Abstracts

Optimization of Irrigation

Bryan J.W. Bell
Yaroslav Gelfand
Simpson H. Wong
University of California
Davis, CA

Advisor: Sarah A. Williams

Summary

We determine a schedule for a hand-move irrigation system to minimize the time to irrigate a 30 m × 80 m field, using a single 20 m pipeset with 10 cm-diameter tube and 0.6 cm-diameter rotating spray nozzles. The schedule should involve a minimal number of moves and the resulting application of water should be as uniform as possible. No part of the field should receive water at a rate exceeding 0.75 cm per hour, nor receive less than 2 cm in a four-day irrigation circle. The pump has a pressure of 420 KPa and a flow-rate of 150 L/min.

The sprinklers have a throw radius of 14.3 m. With a riser height of 30 in, the field can be irrigated in 48 h over four days. Moreover, a single sprinkler is optimal. The pipes should be moved every 5 h and be at least 21 m apart. The resulting irrigation has precipitation uniformity coefficient of .89 (where 1 would be maximum uniformity).

We deal with each constraint in turn. Using geometrical analysis, we convert the coverage problem to determining the least number of equal-sized circles that could cover the field. We perturb the solution to optimize uniformity, by applying a Simultaneous Perturbation Stochastic Approximation (SPSA) optimization algorithm. We perturb this solution further to find the minimal number of pipe setups, by experimentally “fitting” the pipesets through the sprinklers. The rationale for perturbation is that some drop in uniformity can be tolerated in favor of minimizing the number of setups while still ensuring that we irrigate the entire field. We feed the optimal layout of pipe setups to another algorithm that generates an irrigation schedule for moving the pipes.

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