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# SPRINKLER APPLICATION METHODS AND SPRINKLER SYSTEM CAPACITY

by

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**SUMMARY:**

Two LEPA and two spray irrigation methods were evaluated at a fully-irrigated and three deficit irrigation levels. Grain yields with LEPA bubble and sock methods tended to be larger than the yields with the spray methods. With deficit irrigation capacity, LEPA irrigation tends to maximize crop yield potential when compared with spray irrigation.

**KEYWORDS:**

Irrigation, Sprinkler, LEPA, Spray, Deficit



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# SPRINKLER APPLICATION METHODS AND SPRINKLER SYSTEM CAPACITY[1]

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## ABSTRACT

The crop yield response of grain sorghum to four sprinkler methods and four irrigation amounts which simulated varying irrigation water supply capacity was evaluated at Bushland, TX in the Southern High Plains. Irrigation methods were overhead spray, LEPA spray near ground level, LEPA bubble and LEPA sock, and the application devices were installed on a 3-span, hose-fed, lateral-move sprinkler system. All furrows were diked to minimize runoff and enhance surface storage from irrigation and rainfall. Irrigation applications were based on neutron soil water measurements in a designated control plot which received irrigations in the amount of 100% of the depleted soil water below a fixed value equal to approximately 90% of the 1.4 m profile "available soil water". Irrigation treatments varied from the 100% control level to 75%, 50% and 25% of the control level. The 100% treatment amount was 25 mm with 19 mm, 13 mm and 6 mm being applied to the other treatments, respectively, and these amounts were achieved by varying the irrigation system speed over the plots. In a growing season with slightly above normal rainfall, grain sorghum yields were affected mainly by the irrigation amounts and to a lesser extent by the sprinkler method, especially for the two lowest irrigation amount treatments. The 100% treatments received 250 mm of irrigation along with 311 mm of rainfall from emergence to the last irrigation and yielded 9.64 Mg/ha averaged across the four methods and three replicates. The LEPA bubble and sock methods tended to yield better than the spray methods likely due to increasing transpiration and reducing evaporation from the crop canopy and soil. With these two LEPA methods, grain sorghum yields were reduced only 1% while reducing the irrigation amount from 250 mm for the 100% irrigation treatment to 125 mm for the 50% irrigation treatment.

## INTRODUCTION

Spray irrigation was introduced to reduce the droplet evaporation and drift losses from impact sprinklers. For center pivot irrigation sprinkler systems in the Southern High Plains, Musick et al. (1988) reported application efficiencies of 85% for 100 systems equipped with spray heads and 82% for 123 systems equipped with impact sprinklers. Howell et al. (1991) reported on sprinkler evaporation losses and efficiency measured with 9 $m^2$ weighing lysimeters and showed an increase in application efficiency of about 5% by changing from impact sprinklers to spray heads.

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Low energy precision application irrigation (LEPA) was introduced by Lyle and Bordovsky (1981) to further reduce sprinkler evaporation losses due to droplet evaporation and drift. Originally, bubble mode LEPA applications were made to individual furrows, but Lyle and Bordovsky (1983) later reported advantages of alternate-furrow irrigation over every furrow irrigation using LEPA. Several bubble and spray LEPA devices are now commercially available (Fipps and New, 1990), and double-ended socks (Fangmeier et al., 1990) are also being marketed. Application efficiencies for LEPA irrigation have been reported in the range 96 to 98% (Lyle and Bordovsky, 1983; Schneider and Howell, 1990). In obtaining these high application efficiencies, eliminating or reducing the evaporation of sprinkled water from the crop canopy and ground is as important as eliminating the air evaporation and drift losses (Schneider and Howell, 1993).

In general, the cost of sprinkler application devices and the management skill for efficiently using the devices increase with the potential increase in application efficiency. Increased sprinkler application efficiencies with spray heads and LEPA devices are achieved by concentrating the sprinkled water over smaller areas and at higher application rates. Runoff and surface redistribution must be controlled with both of these methods, especially LEPA, and precision tillage is needed to insure that LEPA drops travel between the rows of the crop. Close-spaced drops and expensive application devices add to the cost of using spray heads and LEPA devices.

The goal of the research reported here was to investigate high efficiency spray and LEPA sprinkler application devices and sprinkler system capacity over a fourfold range of water supplies.

## PROCEDURE

### Experimental Design:

Two spray and two LEPA sprinkler application methods were evaluated at four irrigation levels ranging from 25% to 100% of soil water replenishment. Field plots were arranged in a randomized block design with irrigation treatments being the blocks and sprinkler methods being randomized within each replicate within a block. Each of the sixteen treatment combinations was replicated three times.

Spray application methods were LEPA spray, designated as $M_{sl}$, with the level of application about 0.3 m above ground level and overhead spray, designated as $M_{so}$, with the level of application about 0.2 m above the mature crop canopy (1.5 m above ground level). LEPA methods were LEPA bubble, designated as $M_{lb}$, with the point of application about 0.3 m above ground level and Fangmeier LEPA socks (Fangmeier et al., 1990), designated as $M_{ls}$, which were double-ended plastic socks pulled through the furrows.

A fully-irrigated control and three deficit irrigation levels were evaluated with the four sprinkler methods. Soil water for the fully-irrigated control, designated as $I_{100}$, was maintained at a non-yield limiting level. Irrigations were scheduled according to soil water levels in the three plots fully-irrigated with LEPA double ended socks. Deficit irrigation treatments designated as $I_{75}$, $I_{50}$ and $I_{25}$ received

75%, 50% or 25% of applications to the fully-irrigated treatments on the same days.

Soil water was measured by the neutron attenuation method to a 2.4 m depth at 0.2 m depth increments. The neutron moisture meter was a CPN Corporation model 503DR[3] and was locally field calibrated. Weekly measurements were made in the control treatment plots for scheduling irrigations and measurements about four weeks apart were made on all $M_{1s}$ and $M_{80}$ treatments. Irrigations were applied to maintain the soil water in the 1.4-m deep profile of the $I_{100}/M_{1s}$ treatment above 90% of field capacity which is approximately 525 mm of water for the Pullman clay loam soil.

**Irrigation Equipment:**

Irrigations were applied with a hose fed Valmont Model 6000 lateral move irrigation system equipped with a CAMS controller. The system had three, 39-m long spans providing space for forty eight, 0.76 wide beds and furrows under each span. Pressurized water, on demand from as surface reservoir, was supplied to the irrigation system through an underground pipeline and a 114 mm diameter surface hose. Information about the four types of application devices is listed in Table 1. All application devices were spaced 1.52 m apart in alternate furrows, and discharged 19.0 L/min. Pressure to the application devices was 207 kPa, but the LEPA devices were equipped with 41 kPa pressure regulators. Senninger 360° spray nozzles were placed above the LEPA socks to meter the flow at the same rate as the other devices.

**Cultural Practices:**

Cultural practices were generally similar to those used for high-yield grain sorghum production in the Southern High Plains. During the previous fall, the experimental area had been planted to dryland winter wheat to prevent wind erosion, and the wheat was plowed out on April 9, 1992. The field was tandem disked twice in mid-April and smoothed with three passes of a land plane. Then, anhydrous ammonia was applied on May 1 at the rate of 112 kg(N)/ha, and liquid 10-34-0 was applied at the rate of 112 kg(P)/ha. After fertilizer application, the field was bedded with a disk bedder. Because of late spring rainfall, the beds had to be tilled with a rotary cultivator to kill emerging weeds before sorghum was planted at a uniform seeding rate on June 11. Final plant population for the experiment was 17 Plants/m². Atrazine for broadleaf weed control was applied at the rate of 1.7 kg(AI)/ha on June 25, and all furrows on all treatments were furrow diked on July 16 with a Roll-A-Cone shovel and bump diker. Grain yields were determined by hand harvesting two 5-m long rows within each treatment and

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[3]Mention of a trade name or product does not constitute a recommendation or endorsement for use by the U.S. Department of Agriculture, nor does it imply registration under FIFRA as amended.

threshing the sorghum with a small research combine harvester. The grain yields reported here are adjusted to 14% moisture content on a wet weight basis.

The soil at the experimental site was Pullman clay loam a fine, mixed, thermic torrertic Paulestolls, and the field had a uniform slope of 0.0023 m/m in the direction of the rows and a 0.0018 m/m cross slope. Plot size was twelve 0.76-m rows wide by 25 m long, and the plots were separated by 5 m wide borders.

## RESULTS AND DISCUSSION

### Irrigation and Rainfall:

All treatments were irrigated ten times with the first irrigation on July 9 and the final irrigation on Sept. 11. The $I_{100}$ treatments received 25 mm per irrigation and the $I_{75}$, $I_{50}$ and $I_{25}$ received 75%, 50% and 25% of the application to the control treatment. Irrigation treatments were achieved by changing the percent timer setting on the lateral move irrigation system. Weekly irrigation and rainfall for the July 9 to Sept. 11 interval are listed in Table 2. Some of the furrow dikes in the $I_{100}$ treatment plots with LEPA application devices overtopped, but this did not occur on the deficit irrigation treatments. Furrow dikes on the downstream treatment plots were maintained by hand to prevent runoff onto the plots.

Rainfall was favorable for grain sorghum production with a total of 311 mm of rainfall from crop emergence to the date of the last irrigation. Weekly rainfall during the irrigation season is listed in Table 2, and an additional 135 mm of rainfall occurred from planting to the first irrigation. Essentially no runoff occurred from the irrigation season rainfall because of the furrow dikes and low intensity storms.

### Soil Water:

Soil water was plentiful during the initial part of the growing season because of 55 mm of rainfall during the 10 d interval preceding planting and an additional 55 mm of rainfall during the week after planting. Soil water measured on July 2 was uniform across the plots and remained essentially the same on the $I_{100}$ control treatment plots until after irrigation cutoff on Sept. 11. Even on the $I_{25}$ deficit irrigation plots, soil water remained high enough for moderate grain yields.

### Grain Yields:

Grain yields for the individual sprinkler method and irrigation amount treatments are illustrated in Figure 1. Average grain yields for each of the sprinkler methods and irrigation amounts are listed in Table 3. The difference in grain yields due to sprinkler methods ($P=0.0202$) and irrigation levels ($P<0.0001$) were both significant. The two LEPA sprinkler methods were statistically different from the two spray irrigation methods. The highest and lowest irrigation levels were each statistically different from the two mid-level irrigation treatments and from each other.

Grain yields with the LEPA and spray methods followed different trends as the irrigation level varied.. With the LEPA methods, yields for the $I_{50}$, $I_{75}$ and $I_{100}$ treatments were essentially equal and averaged 9.26 Mg/ha. In contrast, the yield of the $I_{25}$ treatment with LEPA irrigation averaged only 6.68 Mg/ha. For the two spray methods, yields were nearly identical at each of the four irrigation levels and decreased almost linearly with decreased irrigation.

Deficit irrigation was more effective with the two LEPA sprinkler methods, and grain yields for the $I_{50}$ and $I_{75}$ treatments were essentially the same as the yields for the $I_{100}$ treatment. Grain yields with the two spray irrigation methods, increased almost linearly over the irrigation range and equaled the yields with the LEPA methods only at the $I_{100}$ irrigation level.

The yield differences between the LEPA and spray irrigation methods illustrate the importance of reducing or eliminating evaporation losses from the wetted soil and crop canopy. With the $I_{100}$ irrigation level, sufficient water was applied so that the increased evaporation losses with spray irrigation had no large effect. For the three lower irrigation levels, the yield difference between the LEPA and spray methods likely reflects the additional water lost from the wetted crop canopy and soil.

Overhead spray yielded nearly the same as LEPA spray at all irrigation levels, and less than the LEPA methods, especially at the two lower irrigation levels. The LEPA spray heads were suspended on drops that were flexible for the lower 1 m and often became entangled in the grain sorghum plants thus spraying up into the crop canopy. As a result, the crop canopy and soil were wetted essentially the same as with the above canopy spray method. Evaporation losses and yields were likely about equal for the two spray head placements even though the spray heads were placed quite differently.

## CONCLUSIONS

1. Grain sorghum yields with the LEPA spray and overhead spray methods were essentially equal even though the application methods were quite different.

2. The LEPA bubble and LEPA sock methods tended to out yield LEPA spray especially at lower soil water replenishment levels - likely due to partitioning of the applied water into more transpiration and less evaporation.

3. LEPA irrigation with deficient irrigation capacity appears to maximize crop yield potential compared to spray irrigation. With larger irrigation capacity however, irrigation management using spray methods may be simpler than the management needed for using LEPA methods.

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Table 1. Irrigation application device information.

| Device | Manufacturer | Model | Nozzle Diameter mm |
|---|---|---|---|
| LEPA Sock | A.E. Quest & Sons (Senninger)[4] | 360 | 4.8 |
| LEPA Bubble | Senninger | Quad IV | 6.8 |
| LEPA Spray | Senninger | Quad IV | 6.8 |
| Overhead Spray | Nelson | Spray I | 4.6 |

[4] Senninger 360° spray head used to meter flow to LEPA sock.

Table 2. Weekly irrigation to the fully-irrigated treatments and rainfall during the irrigation season.

| Week | Irrigation $I_{100}$ Treatments | Rainfall | Weekly Total |
|---|---|---|---|
| | ---------- mm ---------- | | |
| July 5-11 | 25 | 35 | 60 |
| July 12-18 | 25 | 4 | 29 |
| July 19-25 | 25 | 0 | 25 |
| July 26-Aug. 1 | 25 | 30 | 55 |
| Aug. 2-8 | 50 | 5 | 55 |
| Aug. 9-15 | 50 | 3 | 53 |
| Aug. 16-22 | 0 | 43 | 43 |
| Aug. 23-29 | 0 | 46 | 46 |
| Aug. 30-Sept.5 | 25 | 5 | 30 |
| Sept. 6-12 | 25 | 5 | 30 |
| Totals | 250 | 176 | 426 |

Table 3. Grain yields for the four sprinkler methods and four irrigation system capacities. Yields followed by the same letter are statistically different at the 5% confidence level.

| Sprinkler Method | | Irrigation Level | |
|---|---|---|---|
| Method | Yield Mg/ha | Soil Water Replenishment | Yield Mg/ha |
| LEPA Bubble | 8.64a | 100% | 9.51a |
| LEPA Sock | 8.58a | 75% | 8.70b |
| Overhead Spray | 7.99b | 50% | 8.61b |
| LEPA Spray | 7.97b | 25% | 6.34c |
| LSD | 0.54 | LSD | 0.54 |

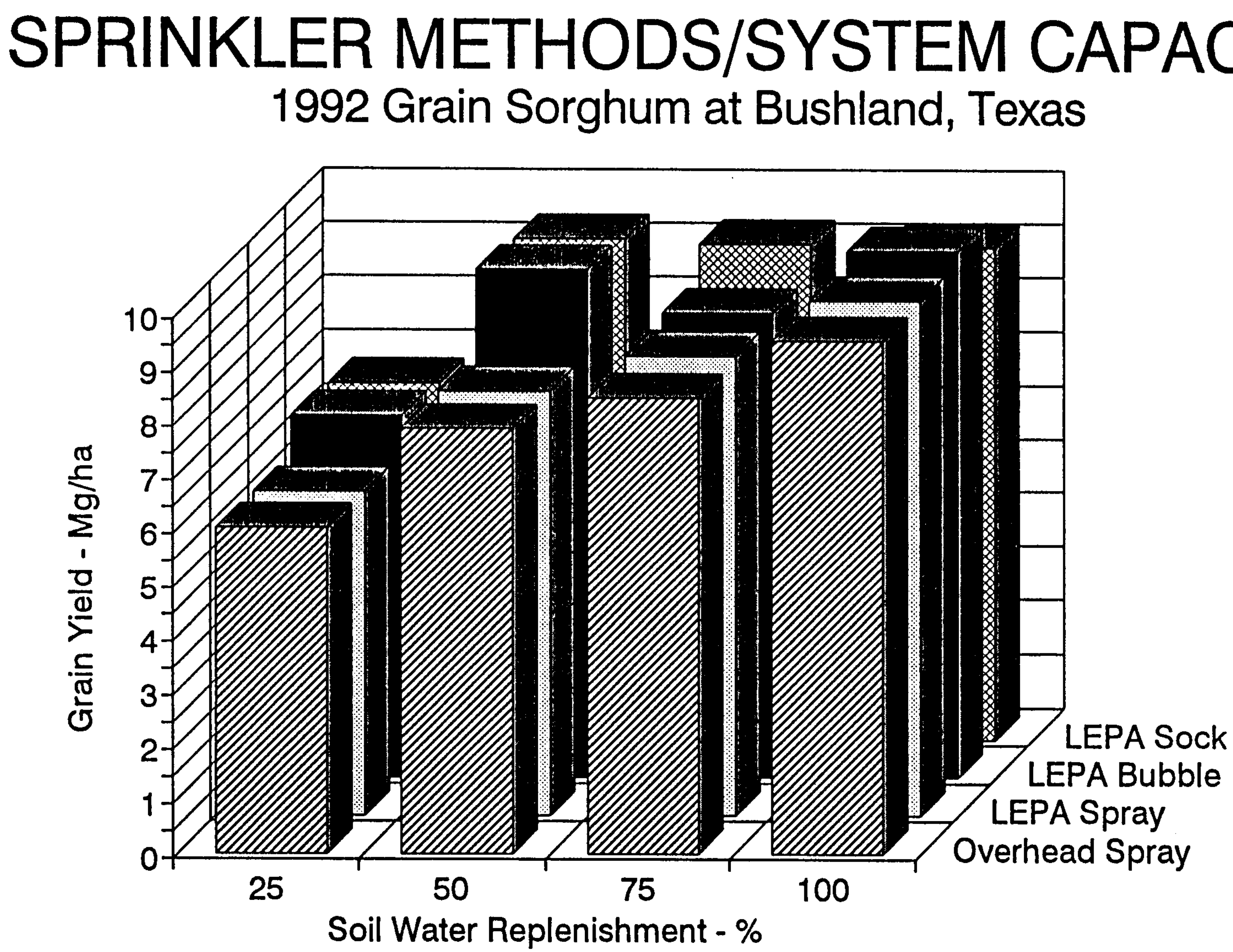


Figure 1. Grain sorghum yields for the four sprinkler methods and four irrigation amounts.