LOW ENERGY PRECISION APPLICATION (LEPA) FOR CENTER PIVOT MACHINES

by

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Decreasing water supplies and increasing energy costs are encouraging the development of improved methods of applying water more efficiently through self-propelled sprinkler systems. Lyle and Bordovsky (1981) developed the LEPA (Low Energy Precision Application) modification to self-propelled sprinklers which distributes water directly to the furrow at very low pressures. Water is applied from a user selectable multi-pattern Lepa Head about 12 to 15 inches above the ground surface. This technique was designed to reduce the energy required for applying water, to minimize the effect of wind on water distribution and to reduce evaporation from free water surface and wet soil surfaces during and following an irrigation.

Although LEPA systems can reduce water application losses, caution is advised when projecting potential water savings. According to the American Society of Agricultural Engineers definition, application efficiency is the ratio of the average depth of irrigation water infiltrated and stored in the root zone to the average depth of irrigation water applied, expressed as a percent (Jensen, 1981). Using this definition, water application losses can occur from evaporation as well as runoff from the point of application. Difficulties in properly accounting for all of the water applied during efficiency tests may make it difficult to quantify the various losses. Considering only evaporation losses which occur from the time of application to the time water reaches the ground, losses in the LEPA bubble mode are 3-4 percent and approximately 12 percent with the LEPA spray mode. This compares to 15-25 percent for conventional impact sprinklers and low pressure spray heads. Because the LEPA heads apply water in a relatively small area, application rates are usually quite high, thereby increasing runoff potential. SPecial tillage or management practices may be necessary to prevent or at least retard runoff and the translocation of water which could negate some of the potential water savings of the LEPA system.

Typically, quarter-mile center pivot LEPA systems are designed for a pressure of 12 to 18 psi at the pivot. Six and sometimes 10 psi pressure regulators are placed just above the LEPA heads which are usually 12 to 15 inches above the ground surface. A minimum pressure of 9 psi is required at the inlet to 6 psi regulators to operate correctly and obtain the design flow rates. This 9 psi requirement can be achieved by 4 psi at the end of the main pipeline when situated on the highest point in the field plus the 12-13 foot difference in elevation between the mainline and the pressure regulator.

LEPA heads which have four different application patterns, offer increased versatility in applying water, fertilizers and chemicals for different crop, soil and slope conditions. The two bubble modes distribute water in an umbrella pattern with a diameter of 16-18 inches at the soil surface. The spray mode produces a horizontal spray pattern approximately 8-10 feet in diameter. The chemigation mode produces an upward spray approximately 60° from horizontal making it possible to apply chemicals to the undersides of plant leaves and also the upper portion of high profile crops such as corn. One person can change modes on a quarter-mile center pivot in approximately 45 minutes.

Considerations for converting to LEPA

There are several factors which should be considered before adopting the LEPA system. Because of low pressures in the LEPA nozzle, water is applied over a relatively small area causing water application rates to be quite high. High application rates on sloping land can cause runoff problems unless controlled by special tillage practices. The high application rates coupled with the intermittent tower movements of the self-propelled sprinklers, can cause the spatial application to be quite variable. The high application rates may dictate irrigating on a 2 to 3 day frequency to minimize runoff or doing special tillage practices which temporarily store water and allow a greater opportunity time for infiltration.

Since LEPA systems operate at low pressures, existing low-head (50-foot) plastic pipe installed for carrying and distributing water under furrow irrigation is sometimes sufficient when converting to LEPA center pivots. If retrofitting a conventional center pivot machine to LEPA, it is probably necessary to install additional outlets on the span pipe so drops can be placed between alternate crop rows. Additional couplers can be either welded on the main pipeline and painted to reduce corrosion, holes drilled and special swedge couplers inserted and compressed to form a tight fit against the inside surface of the pipe, or use special clamp-on drops and plumb water to them from existing mainline outlets.

Management Changes

To successfully operate the LEPA system, some adjustments in management are necessary. Corn and other high profile crops should be planted in a circle to minimize the LEPA drop hose riding on the crop which can hinder the uniform application of water and especially chemicals. Low profile crops where the LEPA head is about the height of the crop canopy can be planted in straight rows without significant problems. Accurate planting using the center pivot tire tracks is necessary if the LEPA drops ar to be between two crop rows.

For most situations, additional equipment costs for LEPA can be minimized without any significant effect on crop production, if LEPA drops are in alternate furrows. In situations where the drop discharge exceeds 8 gpm, it will help control runoff if drops are in every furrow to reduce the application rate per furrow.

Significant runoff can occur on slopes unless special tillage practices such as dammer-diking or in-row ripping, are used to either store the water until it can infiltrate or increase the infiltration rate sufficiently to accept the applied rate. Generally, runoff can be controlled with these practices if slopes are limited to less than 4%. On steeper slopes, runoff and erosion can be a major problem, especially if the rows are in the direction of the slope. Other practices such as using the spray mode of the LEPA head, using a ridge till system to keep crop residue on the soil surface, planting in a circle or more on the contour, can reduce but probably will not alone control runoff entirely. Minimizing soil compaction by avoiding running tractor tires in rows where water is applied, is beneficial especially on soils with low water intake rates. In most cases, the LEPA center pivot should move at a slightly faster speed than those equipped with conventional spray heads or impact sprinklers. This is because more water reaches the ground and all ground surface is not wetted on the bubble mode.

Case Studies

In 1989, LEPA equipment was observed and evaluated on a center pivot machine under field conditions at the Bruce Unruh farm near Burlington, Colorado. The 8 tower system was 395 m (1295 ft) long and designed for a flow of 31.5 lps (500 gpm). Corn was planted in .76 m (30 inch) circular rows using a ridge-till soil preparation and planting system. Soil was a silt or silt-loam with a water holding capacity of approximately .21 cm/cm (2.5 in/ft). Slopes within the field were variable ranging from approximately 1% to 10%.

Because of cost considerations, low pressure spray heads were installed from the pivot to tower 2. Beginning at tower 2, LEPA heads were installed at 1.52 m (5 ft.) intervals so there were alternate wet and dry furrows. All measurements in this study were made with the heads in 'bubble' mode where water is distributed in an umbrella pattern with a radius of 20-23 cm (8-9 inches) at the soil surface. Timed volumetric measurements were made to determine the discharge of each nozzle and determine the application uniformity in the radial direction.

No chemicals. Neither fertilizer, herbicides nor pesticides, were applied through this system so there is no analysis on the effectiveness of applying chemicals. Some control of spider mites was achieved by using the chemigation mode to wash the undersides of the leaves.

Three sites were selected in the field to give a range of radial distances from the pivot and a range of slopes. At each site, application amounts were measured along the direction of travel with 10.2 cm x 152.4 cm x 10.2 cm (4 in. x 60 in. x 4 in.) sheet metal troughs placed at 41 cm (16 in.) intervals perpendicular to the corn rows.

Infiltration depths were determined by the difference in gravimetric water contents taken before and after each irrigation. Soil cores were taken with a 1.22 m (48 in.) long hand-drive sampling tube. Transects consisting of 9 holes spaced 19.1 cm (7.5 in) apart and spanning the center of a dry furrow to the center of the adjacent dry furrow were established with a template. Holes from the 'before irrigation' sampling were backfilled with soil to within 15 cm (6 in.) of the surface and the remainder with bentonite to minimize the effect on infiltration during the irrigation and biasing the 'after irrigation' sampling. 'Before and after irrigation' soil samples were taken within 15 cm (6 in.) of each other to minimize the effects of spatial variability.

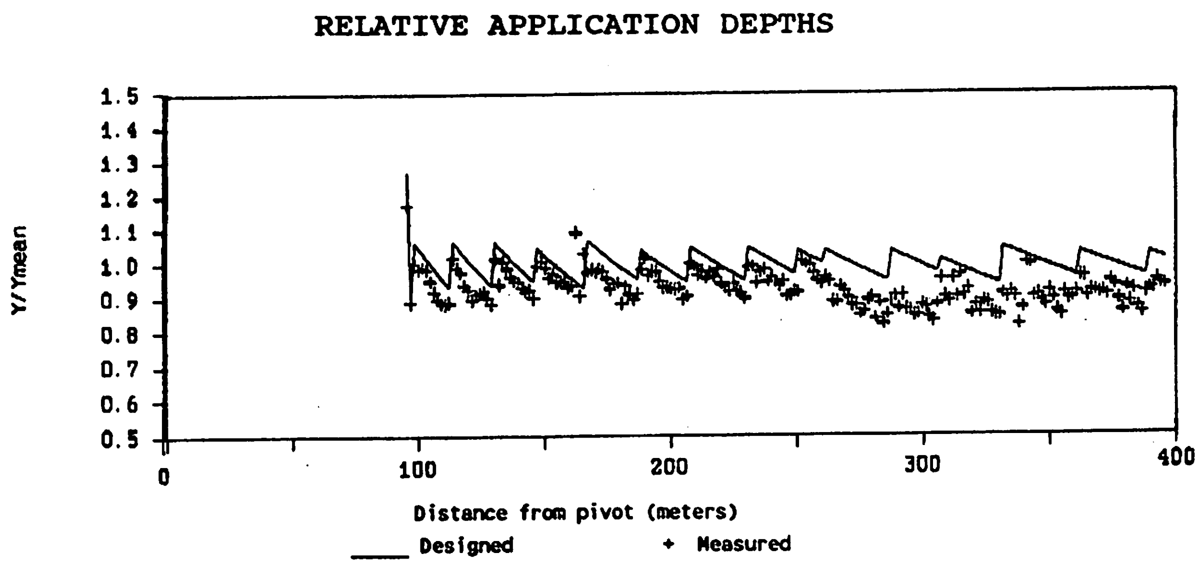

Figure 1. Relative application depths

Figure 1 shows the application uniformity in the radial direction expressed on relative basis. The measured nozzle discharges converted to application depths were divided by the design mean application depth. The Christiansen coefficient of uniformity (CCU) which is a popular method of quantifying application uniformity, was modified to account for the increasing area covered with increasing radial distance from the pivot. The CCU for the LEPA nozzles from tower 2 to the outer end of the system was 96% indicating a well designed nozzle package.

The application uniformity in the direction of travel is affected by the intermittent tower movements and varies considerably depending on the radial distance from pivot. Table 1 shows the mean application depth and CCU for the three different radii.

Table 1. Application uniformities at various radial distances.

Site	Radius meters (ft.)	Mean depth cm (in.)	CCU %
1	233.8 (767)	4.1 (1.6)	8
2	381.7 (1295)	3.2 (1.3)	89
3	182.0 (592)	3.0 (1.2)	42

As expected, the CCU of 89% was highest at the outer end of the system where tower movement is most uniform. Near the middle of the machine, the CCU of 8% is much lower because of the longer stop times between tower movements and the relatively long travel distances between stops.

One of the concerns about using LEPA equipment is how the nonuniformity of application affects the sprinkler's intended tasks. If one of the primary tasks is to apply chemicals to the plants, the great disparity in application uniformity could cause chemical application to be sufficiently variable so crop production is reduced or else it could require excessive application of chemicals on some parts of the field in order to achieve the desired effect over the entire field. Additional work using different application patterns of the nozzle should be done to further investigate this potential problem.

Ideally, the translocation of water in the furrow compensates for the nonuniformities in application by providing more uniform opportunity time for infiltration. Water was observed in the furrows up to 100 meters both ahead of and behind the LEPA head where there was very little slope. With a mean speed of approximately .3 meters/minute, the opportunity time of running water in the furrow is quite large compared with the time periods of intermittent tower movements. Assuming uniform soil infiltration characteristics and slopes, the infiltration uniformity should be much higher than the application uniformity.

The infiltrated depth was estimated by adding the difference in depths of water in the profile before and after an irrigation to the estimated crop water use which occurred during the .5 to 1.5 day period between samplings. At the only site in this study where sufficient data were collected to allow drawing statistical significant conclusions about infiltration uniformity, there was no statistical difference between the application and infiltration depths at the 95% confidence level. Thus these data <u>did not</u> confirm the idea that translocation in the furrows improved infiltration uniformity above the application uniformity. Additional work is necessary to more definitively determine how translocation affects infiltration uniformity.

The difference between the applied depth and the infiltrated depth is assumed to be surface runoff. At the site with an upslope of 1%, the infiltrated depth exceeded the applied depth, suggesting there was additional water entering from adjacent areas during the irrigation. At the 3% downslope site, the runoff was approximately 30% of the application depth and for the 8% upslope site, the runoff was approximately 55% of the application depth.

Special tillage practices such as in-row ripping or dammer-diking can promote better infiltration and reduce runoff. Although data collection was planned onsites with special tillage practices, wet field conditions prevented doing any in-row ripping or micro-basin practices such as dammer-diking. Consequently, no actual comparisons of infiltration and runoff for the various land treatments were possible this year.

In the extreme case, if very short micro-basins were constructed or sufficient in-row ripping performed so infiltration rates were equal or greater than application rates, the water would infiltrate almost exactly where it was applied. The infiltration uniformity would equal to the application uniformity and could be detrimental especially near the middle of the center pivot machine. If the length of the micro-basins increased, limited translocation of water could occur within each micro-basin and reduce the variability of infiltrated water. A time-series analysis of the application depths indicated the infiltration uniformity at the middle of the center pivot machine could be improved from about 7% to 22% by increasing the micro-basin length to 1.22 m (4 feet). While this is a significant improvement, the infiltration uniformity is still quite poor.

Conclusions

LEPA equipment has the potential for increasing the effectiveness of water applied by a center pivot if management is adjusted accordingly. Field data show that poor application uniformities occur near the middle of the center pivot machine, even with a well designed LEPA nozzle package. Because of the very high application rates, significant runoff can occur on slopes greater than 3% unless special tillage practices are done to increase the infiltration rates and/or pond the applied water to increase the opportunity time for infiltration.

References

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