MOBILE IRRIGATION LAB (MIL): Center Pivot Uniformity Evaluation Procedure and Field Results

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Introduction

The Mobile Irrigation Lab (MIL) project is an educational and technical assistance program that is focused on enhancing the irrigation water management practices of Kansas irrigators. It is an outgrowth of experiences gained from long-term on-farm demonstration projects in south-central and western Kansas. The MIL field unit is a 16 foot trailer partitioned into a classroom/office area in the front and an equipment compartment in the rear. The front office area allows on-site training and data analysis opportunities. For larger training sessions, MIL computers are used in conference rooms to conduct hands-on computer software training. MIL tools include KanSched, an ET based irrigation scheduling program and FuelCost. A pumping plant efficiency estimator. The bulk of the field equipment carried by MIL are IrriGages. IrriGages are non-evaporating, in-field measuring devices used to catch irrigation applications by center pivot and linear irrigation systems. The catch data can be used to calculate a distribution uniformity coefficient which is a measure of the sprinkler package performance.

MIL Educational Activities

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Upon the installation and/or after the initial or seasonal operation, it is important that you make checks concerning the sprinkler package. Ensuring that your sprinklers are operating at the correct pressure is one of the most important checks that you can make. Several items you will need are: 1) the correct sprinkler chart 2) accurate pressure gauges. Check the pressure at the pivot point and compare it to the value on the sprinkler chart. The pivot pressure must be measured at the top of the pivot elbow and compare it to the chart value. You should also check the pressure at the end of the machine or the last sprinkler. For both of the checks, the machine should be located so that it is at the highest point of elevation in the field and if it has an endgun, it should also be operating.

Checking the pressure is one of the most important items to check. If the sprinkler package is designed to operate at 20 psi at the end of the machine and it is only operating at 15 psi, a 15% reduction of water is being applied. In most locations pumping conditions can change throughout the growing season, therefore these pressure checks should be performed at least on a monthly basis.

In conclusion the initial design of the sprinkler package is extremely important, yet the operation and maintenance of the machine and sprinklers is also important, which can affect your crop yield and quality results.

MIL educational activities have included the traditional classroom/lecture format where program information and study results are presented. Other presentations have been incorporated into agronomic and/or irrigation management meetings and field tours. The special educational focus of MIL has been hands-on computer training for producers and agency personnel. While the bulk of the training has been conducted in a class room setting, using MIL laptops to set up as a computer lab. A unique feature of MIL is the ability to do one-on-one computer training at the field site. The front half of the MIL trailer can easily accommodate 2 or 3 individuals. The laptop computers can also be carried into the home or office of an interested producer.

The ET based irrigation scheduling program, KanSched, has been the primary focus of the computer training sessions, although other software programs are reviewed. Several hundred MIL resource CD's, containing both information and software, have been distributed upon request. MIL resources are also easily accessed via the MIL website at http://www.oznet.ksu.edu/mil/.

Field Activities : Center Pivot Uniformity Testing

MIL has an emphasis on field evaluation center pivot sprinkler packages for distribution uniformity. The initial rational for testing was that if irrigation scheduling procedures result in "just in time, just enough water application", then the water must be distributed so that plants have equal access to the water to prevent over- or under-water within the field, which would have yield implications.

Center pivot systems are the dominate irrigation system in Kansas, representing about 80 percent of the irrigated acres. The sprinkler package design is based on a number of factors with system pressure and flow rate as major considerations. Center pivot irrigation systems have been largely assumed to be properly operating if the pivot point pressure and flow rate are set at the design operating specifications. Routine evaluation of the center pivot sprinkler package after installation is seldom performed by the installer. Testing involves placement of multiple catch containers along the lateral of the system and then measurement of each catch. The catch containers used had to be measured quickly in order to avoid measurement error that would be introduced by evaporation losses. Therefore, a number of individuals had to be present at the test site for quick measurement. Measurement required entry into a very wet field, making for difficult data collection.

Development of a more streamlined testing procedure has been made possible through the use of IrriGages. IrriGages are a non-evaporating collection device as shown in Figure 1. A series of IrriGages are placed along the center pivot or linear lateral and are normally spaced at about 80 percent of the nozzle spacing. The IrriGages are placed so that all water from a complete pass of the center pivot is collected. The data collected includes the volume of catch and the position radius of the IrriGage relative to the center pivot point or the end of the linear system. System operating and package characteristics are also recorded. The catch data is entered into a MIL uniformity evaluation program where the average depth of application and the coefficient of uniformity (CU) value is calculated. The program also plots the catch data which helps to visually identify the location of package weakness.

The MIL uniformity testing program has several goals including 1) development of the testing procedure, 2) development of a data base of characteristic uniformity performance criteria for various nozzle package types and configuration that could improve design and installation recommendations, and 3) improved performance for an individual operator's system.

The MIL evaluation program is limited to sprinkler packages that are at least four feet above ground as three feet of clearance is recommended between the top of the collector and nozzle outlet. Another restriction is the need for the top of the collector to be above the crop canopy or be placed in a non-vegetated strip of a width of about three times the height differential between the collector top and the nozzle on each side of the catch container. The height restriction means many in canopy systems can not be evaluated with the MIL test procedure. However since the in-canopy system is generally affected by the canopy, the uniformity of distribution pattern is not as important as for above canopy systems. A different evaluation procedure is being developed that will involve pressure or flow testing of nozzles at specified positions along the center pivot lateral. All systems, regardless of the type or configuration of the nozzle package, should be inspected regularly and repairs made to meet original design criteria as specified in the sprinkler design package papers that should have been provided at installation.

Test Result Examples

Field test results have found a number of center pivot nozzle packages that were not performing to expectations. Some of the non-uniformity may be related to the original design where possibly the incorrect well yield and pivot pressure was provided to the designer. Some non-uniformity may be due to incorrect input pressure and flow settings sue to well or pump changes or faulty gauge or meter readings. A number of systems were found to have had the package incorrectly installed, while some had performance problems related to nozzle maintenance issues.

The uniformity test results for four systems are shown in Figures 2 through 5. Figure 2 is a rotator equipped center pivot system with a CU of 84 percent. The major spike in application depth in the inner part of this system, was a leaky tower boot. The inner span of many systems have higher than average application depth, as is noted for this system as well.

Figure 3 shows a flat spray system with a very low CU valve of 50 percent. The water supply for this system has very high iron and other mineral content and there was visible accumulation of materials on the system, nozzles and splash plates. Noted in the visual inspection of the system while operating, were a number of nozzles that had a deficient spray pattern, due to either partial plugging of the orifice or crust accumulation on the splash plate.

Figure 4 shows the results from a flat spray equipped system in rolling sandhills near Garden City, Kansas. The non-pressure regulated flat spray nozzles were tested in high wind conditions. During the set up of the test, it was expected that the CU value would be very low due to the elevation differences along the center pivot lateral and the high wind conditions. However, the CU value of 82 percent was much higher than expected. Two leaks are noted as spikes in the application depth. The center point spike was due to continuous over-spray near the center pivot point, due to the high wind conditions. The spike at the mid-point of the system may have been an unobserved leak.

The results for a new system equipped with I-Wob nozzles in Figure 5 showed an increasing depth of application with increase of radius. The application depth was approximately one-third greater in the outer portion as compared to the inner portion. This is the most problematic of the examples shown, but the cause may be related to improper flow or pressure conditions. The CU value of 82 percent was surprising good, however, the variation in average application down the lateral needs to be addressed.

Other tests have revealed installation problems, such as missing drop nozzles and reversal of tower nozzle sequences. Poor performances have also been attributed to changes in operating conditions as compared to original design specifications. Another possible cause of low uniformity could be internal incrustation similar to the material encrusted on nozzles splash types, which would alter friction loss characteristic of the system resulting in loss of design integrity.

Future Activities

Development of additional decision-support software and computer training activities will continue. Distribution of the information will continue via educational meetings, conferences and training sessions. However, the latest resource materials are available via the web at www.oznet.ksu.edu/mil. Refinement of the uniformity evaluation procedure will continue but an immediate goal will be to develop an IrriGage test kit which would include testing procedure instruction, IrriGages, and data forms and other necessary test equipment. Test kits would be made available for use by producers or agency personnel to increase the number of systems evaluated.

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Figure 1. Series of IrriGages being positioned prior to an evaluation.

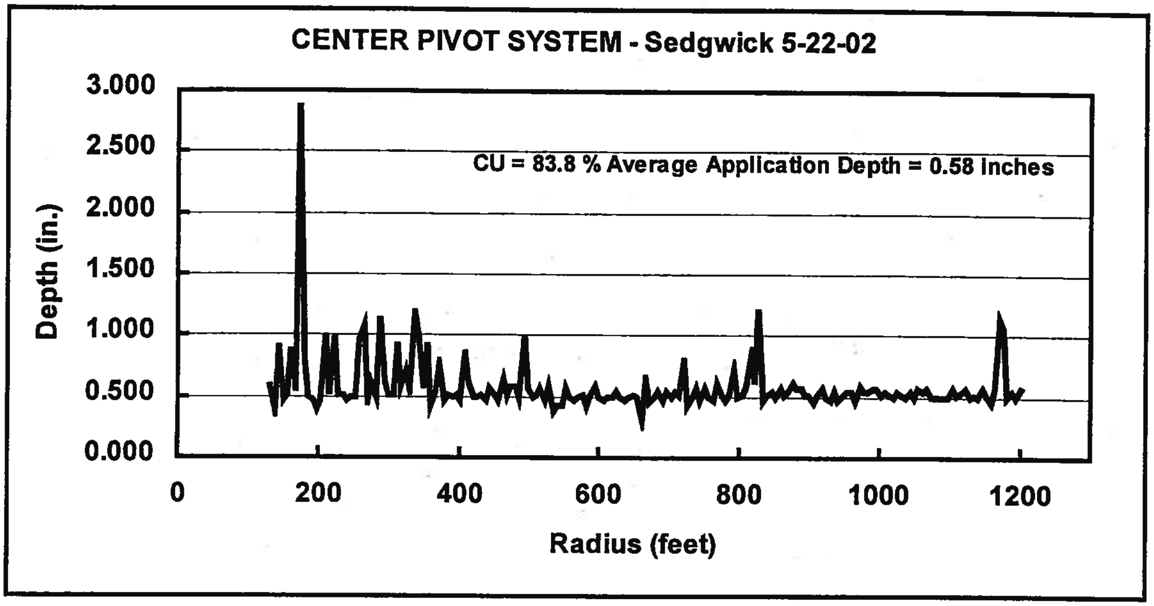

Figure 2. MIL uniformity test results for a center pivot equipped with rotator nozzles.

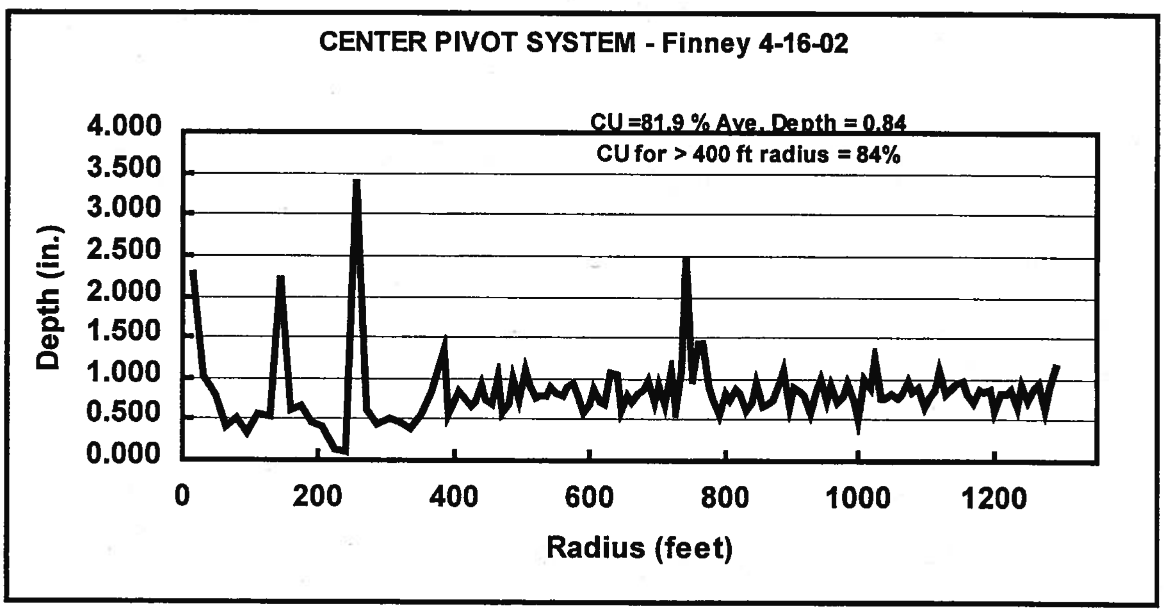

Figure 3. MIL uniformity test results for center pivot equipped with flat spray nozzles.

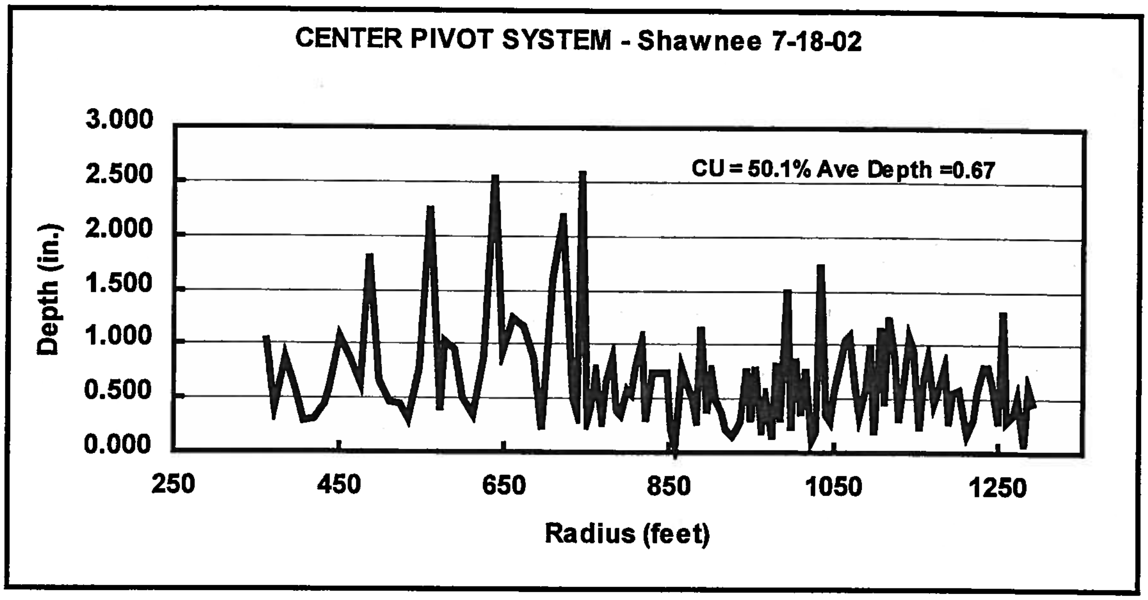

Figure 4. MIL uniformity test results for a center pivot equipped with flat spray nozzles.

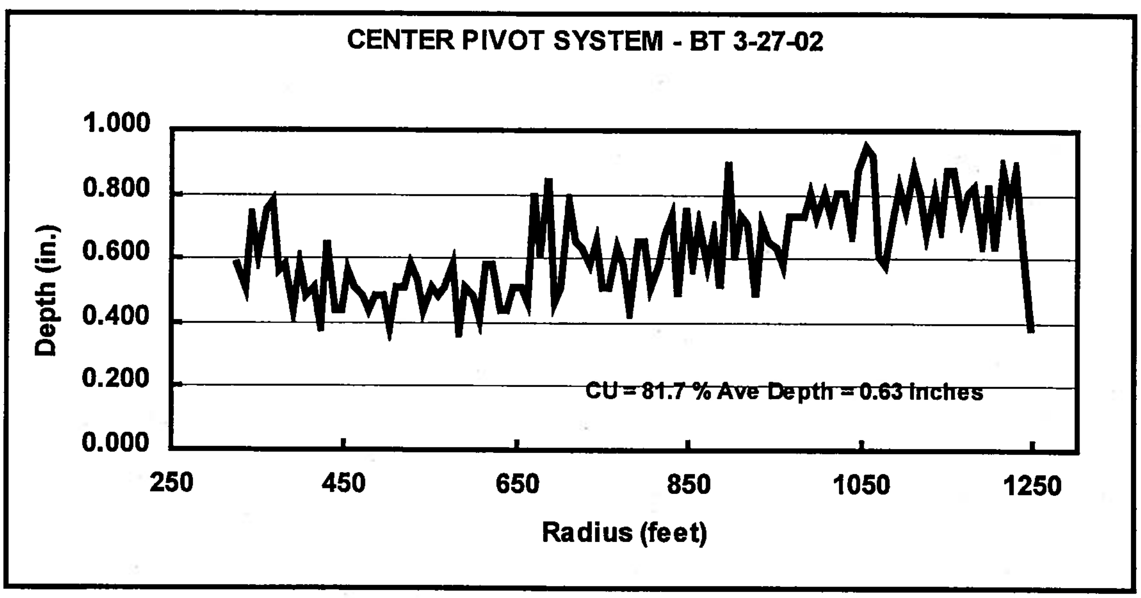

Figure 5. MIL uniformity test results for a center pivot equipped with I-Wob nozzles.