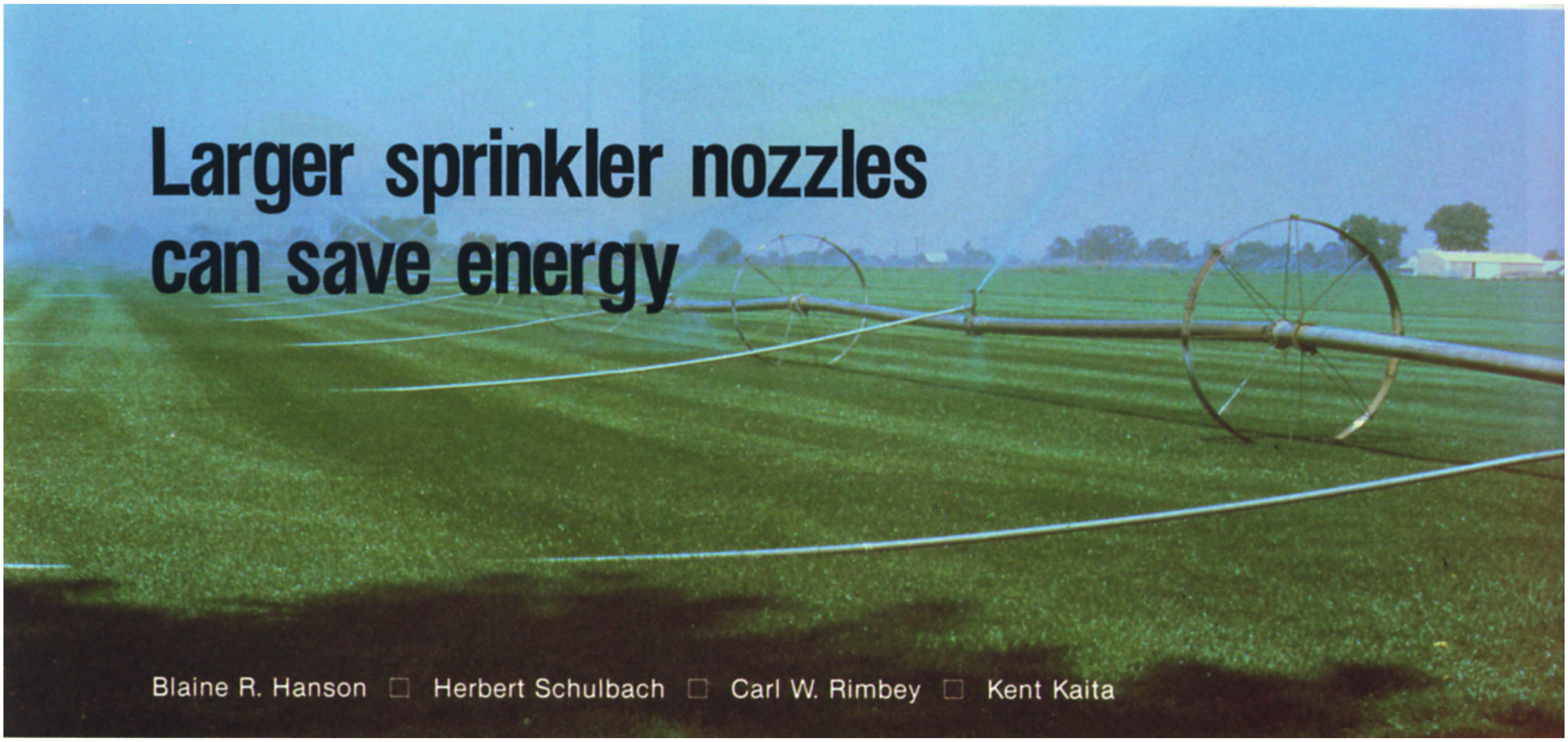

Larger sprinkler nozzles can save energy

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Increasing nozzle diameter can save a considerable amount of energy by reducing pump operating time, if adequate pressure can be maintained.

Today's energy costs for pumping irrigation water have resulted in high operating expenses for many growers, so that interest in minimizing energy consumption for pumping is increasing. Methods to lower these energy costs include selecting efficient pumps matched to irrigation systems, maintaining properly adjusted pumps, and modifying irrigation systems to reduce energy use.

A major factor in the energy consumption for sprinkler irrigation is the pressure requirement of the system, which must maintain uniform application of water for a given application rate and sprinkler spacing. However, if the pressure requirement can be reduced, by increasing the nozzle diameter, for example, and acceptable uniformity is still maintained, considerable energy savings might be realized.

Objective

We evaluated a sprinkler system to determine the effect of increasing the nozzle diameter on energy consumption and on performance of the system and the pump.

The larger nozzle diameter reduces the pressure at the sprinkler head, which in turn increases discharge through the pump. This greater discharge, however, increases drawdown in the well. Thus, the final operating condition resulting from the change depends on the interrelationship between drawdown characteristics of the well and performance characteristics of the pump and of the sprinkler system.

The irrigation system, which irrigated 100 acres, consisted of three wheel-line sprinklers and one hand-line sprinkler (fig. 1). Wheel-lines 1 and 3 had two-nozzle sprinkler heads (diameters: $\frac{5}{32}$ inch × $\frac{3}{32}$ inch), and wheel-line 2 had single nozzle heads (diameter: $\frac{5}{16}$ inch). The hand-line had various sizes of nozzles. The sprinkler spacing on the line was 40 feet,and the lines were moved a distance of 60 feet. Water and pressure were supplied by a four-stage deep-well turbine pump.

Procedure

First, we determined the performance characteristics of the pump by measuring the input power, pumping lift, and discharge pressure for several discharges. This information was necessary to evaluate pump response to different operating conditions. The irrigation system was then operated under the following conditions:

1. Throttled. A valve in the pump discharge line was partially closed until the pressure at the pump was about 55 psi. This was the normal operating condition for which the irrigation system was designed.

2. Unthrottled. The discharge valve was open.

3. Modified. All nozzles (except hand-line) were replaced with $\frac{11}{64}$-inch × $\frac{1}{8}$-inch nozzles. These nozzles were selected, because it was necessary to maintain the same wetted diameter as that of the original nozzles, since the mainline spacing could not be readily changed. The desired operating pressure was 40 to 45 psi. (Special orifices designed for low pressures were considered but rejected because of the reduced wetted diameter attained with these nozzles.) The discharge valve was open.

Under all three conditions, pressure and discharge were measured at selected nozzles along each lateral and at the pump. Pumping

TABLE 1. Operating Conditions of Pumping Plant for Each Test

Test	Discharge	Total head	Overall efficiency
	gpm	*ft*	*%*
Unthrottled	800	256	55
Throttled	740	136	44*
Modified	890	211	50

* This low efficiency is caused by the partially closed valve.

TABLE 2. Performance of Wheel-line 2 for Each Test

Test	Capacity	Application rate	Pressure drop*
	gpm	*in./hr.*	*%*
Unthrottled	350	0.31	14
Throttled	240	0.30	12
Modified	270	0.34	18

* Pressure drop between beginning and distal sprinkler (percent of beginning).

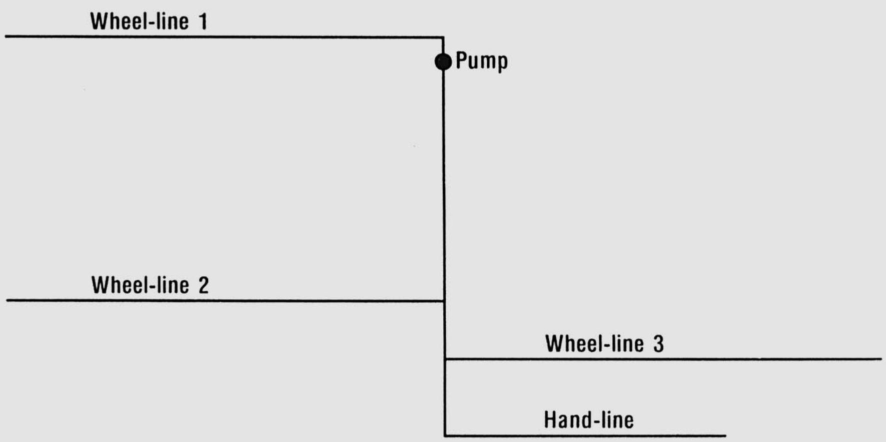

Fig. 1. Layout of test irrigation system. ½ inch = 300 feet.

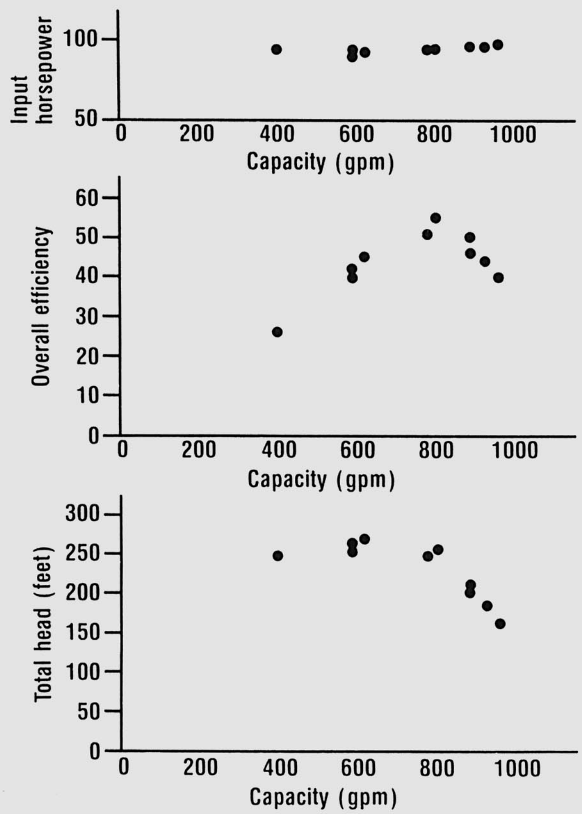

Fig. 2. Pump performance characteristics.

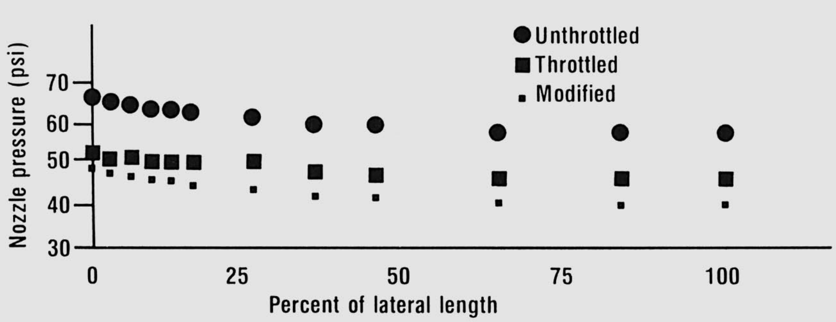

Fig. 3. Sprinkler pressure distribution along wheel-line 2.

lift and input horsepower were also measured. Catch-cans were used to determine the distribution of applied water for wheel-line 2. Application uniformity was evaluated by Christensen's uniformity coefficient.

Results

Maximum overall efficiency (55 percent) was obtained at 800 gpm and 250 feet of head (fig. 2). Input horsepower remained constant with discharge. Table 1 shows the operating conditions of the pump for each test condition. Drawdown in the well did not change significantly during the tests.

Results similar to those shown for wheel-line 2 (fig. 3, table 2) were obtained on the other wheel-lines.

The uniformity coefficient was 90, 83, and 80 percent for the throttled, unthrottled, and modified test, respectively. However, the unthrottled and modified tests were affected by wind.

Discussion

During the unthrottled test, the pump was operating at maximum efficiency. Increasing nozzle diameter caused the operating point of the pump to shift to the right of maximum efficiency. Thus, the efficiency decreased although capacity increased.

For the throttled test, the operating point of the pump shifted to the left of maximum efficiency. According to the performance curve, the efficiency should be about 50 percent. However, if the pressure drop of nearly 15 psi caused by the partially closed valve is considered, efficiency is about 44 percent.

To maintain adequate distribution of water, the pressure drop along the lateral must not be more than 20 percent of the initial pressure. In each test, this requirement was met, although the pressure drop was about 18 percent in the modified test. This may indicate that the nozzle diameter was near the maximum for adequate distribution.

The data on uniformity coefficients show that little difference in water distribution existed between the modified and unthrottled tests. We believe that the uniformity coefficient for wind conditions that occurred during these two tests would be similar also for the throttled test. Thus, little difference in irrigation efficiency is believed to exist between the three operating conditions.

Conclusions

Because similar irrigation efficiencies should exist for the three tests, we believe energy savings could be realized by operating the modified system. The savings would result from decreased operating time due to the higher pump capacity when compared with the normal condition. The energy use of the pump per unit of time would remain constant, regardless of operating conditions, because the input horsepower requirements do not vary with capacity.

In this particular area, about 3.5 feet of water are needed during the growing season. Under the throttled or normal condition, 2,570 hours of operating time would be required to irrigate 100 acres. However, under the modified system, 2,144 hours would be required, or a difference of 426 hours. This decrease in operating time would result in an energy savings of about 22,500 kilowatt-hours. At 5 cents per kilowatt-hour, the monetary savings would be nearly $1,500. Cost of modifying the system was about $60.

For sprinkler systems operating at high pressures, increasing nozzle diameters may result in an energy savings. However, the following should be considered:

The wetted diameter of the larger diameter nozzle should be the same as that of the original, unless sprinkler spacings can be changed.

The final operating pressure should not be so low that poor uniformity of application results.

Pump performance characteristics should be known, because the final operating condition will depend on the interrelationships between the increase in capacity and its effect on drawdown in the well, and the pump characteristics.

An evaluation like that described in this article should be conducted.

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