SUBSURFACE DRIP IRRIGATION SYSTEM UTILIZING DAIRY MANURE EFFLUENT

PROJECT AWARDEE: Sustainable Conservation

CONSERVATION INNOVATION GRANT PROJECT #: 69-3A75-17-53

SUMMARY OF METHODS AND ACTIVITIES

Our project in California demonstrated how subsurface drip irrigation (SDI), an NRCS-approved standard practice, can be modified to apply liquid manure – a natural fertilizer source found on dairies. **This new manure SDI system saves water, protects groundwater quality through precision nutrient application, and reduces irrigation-related greenhouse gas emissions.**

California is the top milk-producing state, accounting for 21% of the milk produced in the U.S. While more common in California, dairies across the country use flush manure management systems and flood irrigation to fertilize feed crops with liquid manure. As flood irrigation makes it difficult for dairy producers to apply water and nutrients at the right rates for crop uptake, inefficiencies can lead to nutrient runoff or leaching to groundwater. Subsurface irrigation – drip tape buried underground, close to roots – allows dairy producers to deliver water and fertilizer to crops more precisely.

In 2014, Sustainable Conservation partnered with Netafim USA and a Merced County dairy to install a pilot project to test the application of liquid manure through subsurface drip irrigation, or "manure SDI." In 2016, with an expanded project partner team, we were awarded a Natural Resources Conservation Service National Conservation Innovation Grant to demonstrate the manure SDI system comparing it against the commonly used flood irrigation system on three dairies in California's San Joaquin Valley. The three dairies represented a range of farm management practices, infrastructure, herd sizes and total acreages, allowing the evaluation of how the manure SDI system could integrate into different types of operations.

The manure SDI fields' performances were compared to flood-irrigated fields using key metrics: change in net income, crop yield, water-use efficiency, nutrient-use efficiency, and salinity loading and build-up.

The manure SDI system is highly scalable for dairies across the U.S. that are using flush manure management systems. Dairy producers will likely be interested in the continued ability to use their manure resources coupled with water and fertilizer savings afforded by the system. Dairy producers are natural innovators and key partners in environmental solutions for our Golden State and beyond. **Manure SDI provides dairies with a new tool to help improve water resiliency and water quality for their communities.**

Visible water savings: our pioneering system, which precisely applies water and manure fertilizer via drip irrigation (LEFT), vs. flood irrigation (RIGHT). With our system, dairy farmers can make the best use of limited water supplies and the "black gold" their cows already produce to grow feed crops.

GLOSSARY OF TERMS AND DEFINITIONS

Blend: A combination of fresh water and lagoon water.

Conservation Innovation Grant (CIG): The Natural Resources Conservation Service grant program that funded the manure subsurface drip irrigation projects.

Conventional Subsurface Drip Irrigation (SDI): A more widely used subsurface drip irrigation system compared to the manure subsurface drip irrigation system that utilizes synthetic fertilizers for fertigation. Also referred to as: synthetic fertilizer irrigation and synthetic fertilizer irrigation system.

Drip Tape: The tubing with emitters that delivers water and nutrients to the field.

Environmental Quality Incentives Program (EQIP): The Natural Resources Conservation Service cost share funding program that recognizes the manure SDI system as a conservation practice and provides funding. Also referred to as: cost share funding.

Fresh Water: Water from either canals or groundwater wells. Also referred to as: surface water; canal water; well water.

Flood Irrigation: Most commonly used practice to irrigate dairy forage crops through opening irrigation valves.

Flush Manure Management: System that pushes recycled water and mixes the recycled water with the manure, then the force of water pushes the entire mixture out of the cow's area and into a liquid manure pond.

Germination: Process of sprouting crops from seeds; requires wetting soils.

Lagoon: Lagoon is the storage pond where the lagoon water (i.e. dairy cow liquid effluent) is stored and sourced for the manure subsurface drip irrigation system and flood irrigation. Also referred to as: manure pond.

Manure Effluent: The liquid dairy cow effluent that is used within the manure subsurface drip irrigation system. Also referred to as: liquid manure, manure lagoon water, manure water, process water, and effluent.

Manure Subsurface Drip Irrigation (Manure SDI): A subsurface drip irrigation system that utilizes dairy lagoon water blended with fresh water to fertigate dairy forage crops. Also referred to as: SDI system

Spacing: The spacing between lateral drip lines in the field.

Subsurface Drip Irrigation (SDI): An irrigation system that delivers water and nutrients directly to crops' root zones through drip tape.

Synthetic Fertilizer: Fertilizer that is used in conventional subsurface drip irrigation systems and sold commercially. Also referred to as: commercial fertilizer.

Water Applied: The volume of water applied to a field.

RESULTS

Change in Net Income Analysis

The manure SDI system has been officially accepted by the NRCS as a certified conservation practice. Cost-share funding for the system is available based on local need priorities as decided by specific states or counties. **In California, cost-share funding is available through the Environmental Quality Incentives Program (EQIP) at $2,871.93 per acre for fiscal year 2020.**

An analysis was done to compare system costs and to evaluate the change in net income of transitioning from flood to manure SDI and from flood to conventional SDI. As costs will vary based on operations, the analysis is presented to provide information so that individual dairies can do their own investment analyses.

Without EQIP cost-share support, both scenarios resulted in a negative change in net income as compared to the existing flood irrigation system (manure SDI – $190.15 per acre; conventional SDI – $288.06 per acre). **With EQIP cost-share support, switching to manure SDI results in a positive change in net income of $96.95 per acre,** while switching to conventional SDI is still negative.

The increasing scarcity and cost of water also factors into the transition. Based on the costs studied, the change in net income from switching to manure SDI without EQIP support becomes positive once the cost of water exceeds $211.81 per acre-foot.

DAIRY PRODUCERS ARE NATURAL INNOVATORS AND KEY PARTNERS IN ENVIRONMENTAL SOLUTIONS FOR OUR GOLDEN STATE AND BEYOND.

TRANSITIONING FROM FLOOD IRRIGATION TO MANURE SDI

WITHOUT EQIP

INCREASED REVENUE: Yield	$ 255.00	INCREASED COST: Inputs (energy, maintenance, germination)	$ 189.71
DECREASED COST: Inputs (water, fertilizer)	$ 123.78	INCREASED COST: Labor (maintenance, germination)	$ 107.25
DECREASED COST: Labor (system operation)	$ 84.00	INCREASED COST: Depreciation	$ 342.32
Total Increased Net Income	$ 462.78	Total Decreased Net Income	$ 639.32

ANNUAL PER ACRE DECREASE IN NET INCOME = ($ 176.54)

WITH EQIP

INCREASED REVENUE: Yield	$ 255.00	INCREASED COST: Inputs (energy, maintenance, germination)	$ 189.71
DECREASED COST: Inputs (water, fertilizer)	$ 123.78	INCREASED COST: Labor (maintenance, germination)	$ 107.25
DECREASED COST: Labor (system operation)	$ 84.00	INCREASED COST: Depreciation	$ 55.26
Total Increased Net Income	$ 462.78	Total Decreased Net Income	$ 352.22

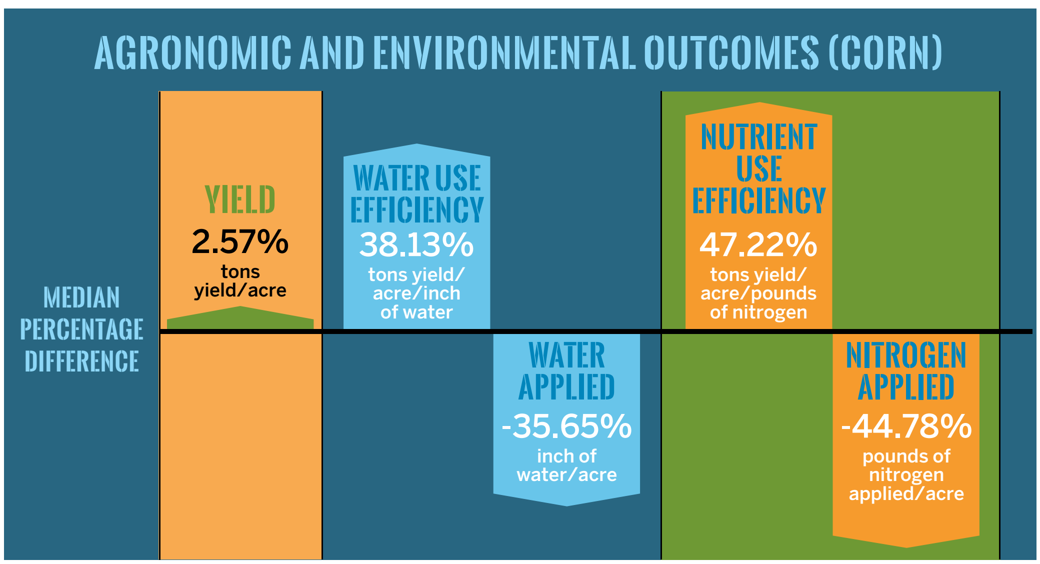
ANNUAL PER ACRE INCREASE IN NET INCOME = $ 110.56

Agronomic and Environmental Impacts

The manure SDI fields usually had similar yields to the flood-irrigated fields for both corn and wheat crops. Most of the manure SDI fields produced those yields with less water, measured as yield per acre-inch of water applied. There are many variables that could have affected yields, so the specific impact of manure SDI on yields remains unclear. A big source of variability was planting and harvest dates, which were sometimes separated by weeks – leading to important differences in growing conditions.

MOST OF THE MANURE SDI FIELDS PRODUCED SIMILAR YIELDS WITH LESS WATER.

The manure SDI fields also generally resulted in less nitrogen applied and greater nutrient-use efficiency, as measured by pounds of nitrogen applied per ton of yield. Similarly, the manure SDI fields received less magnesium, which is an emerging environmental concern. These nitrogen and magnesium reductions reflect how manure SDI allows growers to apply and time crop nutrients much more precisely compared to flood irrigation. Neither the manure SDI nor the flood-irrigated fields' soils showed higher magnesium or electrical conductivity (EC) – suggesting salt build-up was not occurring, which is a concern when using any drip irrigation system.



Nutrient Management

Calculating the whole farm nitrogen balance is the first step for any dairy considering a switch to manure SDI. As manure SDI allows a dairy to use substantially less manure and nitrogen, the dairy needs to have a plan for how to utilize its overall nitrogen. Each dairy will also need to evaluate its infrastructure and management, building up its capacity for a new way of operating.

In order to reap the full benefits of manure SDI, the dairy needs to pay close attention to the crop nitrogen demand curve. **The dairy should monitor water and nitrogen applications closely, comparing planned applications to actual applications and adjusting future applications accordingly to ensure it is keeping up with crop demand.**

For the first year after switching to manure SDI, the dairy should sample liquid manure weekly to evaluate the variability of the manure. This information will improve management of the manure SDI filtration function.

LIKE CONVENTIONAL SDI, MANURE SDI USES SAND MEDIA FILTERS TO REMOVE SOLID PARTICLES SO THEY CANNOT CLOG THE DRIP TAPE.

LESSONS LEARNED

Transitioning from a flood irrigation system to any SDI system includes a learning curve. **Each dairy should start with one to two fields to learn how to operate the manure SDI system successfully, adding more fields over time.** Key elements a dairy must evaluate before making the decision to adopt the manure SDI system include: whole farm nitrogen balance; ability to source liquid manure from a secondary or tertiary lagoon; efficacy of existing solid separation system; availability of infrastructure to feed liquid manure and power to the system; and ability to use flood or sprinklers for germination. Local irrigation dealers can help design and evaluate a dairy producer's fit for this system.

Solids Removal

Like conventional SDI, manure SDI uses sand media filters to remove solid particles so they cannot clog the drip tape. Sand media filters work best when they act as a final polish on liquids with low solid particle content. **Liquid manure has a lot of solid particles, so the effectiveness of pre-system solid separation will directly influence manure SDI performance.** For effective solids removal, it is recommended to source liquid manure from a secondary or tertiary lagoon – ideally with mechanical separation (such as a slope screen) between the lagoons. Pulling from a secondary or tertiary lagoon also improves the consistency of the liquid manure, another important factor in manure SDI performance.

A DEDICATED PIPELINE FOR LIQUID MANURE DELIVERY IS IDEAL.

Dairy Infrastructure

Dairies' use of liquid manure to provide water and nutrients to all of their fields can be a balancing act. One of the dairies utilized an existing irrigation pipeline to deliver liquid manure. That pipeline was also used to irrigate multiple flood irrigated fields; this competition resulted in challenges operating the manure SDI system. It is recommended that dairies have a dedicated pipeline for delivering liquid manure to the manure SDI systems.

Managing Nitrogen

The manure SDI system is less forgiving than flood irrigation when it comes to keeping up with crop nitrogen demand. The grower partners shared that it was necessary to apply manure before the crop demanded it as soil organisms must first break down the manure and release the nitrogen before plants can access those nutrients. **Generally, flood irrigation systems can apply liquid manure much more quickly and in larger amounts, so keeping up with crop nitrogen demand is less of a problem.** The trade-off is flood irrigation requires more water and tends to over-apply nitrogen, increasing the risk of leaching water and nitrogen to groundwater.

POWER AVAILABILITY IS A KEY CONSIDERATION.

Staff Training

The staff at each of the dairies has years of experience with flood irrigation and some of that expertise is applicable to manure SDI. **A key difference that required additional training: the manure SDI system is controlled with an on-site computer, rather than a physical valve that staff can open and close.** Enabling different languages in the computer interface and developing manuals with step-by-step instructions to resolve computer system error codes could help improve ease of use.

Germination

Experiments using the drip tape to germinate were unsuccessful. **Germination with sprinklers or pre-irrigation with flood is recommended to start the crop.**

Power Source

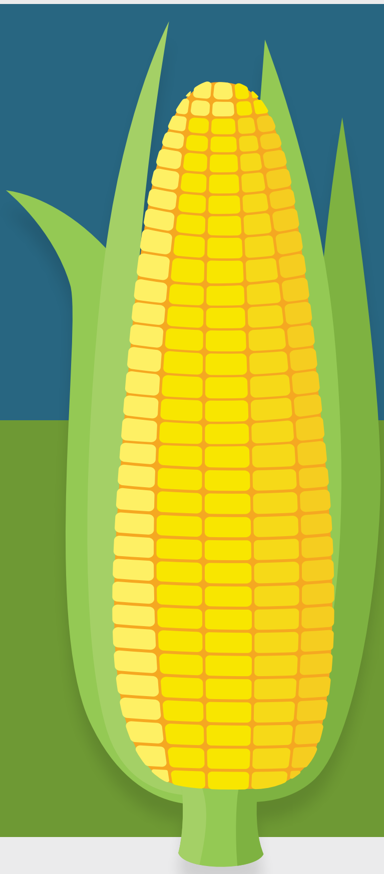
Power availability is a key consideration for dairies interested in the manure SDI system. **Power was not available at one of the project sites, so that dairy needed a substantial amount of time to work with its power company to bring power to the site.** The use of a generator allowed the system to operate until the power company was able to bring power to the system.

MANURE SDI ALLOWS GROWERS TO MAINTAIN CROP YIELDS WHILE APPLYING LESS NITROGEN.

PROJECT IMPACT

The manure SDI system saves water compared to flood, as measured by the volume of water applied compared to the crop's demand (evapotranspiration, ETc). Lowering demand on water means less stress on severely depleted aquifers and more water available for other, critical environmental needs, like in-stream flows for fish. Similarly, the manure SDI system allows growers to maintain crop yields while applying less nitrogen, which reduces the risk of contributing to groundwater contamination.

Over two years, the manure SDI fields studied applied over 900 acre-feet less water and 190 fewer metric tons of nitrogen to produce similar yields, as compared to the flood irrigated fields. As adoption of manure SDI increases, the water and nitrogen savings afforded by the technology can provide significant local and regional benefits.



2 YEAR PROJECT IMPACT

H_2O — 296 million fewer gallons of water applied

N — 423,000 fewer pounds of nitrogen applied

ESTIMATED* ANNUAL IMPACT AT SCALE
(100,000 ACRES)

H_2O — 61 billion fewer gallons of water applied

N — 55 million fewer pounds of nitrogen applied

*Estimated based on median per-acre results from our project.

RESOURCES

- Cost analysis
- Agronomic and environmental impacts
- Considerations for switching to manure SDI
- Nutrient and salinity management guidance
- System overview
- NRCS Practice 441, Scenario #27 – SDI, manure (page 543)

NEXT STEPS

The project partners are supporting adoption of the manure SDI system on more dairies by promoting EQIP cost-share funding availability and actively recruiting dairies to make the transition. Netafim USA is supporting its internal and distributor networks to meet the demand for technical support for dairies switching to manure SDI. **Sustainable Conservation is exploring opportunities with academic research partners to develop real-time nitrogen values for manure effluent, to improve utilization of manure nutrients with manure SDI.**

CONSERVATION INNOVATION GRANT PROJECT:

DEMONSTRATION OF SUBSURFACE DRIP IRRIGATION SYSTEM UTILIZING DAIRY MANURE EFFLUENT TO IMPROVE WATER USE EFFICIENCY AND NUTRIENT APPLICATION UNIFORMITY

Project #: 69-3A75-17-53

United States Department of Agriculture
Natural Resources Conservation Service

PROJECT TEAM

The project team would like to acknowledge and thank the three pioneering dairy partners for their time and effort during the course of the project. Our success was due in large part to their dedication, innovation, and invaluable expertise.

Dellavalle Laboratory, Inc., headquartered in Fresno, CA and with field offices in Hanford, CA and Davis, CA, specializes in soil, water and plant tissue analysis.

As one of the world's leading irrigation companies, **Netafim USA** has dedicated its business to developing solutions to fight the scarcity of food, water and land.

Rivers Consulting (Dan Rivers) provides sampling, data collection, modeling and other field and lab tech services for research and production ag, focusing on sustainable practices.

Sustainable Conservation (project awardee) brings together businesses, landowners and government to solve the toughest challenges facing California's land, air and water resources, and achieve positive results in ways that are just and make economic sense.

UC Cooperative Extension is part of a nationwide network of land-grant university researchers and educators who solve problems in agriculture, the environment, and human and community well-being, for over 100 years helping foster a connection between the university and the public.

Western United Dairies is a trade organization representing more than 60% of the milk produced in California.

To learn more, please contact us: Email: manureSDI@suscon.org | Phone: 209-576-7729

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