduced water evaporation, cooled the root zone, and reduced crusting. (These are among the long-term benefits we seek through this kind of management.) The fall heirloom pumpkin trial in 2011 (*2011 Organic No-Till Pumpkin Demonstration:* http://kerrcenter.com/publication/2011-organic-till-pumpkin-demonstration/) provided an interesting demonstration of how we tapped into these benefits, plus a few more.

For this trial we grew three spring-planted cover crops—sesbania, crotalaria, and pearl millet—and mechanically killed them by close-cutting with a sicklebar mower in mid-summer. We then planted pumpkins for fall harvest. After seeding, we did a small amount of raking to concentrate the cover crop residue close to the plants as a modified form of organic no-till. We provided supplemental irrigation through a T-tape drip line laid over the mulch and as close to the emerging plants as possible.

The pumpkins flourished and produced abundant fruit. There were virtually no weeds and no re-growth of the cover crop. We credit the success, in part, to the effective but isolated irrigation that the dripline afforded. No water was wasted on weeds. Credit also goes to our strategy for mow-killing the cover crops, which in this instance, was as close to the ground as possible.

How short cover crops are mowed or grazed can be most important to their management in a bio-extensive system. For two seasons we grazed a portion of our green fallowed sorghum fields using goats instead of mowing. The first season, in a bad drought year, we allowed the animals to graze much too long. They thinned the sorghum stand and left little stubble. Under the dry, hot conditions of that summer, little to no regrowth occurred. The following year, we managed the goats more carefully, removing them earlier. Despite similar hot and dry conditions, the annual sorghums recovered far better, producing a nice green manure for plow-down in early fall. These and similar experiences have led us to our current recommendations that growers leave generous stubble when seeking regrowth, and mowing or grazing close when trying to kill the cover crop.

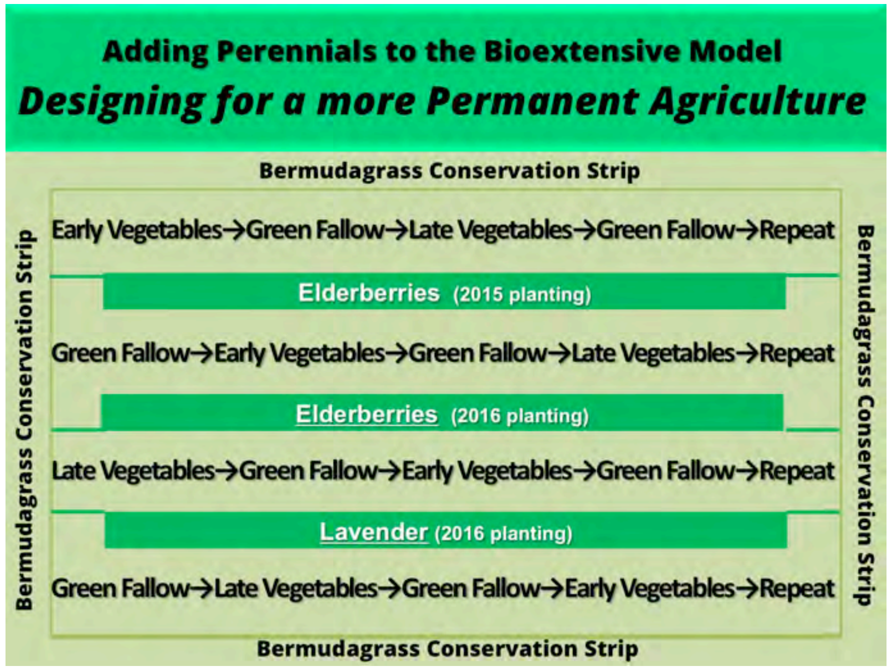
Even in relatively normal summers (whatever *they* are!), the latter half of the season usually sees little rainfall. Managing annual sorghums with proper mowing, as described, still works well in most years. However, strategies based on mid-summer seeded or re-seeded cover crops are risky. What we are referring to are attempts to plant green fallow, short-season cowpeas or buckwheat after harvest of an early spring crop; or allowing an early green fallow planting of these same cover crops to re-seed for late summer emergence and growth. When soil water reserves are good, or adequate rains come, such strategies can work splendidly; when not, they are disappointing, expensive, and leave the soil vulnerable to erosion.

Integrating Perennial Crops

Bio-extensive management, as we have characterized it, is intended primarily for sustainable production of annual vegetables, herbs, and flowers. Beginning in late 2013, however, we began to modify and adapt our bio-extensive system for perennial culture as well.

The Cannon site provides a significant challenge for perennial culture since all of the fields are vulnerable to re-infestation with bermudagrass from the field edges, where it thrives in conservation strips. Weed-suppressive green fallow crops in the bio-extensive rotation were used to eradicate bermudagrass within the fields, and they keep it so, whenever the weed tries to re-invade. Perennial crops, such as tree fruits, berries, grapes, and asparagus, are not rotated and there is no straightforward strategy for using bermuda-suppressive cover crops once they are established. Once bermudagrass gains a toehold in such crops, the grower has a long-term problem he or she might never overcome, especially if they are committed to avoiding herbicides.

In *Market Farming with Rotations and Cover Crops: An Organic Bio-Extensive System*, we presented several approaches for integrating perennials into vegetable systems, and for stand-alone perennial systems, all of which we believe can be successful for overcoming bermudagrass and keeping it at bay.



At the Cannon site, we ultimately chose a design that would retain the familiar four-field bio-extensive rotation, while integrating two perennial crops—elderberries and lavender.

The new demonstration is scaled-down from the original, which covered about 2.5 cultivated acres. It is now only 0.6 acres in size, occupying one of the more productive field units that were part of the original large demonstration. The illustration above provides the details.

We selected these particular perennials, in large part, to accommodate Kerr Center's involvement in other projects of interest. We are always looking for enterprises that might be good options for regional farmers. Both elderberries and lavender piqued our interest in recent years, as have blueberries, shiitake mushrooms, and blackberries in previous times. Elderberries and lavender have certainly suited our needs for evaluating the new bio-extensive demonstration. As regional enterprises, elderberries continue to look promising. However, lavender

is clearly unsuited to our soils and will likely be replaced in 2017 or 2018. Pawpaws and hazelnuts are possible considerations.

Note that the perennials are arranged somewhat like “islands” within the shifting sea that is the bio-extensive rotation, which protects them from bermudagrass encroachment. Also be aware that the “islands” do not extend all the way to the field boundary. Rather, they stop a few feet short of it. Green fallow is always used at these row ends as a barrier to bermudagrass.

Not visible on the map, is the added element of specialized, beneficial insect habitat. At the extreme ends of the elderberry rows (but short of the green fallow bermudagrass barrier), we constructed *beetle banks*. Beetle banks are habitat for predatory beetle species that feed on a number of pest insects. The banks consist of narrow raised beds planted to eastern gamagrass (*Tripsacum dactyloides*). The choice of eastern gamagrass was straightforward. Bunch grasses, like gamagrass, are recommended for beetle banks, and Kerr Center has an abundance of eastern gamagrass on-site—leftovers from earlier research done in the 1980s and 1990s.

An important consideration for implementing this and similar field designs, is the space to allot between perennial crops and adjacent annual crops—vegetables, herbs, etc. It is tempting to plant the annuals as close as possible to the perennials to make the most of available space. This might work well in small gardens, where access is all by foot. However, even small commercial plantings usually require enough room for hand carts and garden tractors, and such space must be planned for. Furthermore, tall-growing perennials are likely to inhibit annuals grown too close to them, anyway. And remember that most perennial crops grow larger each year. What seems like plenty of room in years one and two might prove a squeeze by years four and five. Be certain to plan for adequate space…and then some.

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For more information contact:
Kerr Center for Sustainable Agriculture
24456 Kerr Rd., Poteau, OK 74953
918.647.9123
mailbox@kerrcenter.com,
www.kerrcenter.com

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