

Documenting Impacts of BMP Adoption by Suwannee Valley Watermelon Growers

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EXECUTIVE SUMMARY

The purpose of this project was to document changes in production techniques, consistent with best management practices (BMPs), and to estimate water savings, fuel savings, and changes in nitrogen fertilizer use among Suwannee Valley watermelon growers over the past 25-30 years. Semi-structured interviews with nine watermelon growers and a review of related documents provide a description of changes in the industry and enable estimation of reductions in water, fuel, and fertilizer used on watermelon fields in Florida's Suwannee Valley region.

Agricultural production guidelines, called best management practices (BMPs), have been developed to support farming practices that conserve water and protect water quality. UF/IFAS Extension and government agencies like the Florida Department of Agriculture and Consumer Services (FDACS), the Suwannee River Water Management District (SRWMD), USDA Natural Resources Conservation Service (NRCS) and others have worked together to develop the guidelines and facilitate adoption of conservation farming practices in Florida.

Over the past 25-30 years, watermelon growers in the Suwannee Valley started growing seedless watermelon varieties, began using transplants instead of direct seeding, changed from bare ground to plastic mulch, switched from overhead to drip irrigation, and adjusted their fertilization practices. Many growers have started using plant nutrient testing and soil moisture sensing tools to help them further fine tune fertilizer applications and irrigation schedules.

The changes made by watermelon growers over this time period have led to substantial reductions in water use per acre, fuel use per acre, and fertilizer per plant, while watermelon yields per acre have increased. Growers report reductions in water use per acre ranging from 50% to 80%, with most growers reporting water savings of 67% or more. Growers report that diesel fuel consumption for irrigation pumping has been reduced 50% to 86%, while engineering studies suggest that fuel savings are likely greater than proportional to the water savings. Most growers report reductions in applied nitrogen per acre ranging from 15-30%, and all report improvements in nitrogen efficiency. Over the same time period typical watermelon yields increased from 25,000-40,000 pounds per acre to 50,000-60,000 pounds per acre.

The total reductions in water, fuel, and fertilizer use on 6,000 acres of watermelon fields in the Suwannee Valley are estimated with information from the grower interviews and parameters from other studies. Irrigation changes made by these watermelon growers have saved approximately 2 billion gallons of water per year. Fuel and fertilizer savings are more difficult to estimate with confidence, but fuel savings of at least 120,000 gallons per year and nitrogen savings of about 180,000 pounds per year are realistic. The annual water savings achieved by Suwannee Valley watermelon growers is equivalent to the annual amount of water used by about 65,000 Florida residents.

INTRODUCTION

The Suwannee Valley region of North Florida contains valuable water resources and depends heavily on agriculture for jobs and livelihoods. Balancing and maintaining the benefits to the region from productive agriculture, as well as from other water use and nonuse values, is a major challenge. Groundwater withdrawals from the wide variety of uses have the potential to temporarily deplete the aquifer and reduce surface water flows. Fertilizer applied to crops and manure from livestock operations need to be managed using the latest technology to protect water quality in the aquifer, springs, rivers, and lakes. Agricultural production guidelines, called best management practices (BMPs), have been developed to support farming practices that conserve water and protect water quality (FDACS, 2015). UF/IFAS Extension and government agencies like the Florida Department of Agriculture and Consumer Services (FDACS), the Suwannee River Water Management District (SRWMD), USDA Natural Resources Conservation Service (NRCS) and others have worked together to develop the guidelines and facilitate adoption of conservation farming practices in the region.

Florida historically ranks first nationally in the production of watermelons. In 2015, Florida produced 17% of the nation's watermelon crop by weight and 18% by value (USDA, 2016). The Suwannee Valley region contains about one-third of Florida's 21,000 acres in watermelon production (USDA, 2016). This Suwannee Valley acreage is managed by approximately 40 farm operations. Soils in the Suwannee Valley area are well drained and perfect for watermelon production as long as water and nutrients are managed efficiently.

The research and extension programs of the University of Florida/Institute of Food and Agricultural Sciences (UF/IFAS) have developed production systems that help area farmers conserve water, fuel, and fertilizer. UF/IFAS county extension agents and specialists have been working with Suwannee Valley's watermelon growers for years to help them adopt plastic mulch and drip irrigation and to refine their management of this technology since it was introduced to the region in the late 1980s. The watermelon industry in the Suwannee Valley has shifted nearly 100% from less efficient overhead irrigation techniques on open soils to the current system using drip irrigation placed under plastic mulch.

The purpose of this study is to document the changes in production techniques, consistent with best management practices (BMPs), and estimate water savings, fuel savings, and reduction in nitrogen fertilizer use among Suwannee Valley watermelon growers over the past 25-30 years. By documenting and distributing this information, the public will be better informed about changes in watermelon growing practices that continue to conserve water, reduce water pollution, and maintain the economic viability of the industry.

METHODS

For this study we conducted semi-structured interviews with watermelon growers to document their recollection of production changes and their estimates of the effects on water, energy, and fertilizer use. The target population was all 40 (approximately) watermelon growers in the region. We completed interviews with a convenience sample of nine (23%) of the growers during spring 2016.

Based on information from the interviews and other studies, we provide estimates for the total reduction in water, fuel, and fertilizer used on watermelon fields in the Suwannee Valley region over the past 25 years. Our methods (semi-structured interviews with a nonprobability sample) do not allow us to report the statistical precision of estimates, but confidence in our estimates comes from three observations: (1) responses were similar among the nine growers interviewed; (2) all interviewed growers believed that other watermelon growers have made similar changes; and (3) interview responses were generally consistent with published information on related topics.

CHANGES IN FARMING PRACTICES

Over the past 25 years, watermelon growers in North Florida started growing seedless watermelon varieties, started using transplants instead of direct seeding, changed from bare ground to plastic mulch, switched from overhead to drip irrigation, and adjusted their fertilization practices. Many growers have started using plant nutrient testing and soil moisture sensing tools to help them further fine tune fertilizer applications and irrigation schedules. Grower interviews documented the timing and extent of those changes and provided insight on their motivations.



Figure 1. Growers transitioned from seeded (*left*) to seedless (*right*) watermelon varieties.

Among interviewed growers, all have been growing seedless watermelon varieties since the 1990s. One grower mentioned a seedless trial as early as 1987, and most started growing seedless varieties for the first time in the early 1990s. All interviewed growers were growing seedless watermelons by 2000. The transition to seedless melons was primarily motivated by demand for those varieties in national markets. Some growers continue to grow seeded watermelons (in addition to seedless) to serve as pollinizers for the seedless crop or to sell to local and wholesale markets.

The transition from direct seeding to transplants coincided with the adoption of seedless varieties. Among interviewed growers, this transition occurred between 1990 and 2000. Using transplants instead of direct seeding is one factor that enables an earlier harvest. Hitting an early market window gives growers greater access to national markets and allows them to obtain a higher price. Newer seedless varieties have higher seed costs and lower germination rates in the field, leading the industry strongly toward using transplants. The increase in seed costs was partly driven by the seed industry's management programs to reduce bacterial fruit blotch incidence.

All interviewed growers reported transitioning to plastic mulch during the 1990s. Most growers started experimenting with plastic on at least some of their fields in the early 1990s. All interviewed growers had fully transitioned to plastic by 2000. Instead of planting watermelons in bare soil as had been done previously, growers now plant watermelons in firm, mounded rows covered by black plastic mulch. The black plastic blocks weeds, reducing the need for herbicide except between rows, and warms the soil, allowing earlier planting and therefore earlier harvest. Plastic mulch culture also reduces the likelihood of leaching from rain events and reduces evaporation losses from the soil.

Prior to 1990, most watermelon growers planted in wide row spacing of 10-12 feet between rows and used overhead irrigation systems, primarily traveling volume guns. During the 1990s growers began to change irrigation systems. Initially, some growers continued using traveling guns while experimenting with degradable plastic mulch, and a few switched from traveling guns to pivot irrigation. Ultimately, however, the industry rapidly transitioned to drip irrigation systems. All interviewed growers reported using drip irrigation for their watermelon fields by the early 2000s. Drip irrigation systems work well with vegetables planted in rows of plastic mulch. As plastic mulch and drip irrigation were adopted, growers reduced row spacing (down to 8 feet typically) and increased plant populations in the row. Drip irrigation can save water, reduce labor and pumping costs, and reduce disease problems, relative to overhead irrigation.

Along with the transition to drip irrigation and plastic mulch, fertilization practices changed. Growers started using less pre-plant dry fertilizer and started applying more through the drip system. Most interviewed growers described how they can more precisely deliver what the plant needs, when it is needed, using various tests and applying fertilizer through the drip system. Soil testing, leaf tissue testing, and petiole sap testing are practices that growers have been using to improve nutrient management and fertilizer efficiency. Interviewed growers just

started using leaf tissue testing or petiole sap testing or both in the last three to eight years. Only a few are using GPS to vary fertilizer rates within a field.

The interviewed growers were asked how they learned about different production systems and management techniques. All but one said they had learned from UF/IFAS Extension, including Extension agent field visits and IFAS classes or workshops. Growers mentioned other sources of information too, including other growers, crop consultants, the Florida Watermelon Association, Clemson University, and NC State University.

WATER SAVINGS

Because overhead irrigation systems wet the entire surface area of a field and result in evaporation loss as water is shot through the air, they are not as efficient as drip irrigation systems. In contrast, drip systems placed in the soil surface but under plastic-covered rows deliver water only along the plant rows, where the plants' roots are located, and not in the row middles. Because the emitters are along the ground and under plastic, there is little, if any, evaporation loss.



Figure 2. Growers previously had used traveling guns (*left*) for irrigation, but now irrigate watermelons with drip tape under plastic mulch (*right*).

Although most growers are not metering their water, all but one grower were able to provide approximate estimates of water savings based on irrigation run times and flow rates. Estimates ranged from 50% to 80% less water for irrigation now than what they had been using previously. Six out of nine interviewed growers estimated at least two-thirds (67%-80%) water savings with their current irrigation practices. Water savings were achieved primarily by switching to drip irrigation and reducing irrigation run times, in some cases with assistance from soil moisture sensors.

Growers learned how to more efficiently deliver water from UF/IFAS Extension programs, including drip irrigation schools, on-farm demonstrations of soil moisture monitoring, and using

blue dye in irrigation water to visualize the movement of water through the soil profile. The on-farm blue dye demonstrations were especially effective in teaching farmers how to shorten irrigation events and reduce nutrient leaching (Simonne et al., 2005).



Figure 3. UF/IFAS Extension faculty used blue dye studies to demonstrate how water and nutrients move through the soil (and plants' root zone) at various irrigation rates.

To estimate the total amount of water saved by watermelon growers in the Suwannee Valley, we first estimated the amount of irrigation water applied per acre in a typical spring watermelon season. Grower interviews indicated that about 18-21 acre inches of water per acre had been applied with overhead irrigation guns in a typical season in the early 1990s. Considering the inefficiency of overhead irrigation, that estimate is consistent with University of Florida research on water requirements for a watermelon crop (Shukla et al., 2014). Taking midpoint estimates from the interviews of a 65% reduction in water use and a starting point of 19.5 acre inches, provides an estimate of 344,177 gallons (12.675 acre inches) of water savings per acre per season. In the 1990s, more than 8,000 acres in the Suwannee Valley were planted in watermelons. More recently about 6,000 acres have been planted in watermelons each year in the Suwannee Valley. Saving 344,177 gallons of water per acre on 6,000 acres amounts to a total water savings of 2.1 billion gallons per year. With Florida residents consuming about 85 gallons of water per capita per day for household use (Marella, 2014), 2.1 billion gallons is equivalent to the amount of water used by more than 65,000 residents in a year.

FUEL SAVINGS

Irrigation pumps may be powered by electric motors or engines that run on diesel fuel or propane. Most of the growers interviewed use diesel engines for irrigation pumping. All interviewed growers believed that they had reduced diesel fuel or electricity use with their change from overhead to drip irrigation. Some growers believed that the reduction in fuel use was proportional to the reduction in water use (50% to 80% reduction). Other growers believed that their fuel savings were even greater than their water savings. Growers said they need to run the irrigation pump for fewer hours with drip than with overhead, and the engine does not

run as hard (i.e., runs at lower RPM) with the lower pressure drip system. One grower said he reduced fuel consumption from 700 gallons per week to 100 gallons per week (86% reduction).

Other published sources verify that the reduction in fuel use would be more than proportional to the reduction in water use when converting from a typical overhead irrigation system to a drip system. Drip systems require lower operating pressure than overhead systems, 20-25 psi for drip compared to 50-80 psi for overhead at field entrance (Simonne et al., 2008). Engineering estimates for diesel fuel consumption by irrigation pumps indicate that a reduction in pumping pressure from 50 to 20 psi reduces fuel use by approximately 30% for a given volume of water pumped (Martin et al., 2011). These estimates suggest that a 70% reduction in irrigation water use could be expected to reduce diesel fuel consumption by approximately 80% when converting from a higher pressure overhead system to a lower pressure drip system.

Differences in pump motors and pumping conditions make it difficult to estimate total fuel savings for the region as a result of the switch from overhead to drip irrigation. Grower interviews and engineering estimates (Martin et al, 2011) suggest that these irrigation changes could be saving 20 to 45 gallons of diesel fuel (or other fuel equivalent) per acre per season. Across 6,000 acres of watermelon fields that would amount to between 120,000 and 270,000 gallons in fuel savings.

NUTRIENT MANAGEMENT

All interviewed growers described changes in fertilization along with the change to drip irrigation and greater use of soil and plant nutrient tests. Typically the changes involved applying more fertilizer through the drip irrigation system and less broadcast dry fertilizer. They also adopted better timing of fertilizer applications to coincide with the plants' growth needs.

Summarizing reduction in nitrogen use among growers is complicated, because prior to 1990 growers were using a wide range of fertilizer programs, various methods of application, and varying row spacing and plant populations. Several growers said they are applying less nitrogen than they did previously even with an increase in plant populations over time, with estimates ranging from 30 lbs/acre to 66 lbs/acre less (reductions of approximately 15-30%). A few of the interviewed growers believed they are applying about the same amount of nitrogen per acre as they did previously, however those growers have also reduced row spacing and therefore are actually using less fertilizer on a linear-bed-foot method of calculating fertilizer rates (Hochmuth and Hanlon, 2010). An average reduction of 30 lbs/acre in applied nitrogen, across 6,000 acres of watermelon fields, amounts to 180,000 pounds less nitrogen applied per year.

Among growers noting they were using less fertilizer overall, a few different factors have contributed to the reduction. Soil testing is used to adjust the amount of pre-plant fertilizers applied. Then leaf tissue testing and petiole sap testing are used to assess nutrient needs as the plants are growing. These tests help growers fine tune their fertilizer timing and amounts, especially for nitrogen and potassium, to avoid over applying or under applying.



Figure 4. Watermelon growers use petiole sap testing to further fine tune their nutrient applications and irrigation scheduling.

Improved irrigation scheduling and reductions in irrigation water applied through drip systems have reduced the amount of fertilizer that is leached. Extension programs using soil moisture sensors and a demonstration using blue dye in the irrigation water showed growers how quickly the irrigation water goes down into the soil profile. These educational programs helped growers learn how to keep irrigation water in the watermelon root zone and minimize leaching of water and fertilizer below the root zone. Growers believe they are leaching much less today than before by adopting these changes in irrigation practices. Reduced leaching not only reduces negative impacts on groundwater and surface water quality, it also reduces wasted fertilizer expense and improves efficiency.

WATER AND NITROGEN EFFICIENCY

Various measures of efficiency can be estimated, including watermelon yield per unit of irrigation water or per unit of nitrogen applied. Grower interviews indicate that both water and nitrogen efficiency have increased substantially in watermelon production.

Many growers are achieving higher yields per acre now than they did in 1990. Higher yields are obtained through better nutrient and irrigation management, selection of new watermelon varieties, higher plant populations per acre, and other changes in production practices. The change from overhead to drip irrigation is also associated with fewer disease problems and less weed pressure (Hochmuth and Hanlon, 2010). All interviewed growers stated that their yields per acre have increased over the past 25 years. In the early 1990s, typical yields ranged from 25,000 to 40,000 pounds per acre. Although there was considerable variation in the current yield expectations among the growers interviewed, most growers reported typical yields of 50,000 to 60,000 pounds per acre in recent years.

Water use efficiency can be calculated as yield (lbs/acre) divided by water use (gals/acre). A farm that applies 500,000 gallons of irrigation water per acre and obtains a yield of 40,000

pounds of watermelon has a water-use efficiency ratio of 0.08 lbs/gal. A 70% reduction in water use, to 150,000 gallons per acre, and the same yield increases the water-use efficiency ratio to 0.27. If a yield increase from 40,000 pounds to 60,000 pounds coincides with the 70% reduction in water use, the efficiency ratio increases to 0.40 lbs/gal.

Nitrogen efficiency can be calculated as yield (lbs/acre) divided by applied nitrogen (lbs/acre). A farm that applies 200 pounds of nitrogen per acre and obtains a yield of 40,000 pounds of watermelon has a nitrogen efficiency ratio of 200 lbs/lb. A yield increase to 60,000 pounds with the same amount of nitrogen applied gives a nitrogen efficiency ratio of 300 lbs/lb. If a 25% reduction in applied nitrogen per acre (i.e., 150 lbs) coincides with the yield increase, the nitrogen efficiency ratio increases to 400 lbs/lb.

By reducing water use and increasing watermelon yields, growers in North Florida have increased their water-use efficiency immensely. Nitrogen efficiency also has improved as growers have increased yields and kept nitrogen application at or below prior levels.

CONCLUSIONS

Watermelon growers in Florida's Suwannee Valley region have made significant changes to their production practices over the past 25 years. Most notably, they switched from overhead irrigation of watermelons planted in bare ground to drip irrigation with plastic mulch. Also, many growers now rely on soil moisture sensors and plant nutrient testing to adjust irrigation scheduling and fertilizer applications. UF/IFAS Extension and other organizations have assisted growers with these changes.

Interviews with nine watermelon growers document these changes and provide estimates of reductions in water use, fuel use, and fertilizer applied. Growers report reductions in water use per acre ranged from 50% to 80%, with most growers reporting water savings of 67% or more. Growers report that diesel fuel consumption for irrigation pumping has been reduced at least proportional to the reduction in water use. Some growers and engineering studies suggest that fuel savings are likely greater than proportional to the water savings. Although some growers believe they are using about the same amount of nitrogen per acre, most report reductions in applied nitrogen ranging from 15-30%. Watermelon yields per acre have increased dramatically over the time period with less natural resource inputs.

Relying on information from the grower interviews and parameters on water, fuel, and fertilizer rates from other studies, we provide estimates for the total savings on 6,000 acres of watermelon fields in the Suwannee Valley over the past 25 years. Irrigation changes made by watermelon growers have saved approximately 2 billion gallons of water per year. Fuel and fertilizer savings are more difficult to estimate with confidence, but fuel savings of at least 120,000 gallons per year and nitrogen savings of about 180,000 pounds per year are realistic.

Suwannee Valley watermelon growers have reduced water, fuel and fertilizer use, and improved efficiency. More watermelons are being produced with less water and in many cases less nitrogen fertilizer per acre. Improved nitrogen efficiency implies that a greater percentage of applied nitrogen is being taken up by the plant and less nitrogen is being lost to leaching. Similarly, more efficient irrigation through a drip system and soil moisture monitoring implies less leaching. Taken together, these changes indicate a substantial reduction in the likelihood of negative impacts from watermelon production on the region's water quality.

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