Fastidious Farmer Algorithms (FFA)

Matthew A. Fischer  
Brandon W. Levin  
Nikifor C. Bliznashki  
Duke University  
Durham, NC

Advisor: William Mitchener

Summary

An effective irrigation plan is crucial to "hand move" irrigation systems. "Hand move" systems consist of easily movable aluminum pipes and sprinklers that are typically used as a low-cost, low-scale watering system. Without an effective irrigation plan, the crops will either be watered improperly resulting in a damaged harvest, or watered inefficiently, using too much water.

We determine an algorithm for "hand move" irrigation systems that irrigates as uniformly as possible in the least amount of time. We physically characterize the system, determine a method of evaluating various irrigation algorithms, and test these algorithms to determine the most effective strategy.

Using fluid mechanics, we find that we can have at most three nozzles on the 20-m pipe while maintaining appropriate water pressure. We model our sprinkler system after the Rain Bird 70H 1" impact sprinkler, which works at the desired pressure and has approximately a 0.6 cm diameter. Combining data and analysis, we confirm that the radius of the sprinkler will be 19.5 m.

Researchers have proposed several models for the water distribution pattern about a sprinkler; we consider a triangular distribution and an exponential distribution.

We do not consider schemes that do not water all areas of the field at least 2 cm every 4 days or water areas more than 0.75 cm/h. The largest cost in time and labor is in moving the pipe. Thus, we look for a small number of moves that still gives the desired time and stability. From these configurations, computer analysis determines which is most uniform.
For various situations, we propose an optimal solution. The bases of the sprinkler placement patterns are triangular and rectangular lattices. We craft three patterns to maximize application to the difficult edges and corners.

- For calm conditions and a level field, the field can be watered with just two moves (the “Lazy Farmer” configuration). However, this approach is unstable, and even weak wind would leave parts of the field dry. With three moves, little stability is gained; so four positions is best.

- The “Creative Farmer” triangular lattice gives both stability and uniformity. The extra time is warranted because of its ability to adapt.

- We obtain even more stability using the “Conservative Farmer” model but at the price of a decrease in uniformity from the “Creative Farmer” approach.