Forage Systems to Optimize Agronomic and Economic Performance in Organic Dairy Systems

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Presenter Information

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Abstract
Organic dairy production in the USA is growing, but most forage systems research focuses on conventional production practices. As a result, organic dairy producers have limited science-based information to assist with farm and livestock management. The objective of this project was to use a multi-faceted approach to determine the ideal species mixtures for organic dairy production as well as document forage quality, forage yield, soil characteristics, milk production and milk quality during the grazing season. The forages studied ranged from a single species monoculture to a four species mixture of warm and cool season grasses and legumes. Nine distinct forage systems were seeded into small plots at the University of Tennessee and University of Kentucky research farms using organic practices. These plots were monitored for three years for yield, quality, species composition, and soil characteristics. The four best performing forage systems were planted in small paddocks on organic dairy farms in Tennessee and Kentucky to evaluate forage yield, forage quality, seasonality of production, and suitability for on-farm milk production. The superior forage system was established on a 4 ha paddock and compared the existing forage system used by each of the dairy farms. These larger paddocks allowed continued measurements of forage yield and quality, as well as measurements of milk production, milk quality, and grazing behaviour of the animals. The information from this project is currently being incorporated into a total farm management system for organic dairy producers in the Southeastern USA.

Introduction
The demands for organic milk continue to rise in the United States, with supply not keeping pace with demand. In the southeast, pastures are available for extended periods of time compared to the midwest and northeast, and there is an opportunity to increase the supply of organic milk while minimizing costs spent on grains and fuel. There also is increasing interest by producers in the Southeast to transition to organic milk production as a means to increase the viability of small, family farms. However, there is limited research and extension information from this region to help with the transition to organic or help farmers once the switch to organic has been established. This is especially true in the areas of forage management, maximizing forage use for greatest efficiency and productivity, animal health, managing heat stress, economics of organic systems, and effective decision support tools.

The overall objective of this project was to use a multi-faceted approach to determine the ideal species mixtures for organic dairy production in the Southeastern USA as well as document forage quality, forage yield, soil characteristics, milk production, milk quality and animal health during the grazing season. This paper focuses on the forage components and economics of the project and future papers will highlight the animal health and milk quality aspects of the research.

Methods
<u>Agronomic Research</u> - This research project was initiated with a study that compared standard perennial monocultures with simple and complex mixtures of species and functional groups (warm- and cool-season annual and perennial grasses and legumes) in order to determine feasible forage mixtures suited to organic production in the region. Small plots (1.5 x 7.5m) were established on the organic research units of the University of Kentucky, Lexington, KY and the University of Tennessee, Knoxville, TN. Nine forage mixtures were planted in a randomized complete block design with four replicates. Initial establishment was fall of 2015, with some reestablishment in TN spring of 2016 and harvests occurred during the 2016-2018 growing seasons. Annual warm and cool season components were planted in May and September each year, respectively. These plots were managed organically with no application of herbicides, insecticides, or commercial fertilizers. The growth and maturity stage of the plots were assessed weekly to ensure timely harvests. The forage mixtures were as follows: A - red clover (*Trifolium pratense* L.) monoculture; B - orchardgrass (*Dactylis glomerata* L.) monoculture; C - red clover + orchardgrass mixture; D - alfalfa

(*Medicago sativa* L.) + orchardgrass mixture; E - red clover + orchardgrass + novel endophyte tall fescue (*Schedonorus arundinaceus* (Schreb.) Dumort.) mixture; F - red clover + orchardgrass + crabgrass (*Digitaria ciliaris* (Retz.) Koeler) mixture; G - red clover + annual ryegrass (*Lolium multiflorum* (Lam.) Husnot) + crabgrass mixture; H - crimson clover (*Trifolium incarnatum* L.) + annual ryegrass followed by sorghum-sudangrass (*Sorghum bicolor* (L.) Moench *x S. bicolor* (L.) Moench *var. sudanense* (Piper) Hitchc.) + cowpea (*Vigna unguiculata* (L.) Walp.) mixture; and I - crimson clover + annual ryegrass followed by crabgrass + annual lespedeza (*Kummerowia spp.* Schindl.)

<u>Economic Modelling</u> – One component of this project was the development of a linear programing model to represent a typical whole-farm organic dairy operation in the Southeastern United States. The representative dairy farm modelled was based on actual organic dairy operations in Tennessee and Kentucky. The model was designed investigate and optimize enterprise and feed options for the operation.

Results

The highest yielding treatment in Kentucky over the 3 year study was the alfalfa/orchardgrass mixture (Fig. 1). In contrast, 150 miles south in Tennessee, the cool season/warm season mixture of crimson clover/annual ryegrass and sorghum-sudangrass(SS)/cowpea was the highest yielding mixture (Fig. 2). During the summer of 2016 the perennial cool season forage treatments had the highest summer crude protein (CP) (~20%) in KY with the exception of the pure orchardgrass stand. Crude protein values in TN were overall lower than KY (<13%) and the lowest CP was the high yielding SS containing mixture at 8%. Fiber values were similar for all treatments in KY (NDF=39-45), with the exception of the SS treatment at NDF=55. In Tennessee, NDF values were all above 50 and the SS value was highest at NDF=64. The alfalfa/orchardgrass ADF value was 29 in KY, but not significantly different than the other treatments that ranged from ADF=30-35. In TN, the crabgrass/annual lespedeza mixture had the lowest ADF at 34, with the other treatments ranging from ADF=38-43. Overall, forage quality was related to the legume percentage in the mixtures, partly explaining the higher forage quality for most of the treatments in KY.

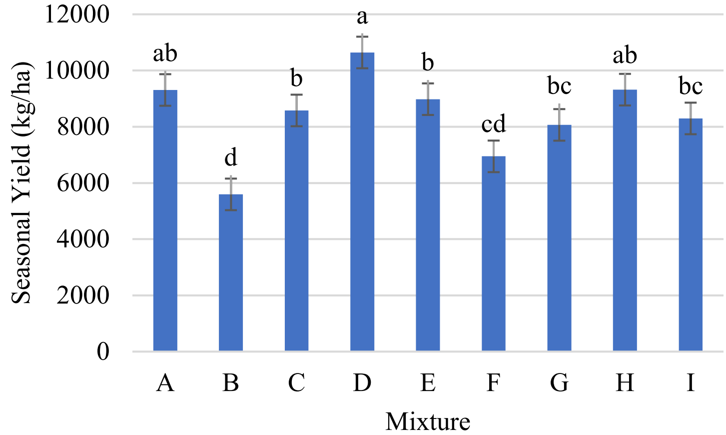

Figure 1. Yield of organically managed warm and cool season forages in Kentucky averaged over the 2016, 2017, and 2018 growing seasons.

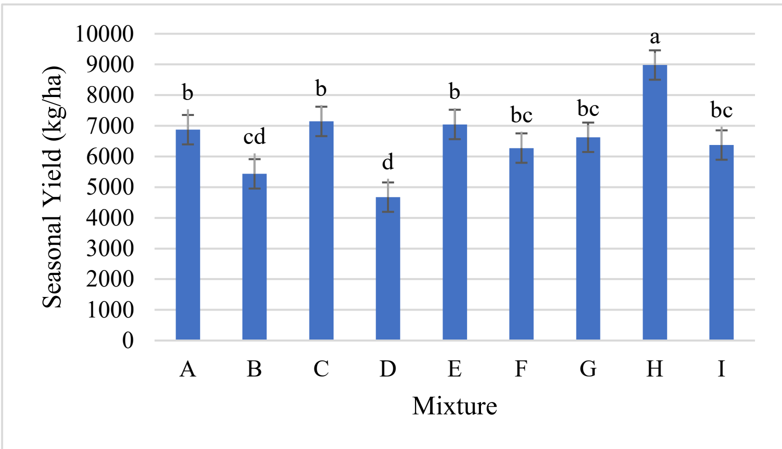

Figure 2. Yield of organically managed warm and cool season forages in Tennessee averaged over the 2016, 2017, and 2018 growing seasons.

Discussion

The economic modelling component used the small plot and on-farm data and was published in Agricultural Systems Journal by Allison et al. (2021). The model showed that the perennial cool season mixture provided the most cost efficient forage production in comparison to the annual cool/warm season mixtures mainly because of the added cost of planting annual forages twice per year. Based on 2019 organic milk price levels, the modelled farm was profitable, but price trends for organic milk and the cost of transitioning to an organic dairy production system created significant potential challenges. The model confirmed the cost-effectiveness of significant feed allocation through grazing (a minimum of 30% dry matter intake from grazing is required for USDA certified organic production), but the production and purchasing of additional supplemental feeds provided economically viable increased milk production.

Agronomically, the results from the small plot research agree with the conclusions of the modelling project, in that the yield and quality of the alfalfa/orchardgrass mixture (at least in KY) was superior to the annual mixture containing sorghum-sudangrass. It is important to note that these conclusions were based on organic forage production, in a conventional system with high fertilizer N inputs, the annual warm season forages would likely have higher yields and potentially higher quality.

Application of Research

Based on the yield and quality results of these small plot studies, four mixtures were planted in on-farm trials in KY and TN. The results from these on-farm trials were incorporated into an Excel based decision support tool that provides producers the ability to calculate estimated costs of production for organic pasture mixtures. This decision tool also allows producers manipulate all of the input options. The tool does not take forms of revenue into consideration, but considers input and machinery costs relevant to annual yields. All calculations are done on a per unit area basis as well as at the whole-farm level. The field sizes are in acres (2.5 acres = 1 ha) and English units of yield (1 lb = 0.4 kg and 1 ton = 0.91 tonnes) to better facilitate interpretation by US producers. Individual sheets are provided for each budget, and a summary sheet is used to easily compare total costs across the mixtures.

Table 2. Input Quantities per Acre

Input	Quantity (units/acre)
Manure (tons)	2
Lime (tons)	2
Grazing/Roatation Labor (hours)	1
Fence Maintenance Labor	1
Other Labor (hours)	0
Operating Interest (%)	6%
Interest Period (Months)	6
Forage Stand Useful Life (years)	4
Forage Utilization Efficiency (%)	70%

Table 3. Input Prices ($/units)

Input	Dollars Per Unit
Manure ($/ton)	$15.00
Lime ($/ton)	$20.00
General Labor ($/hour)	$11.00
Operator Labor ($/hour)	$18.00
Farm Diesel ($/gallon)	$2.25
Pasture Cash Rent Equiv. ($/acre)	$45.00
Rental	$0.00
Other Variable Costs	$0.00
Other Fixed Costs	$0.00

Table 4. Seed Prices

Species	Dollars Per Pound
Alfalfa	$4.50
Annual Lespedeza	$4.50
Annual Ryegrass	$0.95
Cowpea	$1.69
Crabgrass	$7.50
Crimson Clover	$1.50
Orchardgrass	$3.50
Rape	$2.50
Red Clover	$3.00
Sorghum-Sudangrass (Sudex)	$1.06
Spring Oat	$0.40
Tall Fescue	$3.50
Turnip	$2.50

Table 5. Seeding Rates By Mixture

Mixture and Species	Pounds Per Acre	Mixture and Species
Mix A - Warm Red Clover (WRC)		**Mix B - Warm Crimson Clover (WCC)**
Red Clover	8	Crimson Clover
Annual Ryegrass	20	Annual Ryegrass
Crabgrass	4	Sorghum-Sudangrass (Sudex)
Annual Lespedeza	15	Cowpea
Mix C - Cool Season (CS)		**Mix D - Warm Turnip and Rape (**
Red Clover	5	Turnip
Alfalfa	10	Rape
Orchardgrass	5	Spring Oat
Tall Fescue	8	Annual Ryegrass
		Sorghum-Sudan (sudex)
		Cowpea

Cover | Instructions | Inputs | Machinery | Summary | A - Annual Budget | B - Annual Budget | C - Annual

Figure 3. General input quantities and prices are accounted for on the Inputs page. The seed quantities and yields that are present are the actual values from on-farm research trials.

Summary of Costs Per Acre

	Mix A (WRC)	Mix B (WCC)	Mix C (CS)	Mix D (WTR)
Typical Annual Yield (tons/acre)	4	4	4	4
Annual Costs ($/acre)				
Total Seed Costs	$122.50	$117.05	$26.38	$115.75
Prorated Establishment Costs	$16.00	$10.00	$50.50	$10.00
Variable Costs	$331.58	$325.96	$168.84	$310.80
Fixed Costs	$0.00	$0.00	$0.00	$0.00
Total Costs	**$331.58**	**$325.96**	**$168.84**	**$310.80**
Average Cost per Ton Dry Matter	$82.89	$81.49	$42.21	$77.70
Average Cost Per Ton Of Utilized Forage	$118.42	$116.42	$60.30	$111.00

Summary of Costs Whole-Farm

	Mix A (WRC)	Mix B (WCC)	Mix C (CS)	Mix D (WTR)	Total Whole-Farm
Typical Annual Yield (tons/acre)	4	4	4	4	
Total Acres Planter	10	10	10	10	
Total Annual Yield (tons/farm	40	40	40	40	
Annual Costs ($/acre)					
Total Seed Costs	$1,225.00	$1,170.50	$263.75	$1,157.50	$3,816.75
Variable Costs	$3,315.76	$3,259.62	$1,688.36	$3,108.03	$11,371.76
Fixed Costs	$0.00	$0.00	$0.00	$0.00	$0.00
Total Costs	**$3,315.76**	**$3,259.62**	**$1,688.36**	**$3,108.03**	**$11,371.76**

Figure 4. A summary page displays costs per acre for each mixture. The summary page is useful to compare costs across mixtures or to produce a whole farm budget that includes several forage mixtures.

Conclusions

This research demonstrated that complex forage mixtures can be beneficial for organic dairy producers, but perennial cool season mixtures likely provide the most economical forage production in the transition zone of the United States.

Acknowledgements

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References

Allison, J., Burdine, K.H., Dillon, C., Smith, S.R., Butler, D.M., Bates, G. and Pighetti, G. 2021. Optimal forage and supplement balance for organic dairy farms in the Southeastern United States. *Agricultural Systems,* 189 (2021) 103048. http://doi.org/10.1016/j.agsy.2021.103048

Allison, J., Smith, S.R., and Burdine, K.H. 2019. Organic forages for pasture – estimated costs of production. Joint University of Kentucky and University of Tennessee publication. http://forages.ca.uky.edu/file/decisionaids