IMPACT OF WIDE DROP SPACING AND SPRINKLER HEIGHT FOR CORN PRODUCTION

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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 the result of water stress on the crop is not completely 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.

The impact of sprinkler spacing on corn yield was the focus of a University of Nebraska project in which yield data was collected from center pivots at several sites across Nebraska. Kansas State researchers conducted several research experiments to determine the impact of sprinkler height on water distribution. The results from these studies will be discussed.

Field Evaluation of Sprinkler Spacing

To evaluate rings showing up in Nebraska fields, a series of field samples were collected to determine cause and impact. Many center pivot systems are designed with wider sprinkler spacing for interior spans and closer sprinkler spacing for the outer most spans where additional sprinklers are needed to meet application requirements. When possible, yield samples and soil moisture data were collected in this transition area 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. Corn rows were identified within each sprinkler device spacing section of the pivot. In other words, in those areas with wide spacing or those with narrow spacing. Samples were then collected from those rows of corn that were between a series of three sprinkler devices, regardless of sprinkler spacing. Corn yield was determined by sampling 10 feet of row. Soil water content was measured to a depth of 4 feet at one location within each sampled row.

The results of field measurements at the different sites are shown in the following figures. As can be seen, the yield at a number of the sites declined between the sprinkler devices when sprinkler spacing was approximately 19 feet while yield tended to be more uniform for the narrow sprinkler spacing of 9 feet.

Because soil water data was collected at the end of the season when the crop was mature, some of the differences in soil moisture content may have been eliminated with late season precipitation or added irrigation. However, a number of the sites still show soil water levels at the 4 foot level to be much less in the rows that are located directly between two sprinkler devices. Site description and yield and soil moisture results are discussed below:

McCook site 1 had sprinkler devices spaced 6 ft apart and located in the corn canopy at alternating heights of 3.0 and 4.5 ft. Soil moisture was nearly constant across the rows while yield was nearly 25 bu less in the row directly between the sprinklers.

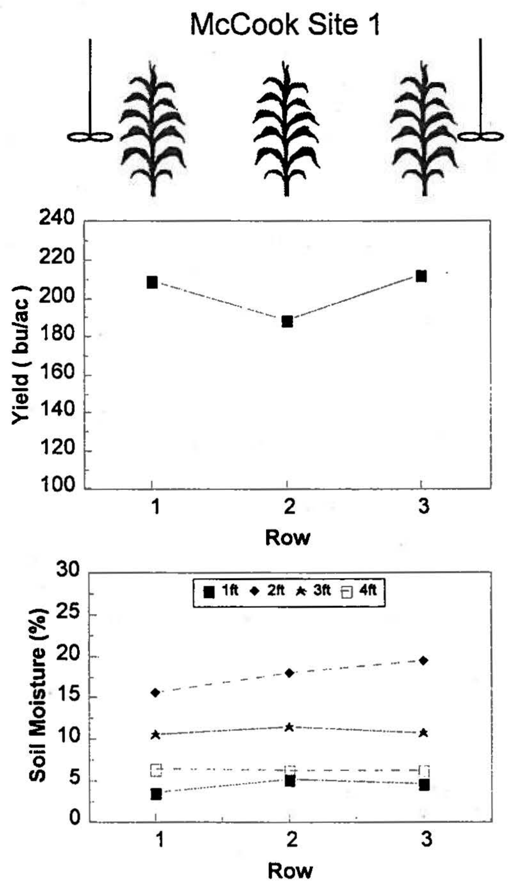
McCook site 2 had sprinkler devices spaced 10 ft apart at an 8 ft height. At this height, the sprinkler devices were out of the canopy for the bulk of the season. Soil moisture content was constant among the rows and yield varied by approximately 15 bu/acre.

Sprinkler devices were spaced 19 ft apart at a height of 2 ft at McCook site 3. Although yield was similar, soil moisture content declined by nearly 10 % when comparing the row next to the sprinkler device to the row furthest from the sprinkler device.

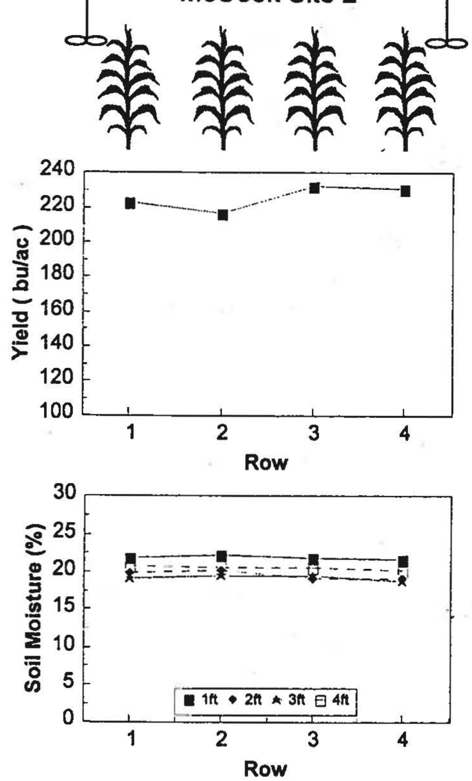
At the Hay Springs sites, data was collected for both wide and narrow sprinkler spacing within the same field. Hay Springs sites1 and 2 were from one field and Hay Springs sites 3 and 4 from another field. Hay Springs site 1 had sprinkler devices located at a 7 ft height and spaced 9 ft apart. There was no reasonable pattern for either yield or soil moisture content at this location. At Hay Springs site 2, sprinkler devices were also at a 7 foot height but spaced 18 feet apart. Soil moisture differences were not detectable at the end of the growing season but corn yield did decline by approximately 25 bu/acre as the distance increased from the sprinkler devices.

Hay Springs site 3 had sprinkler devices spaced 9 ft apart at a height of 7 ft. No differences can be seen in soil moisture content and corn yield averaged approximately 215 bu. At Hay Springs site 4 sprinkler devices were spaced 18 ft apart at a height of 6.5 ft. Both soil moisture content and corn yield declined for the rows furthest from the sprinkler device. Corn yield dropped from over 220 bu/acre to less than 180 bu/acre.

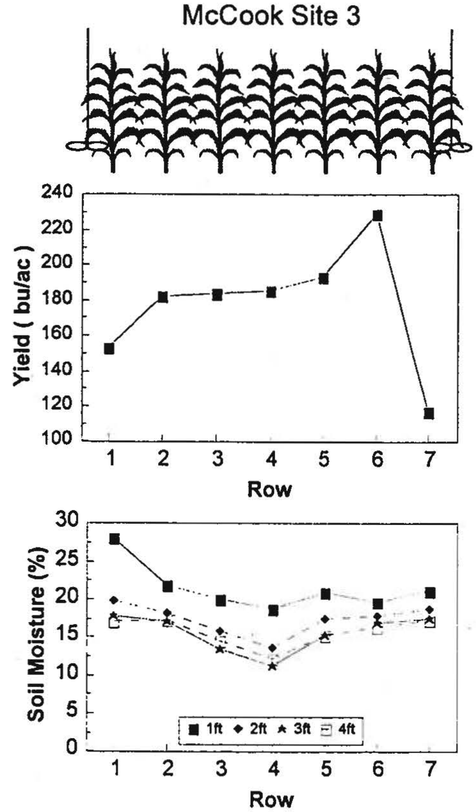
As the cost of pumping increases and water supplies become more restricted, irrigation schedules that more closely match water application to water use will exaggerate the nonuniform application of water due to sprinkler spacing and in-canopy operation of sprinkler devices.



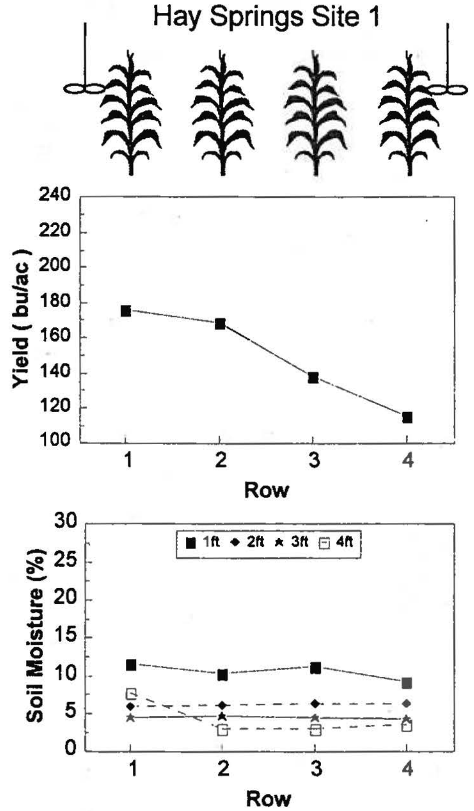
McCook Site 2



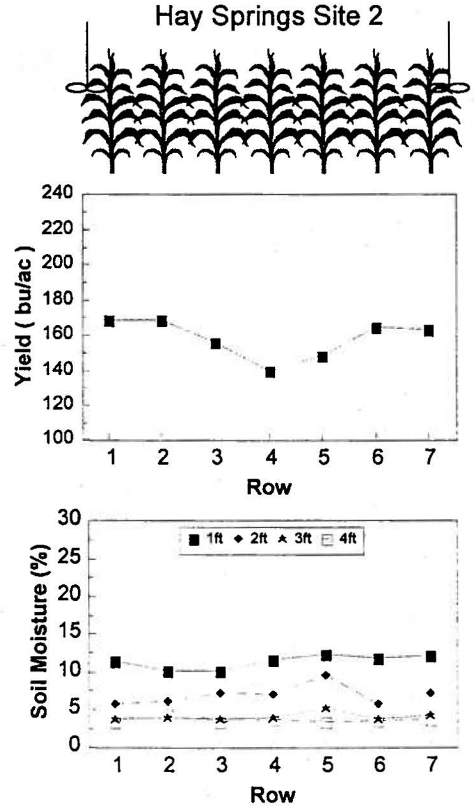
McCook Site 3



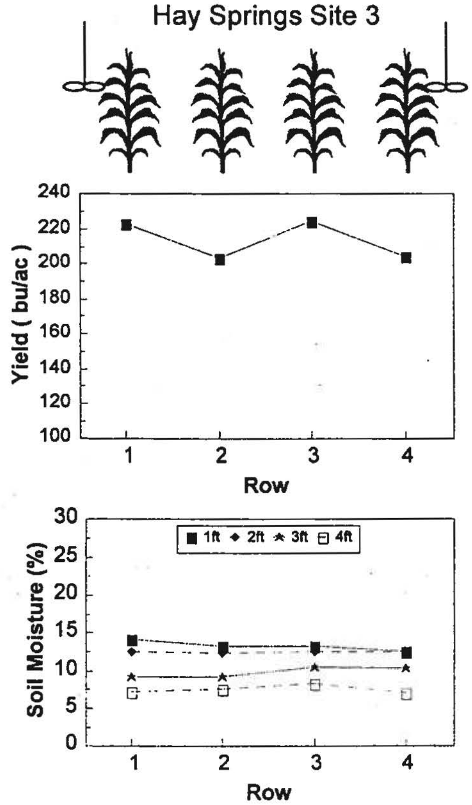
Hay Springs Site 1



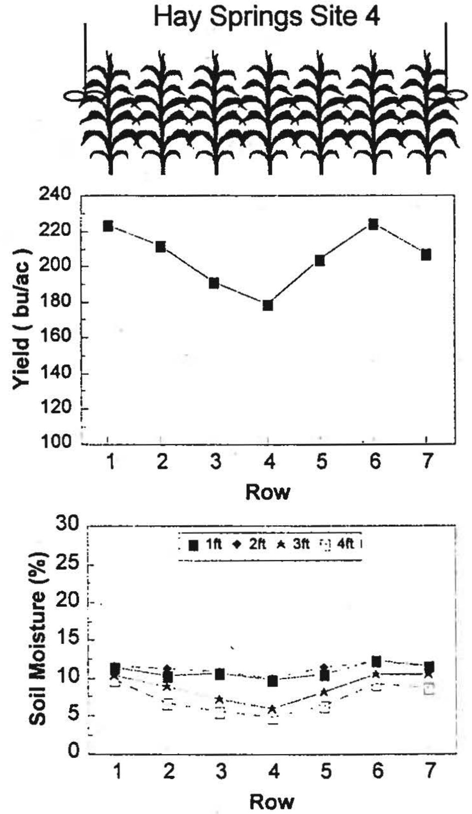
Hay Springs Site 2



Hay Springs Site 3



Hay Springs Site 4



Effect of sprinkler height on corn production

The first project by Kansas State University was conducted from 1983-1986 at Northwest Research-Extension Center on a Keith silt loam soil with land slope of less than 0.5% to compare high pressure (60 psi) impact sprinkler system and a low pressure (20 psi) spray nozzle system. The impact sprinklers were at a height of approximately 13 ft. The spray system was equipped with drops, leaving the nozzles approximately 7 ft. above the soil surface. The spray nozzle was within the corn canopy after tasseling. Corn production was compared under four different tillage systems (Conventional chisel in fall followed by spring disking, Conventional plus corrugation at corn lay-by, Conventional plus furrow basins at corn lay-by, and No tillage) for both impact and spray nozzles. Irrigation amounts were the same for each sprinkler package at 1.5 inches/event and the system capacity simulated a 575 gpm center pivot covering 125 acres.

The results from the study indicate controlling runoff is a key area in optimum management of center pivot systems. In general, higher yields were obtained with the spray nozzle system as long as runoff was controlled by surface modification or residue management (Figure 1). However, in the absence of runoff control, the impact sprinkler was much better. This was particularly evident in 1983, when secondary tillage was critical in attaining high yields under the low pressure spray system. Conventional yields of only 140 bu/acre as compared to 176 bu/acre for the furrow basin treatment were obtained under the spray nozzle system in 1983. Furrow basins have increased yields by an average of 3 to 12 bu./acre for the impact and spray systems, respectively (Figure 1).

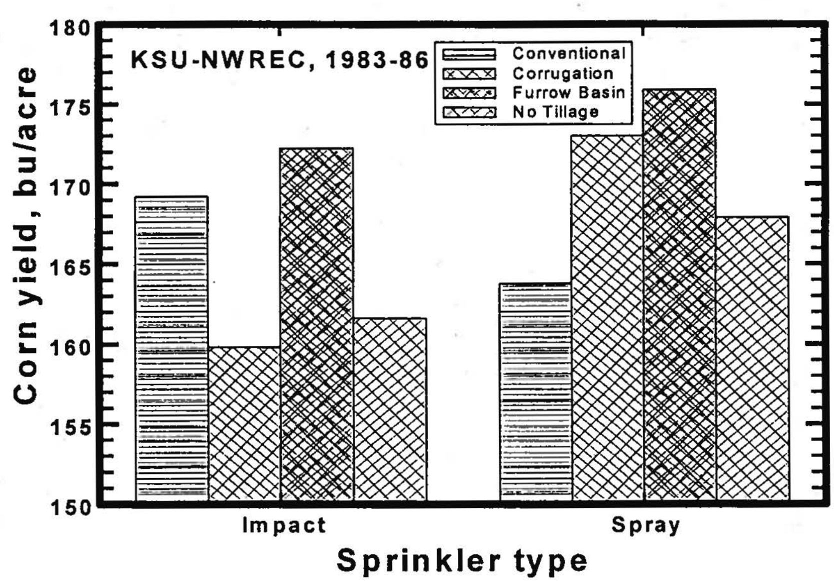


Figure 1. Corn grain yields as affected by sprinkler nozzle type and tillage management, Colby, Kansas, 1983-1986.

It has been a common practice for several years in northwest Kansas 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 in-canopy sprinklers at a height of 16-24 inches that may experience pattern distortion for more than 60 days of the irrigation season. Assuming a 50% distortion for the lower sprinklers beginning 30 days earlier would result in irrigation for some rows being approximately 40% less than the needed amount. Yield reductions would be expected for the latter case because of the extended duration and severity.

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 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 low-energy precision application (LEPA) package to perform better than spray nozzles at limited irrigation capacities and worse than the spray nozzles at the higher irrigation capacities (Figure 2). 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 the water applied in a bubble mode to every other row. The term LEPA often is misused to also 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.

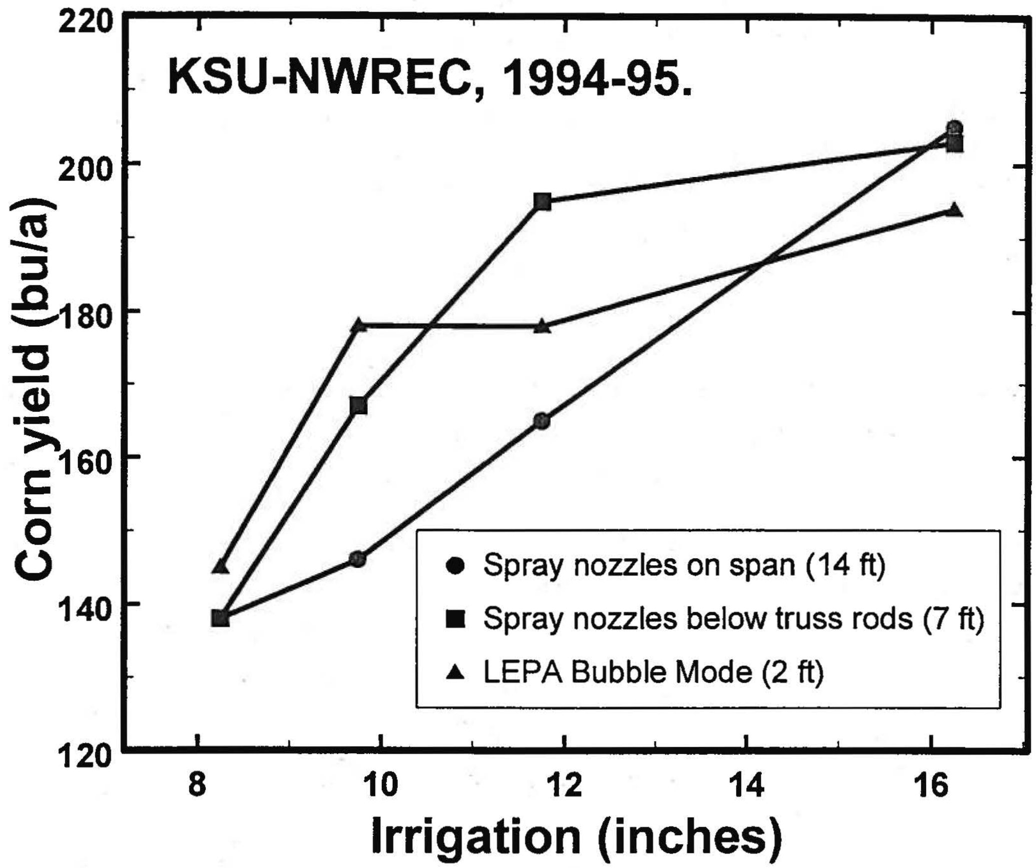


Figure 2. Corn grain yields as affected by sprinkler height and type at four different irrigation levels, KSU Northwest Research-Extension Center, Colby, Kansas, 1994-1995.

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.

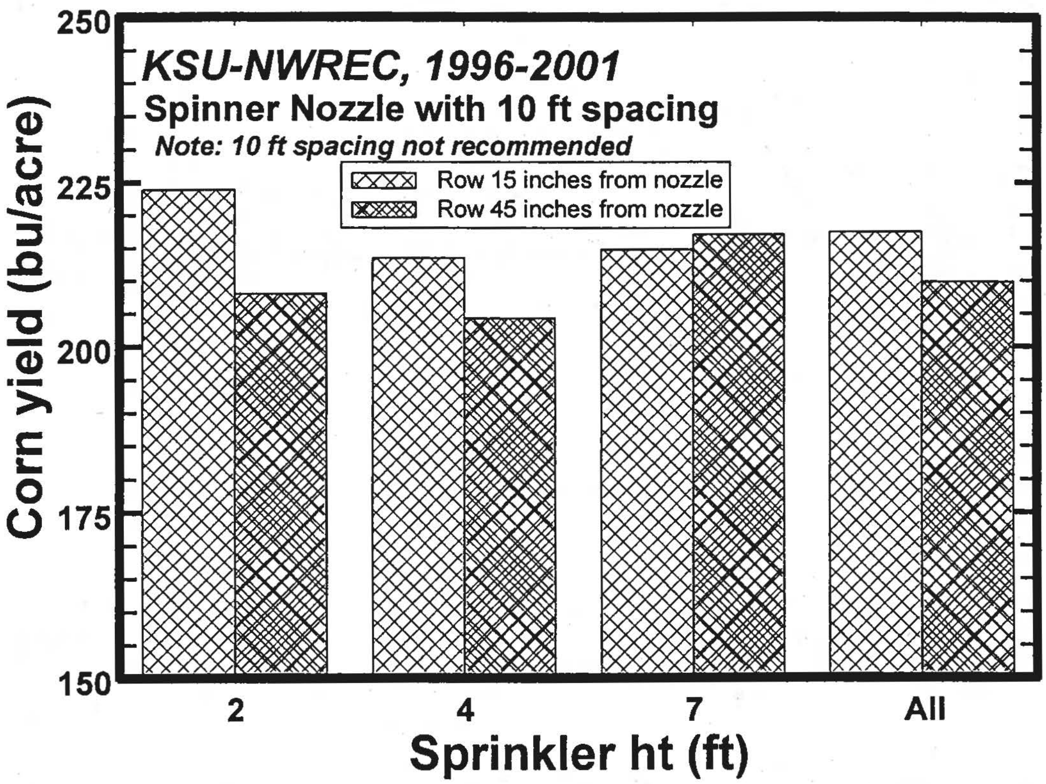


Figure 3. Row-to-row variation in corn yields as affected by sprinkler height in a study with a nozzle spacing too wide (10 ft) for in-canopy irrigation, Colby, Kansas. Data averaged across 4 different irrigation levels. Note: The average yield for a particular height treatment would be obtained by averaging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