Sustainable Irrigation Methods for Alternative Crop Production

Final Report for OS08-040

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Principal Investigator:

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Project Information

Abstract:

Recent changes in commodity programs and competition from imported commodities have increased the income risk to farmers. As a result, many farmers are considering a transition to an alternative, high-value crop production as a way to sustain their income. One crop of significant interest is rabbiteye blueberry. Recent demand for this fruit has increased dramatically and so have prices received for the product by producers. Over 270 acres of blueberries have been planted in southeastern Alabama in the past three years. Sites selected for blueberry establishment generally followed row crops land, where soils were marginally suited for blueberry production, featuring low soil organic matter content, and high soil pH. Supplemental irrigation water sources in the southeastern part of the state are carbonate aquifers. In events where the supplemental irrigation is the predominant water source, particularly in drought years, alkaline irrigation water will create alkaline soil conditions that will not favor successful blueberry establishment and production. The purpose of this on-farm study was to generate an enhanced knowledge of the benefits of using different approaches to improve the soil organic matter content, to correct soil pH, and to manage irrigation water alkalinity for sustainable blueberry production.

Introduction

Irrigation is a determinant factor in the growth and production of blueberry, mainly because the plant root system is superficial and confined, which restricts the water uptake capacity. Furthermore, blueberry plants are especially sensitive to irrigation water quality. Alkaline irrigation water will eventually raise the soil pH to a level harmful to blueberries. Acid injection through the irrigation system is required to lower pH to an acceptable level and to promote blueberry plant establishment and development.

The most common irrigation systems used to irrigate blueberries are micro-jet and drip. Previous studies demonstrated that during the first 2 years of harvest, plants under drip irrigation produced higher yields compared to those with the microjet system, whereas in the fourth and subsequent season micro-jet system surpassed drip irrigation. The objectives of our study were to assess the feasibility of acid injection through the irrigation system in combination with micro-jet or drip system on the establishment and development of selected rabbiteye blueberry cultivars. Another method to buffer soil pH changes, increase the soil organic matter and help retain water in the root zone is adding soil amendments such as peat moss and mulch that promote root development, and maintain high soil water content with a good level of aeration in the soil. Thus, another objective of our study was to evaluate the effect of three mulching treatments on blueberry growth and development.

Project Objectives:

The main objectives of our study were to:
1) Assess the effect of sulfuric acid treatment injected through the irrigation system on soil pH and blueberry growth and development;
2) Evaluate the effect of plug-in emitter and micro-jet irrigation systems on soil pH and blueberry performance;
3) Determine the effect of different rates of pine bark and peanut hull treatments on soil organic matter content and blueberry establishment and plant growth.

Research

Materials and methods:

Eight newly established blueberry farms in the Wiregrass region of Alabama were visited prior to project initiation in search of a blueberry plot that would accommodate the irrigation and soil amendment treatments planned for our test. The main challenge was the growers had installed the irrigation system to fit their field and to match their supplemental water source capacity and these pre-existing systems could not be easily modified to accommodate our irrigation treatments. A five acre blueberry farm located in Columbia, AL was selected in 2008 to apply a set of irrigation treatments. In the second experiment, soil organic amendments were applied to a nearby blueberry field in the same vicinity. Site soil is Dothan Loamy Sand (loamy sand 0-6” and sandy clay loam 6-33”).
Available water holding capacity (AWHC) in 12” deep root zone with a 6’ x 5’ area per plant is 28 gallons (from NRCS soils data). Plant stress and visible wilting generally occur around 50% AWHC (14 gallons). For sandy clay loams, this corresponds to 50-70 centibars (cb) of soil moisture tension. Drip/micro-irrigation should operate to daily replenish AWHC to maintain at least 14 gallons WHC (cb readings below 50-70 for cb sensors in sandy clay loam). Soil moisture feedback (SMF) was independently applied in three of the irrigation treatments at this site. Data were used to compare the effect of SMF on irrigation scheduling and potential economic benefits of SMF vs. drip irrigation scheduling without SMF. Soil moisture feedback was provided by two WaterMark soil moisture sensors installed in series at 9” depths at least 3’ apart within the irrigation-wetted zone. These sensors were connected to a WEM controller that read average soil moisture tension (SMT) from the two sensors and opened or closed a 24VAC switch in the solenoid circuit based on the SMT value (5-7) manually set on the WEM dial. The WEM provided further control of the solenoid valve operation during the ON period. SMT values higher than setting allowed irrigation. SMT values below setting prevented irrigation during ON time. A red light on the WEM indicated higher SMT values and an irrigation call. SMF also responded to rainfall in each treatment to reduce irrigation.

Low-flow residential-type water meters were installed in all treatments to record water applied and time of operation (by recording successive readings, subtracting, and dividing by system flow rate to get time of operation).

Experiment 1. Irrigation treatments consisted of:
CONTROL: Grower-installed drip tape with timer for irrigation scheduling.
Treatment 1: Grower-installed drip tape with timer for irrigation scheduling and project-installed soil moisture feedback to adjust solenoid valve operation to monitored soil moisture: Grower had installed drip tape with 0.61 GPH emitters built-in at 30 inch intervals along tape above ground along blueberry row line. The 2’ wide soil wetting pattern of 2, 0.61 GPH emitters overlapped each blueberry bush and covered 67% of the root zone (1.22 GPH per plant).
Standard irrigation timer was used to daily switch solenoid valve supplying drip tape emitters ON for BASE TAPE TIME (BTT) irrigation period selected by grower. Soil moisture feedback was provided to further control solenoid valve operation during this ON period. Lower than desired soil moisture in the irrigation-wetted zone allowed irrigation during this ON time. Adequate soil moisture prevented irrigation during this ON time.
Treatment 2: Plug-in drip emitters and timer with soil moisture feedback for irrigation scheduling - two 2 GPH emitters were punched onto an in-row poly drip hose 1’ either side of each blueberry plant. The 2’ x 2’ soil wetting pattern of each 2 GPH emitter overlapped each blueberry bush and covered 67% of the root zone (4 GPH per plant).
Standard irrigation timer was used to switch solenoid valve supplying plug-in emitters ON for 30% BTT. Soil moisture feedback was provided to further control solenoid valve operation during this ON period. Lower than desired soil moisture in the irrigation-wetted zone allowed irrigation during this ON period. Adequate soil moisture prevented irrigation during this ON time.
Treatment 3: Micro-jet spray emitters and timer with soil moisture feedback for irrigation scheduling. One 10.5 GPH micro-spray jet with 2 x 20o spray pattern at height of 1’ was placed in-row half-way between every other blueberry plant. The 6’ x10’ “Center Strip” spray pattern covered 100 % of the root zone of two blueberry plants (5.25 GPH per plant) with a flat spray angle.
Standard irrigation timer was used to daily switch solenoid valve supplying micro-sprays ON for 30% BTT. Soil moisture feedback was provided to further control solenoid valve operation during this ON period. Lower than desired soil moisture in the irrigation-wetted zone allowed irrigation. Adequate soil moisture prevented irrigation during this ON time.
Irrigation treatments were applied to two rabbiteye blueberry cultivars – “Austin” and “Climax” and resumed at bud break. To buffer the irrigation water alkalinity, we chose to apply sulfuric acid through the irrigation system. Sulfuric acid is available locally and is one of the most commonly used acids in plant irrigation. Our goal was to achieve 80-90 percent neutralization of the supplemental water alkalinity. Sulfuric acid was injected in much the same way as fertilizer. The product is 93% and costs approximately $0.24/lb. Sulfuric acid injection applied in a preliminary study conducted in 2007 indicated that sulfuric acid rates ranged from 12.36 oz/acre to 39.54 oz/acre (depending on water flow of the particular irrigation system) and provided a sufficient decreased the soil pH values.

Experiment 2. Four soil amendment treatments were applied to 3’ X 15’ plots as follows:
1). Four inches (134 yd3/acre) pine bark (PB) incorporated into the soil prior to planting; Served as a control treatment;
2). Additional 4” of pine bark added at the beginning of the experiment for a total of 8” PB (269 yd3/acre);

3). Additional 8” of pine bark added at the beginning of the experiment for a total of 12” PB (403 yd3/acre);
4). Additional 4” of peanut hulls (PH), applied at the beginning of the experiment, for a total of 4” PB + 4” PH, or 269 yd3/acre.
The experimental plots were replicated three times, and each replication consisted of two plants. ‘Climax’ was the blueberry cultivar used in this experiment. Rototiller was used to incorporate the amendment into the soil (Figure 3). Grower field had sulfur applied to lower soil pH and in-line emitter drip irrigation was installed for supplemental irrigation.

Soil and water pH level were tested at the time of experiment initiation, and at the end of each growing season during the two years of our study to monitor changes in soil pH, organic matter content and the level of soil nutrients. Leaf samples were collected in July of 2008, and shortly after harvest in 2009 to determine the nitrogen and other nutrients in plant tissue. In 2008, measurements were collected to determine plant growth index, leaf area, chlorophyll content and plant photosynthetic activity. In 2009, the blueberry plants produced their first crop. Fruit samples were collected and analyzed in the lab to determine the treatment effect on various fruit quality characteristics. An attempt was made to collect yield data. Due to miscommunication with the labor hired to harvest the blueberry field where the irrigation treatments were applied, the majority of the experimental bushes were harvested prior to the arrival of our crew in the field, and the scattered yield data we recorded are not representative and we are not going to include them in the current report.

- Figure 1. Grower-installed drip tape with built-in emitters at 30 inch intervals
- Figure 3. Soil amendment treatments application to ‘Climax’ blueberries in May 2008.
- Figure 2. Micro-jet sprinkler treatment was applied in-row half-way

Research results and discussion:

Experiment 1: The 2008 irrigation operation time behind the water meters began at water meter installation on 6/11/2008. Total season operation time with this start date was 227.29 hours for grower- installed drip tape with timer (CONTROL). For treatment 1 - drip tape with timer and soil moisture control/feedback operation time was 204.06 hours. The operation time tor treatments 2 and 3 was 112.84 hours. Comparing CONTROL (drip tape with timer) and treatment 1, soil moisture control/feedback reduced operation time by 10%. The estimated savings corresponded to 10% of water and electric power and pH control chemicals. The operation time for treatments 2 and 3 was 50% of that of CONTROL time, but almost twice the amount of CONTROL water was applied. Apparently timer ON interval for treatments 2 and 3 was set to 50% BTT instead of the planned 30% BTT.

In 2009, drip tape with soil moisture control/feedback (treatment 1) reduced the system operation time by 12% when compared with CONTROL (grower-installed drip tape with timer), which would be a very good return for this soil moisture control/feedback. Fertigation with nitrogen was started in early April and the cooperator noticed a problem of no fertilizer being injected into treatments 2 and 3. Large system flow differences between CONTROL/treatment 1 and treatments 2 and 3 required injector adjustment for proper operation. For whatever reason, there was no assurance that these adjustments were routinely made. We, therefore, have little confidence that either nitrogen fertilizer or sulfuric acid pH was successful on treatments 2 and 3. Also, operation time for treatments 2 and 3 was only 17% of the control treatment, which is a concern relative to adequate irrigation water application to these treatments. We are not aware of the 2009 start irrigation date and stop irrigation date, which presents a limitation in calculating the 2009 average hours per day or average gallons/plant/day applied.

Our results revealed the irrigation treatment had no effect on Austin blueberry leaf area in both years of this study. Climax blueberry produced bushes with a similar leaf area in response to the plug-in emitters and drip tape irrigation systems, while plants with a smaller leaf area were evident for the micro-jet treatment applied.

In each experimental year measurements were collected to determine the plant vegetative growth index. When comparing the effect of the irrigation system on Austin and Climax cultivars vegetative growth we observed that Climax plants grew larger than Austin blueberries regardless of the irrigation treatment applied during the first year of our study. Climax cultivar responded with similar vegetative growth when plants were irrigated using drip tape and plug-in emitter systems, while micro-jet system resulted in smaller plant growth in 2008. During the second year, the greatest vegetative growth was observed for Climax plants receiving drip tape irrigation, whereas the micro-jet treated Climax plants showed the smallest increase in bush growth. In both experimental years, Austin blueberries had similar vegetative growth across the irrigation systems in our test.

The analysis of the leaf chlorophyll content suggests no differences between the irrigation treatments tested were observed. In general, Climax blueberry plants had greater chlorophyll levels, which correspond to the greater Climax plant growth found in this study.

While performing the leaf tissue analysis in 2008, we found the blueberry plants in cooperating growers fields were nitrogen deficient. This finding was communicated to our grower cooperators and an adjustment of the fertilization management practice was suggested as a mean to increase the effectiveness of the plant nutrition program. As a result, nitrogen fertigation was implemented in the following growing season, and the tissue nitrogen level was increased as evident by the conducted lab tests.

More than likely, pH injection problems caused by inadequate injector adjustments for much lower water flow to the spray-jets and plug-in emitters prevented application of adequate amounts of pH-corrected water and injected fertilizer, which could tend to explain poor bush growth and yield performance of these two treatments during the 2009 season. No apparent injector problems occurred with the higher water flows to CONTROL and treatment 1 valves.

This would also tend to validate our grower recommendations related to irrigation water pH correction and soil moisture control/feedback. Effect of pH injection problems with the type injector and variable system flows present does not allow any differences in spray-jet and drip tape pH-adjusted water soil application area to be evident.

In 2009 fruit samples were analyzed to determine the average berry size and other important berry characteristics. The plug-in emitter treatment resulted in largest mean berry size when compared to the micro-jet and the control treatments. Between the two blueberry cultivars tested Austin had larger berries (2.1 g on average) than Climax (1.2 g on average). Plug-in emitter treatment resulted in sweetest berries (12.9 % soluble solids content), followed by the control treatment (12.6% soluble solids), while the soluble solids content for micro-jet irrigated berries was 10.8%.

A high percentage of Austin blueberry plant decline was evident in the experimental plot. We found out that a new disease named bacterial leaf scorch of blueberries, considered a problem of southern highbush blueberry varieties was found to infect Austin rabbiteye blueberry and may be accountable for Austin cultivar plant decline.

Experiment 2:

Results on the effect of the three mulching treatments tested on Climax leaf area suggest that the 12” PB and 4” PB + 4” PH treatments resulted in greater blueberry leaf area in the second year of our study, when compared to the control treatment. We also observed that the 12” PB treatment produced the greatest plant growth and the largest average berry size in the second year of this experiment based on the calculated plant growth index. This treatment corresponded to the largest amount of organic matter incorporated into the soil.

Overall, a significant improvement in plant development was observed in the experimental plots following acid injection implementation/adoption and soil amendment enrichment by participating growers. We also observed a considerable improvement of blueberry plant growth and development in cases where the growers implemented irrigation water acidification for their blueberry operation.

- Figure 4. Effect of three irrigation methods on vegetative plant growth (cm3)
- Figure 5. Effect of three irrigation methods on vegetative plant growth (cm3)

Participation Summary

Educational & Outreach Activities

PARTICIPATION SUMMARY:

Education/outreach description:

The following talk was presented at the Southern Region ASHS Annual Meeting in Orlando, FL, and an abstract published in HortScience is titled:
Elina Coneva, T. Tyson, R. Boozer, N. Kelly, and E. Vinson. 2010. Effect of Irrigation on Fruit Production and Quality of Rabbiteye Blueberry. HortScience 45:486-522.

The following Timely Information Sheet was published on the aces.edu/anr/irrigation website:
Tyson, Ted W., and Larry M. Curtis. 2009. "Evaluating Water Distribution Uniformity in
Micro-Irrigation Systems: BSEN-IRR-09-01, Web publication, http://www.aces.edu/anr/irrigation/documents/BSENIRR0901FieldEvaluationofSystemUniformity.pdf. Alabama Cooperative Extension System, 8 pp.
This was an update of an earlier publication that was redirected to blueberry micro-irrigation.

Project Outcomes

Project outcomes:

A blueberry production workshop was hosted by the project leaders and farmer-cooperators on October 21, 2008. An overview of the general blueberry production practices and the results generated during the first year of our investigation was

discussed with blueberry growers in the Wiregrass region of Alabama.
On May 28, 2009, we conducted a commercial blueberry production workshop at the Wiregrass Research and Extension Center in Headland. Invited speakers included extension specialists from Alabama Cooperative Extension System, the Department of Agricultural Economics and Rural Sociology, Department of Agronomy and Soils, Biosystems Engineering Department, and the Department of Horticulture, Auburn University. Educational program included outdoor demonstrations and indoor discussions on the following topics: irrigation system maintenance, fertigation practices for blueberries, and fire ant bait demonstrations in commercially grown blueberries. An update on the project findings and emerging problems in blueberry production for the Wiregrass region were provided.
Summary of our experience was presented at the Annual Meeting of the Southern Region ASHS in Orlando, Florida in February 2010.
This study was designed to facilitate developing alternative crops that help a producer’s operation to become more economically sustainable and investigates practices and systems that increase the viability of an existing farming practice. Other contribution of this research is the promotion of low-volume systems that can apply precise and uniform water volumes while conserving natural resources, and make the most efficient use of on-farm resources. The integration of natural biological cycles will contribute to improving soil physical properties and soil health.

Economic Analysis

The 2008 irrigation operation time behind the water meters began at water meter installation on 6/11/2008. Total season operation time with this start date was 227.29 hours for Mr. Smith's drip tape with timer controller. For treatment 1 - drip tape with timer and soil moisture control/feedback operation time was 204.06 hours. In 2008 recorded operation time tor treatments 2 and 3 was 112.84 hours. Comparing drip tape with timer controller and treatment 1, soil moisture control/feedback reduced operation time by 10%. The estimated savings corresponded to 10% of water and electric power and pH control chemicals. The operation time for treatments 2 and 3 was 50% of that of treatment 1 time, but almost twice the amount of treatment 1 water was applied.
In 2009, drip tape with soil moisture control/feedback reduced operation time by 12% when compared with grower-installed drip tape with timer (CONTROL). Operation time for treatments 2 and 3 was only 17% of treatment 1.
The observations made from the 2008 and 2009 water meter data: Soil moisture control/feedback saved 10% to 12% on applied water, pumping energy, and acidifying chemical.

Farmer Adoption

As a result of our efforts to help blueberry producers to overcome problems associated with high irrigation water alkalinity, about 70% of the growers in the southeast are using supplemental water acidification and observing much improved plant growth and development in their blueberry operation.

Recommendations:

Areas needing additional study

Due to the blueberry orchard juvenility at the time of treatment application, we were not able to collect consistent yield data and provide sound conclusions on cultivar responses to different irrigation systems and soil amendments tested. Furthermore, blueberry response to the irrigation system differ with plant age. While generally drip system provides sufficient plant development up to the second harvest, the micro-jet is expected to be the most efficient system for the rest of the blueberry planting. The two year term of this project allowed us to compare the effect of the systems on blueberry development in the years of plant establishment, but we hope we can continue our cooperation with blueberry producers and investigate further the treatment effect of plant growth and production potential.

Information Products