FIELD PERFORMANCE TESTING OF IN-CANOPY CENTER PIVOT NOZZLE PACKAGES IN KANSAS

Danny H. Rogers, Gary A. Clark, Mahbub Alam, Kent Shaw[1]

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Abstract: Traditional performance evaluation procedures of center pivot nozzle packages involved placement of catch cans under the nozzles. An accurate catch requires at least three feet of separation between the top of the can and the nozzle outlet. In the Ogallala irrigated regions of western Kansas, the majority of the nozzle packages are in-canopy systems that preclude a catch can type performance evaluation. An in-canopy nozzle package testing procedure was proposed, using individual nozzle pressure and flow readings at prescribed locations along the center pivot lateral to compare to design specifications. The goal is to develop a streamlined protocol to allow individuals, consultants, and/or agency personal to evaluate systems in a timely and efficient matter. Such evaluations would allow independently gathered flow and pressure reading to verify on-site monitoring equipment readings, add to the information data base on nozzle package performance under various operating conditions and help producers track performance and help them decide when a nozzle package upgrade or change is needed. The evaluation procedure and testing are being conducted as part of the Mobile Irrigation Lab (MIL) project. MIL software and information are available on the MIL website (http://www.oznet.ksu.edu/mil/).

Introduction

The Mobile Irrigation Lab (MIL) project is an educational and technical assistance program focused on enhancing the irrigation water management practices of Kansas irrigators (Clark et. al., 2002 and Rogers et. al., 2002). The MIL has two parts: one part emphasizes irrigation software development and hands-on computer training for producers; the second part has emphasis on field activities, which has included on-farm irrigation demonstrations and center pivot performance evaluations. Center pivot nozzle package evaluations have used catch can data to calculate a distribution uniformity coefficient (Figures 1 and 2). However in the Ogallala irrigated areas of western Kansas, the most commonly utilized center pivot nozzle package is an in-canopy placement of the nozzles, which can not be tested using the catch can procedure. The development of a testing procedure for these types of systems that can be done in a time efficient manner would help producers evaluate systems and make adjustments as needed to keep the system distributing irrigation water and chemicals effectively and allow for good irrigation water management.

In-canopy Nozzle Package Testing

Unlike an above canopy nozzle package, where the uniformity of water distribution is dependent on non-

[1]Danny H. Rogers, Professor, Irrigation, Biological & Ag Engineering, K-State Research & Extension, Gary Clark, Professor Biological & Ag Engineering, K-State University, Mahbub Alam, Assoc. Professor, Irrigation Engineer, Southwest Area Extension, Garden City, KS, Kent Shaw, Irrigation Management Specialist, Southwest Area Extension, Garden City, KS.

interference by the crop canopy, the in-canopy nozzle package almost always has the water streams from the nozzle being intercepted and/or redirected by the crop stocks and leaves. The primary exception to this would be a LEPA system utilizing circularly planted rows and bubble mode nozzles or drag tubes. Few of these types of system are utilized in Kansas. However, even these types of systems would have non-uniform water distribution if the design flow rate and pressure conditions are not met. Above-canopy testing experience revealed that some package uniformity problems were related to the package design conditions not being met. This could be caused due to a variety of reasons, including mis-communication between the designer and the installer, errors in measuring or estimating well yield, changes in well capability due to water declines or wear, and monitoring equipment errors resulting in incorrect operation flow and pressure setting. Another package error discovered was improper installation, the most common of which was the reversal of pivot span nozzles. This latter error could be more easily be discovered and corrected for an in-canopy package than for most above canopy systems, since access to the nozzles for size reading and changing is convenient.

The concept of the in-canopy test was to develop a protocol to minimize data collection from a system that would still allow a determination of whether design and operating conditions matched. The intent was to take a number of pressure and flow readings from nozzles along the center pivot lateral and measure total flow and pivot point pressure and compare this information to the design sheet specifications. It was thought that eventually only readings of a few nozzles at the beginning and end of the pivot lateral would be sufficient to verify the system performance in terms of water distribution along the center pivot lateral.

Since the nozzles are near the ground and many are mounted on a flexible drop tube, it was thought that installation of a pressure shunt could be done by crimping off the water flow to an individual nozzle and installing the pressure shunt to determine the nozzle pressure. The flow rate could be determined by volume flow measurement and a stop watch. However before testing began, several small digital flow meters (F-1000-RB flow rate meters from Blue-White Industries[2]) were purchased and configured with the pressure shunt as shown in Figure 3.

Most irrigation wells are metered in Kansas and flow meter readings were accepted for use in the previous above-canopy evaluations. However, several of the systems that were evaluated had poor performance ratings for no apparent reason. One reason might have been improper flow or pressure at the pivot point. However input flow and pressure readings were not independently verified, so this could not be proven. One of the systems was retested at a later date and the performance rating was good and both input flow and pressure were verified independently. To allow this to routinely occur, a non-intrusive flow meter was obtained.

The digital flow meters were lab tested and worked well over the specified flow range. However, during field tests, we have had some difficulty with moisture accumulation in the LED display to the degree that the display can not be read. Although the instrument specifications indicate they can be used in a wet environment, the instruments would also shut down after several readings presumably due to the moisture condensation within the body of the instrument. The instrument bodies can be opened to allow drying without apparent effect on accuracy. Several ideas to prevent condensation have been tried without much success, so this remains an issue for these particular instruments. The back up method for obtaining flow readings is the bucket and stop watch.

Data collection as not been as easily obtained as hoped for. A minimum of two individuals are needed on-site, although three can be efficiently used. One “dry” individual is needed to record the data.

[2][2] No criticism or endorsement is intended by the use of commercial name. The use is only for clarity of the presentation.

Example Test Results

Test results from the first in-canopy pivot analysis are shown in Table 1. Most of the measurements were taken adjacent to a pivot tower. The test was conducted early in the irrigation season. The center pivot was 1305 feet long and equipped with 251 Senninger LDN nozzles using concave grooved by chemigation pads with 6 and 10 psi pressure regulators. The design flow rate was 350 gpm with a top of pivot pressure of 14 psi.

Figure 4 shows the field measured pressure distribution and the design pipe pressure. The field pressures were measured at approximately the nozzle height of 3 feet from the ground. The design pipe pressure would be at an elevation of approximately 12.5 feet, for about a 4 psi pressure differential. The measured values appear to be slightly higher than the design values. However, all nozzles are pressure regulated, so much of the pressure differential would be dampened out through the regulators.

Figure 5 shows measured flow rates and design flow rates. Measured observations appeared to be slightly higher at the end of the center pivot than design values. The test was conducted before the start of the general irrigation season, which could mean the well yield was higher than what it might be after long term pumping. However flow measurements at the beginning of the pivot lateral were matched very closely to the design values. Overall, it appears this system's performance was satisfactory.

Future Activities

The obvious improvements needed for the in-canopy test procedure are 1) reliable measurement of the pivot point flow rate and pressure, 2) either a different nozzle flow measurement instrument or a method to better seal the existing instrument, and 3) a standardized data collection routine. The latter comes with multiple testing and analysis. Items one and two are being addressed. In addition to moisture condensation or accumulation within the instrument, the instruments also shut down completely after a number of uses. This was originally thought to be due to the moisture exposure, but an additional suggestion that exposure to cold ground water may be having an effect on the instrument. This will be tested in the lab. During the test, the instruments are not exposed to direct spray from other nozzles, but do get wet from handling.

Center pivot irrigation systems are the dominate type of irrigation system in Kansas. The most common type of nozzle package uses an in-canopy configuration. The goal of developing a method to allow a cost effective verification of the nozzle package performance will help irrigators management the irrigation water resources to the highest degree possible.

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References:

Clark, G.A., D.H. Rogers, M. Alam, D. Fjell, R. Stratton, and S. Briggeman. 2002. A Mobile Irrigation Lab for Water Conservation: I. Physical and Electronic Tools. In proceedings of Irrigation Association International Irrigation Technical Conference, October 24-26, 2002, New Orleans, LA, available from I.A., Falls Church, VA.

Rogers, D.H., G. A. Clark, M. Alam, R. Stratton, and S. Briggeman. 2002. A Mobile Irrigation Lab for Water Conservation: II Education Programs and Field Data. In proceedings of Irrigation Association International Irrigation Technical Conference, October 24-26, 2002, New Orleans, LA, available from I.A., Falls Church, VA.

Figure 1. Series of IrriGages being positioned prior to an above canopy nozzle package evaluation.

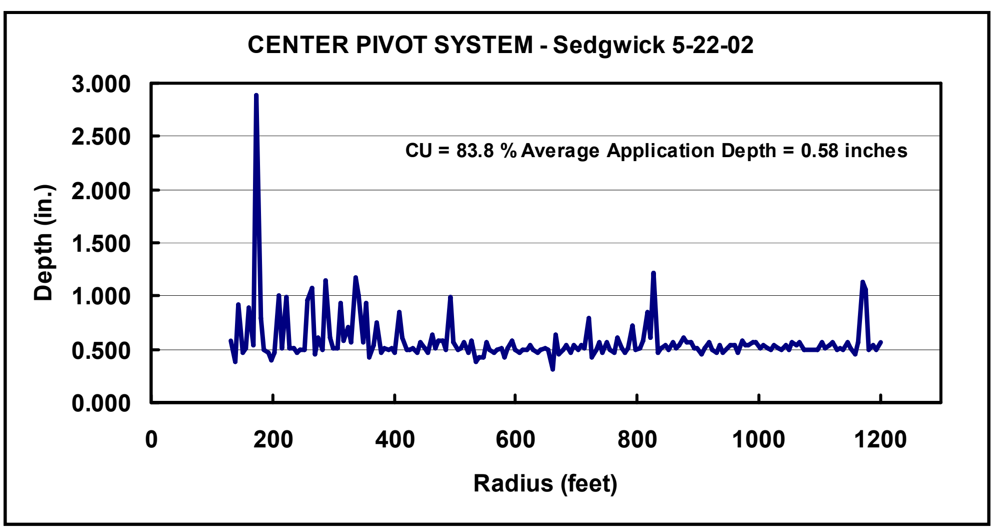

Figure 2. MIL uniformity test results for a center pivot equipped with an above canopy nozzle package of

rotator nozzles.

Figure 3: Digital flow meter and pressure shunt apparatus used for in-canopy performance evaluation**.**

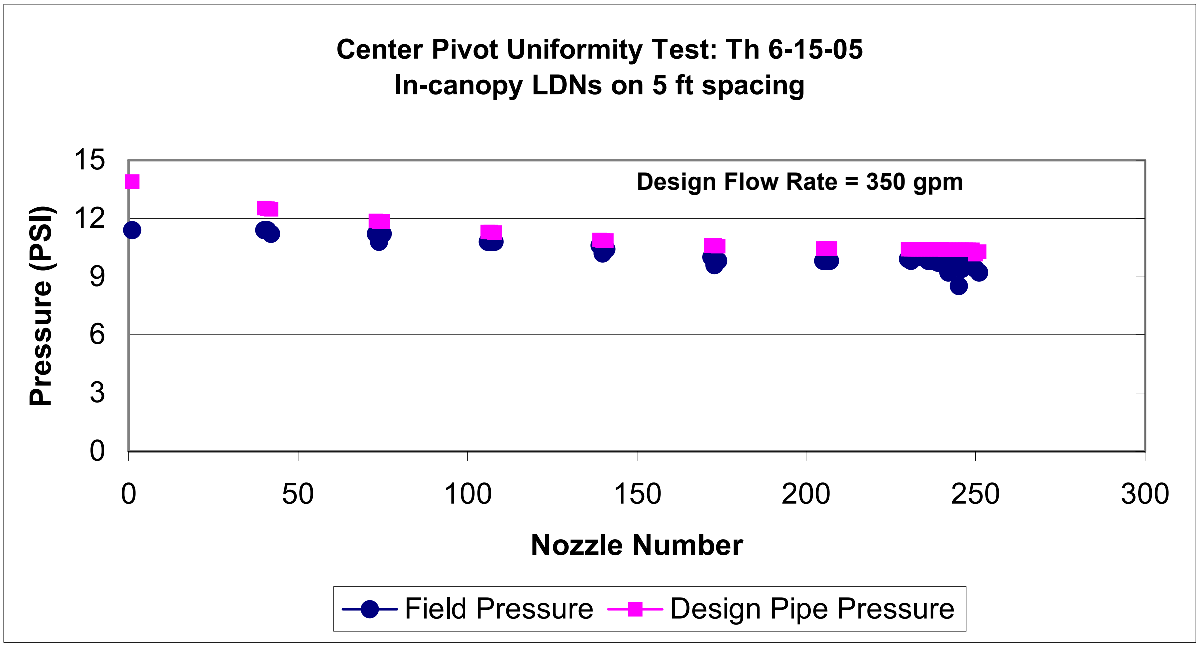

Figure 4: Field measured verses design pressure from an in-canopy center pivot evaluation.

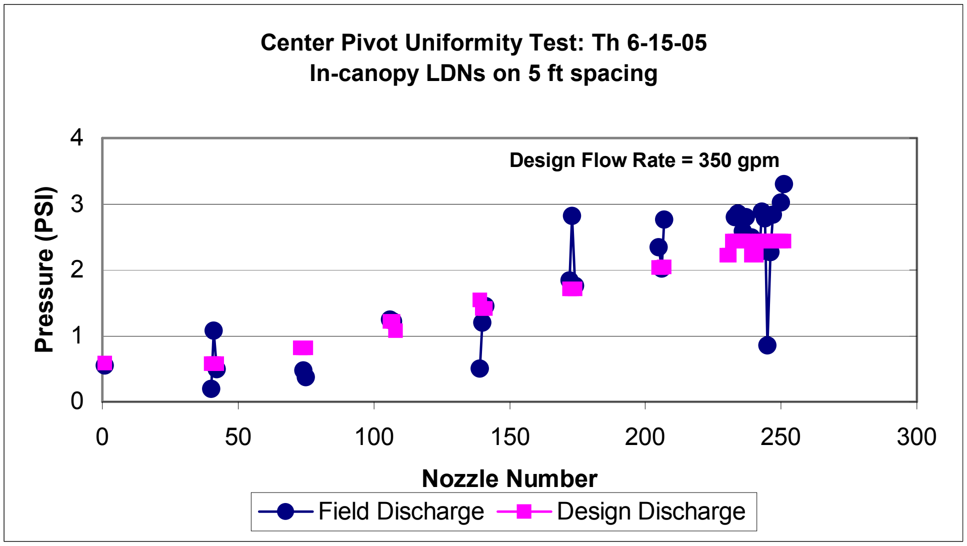

Figure 5: Field measured verses design nozzle flow rates from an in-canopy center pivot evaluation.

Table 1: Field Observed and Design Pipe Pressures and Nozzle Flow Rates from an In-canopy Center Pivot Nozzle Package in Thomas County, Kansas.

Nozzle number	Field psi	Design psi	Field gpm	Design gpm
251	9.2	10.3	3.3	2.44
250	9.4	10.15	3.02	2.44
247	9.8	10.39	2.84	2.44
246	9.4	10.39	2.27	2.44
245	8.5	10.39	0.86	2.44
244	9.8	10.39	2.78	2.44
243	9.8	10.39	2.88	2.44
242	9.2	10.39	2.27	2.44
240	9.8	10.4		2.23
239	9.7	10.4	2.49	2.22
238	10	10.4		2.44
237	9.8	10.4	2.8	2.44
236	9.8	10.4	2.59	2.44
234	10	10.4	2.86	2.44
233	10	10.4	2.8	2.44
231	9.8	10.4		2.22
230	9.9	10.4		2.22
207	9.8	10.44	2.76	2.05
206	9.8	10.44	2.02	2.04
205	9.8	10.44	2.34	2.04
174	9.8	10.58	1.76	1.71
173	9.6	10.59	2.82	1.71
172	10	10.59	1.84	1.71
141	10.4	10.86	1.45	1.41
140	10.2	10.87	1.2	1.41
139	10.6	10.88	0.5	1.54
108	10.8	11.27		1.08
107	10.8	11.29	1.22	1.22
106	10.8	11.3	1.25	1.22
75	11.2	11.82	0.37	0.82
74	10.8	11.84	0.47	0.82
73	11.2	11.86		0.82
42	11.2	12.48	0.49	0.58
41	11.4	12.5	1.08	0.58
40	11.4	12.52	0.2	0.58
1	11.4	13.9	0.55	0.59