EFFECTS OF VARIABLE-RATE SPRINKLER CYCLING ON IRRIGATION UNIFORMITY

Calvin Perry and Kerry Harrison
NESPAL and Bio & Ag Engineering, The University of Georgia, Tifton

Introduction

Beginning in 1999, the Precision Ag research team at the University of Georgia partnered with the Farmscan company (Perth, Western Australia) to develop variable-rate irrigation (VRI) controls for center pivot (CP) irrigation systems. The VRI system enables a CP to precisely supply water in optimal rates relative to the needs of individual areas within fields. The UGA system, which retrofits on existing CP systems, integrates GPS positioning into a control system which cycles individual sprinklers or groups of sprinklers OFF and ON (seconds ON per minute) and varies travel speed to achieve desired rates within management zones.

However, the relative immaturity of VRI technology leaves many practical questions yet to be answered. A primary question is whether the cycling of sprinklers ON and OFF to achieve variable application rates affects the overall application uniformity of an irrigation system. Preliminary testing indicated VRI cycling had no effect on uniformity. However, that testing was quite limited.

The objective of this research was to more adequately compare uniformity of application with and without VRI controls cycling sprinklers ON and OFF.

Materials and Methods

The cycling tests were conducted on a CP system at the UGA Tifton Campus The irrigation system was a 186 m (611 ft), four span Reinke center pivot fitted with Nelson R3000 rotator sprinkler nozzles on flexible drop hoses, with sprinklers set at 1.3 m (4.4 ft) above soil surface. Each sprinkler was fitted with a 67 kPa (10 psi) pressure regulator. In the first span, sprinklers were spaced 5.06 m (16.6 ft) apart and spaced 3.05 m (10 ft) on the remaining spans. In non-VRI mode, the CP operated at 882 L/min (233 gal/min) at 262 kPa (38 psi). For this research, only spans 3 and 4 were included in the test area. This system does not cover a full circle (approximately 80 degrees).

The CP was fitted with the aforementioned VRI control system. Each sprinkler was controlled ON/OFF by a normally-open, pneumatically-controlled, flow-control valve. The pivot's 54 sprinklers were grouped into 15 control zones with 2, 3, or 4 sprinklers each. An electronically-actuated solenoid provided control actuation to the sprinkler valves via 8 mm air tubing. A 1.5 kW (2 HP) 120 VAC air compressor mounted on the mainline at the first support tower supplied compressed air for valve actuation. To accomplish the tests in this project, all the control zones in the test area were set to apply water at 20%, 50%, or 80% of "normal" application. "Normal" application was set by travel speed of pivot. To achieve 50% of "normal", the Farmscan system controlled a sprinkler such that it watered for 30 sec and shut OFF for 30 sec, repeating continuously. A rate of 80% would correspond to 48 sec ON and 12 sec OFF. All control zones outside the test area were set to 100% application.

The center pivot testing consisted of 3 pairs of lines of collectors (plastic paint buckets, 16 cm diam., 20 cm tall) extending radially from the pivot point, beginning 90.8 m (298 ft) from the pivot point, which corresponded to the area beneath the 3rd and 4th spans, to the end of the last span, for a total of 30 collectors in each line. Each pair of lines represented a replication of the test for a total of 6 lines representing 3 replications.

Collectors were leveled and spaced 3 m (10 ft) apart in the lines and the distal ends of the radial lines were 15.2 m (50 ft) apart. Because the system did not move through a full circle, the first line of collectors was located such that the irrigation system could be started and water flow stabilized 15.2 m (50 ft) before encountering the collectors. Ample space remained beyond the last radial line to allow the system to move completely past the collectors. A 1000 mL graduate cylinder was used to measure collector volume. Tests were conducted under low wind conditions (< 8.05 km/hr (5 mi/hr)) well below limits suggested by ASAE Standards (ASAE S436.1). The pivot's end gun was not used during the tests. The tests were conducted several days after emergence of cotton planted in the test area.

The VRI controller was programmed to apply water at test rates of 20%, 50%, 80%, and 100% of "normal" application in the test area, as described earlier. For each test, the application map corresponding to the test rate was selected, "normal" application was set with CP travel speed, water was started, and the system was walked over the 3 pairs of collector lines. Collector volumes were measured as soon as the system had moved past a line.

Results and Discussion

Results of tests performed with the CP system are given in Table 1. Tests were performed May 20-21, 2004. Because the cotton crop under the CP was growing rapidly, only the 11% travel was tested. The Heerman and Hein Coefficient of Uniformity (CUH) for each replicate was calculated according to ASAE Standard S436.1. The low quarter Distribution Uniformity (DUlq) was calculated by:

DUlq = (Avg LQ / V Avg) x 100 ....[1]

where: *Avg LQ* = the lowest one-fourth or quarter of the measurements

V Avg = average depth of application

The CUH and DUlq values were quite high for all the tests (all > 89). The 100% test, representing the baseline or "normal" mode, had CUH and DUlq values 94 or greater, indicating a very uniform system. The CUH and DUlq values did tend to decrease slightly as the sprinkler cycling rate decreased. The reduced sprinkler cycling rates (20%, 50%, 80%) produced average application depths that were reduced by similar percentages, as compared to the "normal" or 100% application.

Sprinkler cycling ON and OFF appears to have no discernable impact on overall CP application uniformity. Thus, this method of creating a variable application rate in zones along a CP mainline should not cause unintended degradation of the system's sprinkler uniformity.

Table 1. Results of center pivot uniformity testing.

Date	Pivot Speed/ Rate (%)	Sprinkler Cycling Rate (%)	Rep	CUH	DUlq	Avg Depth (cm)	Avg Wind Speed (km/hr)	Avg RH (%)
5-20	11	100	1	95	95	0.86	2.1	62
			2	94	94	0.89		
			3	95	95	0.86		
5-21	11	80	1	93	89	0.71	5.0	44
			2	93	87	0.71		
			3	93	89	0.74		
5-21	11	50	1	92	92	0.43	2.3	62
			2	95	92	0.48		
			3	93	91	0.43		
5-20	11	20	1	92	92	0.20	3.8	48
			2	91	90	0.20		
			3	91	89	0.15		

Acknowledgements

Funding to aid this project came from Georgia Cotton and Peanut Commissions, the National Peanut Council, the Cotton Foundation, The Georgia Research Alliance, the USDA FFRA and the joint USDA/NASA-IFAFS program, and State and Federal appropriations to the University of Georgia College of Agricultural and Environmental Sciences.