Development of an Automated System to Incorporate Holes in Lay-Flat Irrigation Tubing During Initial Deployment in Mississippi Soybean Production Systems, Project 27-2021

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Background and Objectives

The ability to irrigate row crops from the Mississippi River Valley Alluvial Aquifer (MRVAA) is crucial to the sustainability of soybean production in Mississippi and the Mid-South. However, groundwater is a limited resource; therefore, even in humid regions, groundwater must be prudently managed to ensure its continued viability and protect the ability to groundwater access for agricultural production. Declining aquifer levels, coupled with impending well monitoring, serve as a catalyst to improve water use efficiency. The RISER program has identified several technologies and management practices that have the potential to eliminate the 300,000 ac-ft/yr. overdraft on the Mississippi Alluvial Aquifer while ensuring that producers stay within permitted irrigation limits. However, the adoption of Best Management Practices (BMPs) by producers in the Mississippi Delta is minimal.
One technology that has been proven to reduce water usage and provide these positive economic impacts is the use of Computerized Hole Selection (CHS). CHS determines the correct hole size for each individual furrow in a lay-flat irrigation pipe system by accounting for row length, inlet and required individual furrow flow, pipeline pressure and hydraulics, and crown elevation. Two software programs exist for CHS: a research-based tool, Pipe Hole and Universal Crown Evaluation Tool (PHAUCET), (Burch, 2012), and a commercial product, Pipe Planner, developed and maintained by Delta Plastics (2020). From 2013 to 2017, the four irrigation water management practices were evaluated in the region using paired field comparisons (Bryant et al., 2017; Spencer et al., 2019). The paired field comparisons consisted of one field receiving the demonstration of irrigation water management practices while the other field was the producer-managed field, holding other management practices (e.g., cultivar selection) constant. Bryant et al. (2017) implemented these practices on 20 paired furrow-irrigated soybean fields and found no significant difference in yield between irrigation water management and the control ($p = 0.67$), while irrigation water management reduced water use by 21% ($p = 0.0198$) and increased irrigation water use efficiency by 36% ($p = 0.0194$).

OBJECTIVE(S): Year 1 - Develop and assess methodologies for hole insertion into lay-flat irrigation tubing.

1. Assess material properties (modulus of elasticity, burst strength, tensile strength) of lay-flat irrigation tubing for 8, 9, 10, & 15 mil. thicknesses.
2. Develop outlet formation methodologies for punched and slitted holes; assess hole performance (flow characteristics over time change in flow, hole integrity, etc.) for each tubing size and over working pressure range of typical irrigation systems in small-scale laboratory experimentation (single hole or equivalent in transverse cross-sectional area of tubing).
3. Assess lay-flat irrigation tubing material and hole performance characteristics in large-scale experimentation (outdoor, multiple holes, timeline to mimic growing season use and conditions).

   Results from each of the components of these studies will be utilized to guide the development of the mechanism to insert holes into lay-flat irrigation tubing, to determine the acceptable size or sizes for use by hole insertion type, and to assess the performance of each hole type across a growing season. Moreover, these results will be the primary driver of project objectives and assessments for subsequent years.

Report of Progress/Activity

OBJECTIVE 1.

Virgin poly-pipe material (Delta Plastics) with thicknesses of 8, 9, 10, & 15 mil. were cut into 12.7 mm x 305 mm (0.50 in. x 12 in.) samples and analyzed according to ASTM D882 – 18 “Standard Test Method for Tensile Properties of Thin Plastic Sheeting” to assess the material properties in tension (modulus of elasticity, burst strength, and tensile strength) for each mil. thickness. The procedure was replicated on post-season used poly-pipe to asses if material degradation due to use and exposure to environmental conditions were present. The material properties of each mil. thickness were found to be statistically different ($p<0.05$); however, there was no statistical difference ($p<0.05$) found between virgin and used materials of like thickness for Delta Plastics poly-pipe.

Discussions were held with Berry Global, Inc., a competing poly-pipe supplier, at the Mid-South Farm and Gin Show in February. The results of the discussions resulted in an agreement to evaluate their poly-pipe in the same manner as the Delta Plastics material and with virgin testing materials arriving in early April and used material to be supplied at the conclusion of the 2022 irrigation season. This evaluation will give additional information that growers will be able to utilize to determine the correct size and thickness of poly-pipe for each supplier.

OBJECTIVE 2.

A testing system was constructed to assess the characteristics of the hole size in the lay-flat irrigation tubing. The automated system collects poly-pipe performance data (flow, pressure, hole size, mil thickness, etc.) as it runs through the range of operation. Initial evaluation of 15-inch diameter lay-flat irrigation tubing at six common hole sizes (½” , $^{9}/_{16}$” , $^{5}/_{8}$” , $^{11}/_{16}$” , ¾” , $^{13}/_{16}$”) and comparisons of hole geometries (punched, through-hole, slitted).

Poly-pipe tubing of the correct mil thickness is affixed between two rigid PVC end caps with hose clamps, simulating a standard well-riser connection utilized in the field and the sealed end of the pipe opposite the riser. The water supply and pressure transducer are then attached via Banjo® quick-connection fittings to the PVC end cap. Quarter-turn ball valves installed in both end caps are opened, serving a dual purpose; allowing trapped air to escape during poly-pipe filling and in preventing over pressurization of the pipe prior to hole insertion, which could result in poly-pipe damage that could negatively affecting accurate data collection. Once filled with water, a single hole of the correct size is inserted into the poly-pipe using the industry-adopted Poly Piranha II®. After hole insertion, the quarter turn ball valves are slowly closed to establish the correct starting pressure for testing and to close the system in order to capture the flow characteristics of the hole in the poly-pipe. Testing consists of a series of increases and decreases in pressure relative to the material properties of the pipe to assess flow performance and effects of over pressurization on hole distortion, changing the size/shape of the hole, resulting in an undesired increase in flow.

Data collection on virgin Delta Plastics 15” poly-pipe of 7,9, & 10 mil. indicates that there is a fundamental change in the flow characteristics of the poly-pipe when it is subjected to pressures greater than the elastic yield of the material (determined from Objective 1). Analysis indicates that changes are greatest in 7 mil. poly-pipe, the thinnest of the materials tested and also the lowest elastic yield coefficient: a 1.6% change in 10 mil, up to a 0.75% change in 9 mil, and up to a 3.6% change in 7 mil..

The evaluation of flow by hole size and mil thickness demonstrate the effects of over-pressurization on the hole size-pressure flow relationship: 7mil. 1.035 psi (head), 9mil. 1.144 psi (head), 10mil. 1.368 psi (head). 7 mil. experienced the greatest change in post over-pressurization flow, with increases near 3%. 10 mil. material was affected the least by the 150% over-pressurization, exhibiting an increase in flow of 0.5%. This resultant data is being compiled and, along with the data from the Berry poly-pipe evaluations (to be collected in 2022) will be used to develop a recommendation guide for producers to utilize to determine the correct poly-pipe diameter and mil thickness to use and to establish a reference when adjusting well output pressures to prevent material or flow failures when utilizing computerized hole selection prescriptions and to direct further research in this project.

OBJECTIVE 3.

Delays from equipment, materials, and inclement weather have currently prevented the completion of Objective 3. A variable-frequency drive and additional poly-pipe materials are on-hand and ready for testing in simulated real-world irrigation scenarios as soon as weather permits. With the addition of the Berry Global, Inc. materials, the testing will give a more complete data set from which to create poly-pipe recommendation guides and to better understand the similarities and differences in performance between the two material suppliers. This objective is also targeted to be completed in 2022 and will run concurrently with the new objectives of the 2022-2023 research cycle.

OBJECTIVE 4.

Discussions have been ongoing with manufacturers to identify hole insertion mechanisms capable of meeting the needs and intent of the project. Additional guidance has been sought with USDA ARS engineers at Stoneville, MS to assist in the evaluation and selection of mechanisms. Within the first quarter of the 2022-2023 year, a mechanism or mechanisms will be selected for testing with the intent to begin the design for incorporation onto a commercially-available poly-pipe implement throughout the year.

Impacts and Benefits to Mississippi Soybean Producers

Current research accomplishments have exposed previously unknows about commercially-available poly-pipe and data collected from testing is being compiled into a recommendation guide that producers will have at their disposal for selecting the correct diameter and material thickness for poly-pipe purchases to prevent costly failures during the growing season. Additionally, data from this research has uncovered hole flow changes with only slight over-pressurization which does not cause any observable changes to the poly-pipe. These results will be useful in continuing water conservation strategies and in evaluating water use efficiencies relative to irrigation effort and effectiveness.

End Products–Completed or Forthcoming

Communications: Presentations at conferences - (ASABE, MWRRI, Mid-South Farm & Gin Show, etc.); Poster Presentations; Field Days – Turnrow talks, etc.; Congressional Visits; etc.

Publications: Producer poly-pipe use and selection guide; Extension publication on the importance of well operation to maintain correct pressures; Academic (ASABE, etc.).

Technology: Poly-pipe Hole Insertion Implement and add-on mechanism development; poly-pipe material performance information

Demonstration: Field Days, Producer Advisory Council; On-farm demos, continued on-farm research, etc.

Graphics/Tables

Material Thickness (mil.)	Individual Hole Flow (GPM)		
	Pre	Post	Increase (GPM)
7	16.00	17.28	1.28
9	16.17	16.60	0.43
10	14.64	14.84	0.20

Material Thickness (mil.)	Simulated Irrigation Event Flow (Gallons)		
	Normal	Overpressure	Increase
7	10,137,600	10,948,608	811,008
9	10,245,312	10,517,760	272,448
10	9,275,904	9,402,624	126,720