GRAZING COVER CROPS

IN ORGANIC VEGETABLE CROP SYSTEMS

What is an Integrated Crop Livestock Vegetable System (ICLS)?

An ICLS incorporates animals for grazing cover crops, crop residues or other vegetation between cash crops in the same plot of land or operation. In these systems, grazing typically occurs before seeding or transplanting fresh produce crops. Small ruminants, sheep and goats, are frequently used in these integrated systems.

Why use Integrated Crop Livestock System (ICLS)?

1

Soil health is improved when soil remains "covered" between cash crops using cover crops. Since ICLS require cover crops for forage, livestock grazing allows implementation of several soil health principles to help conserve natural resources and reduce nitrate leaching during winter. Over time, this will increase soil fertility and lead to higher nutrient density of the crops.

2

ICLS can improve animal health. Animals in ICLS have access to a diverse range of residue crops from cover crops to cover crops from pasture grazing. This diversity of forage and grazing improves animal health and welfare.

3

Costs related to mechanical cultivation and fertility inputs are offset by animals grazing in the field, providing animal manure and cover crop residue (green manure) and general land maintenance through grazing.

4

ICLS provides an innovative solution for organic farmers to manage soil fertility and improve soil health without the use of synthetic fertilizers, as mandated by organic rules.

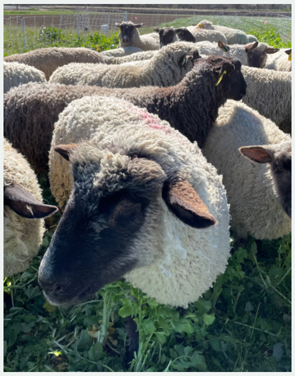
How does ICLS fit into USDA Certified Organic farming systems?

The USDA National Organics Program (NOP) prohibits producers from using any form of harmful material that might lead to the contamination of the environment or the crop itself, this includes synthetic fertilizers.

Organic standards require farmers to implement tillage and cultivation practices that maintain or improve the physical, chemical, and biological condition of soil and minimize soil erosion.

ICLS can help replace soil nutrients while also protecting important soil properties that lead to the improvement of soil health.

Despite the benefits of ICLS, there is concern about the potential transfer of foodborne pathogens from animals to the soil and subsequent crops.



Grazing animals inherently have foodborne pathogens in their gut like *Salmonella* and pathogenic *E. coli* and shed them in feces. To safely adopt...farmers are encouraged to voluntarily consider applying wait periods between grazing and harvest, and organic farmers typically follow NOP standards.

Based on the USDA National Organics Program rules, when raw manures are applied in fresh produce fields, there should be a wait period of 90–120 days between the placement of raw manure and the harvesting of the crops. Untreated animal manure must be incorporated into the soil at least 90 days prior to harvest for crops whose edible portions are not in contact with soil, or 120 days for those whose edible portions are in direct contact with soil.

How is ICLS used across different production systems?

GRAZING OF COVER CROPS BETWEEN CASH CROPS AND RESIDUE CROPS

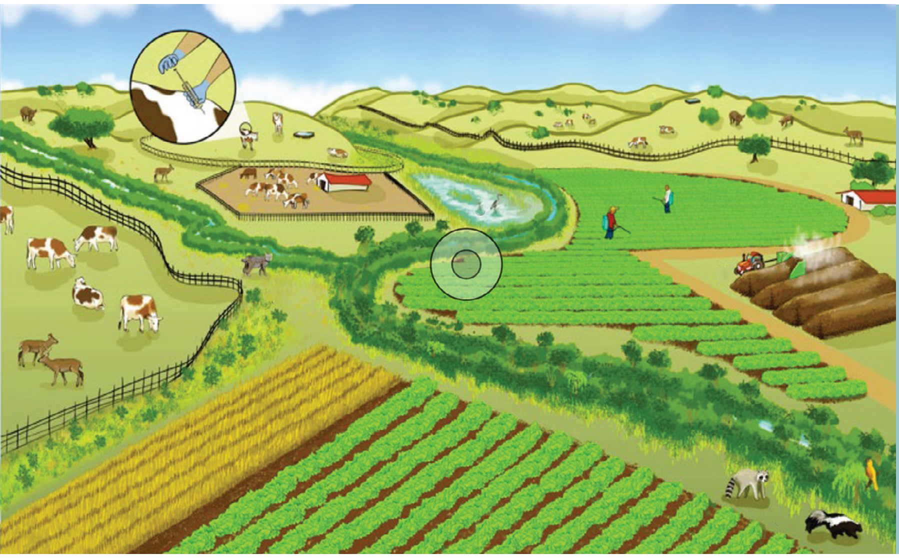
WINTER VINEYARD UNDERSTORY GRAZING DINING VINE DORMANCY

SPRING COVER CROPS; GRAZING IN NUT CROPS SYSTEMS

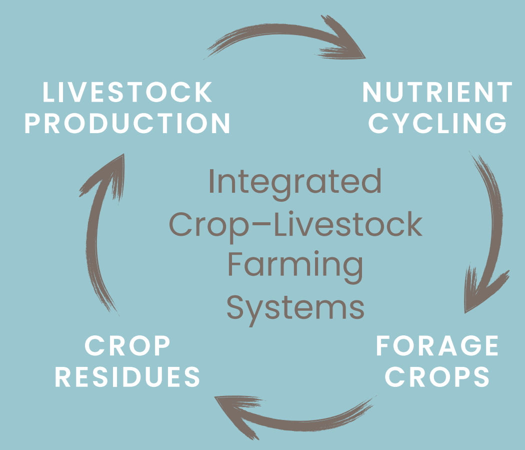
CASE STUDY

Integrated Crop-Livestock in Fresh Produce

A MULTI-STATE STUDY



Adapted from UC Berkley News



PROBLEM STATEMENT

Despite the well-known benefits of animal-crop integration, concerns over microbial food safety have been limiting the expansion of animal integration into cropping systems. While recent research has shown that integrated crop-animal systems perform well in keeping pathogens out of meat, additional research is needed to examine the impacts of integrating livestock for cover crop grazing on ecosystem health and food safety.

PROJECT GOALS

This project aimed to fill this research need to evaluate the food safety impacts of sheep/goats grazing cover crops, compared to tilled termination of cover crops, and winter fallow, before spinach and cucumber. The project had three major goals:

1

Determine foodborne pathogen survival and persistence in soil and potential risk of transfer to vegetable crops,

2

Examine soil health outcomes of grazing cover crops in highly tilled systems and potential to build up soil fertility and nutrient cycling,

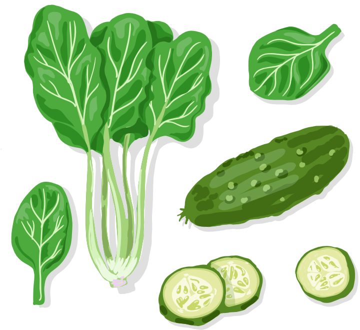
3

Determine the relationship between soil health proprieties, environmental factors like rainfall and temperature and pathogen survival in grazed cover crop-vegetable production.

PROJECT APPROACH

Organic fresh produce fields in **California**, **Minnesota**, and **Maryland** were involved in extensive research using sheep/goats as grazing animals to make decisions on adoption, management, and environmental benefits of winter cover crop and evaluation of potential food safety risks in annual ICLS vegetable systems.

In the multi-state ICLS field trials held over 2 years (2021–2023), the soil health and composition benefits, and food safety risks were assessed using a randomized complete block design with four replicates in organically managed fields, with three different treatments—fallow, plots with cover crops but no grazing, and plots with cover crops and grazing events. For fresh produce, spinach and cucumber were planted in the first and second year of the trials.



This work took place in three states with distinct pedoclimatic features.

FUNDING

U.S. Department of Agriculture's (USDA) Agricultural Marketing Service through grants AM190100XXXXG08 and AM200100XXXXG032.

Timeline

CALIFORNIA	YEAR 1	11/23/2020–7/1/2021
	YEAR 2	11/8/2021–7/14/2022
MINNESOTA	YEAR 1	8/19/2020–8/23/2021
	YEAR 2	9/7/2021–10/10/2022
MARYLAND	YEAR 1	03/15/2021–12/2/2021
	YEAR 2	11/20/2021–10/26/2022

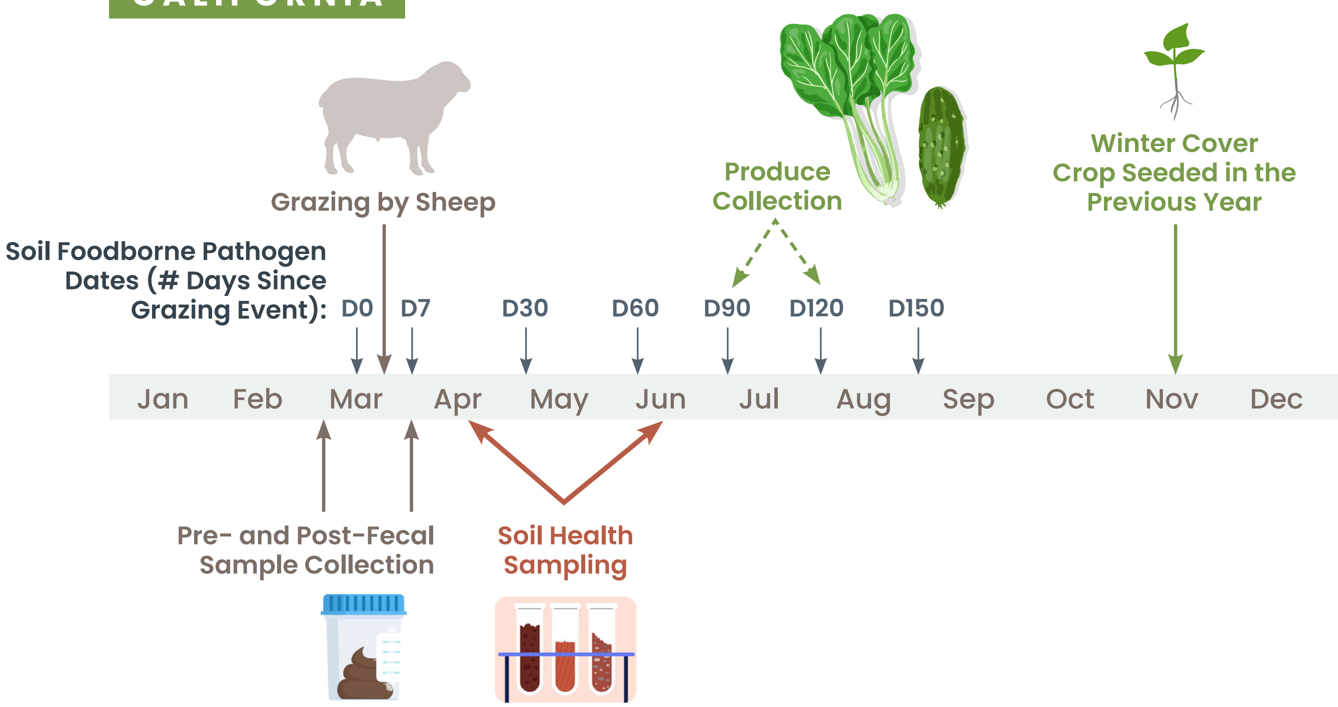
Multi-state research makes for a complicated timeline, especially when experiments take place in regions with very different climates.

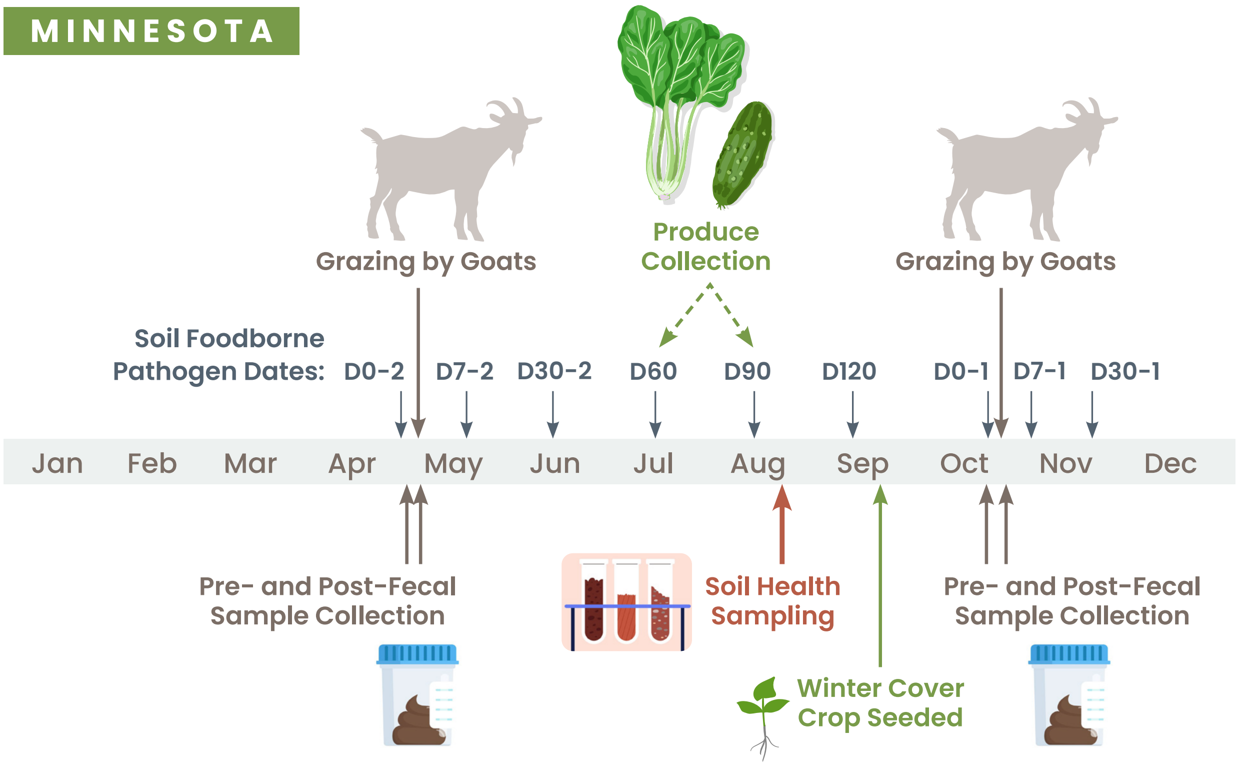
Growing seasons depend on the climate conditions so cropping schedules which varied dramatically for the different study regions.

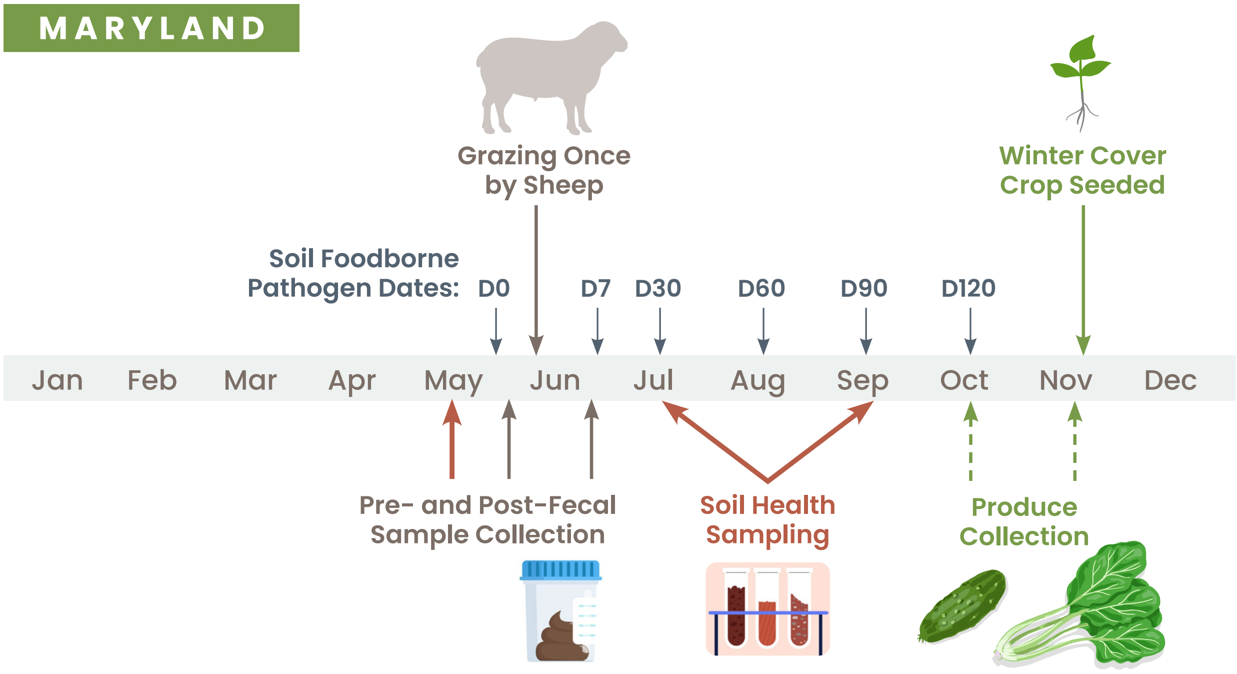
For instance, California's climate in the Central Valley, where this research took place, is considered semi-arid, while Minnesota's climate is considered humid-continental, and Maryland has humid coastal climates.

The typical growing seasons of each state were March through July in California, May through August in Minnesota, and May through October in Maryland. It's worth noting that average rainfall and snowfall in these regions also varied dramatically.

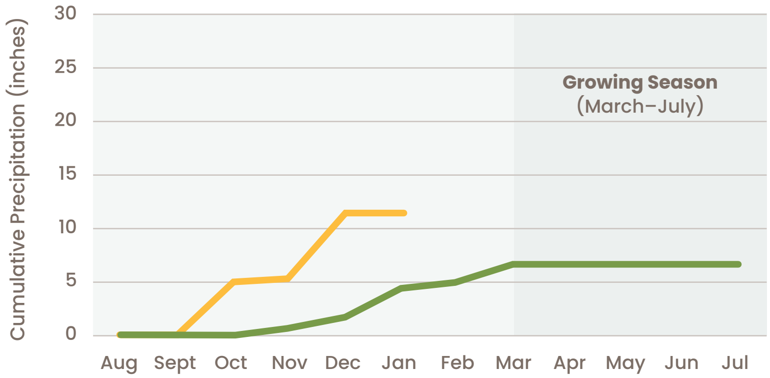
CALIFORNIA




MINNESOTA
Grazing by Goats
Produce Collection
Grazing by Goats
Soil Foodborne Pathogen Dates:
D0-2
D7-2
D30-2
D60
D90
D120
D0-1
D7-1
D30-1
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Pre- and Post-Fecal Sample Collection
Soil Health Sampling
Winter Cover Crop Seeded
Pre- and Post-Fecal Sample Collection


MARYLAND
Grazing Once by Sheep
Winter Cover Crop Seeded
Soil Foodborne Pathogen Dates:
D0
D7
D30
D60
D90
D120
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Pre- and Post-Fecal Sample Collection
Soil Health Sampling
Produce Collection

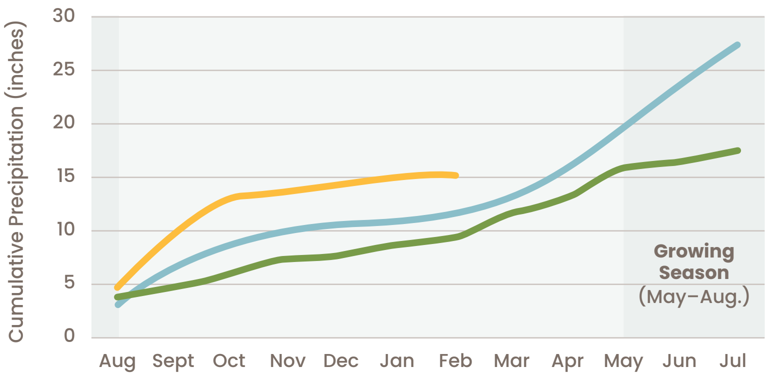
DAVIS, CALIFORNIA PRECIPITATION 2020–2022



2020–2021
2021–2022

There is a lot of variation in annual rainfall and the “average” is rarely the experience in **Davis, California**. In most years the rainfall is either much lower or higher than the average of 20 inches. Drought conditions were experienced during this experiment with less than 6 and 12 inches of rain for the two years respectively.

LAMBERTON, MINNESOTA PRECIPITATION 2020–2022



2020–2021
2021–2022
Longterm Cumulative Precipitation 1961–2022

Minnesota typically experiences variable rainfall throughout the year up to about 25 inches annually, and during this experiment rainfall was below average the first year, and above average the second year.

Cropping sequences for the experiments also varied by region

- Each state followed a cropping sequence generally accepted by regional organic vegetable growers. Accordingly, winter cover crops were seeded in November in California, September in Minnesota and Maryland before long snowy winters.
- Goats and sheep were allowed to graze after cover crop growth for durations that depended on the cover crop length at the start of the grazing period. Depending on the weather and crop growth, some states had two grazing events before seeding or transplanting fresh produce.

Cover crop mixes varied across states

CALIFORNIA

In California, the cover crop mix (cereal rye, crimson clover, and daikon radish) was only grazed once in March (2021) and in February (2022), and then spinach (2021) or cucumber (2022) were planted because spring is typically shorter and there is a smaller window for successfully growing fresh produce. Spinach and cucumber were grown by June (2021) and July (2022) in California.

MINNESOTA

In Minnesota, the cover crop mix (winter rye, berseem clover and daikon radish) was grazed once in the fall (November in 2021 and October in 2022), then buried under snow for much of the winter. It grazed again in Spring (April in 2021 and May in 2022), once the snow melted. Spinach and cucumber were grown by June (2021) and September (2022).

MARYLAND

In Maryland, the cover crop mix (winter rye, crimson clover and daikon radish) was planted in March 2021 and grazed once in July, then minimally tilled before next planting. Spinach was direct seeded and harvested. Same type of cover crops were replanted in November 2021 and grazed once in June 2022. Cucumbers were transplanted, but were not able to harvest because crops failed.

These differences in the cover crop/crop cycle added to the robustness of our analysis of the impacts of grazing on foodborne pathogen risk and soil health indicators.

Behavior of sheep and goats—Meet your four-legged friends!

SHEEP are primarily grazers that favor grasses, and can overgraze land right down to the dirt if not moved and managed properly sheep are selective grazers, choosing plant parts which are higher quality than cattle.

While **GOATS** have a reputation for nibbling on anything and everything, they are actually “browsers” and can be very selective about what foliage they want to eat. Goats tolerate more bitter feeds than sheep and often consume browse plants in preference to grasses.

Study Results

How ICLS impacted soil health

Soil physical properties

- Aggregation and compaction were not altered by cover crop grazing

Soil chemical properties

- Grazing did not increase soil salinity and macronutrients (Mg, Ca, K, Na, P)
- Slight increase in availability of micronutrients at peak uptake in grazed compared to fallow (Zn, Mn, Cu)
- Cover crop and cover crop + grazing both had an acidifying effect on the soil

  pH of ~ 7.2 compared to ~ 7.5 in fallow
- The effect of using cover crops was stronger than the effect of grazing on labile nitrogen pools which are important food sources for beneficial soil microbes
- However, grazing can improve the timing of organic nitrogen release from inorganic pools for uptake by crops

  For example, 22, 59, and 85 lbs of N per acre were measured in fallow, ungrazed with cover crop, and grazed cover crop, respectively, during crop in project Year 3
- Nitrate leaching was not significantly higher in grazed cover crop plots

Soil health indicators used in this study

PHYSICAL

- Aggregate stability (how soil sticks together)
- Water-holding capacity
- Infultration and porosity
- Susceptibility to runoff and erosion

CHEMICAL

- Nitrogen
- Phosphorus
- Potassium

BIOLOGICAL

- Organic matter
- Microbial biomass
- Earthworm abundance
- Weed pressure and diversity

Soil microbial properties

Grazing cover crops resulted in:

- Trends of greater microbial activity, measured as respirable carbon

  For example, grazed plots had a 35% and 9% increase in microbial activity over fallow and ungrazed cover crop plots respectively, in project Year 3

- Lower fungi to bacteria ratios, indicating a drastic shift in microbial communities and processes with grazing. Thriving bacterial communities in these systems increase nutrient cycling.

  For grazing cover crops in California, fungi:bacteria ratios were 0.23, 0.11, 0.03 in fallow, ungrazed cover crops, and grazed cover crops, respectively, at the final sample period

Reduced weed pressure

The emergence of barnyard grass (a summer weed) was suppressed with grazing in cover cropped plots

How ICLS impacted food safety risk

The results of this multi-year project support using the USDA National Organic Program (NOP) 90- or 120-day interval rule between applying raw manure or grazing and harvesting

- The two-year data of the multi-state ICLS trials showed minimal risk of transferring foodborne pathogens from fecal into to the soil and produce after grazing.
- To assess the application of a 90–120 day wait period between grazing and harvesting in ICLS, recent meteorological events should be considered, because the survival of indicators of fecal contamination were relevant to precipitation and soil/air temperature of the regions.

  For example, more rainfall and lower soil temperatures were associated with a greater risk of generic E. coli *across all treatments.**

  Within grazed soil, lower air and soil temperature were linked to the higher generic E. coli *concentration once it is contaminated.**

  *Presence of pathogens in the soil environment was infrequent during the sampling periods.**

- Furthermore, other sources of contamination such as a presence of wildlife and water contamination should be investigated to minimize the risk of foodborne pathogen contamination as an integrated risk assessment of the farm environment.

**Findings from California and Minnesota only.*

RECOMMENDATION FOR FARMERS

What can you do on your farm when using this system?

- Plan around the weather patterns typical to your region.
- Follow the USDA-NOP 90–120 days standards between application of manure and harvesting of the crops.
- Plan your crop planting and grazing schedule in agreement with the USDA–NOP 90–120 days standards.
- Follow the food safety requirements by third-party certifiers and food safety experts.
- Keep a recording log of your crop planting, grazing schedule and planned harvesting.
- Be in compliance with the FSMA-FDA food safety rule and best practices for reducing the risk contamination of covered produce. For more information on food safety compliance, check the PSA, University of Cornell website.
- Work with your farmer advisor(s) or extension agent(s) on selection of cover crop mix and grazing approach adequate to your region.

RECOMMENDATIONS FOR FUTURE RESEARCH

- Timing of nutrient release in no till systems and soil health accrual on the longer term.
- Pest suppression potential, both in terms of weed suppression and mobile organisms.
- Integrated socio-ecological analysis of outcomes: How to implement these systems practically in vegetable and orchard production and what are the economic benefits and cost structures.

Resources

Research and Outreach Team

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Webinars

Virtual Field Day: Integrating Livestock in Organic Crops and Its Impacts on Food Safety and Soil Health
https://www.organic-center.org/%F0%9F%92%BB-webinar-demand-virtual-field-day-integrating-livestock-organic-crops-and-its-impacts-food-safety

Crop-Livestock Integration in Organic Produce Crops: Its Impacts on Food Safety & Soil Health
https://www.organic-center.org/%F0%9F%92%BB-webinar-demand-crop-livestock-integration-organic-produce-crops-its-impacts-food-safety-soil

Balancing Soil Health and Food Safety for Organic Fresh Produce Production
https://www.organic-center.org/%F0%9F%92%BB-webinar-demand-balancing-soil-health-and-food-safety-organic-fresh-produce-production

Resources from Other Organizations

Organic Farming Research Foundation (OFRF) has farmer stories, videos and fact sheets about livestock integration
https://ofrf.org/crop-livestock-integration/

Rodale Institute Study on Livestock Integration
https://rodaleinstitute.org/science/crop-livestock-integration/

NRCS Livestock and Pasture Management
https://www.nrcs.usda.gov/getting-assistance/other-topics/organic/nrcs-assistance-for-organic-farmers/livestock-and-pasture-management

NRCS Assistance for Organic Farmers
https://www.nrcs.usda.gov/programs-initiatives/eqip-organic-initiative

Publications from the Research Team

Presence of foodborne pathogens and survival of generic *E. coli* in an organic integrated crop-livestock systems. Front. Sustain. Food Syst., Agro-Food Safety
https://doi.org/10.3389/fsufs.2024.1343101

Risk factors associated with the prevalence of Shiga-toxin-producing *Escherichia coli* in manured soils on certified organic farms in four regions of the USA
https://www.frontiersin.org/articles/10.3389/fsufs.2023.1125996/full

Evidence for the efficacy of pre-harvest agricultural practices in mitigating food-safety risks to fresh produce in North America
https://wwsw.frontiersin.org/articles/10.3389/fsufs.2023.1101435/full

Salmonella and *Escherichia coli* Prevalence in Meat and Produce Sold at Farmers' Markets in Northern California
https://www.sciencedirect.com/science/article/pii/S0362028X22107623

Assessment of Biological Soil Amendments of Animal Origin Use, Research Needs, and Extension Opportunities in Organic Production
https://www.frontiersin.org/articles/10.3389/fsufs.2019.00073/full

Small-scale and backyard livestock owners needs assessment in the western United States
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0212372

Persistence of *Escherichia coli* in the soil of an organic mixed crop-livestock farm that integrates sheep grazing within vegetable fields
https://doi.org/10.1111/zph.12503

Assessment of Current Practices of Organic Farmers Regarding Biological Soil Amendments of Animal Origin in a Multi-regional U.S. Study
https://www.foodprotection.org/files/food-protection-trends/sep-oct-18-pires.pdf

Survival and Persistence of Foodborne Pathogens in Manure-Amended Soils and Prevalence on Fresh Produce in Certified Organic Farms: A Multi-Regional Baseline Analysis
https://www.frontiersin.org/articles/10.3389/fsufs.2021.674767/full

Risk factors of Shiga toxin-roducing *Escherichia coli* in livestock raised on diversified small-scale farms in California
https://www.cambridge.org/core/journals/epidemiology-and-infection/article/risk-factors-of-shiga-toxinproducing-escherichia-coli-in-livestock-raised-on-diversified-smallscale-farms-in-california/2B531E19A4D275E6E69AECE3A68DFA3B