IMPACT OF WIDE DROP SPACING AND SPRINKLER HEIGHT FOR CORN PRODUCTION

C. Dean Yonts
Panhandle Research and Extension Center
University of Nebraska
Scottsbluff, NE 69361
308-632-1246
cyonts1@unl.edu

Freddie Lamm
Northwest Research-Extension Center
Kansas State University
Colby, KS 67701-1697

Bill Kranz
Northeast Research and Extension Center
University of Nebraska
Norfolk, NE 68701

Jose Payero
West Central Research and Extension Center
University of Nebraska
North Platte, NE 69101

Derrel Martin
Biological Systems Engineering Department
University of Nebraska
Lincoln, NE 68583

Introduction

Using center pivot sprinkler nozzles below the top of the corn crop canopy presents unique design and management considerations. Distortion of the sprinkler pattern can be large and the resultant corn yield can be reduced. In many areas, water available for irrigation is being limited due to reduced supply of both ground and surface water. During periods of drought, uniformity problems associated with center pivot irrigation become quite visible. Many times water stress on the crop is not evident until late in the season when the crop has nearly matured. In many cases aerial observations of fields have revealed concentric rings that corresponded to sprinkler spacing (Figures 1a - b).

Figure 1a. Height reduction in corn caused by drops spaced too wide.

Figure 1b Concentric rings in corn field caused by having drops spaced too wide.

The impact of sprinkler spacing on water distribution and corn yield was the focus of University of Nebraska and Kansas State research studies. Researchers conducted field experiments along with on-farm evaluations to gain a better understanding of operating sprinkler devices within the corn canopy. The results from these experiments will be discussed.

Field Evaluation of Changes in Soil Water Content

In a Nebraska study soil water content was measured as a method to evaluate the uniformity of water distribution. Soil water content was measured in the top 12 in. of soil before and after irrigation. Spinners[1] were spaced 12.5 ft apart and located at a height of 42 inches in a mature corn crop. Sprinklers were moving parallel to the corn rows but not necessarily between the corn rows. Figure 2 shows the location of the sprinklers in the corn rows and the change in soil water content measured before and after irrigation. Soil water content increased nearly 12% in the rows nearest the sprinkler device. Soil water content averaged less than a 2% increase at locations directly between the sprinkler devices. The small change in soil water content indicates the rows between the sprinkler devices received little or no water during the irrigation event.

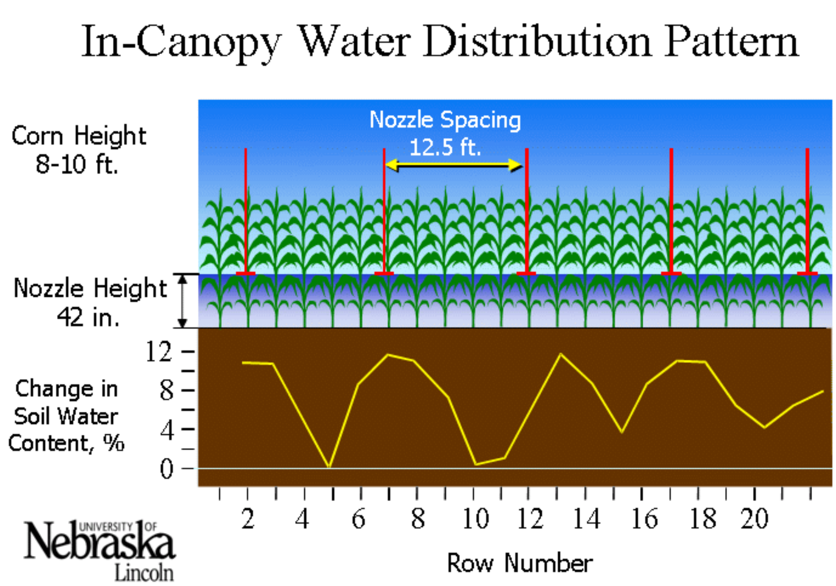

Figure 2. Changes in water content following irrigation with sprinkler nozzles located in a corn canopy.

[1]Mention of trade name is for information only and does not imply endorsement

Variation in Corn Yield as Affected by Sprinkler Height

When the sprinkler pattern is distorted and the nozzle spacing is wide enough to prevent some corn rows from getting equal opportunity to water, yields can be reduced. A study was conducted at the KSU Northwest Research-Extension Center from 1996-2001 to examine the effect of irrigation capacity and sprinkler height on corn production when the spray nozzle spacing was too wide for adequate in-canopy operation (10 ft instead of more appropriate 5 ft spacing). Performance of the various combinations was examined by measuring row-to-row yields differences (i.e. Row yields 15 inches from the nozzle and 45 inches for the 10 ft nozzle spacing.) Corn rows were planted circularly allowing the nozzle to remain parallel to the corn rows as the nozzle traveled through the field. As might be expected, yield differences were greatest in dry years and nearly masked out in wet years. For the purpose of brevity in this report, only the 6 year average results will be reported. Even though the average yield for both corn rows was high, there is a 16 bu/acre yield difference between the row 15 inches from the nozzle and the corn row 45 inches from the nozzle for the 2 ft nozzle height and 10 ft nozzle spacing (Figure 3). At a four ft nozzle height the row-to-row yield difference was 9 bu/acre and at the 7ft height the yield difference disappeared. This would be as expected since pattern distortion was for a shorter period of time for the higher nozzle heights. It should be noted that the circular row pattern probably represents the least amount of yield reduction, since all corn rows are within 3.75 ft of the nearest nozzle. For straight corn rows, the distance for some corn plants to the nearest nozzle is 5 ft.

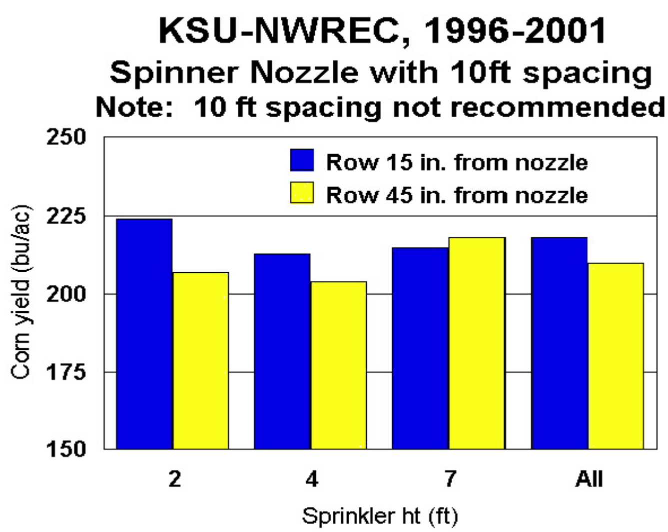

Figure 3. Row-to-row variation in corn yields as affected by sprinkler height in a study with a nozzle spacing too wide (10 ft) for in-canopy irrigation, Colby, Kansas. Data averaged across 4 different irrigation levels. Note: The average yield for a particular height treatment would be obtained by averaging the two row yields.

On-Farm Evaluation of Sprinkler Spacing

Many center pivot sprinkler systems are designed with wide sprinkler spacing as a method to reduce equipment cost. For outer spans closer sprinkler spacing is needed in order to meet the water application requirements. Although concentric rings were showing up in Nebraska fields, the outer portions of the fields showed no such pattern. To evaluate the rings, a series of samples were collected to determine crop yield and soil water content. Samples were collected from both sprinkler spacings where the spacing transition occurred to insure similar soil type and cultural conditions.

The location of sprinklers were first identified in relation to the wheel tracks. Then the location of sprinklers were superimposed in that area of the field where the center pivot sprinkler devices run nearly parallel with the planted rows of corn. All corn rows between two sprinkler devices were sampled to determine soil water content and grain yield. Yield was determined by harvesting 10 feet of row. Soil water content was measured to a depth of 4 feet at one location in each row. The results given are the average of two yield and soil water content samples.

Field measurements were collected for two different center pivot fields represented in figures 4 and 5. Sprinklers were located at a height of 7 ft. and at either a 9 or 18 ft. spacing. Corn rows were planted 30 in. apart. Figures 4a and 5a shows the results for the narrow spacing of the two fields while figures 4b and 5b show results for the wide sprinkler spacing.

Generally, there were no reasonable patterns for either yield or soil moisture content for the 9 ft. sprinkler spacing in figures 4a and 4b. However, corn yield did decline when the sprinkler spacing increased to 18 ft. in figures 5a and 5b. Because soil water data was collected at the end of the season when the crop was mature, some of the difference, or lack of difference, in soil water content may have been eliminated with late season precipitation or added irrigation. It should also be noted that soil water content is extremely low and most likely approaching wilting point.

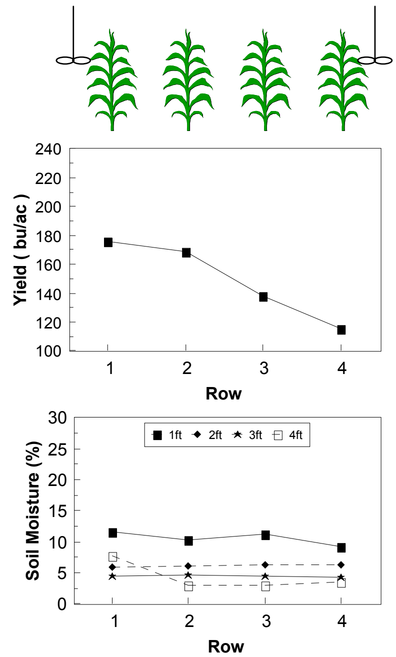

Figure 4a. Corn yield and soil water content for sprinkler devices spaced 9 ft apart at 7 ft height.

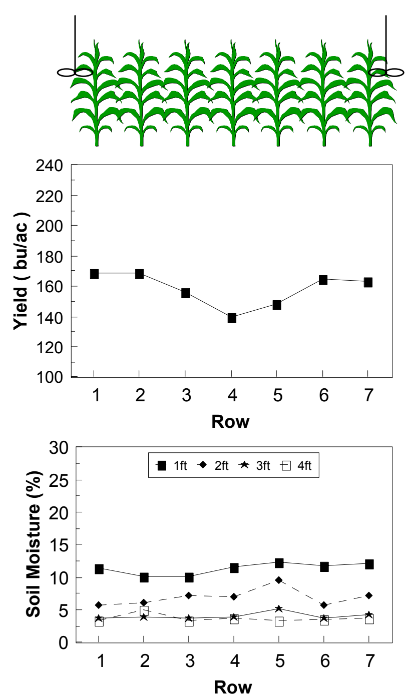

Figure 4b. Corn yield and soil water content for sprinkler devices spaced 18 ft apart at 7 ft height.

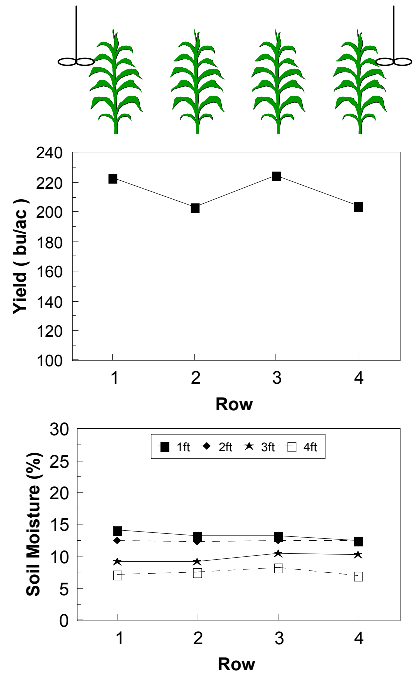

Figure 5a. Corn yield and soil water content for sprinkler devices spaced 9 ft. apart at 7 ft height.

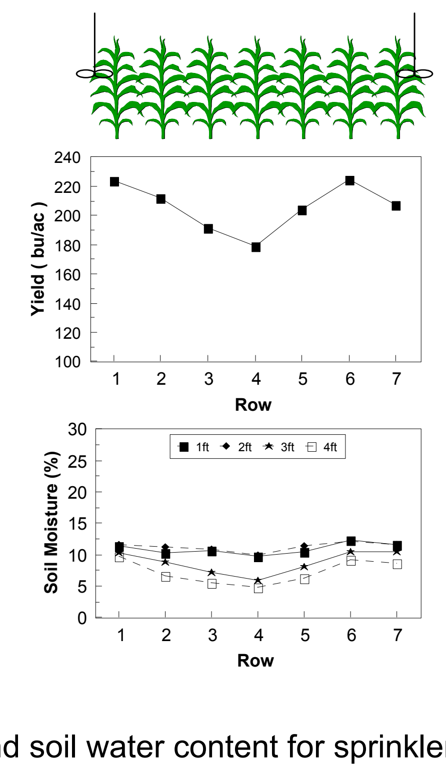

Figure 5b. Corn yield and soil water content for sprinkler devices spaced 18 ft. apart at 7 ft height.

Effect of sprinkler height and type on corn production

Another study conducted from 1994-95 at the KSU Northwest Research-Extension Center examined corn production as affected by sprinkler height and type and irrigation capacity. Spray nozzles on the span (14 ft), spray nozzles below the truss rods (7 ft) and low energy precision application (LEPA) nozzles (2 ft) were compared under irrigation capacities limited to 1 inch every 4, 6, 8 or 10 days.

Corn yields averaged 201, 180, 164, and 140 bu/a for irrigation capacities of 1 inch every 4, 6, 8, or 10 days, respectively. No statistically significant differences in corn yields, or water use efficiency were related to the sprinkler package used for irrigation. There was a trend for the (LEPA) package to perform better than spray nozzles at limited irrigation capacities and worse than the spray nozzles at the higher irrigation capacities (Figure 6).

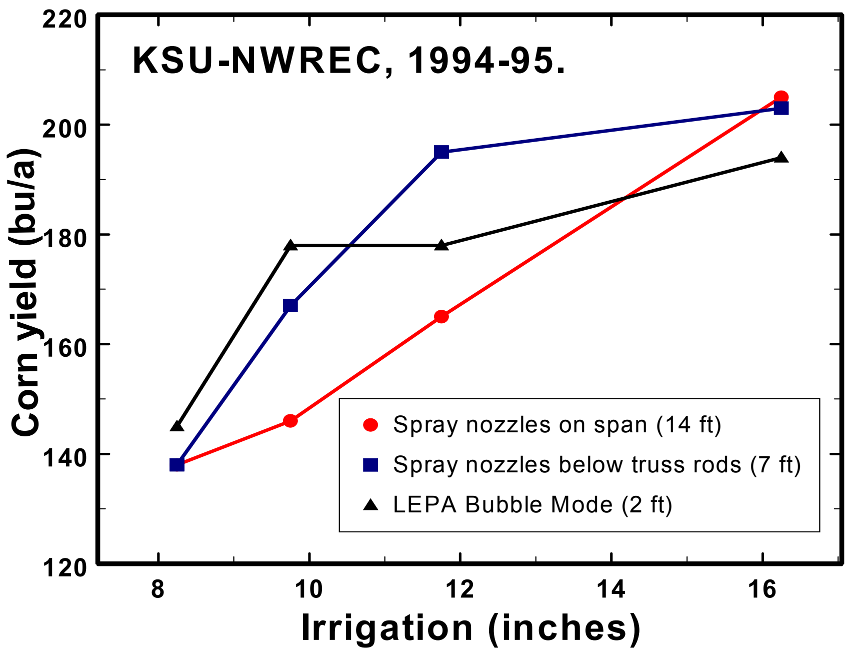

Figure 6. Corn grain yields as affected by sprinkler height and type at four different irrigation levels, KSU Northwest Research-Extension Center, Colby, Kansas, 1994-1995.

The first observation is supported by research from other locations, which shows that LEPA can help decrease evaporative water losses and thus increase irrigation efficiency. The second observation indicates that LEPA may not be suited for higher capacity systems on northwest Kansas soils, even if runoff is controlled as it was in this study. It should be noted that this study followed the true definition of LEPA with water applied in bubble mode to every other row.

The term LEPA is often misused to describe in-canopy spray nozzle application.

The reason that LEPA is not performing well at the higher irrigation capacities may be puddling of the surface soils, leading to poor aeration conditions. However, this has not been verified. In 1995 with a very dry late summer, LEPA performed better than the other nozzle orientations at the lower capacities and performed equal to the other orientations at the higher capacities. Averaged over the two years, the trend continued of LEPA performing better at the lower irrigation capacities. Overall, spray nozzles just below the truss rods performed best at the highest two capacities, but LEPA performed best when irrigation was extremely limited.

Conclusions

As the cost of pumping increases and water supplies become more restricted, irrigation schedules that more closely match water application to water use will exaggerate the nonuniform application of water due to sprinkler spacing and in-canopy operation of sprinkler devices with similar results to what we have shown here.

It has been a common practice for several years to operate drop spray nozzles just below the center pivot truss rods. This results in the sprinkler pattern being distorted after corn tasseling. This generally has had relatively little negative effects on crop yields. The reasons are that there is a fair amount of pattern penetration around the tassels and because the distortion only occurs during the last 30-40 days of growth. In essence, the irrigation season ends before severe deficits occur. Compare this situation with sprinklers operated within the corn canopy that may experience pattern distortion for more than 60 days of the irrigation season. Assuming a 50% distortion for sprinklers beginning 30 days earlier, it would result in irrigation for some rows being approximately 40% less than the needed amount. These experiments have shown that significant yield reductions do occur because of the extended duration and severity of water stress.