ID-277

Cooperative Extension Service

The Great Debate of Annual vs. Perennial Forages

A Case Study of Two Kentucky Organic Dairy Farms

The organic dairy sector in Kentucky and Tennessee contributed $5.8 million in organic product sales in 2021 (Figure 1) (USDA-NASS 2021 Certified Organic Survey). Organic dairies rely more heavily on pastures as a significant source of dry matter intake compared to most conventional dairies. In fact, the National Organic Program requires a minimum of 30% of cows' dry matter intake to be obtained from grazing during the grazing season (USDA-National Organic Program, 2022). Interest in organic dairy production is rising in the southeast, increasing the need for information on improved organic pasture production.

Perennial cool-season pastures are the predominant forage source for ruminants in the transition zone of the United States, as they often provide the most economical systems for pasture (Ball et al., 2007). Cool-season forage systems are characterized by high yields in spring and early summer and low summer production with variable fall regrowth depending on species and weather. Providing grazing year-round can be challenging due to fluctuating weather patterns and differences in seasonal growth distribution of pastured forages.

One way to fill in the gaps between peaks in forage production in cool-season systems is to utilize both summer and winter annuals. These provide alternative forage sources when cool-season pastures are less productive or dormant. Annual forages also tend to have greater nutritive value than perennials but are a more expensive source of nutrients due to high and recurring establishment costs (Ball et al., 2007).

To gain more information on the economics of various forage systems for organic dairies in the Mid-South, the University of Tennessee led a large collaborative study funded by a USDA National Institute of Food and Agriculture Organic Agriculture Research and Extension Initiative grant. One of the goals of the study was to compare the on-farm yield and nutritive value of summer and winter annual forage mixtures to a multi-species perennial pasture mixture with the goal of extending for both spring and summer grazing. Five farms in Kentucky and Tennessee were chosen to participate in this project, and on-farm results will be presented from two of the farms in Kentucky that had similar grazing systems and consistent forage stands.

On-farm Case Study

Forage systems evaluated included 1) a perennial cool-season mixture, 2) annual ryegrass/crimson clover followed by sorghum x sudangrass/cowpea, 3) annual ryegrass/red clover followed by crabgrass/Korean lespedeza, and 4) annual ryegrass/brassicas/spring oats followed by sorghum x sudangrass/cowpea. Seeding rates for each mixture are listed in Table 1.

Both winter annual and perennial forages were first established

Figure 1. Dairy cows grazing a perennial organic pasture in Kentucky, which contributed $5.8 million in organic milk sales in 2021.

Table 1. Spring and summer forage mixtures were established in small plots in the fall of 2016 on two organic dairy farms in Kentucky as part of a two-state study.

Mixture	Spring		Summer	
	Species	Seeding Rate (lb/a)	Species	Seeding Rate (lb/a)
1	Tall Fescue Orchardgrass Alfalfa Red Clover	8 5 10 5	Tall Fescue Orchardgrass Alfalfa Red Clover	8 5 10 5
2	Annual Ryegrass Crimson Clover	20 16	Sorghum x Sudangrass Cowpea	30 25
3	Annual Ryegrass Red Clover	20 8	Crabgrass Korean Lespedeza	4 15
4	Annual Ryegrass Brassicas Spring Oats	12 7 32	Sorghum x Sudangrass Cowpea	30 25

in fall of 2016 into a prepared seedbed at each farm in plots between ¼ and ½ acre in size. Winter annuals were grazed in the fall if enough forage accumulated, otherwise grazing was deferred until spring. Plots were grazed by Jersey-based crossbred herds approximately once per month for no longer than 24 hours.

Both perennial and winter annual plots were generally grazed in the spring from mid-March through the end of May or early June. Annual plots going into the sorghum x sudangrass treatments were planted into a tilled seedbed to reduce competition with residual annual ryegrass. Crabgrass plots were overseeded as opposed to being planted into a prepared seedbed to preserve the existing red clover. The perennial treatment was not replanted throughout the trial.

Summer grazing generally occurred in late June/early July through late August. Plots containing sorghum x sudangrass were terminated by tillage and replanted with corresponding winter annual mixtures in early September. Crabgrass plots were overseeded (rather than tilled) with annual ryegrass to preserve existing red clover.

Plots were sampled prior to grazing events in 2017 and 2018 and were sampled weekly in 2019. Known areas of each plot were clipped to determine dry matter yield and forage nutritive value and samples were separated into botanical components. Forage nutritive value was determined by Near Infrared Reflectance Spectroscopy. Forage yield, botanical proportions, and nutritive value are presented as averages of all three years of the study.

Forage Yield

Seasonal forage yields are presented in Figure 2 as yields *relative* to the perennial mixture to more clearly express the differences between annual and perennial systems. Within each season, if a treatment shares the same letter above the bars with another treatment, the two treatments are statistically similar. A treatment is statistically different than another treatment if their letters are not the same.

In the spring, even though the annual mixtures yielded less than

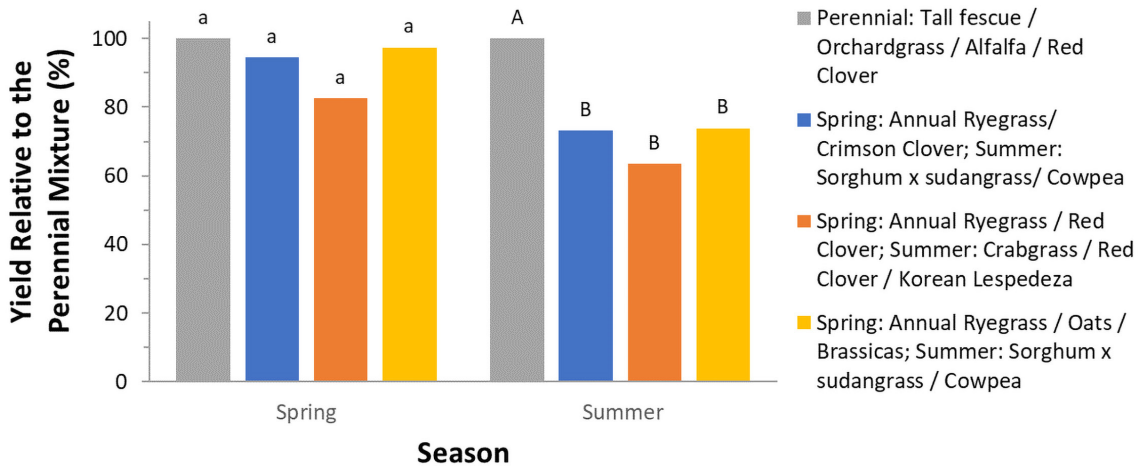

Figure 2. Relative yields of organic forage mixtures (includes weeds). Treatment differences were significant at $P < 0.15$.

Figure 3. Nitrogen-limited sorghum x sudangrass grown with legumes but no other N source. The pale green color of the sorghum x sudangrass is an iconic indicator of nitrogen deficiency as compared to the dark green color of the cowpea.

the perennial mixture, yields of the annual mixtures were not significantly different from the perennial mixture because they share the same letter "a." The summer annual mixtures yielded similarly to each other, but they yielded significantly less than the perennial mixture (30% less yield on average).

The summer annual yields may have been partially hampered by a nitrogen-limited environment. Nitrogen input into the annual systems likely occurred following tillage when the winter annual organic matter was decomposing, and from grazing the nitrogen-rich forage of annual legumes that was returned to the soil as manure/urine. The nitrogen obtained from decomposing winter annual legumes was likely not sufficient to support the high nitrogen demands of sorghum x sudangrass (Figure 3).

An additional component of the University of Tennessee's funded project was to evaluate multiple species combinations on a small plot scale managed with mechanical harvesting. This was done to simulate grazing in a controlled environment and to provide forage yields when grown in an optimal environment. Average three-year annual yields of mixtures similar to those used on-farm were as follows: Alfalfa/Orchardgrass = 4.75 T/A, Orchardgrass/Tall Fescue/Red Clover = 4.00 T/A, Annual Ryegrass/Red Clover/Crabgrass = 3.59 T/A, and Annual Ryegrass/Crimson Clover/Sorghum x Sudangrass/Cowpea = 4.16 T/A (unpublished data). The annual systems yielded an average of 11% less than the perennial systems, whereas the on-farm annual systems yielded 20% less than the perennial system. These data likely reflect the differences in forage recovery under mowing versus grazing, where the perennial forages are more likely to be less sensitive to the added stresses of grazing due to a more developed root system.

It is worth noting that during the summer the cool-season perennial system yielded more than the summer annuals. Although alfalfa is considered a cool-season forage, it often remains productive throughout much of the summer as seen in the on-farm data where the perennial mixture (containing alfalfa) yielded greater than all annual systems. Therefore, there may be limited situations where incorporating summer annuals would improve seasonal forage distribution on organic farms that utilize alfalfa. Summer annual yields greater than those observed on-farm would be needed to offset establishment cost and risk of seeding failure (Allison Jr. et al., 2021). Supplementing summer annual systems with appropriate nitrogen sources could significantly improve the yields of these systems but may not be economical if the cost per pound of nitrogen is high (Mercier et al., 2022).

Participating Farmer Perspectives

- Perennial forage systems seem to be more reliable than annuals. One producer's preference is for BarOptima tall fescue/orchardgrass/Kentucky bluegrass/clover mixtures.
- "On a year when I have more perennials on the ground, I have more hay the following spring."

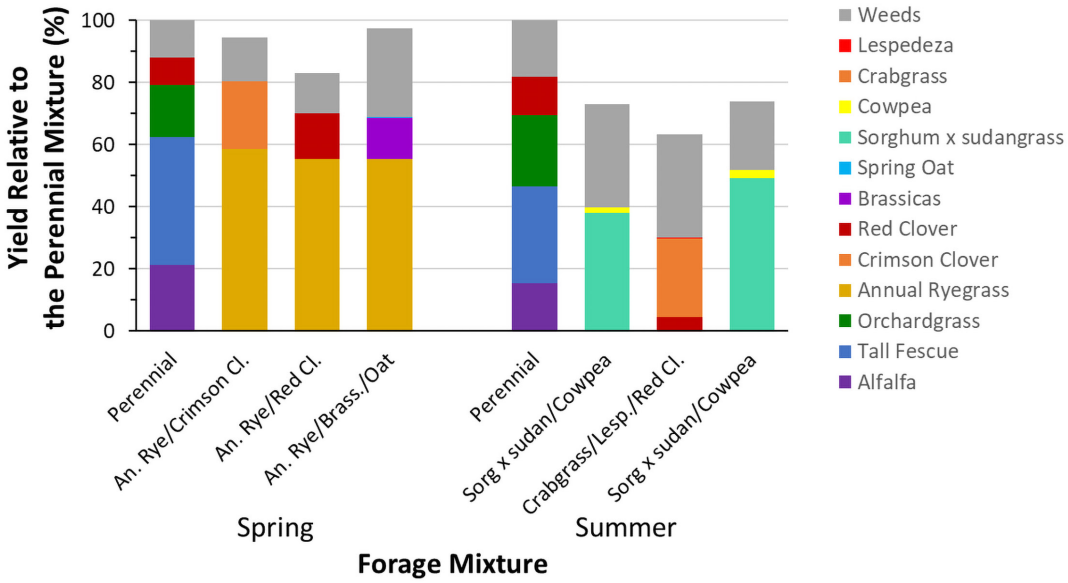

Figure 4. Species composition of organic forage mixtures from two Kentucky farms during spring and summer (averaged over three years). Bars depict mixture yields relative to the perennial mixture yield divided into each species contribution to yield.

Botanical Composition

Figure 4 depicts the species composition of each mixture during both spring and summer (average of three years). Bars depict mixture yields relative to the perennial mixture yield (the same as shown in Figure 2) divided into each species contribution to yield.

Winter annual mixtures were comprised of >50% annual ryegrass, approximately 20% legumes or 14% brassicas, and 15-30% weeds (Figure 5). Oats generally did not overwinter and contributed less than 1% to sward biomass the following spring after fall planting. The perennial mixture contained 41% tall fescue, 21% alfalfa, 17% orchardgrass, 9% red clover, and 12% weeds. These proportions were similar to what was targeted based on seeding rates.

During the summer, the sorghum x sudangrass (SS)/cowpea mixtures on average contained 60% SS, 3% cowpea, and 38% weeds. The crabgrass mixture averaged 40% crabgrass, 7% red clover, 52% weeds, and less than 1% Korean lespedeza. The perennial mixture composition was similar to the spring with 31% tall fescue, 15% alfalfa, 23% orchardgrass, 12% red clover, and 18% weeds.

Korean lespedeza and cowpea did not contribute significantly to the yield in summer annual systems. The poor establishment of Korean lespedeza may have been due to competition with red clover. Producers have communicated their difficulty in establishing Korean lespedeza consistently, which limited its value under conditions of this study. Cowpea did not establish well, but also did not regrow after the first grazing event. Unlike grasses, cowpea and other larger upright growing annual legumes (such as soybeans or sunn hemp) often do not regrow if defoliation occurs close to the ground and auxillary buds are damaged.

Weed pressure was particularly high in the summer annual mixtures. Wide row spacing coupled with poor cowpea establishment may have led to more bare ground and subsequent opportunities for weeds to take hold. Additionally, there were generally less weeds germinating following late summer tillage when the cool-season plots were established, as compared to the late spring plantings of the summer annual mixtures. Perennial systems had less bare ground throughout the year, leading to less opportunities for weed establishment.

Figure 5. Successful brassica establishment in a cool-season forage mixture. Brassicas are leafy annuals that are high in forage nutritive value.

Participating Farmer Perspectives

- Perennial clovers are a more dependable legume than cowpea.
- One farmer noted that his cows eat more when there is 30%-40% clover in the pastures, which translates to more milk.
- Crabgrass establishment isn't always dependable and can get outcompeted by other less desirable annual grasses. However, it is a useful species for filling in gaps. Naturalized crabgrass often shows up during the summer, and cows have good milk production while grazing it. This farmer questions whether it is worth establishing crabgrass as he seems to have a good existing seedbank.

Forage Nutritive Value

Nutritive analyses from the mixtures planted on-farm are presented in Figure 6. Components presented are crude protein (CP), total digestible nutrients (TDN, calculated with a summative equation in order to give a more accurate estimate of TDN as compared to an equation based solely on acid detergent fiber), acid detergent fiber (ADF), neutral detergent fiber (NDF), in vitro digestible dry matter (IVDMD), and relative forage quality (RFQ). Net energy of lactation (NE_L) was calculated from TDN and is presented in conjunction with TDN as an additional measure of energy content of the forage mixtures. The graphs present averages for each season.

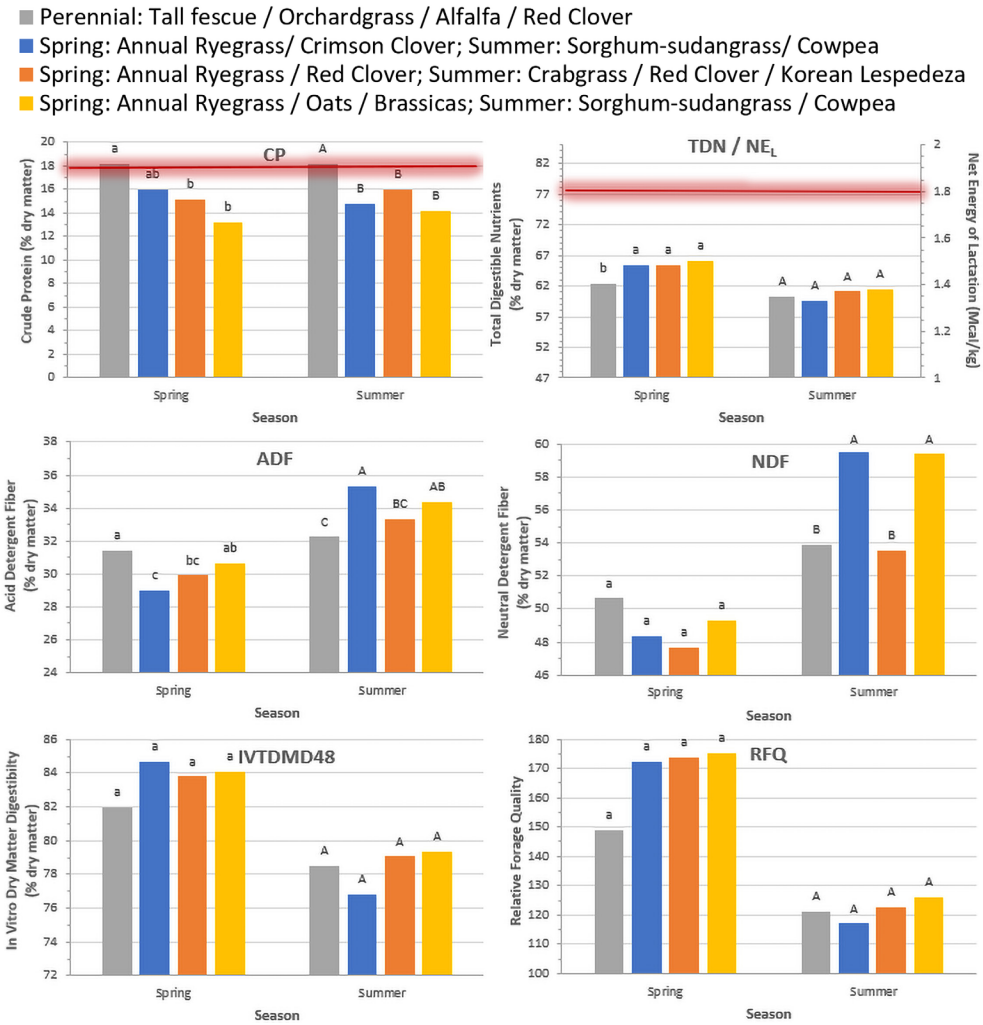

Figure 6. Forage nutritive value during spring and summer of organic forage mixtures planted on two Kentucky farms. CP = crude protein; TDN = total digestible nutrients calculated with a summative equation; NEL = net energy of lactation, calculated from TDN; ADF = acid detergent fiber; NDF = neutral detergent fiber; IVTDMD48 = in vitro true dry matter digestibility after 48 hours; RFQ = relative forage quality. Red lines denote the approximate range of nutrient requirements for a mature Jersey producing 35 lb milk/day) according to *Nutrient Requirements of Dairy Cattle* published by the National Academies of Sciences, Engineering, and Medicine (2021). Treatment differences were significant at $P < 0.15$.

Crude Protein: In the spring, the perennial and the annual ryegrass/crimson clover mixtures had the highest CP, likely due to greater legume content compared to other mixtures. Crude protein was also highest in the perennial mixture in the summer due to low legume yields in all annual systems.

Total Digestible Nutrients: During the spring, the perennial mixture had lower TDN than the annual mixtures which is consistent with other research demonstrating that annual cool-season species generally have greater forage nutritive value than perennials. During the summer there was no difference in TDN between all mixtures and the values were lower than the spring mixtures.

Acid and Neutral Detergent Fiber: Both ADF and NDF increased during the summer, likely because greater temperatures often increase fiber concentrations. Most research confirms that winter annuals have lower fiber values than summer annual grasses at similar stages of maturity. Lower fiber values typically result in greater intake and digestibility. During the spring, the perennial mixture had greater ADF than the annual ryegrass/crimson clover mixture, although the difference was small (2 percentage units). During the summer, the perennial mixture had lower ADF and NDF than the SS/cowpea mixtures. This likely would result in greater intake and digestibility of the perennial mixture as compared to the SS/cowpea mixtures during the summer. Interestingly, the crabgrass mixture had similar ADF and NDF values as the perennial mixture.

In Vitro Digestibility and Relative Forage Quality: No statistical differences between forage mixtures occurred for either the spring or summer, although both parameters were lower during the summer.

It is important to note that pasture is generally not the only feed source for grazing dairy cows, as many are supplemented with a PMR (partial mixed ration) and/or grain.

Recap and Tips for Success

- Overall, the perennial mixture had greatest annual yields and the highest crude protein in each season. The perennial mixture also yielded higher and had less weeds than the summer annual mixtures.
- Summer annual production appears to be nitrogen-limited.
  - Yields may be improved with an affordable nitrogen source, such as poultry litter.
- Sorghum x sudangrass mixtures were weedy and often displayed poor regrowth following grazing.
  - Utilization and/or regrowth of summer annuals may be improved with more intensive grazing management, or by making baleage, although this requires more input and results in a costlier forage source but offers the ability to store forage for winter use and allows legumes more chance to contribute to yield.
- Winter annual mixtures had greater TDN in spring than the perennial mixture and would fit well as a grazeable cover crop on a portion of the farm.
- Summer TDN was low in all mixtures.
  - Energy supplementation may be warranted (or increased) during the summer months. On organic dairies, offering grain or other supplements has been shown to result in increased milk production and greater return over feed costs (Hardie et al., 2014) and net returns to the farm (Allison Jr. et al., 2021).
  - Remember to test forage to optimize the economics of supplements, if used.
- Although summer annuals did not offer greater yield or forage nutritive value compared to the perennial mixture, planting annuals may be useful as:
  - A transition or smother crop
  - Grazeable cover crops if fencing/water exists around crop fields
  - Emergency forage
- Crabgrass mixtures may have yielded higher if they were to have had minor tillage or soil disturbance to improve reseeding.
  - Winter and summer annual rotations of annual ryegrass and crabgrass may result in higher yields if grown further south where the growing season is extended during times when each species is more active.
  - A properly managed annual ryegrass/crabgrass/red clover rotation can result in crabgrass re-seeding, resulting in fewer establishment costs in subsequent years.
- Summer annual legumes did not yield well on these farms.
  - These forages may not be cost effective unless utilized as silage or baleage, as many do not regrow well after grazing.
- Winter and summer annual rotations have risk of establishment failure twice a year.
- The transition zone has a very short window for grazing winter annuals.

Final Thoughts

Overall, the perennial cool-season mixture was the most dependable on these farms. Other studies have also shown that perennial forage systems are a more economical forage source than annual systems for organic diaries (Allison Jr. et al., 2021). Annuals should likely not comprise the majority of the forage system for organic dairies, however, annuals may offer additional flexibility to a grazing rotation during times when perennial forage production is low.

Acknowledgements

Many thanks to the farmers who participated in this research project: Irvin Raymer, Nathan Weaver, John Beiler, Jake Beiler, Melvin Troyer, and Butch Lay. This project was funded by a USDA NIFA OREI grant (2015-51300-24140) and seed was supplied by Jesse Ramer.

References

Agriculture, 7. 7 C.F.R. § 205.237(c)(2) (2022)

Allison Jr, J., K. H. Burdine, C. Dillon, S. R. Smith, D. M. Butler, G. E. Bates & G. M. Pighetti. 2021. Optimal forage and supplement balance for organic dairy farms in the Southeastern United States. Agricultural Systems, 189, 103048.

Ball, D. M., C. S. Hoveland, and G. D. Lacefield. 2007. Southern forages 4th edition. International Plant Nutrition Institute, Norcross, GA.

Hardie, C. A., M. Wattiaux, M. Dutreuil, R. Gildersleeve, N.S. Keuler, and V.E. Cabrera. Feeding strategies on certified organic dairy farms in Wisconsin and their effect on milk production and income over feed costs. Journal of Dairy Science 97(4612-4623).

Mercier, K., C. Teutsch, S. Smith, K. Burdine, E. Ritchey, and E. Vanzant. 2022. Is There an Economic Advantage to Planting Diverse Summer Annual Forage Mixtures? Journal of Extension.

NASEM, National Academies of Sciences, Engineering, and Medicine. (2021). Nutrient requirements of dairy cattle: Eighth revised edition. The National Academies Press. .

USDA-NASS. 2022. 2021 Certified Organic Survey. Table 18: Certified Organic Livestock Products and Poultry Products Sales: 2021.

USDA, NASS, Kentucky Field Office. 2020. Farm sales of Kentucky organic products triples. Press Release.

USDA-National Organic Program, Livestock feed, 7 C.F.R. § 205.237I(2) (2022).

Authors

Kelly Mercier
USDA-ARS Area Grazing Specialist
Former University of Kentucky Graduate Research Assistant

Ray Smith
University of Kentucky Extension Professor and Forage Specialist

Kenneth H. Burdine
University of Kentucky Associate Extension Professor and Livestock Economist

Katie Payne
Virginia Tech Applied Forage Systems Specialist
Former University of Kentucky Graduate Research Assistant

Liz Eckelkamp
University of Tennessee Assistant Professor and Dairy Extension Specialist

Gina Pighetti
Former University of Tennessee Associate Professor of Animal Science

Gary Bates
University of Tennessee Professor and Forage Extension Specialist

David Butler
University of Tennessee Professor of Plant Sciences

Cooperative Extension Service

Agriculture and Natural Resources
Family and Consumer Sciences
4-H Youth Development
Community and Economic Development

MARTIN-GATTON COLLEGE OF AGRICULTURE, FOOD AND ENVIRONMENT

Lexington, KY 40506 Issued 3-2024