A Schedule for Lazy but Smart Ranchers

Team # 1234

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Abstract

We present our three-stage model constructing process in this paper. Firstly, we determine the number of sprinklers to use by analyzing the energy and motion of water in the pipe and examining the engineering parameters of sprinklers available in the market.

Secondly, we build a model to determine how to layout the pipe each time the equipment is reinstalled. This model leads to a computer simulation of catch-can tests of the irrigation system and an estimation of both distribution uniformity (DU) and application efficiency of different schemes of where to move the pipe. In this stage, DU is the most important factor we considered. We also found a schedule in which one of the sprinklers will be positioned out of the field in some moves, but it results in higher DU (92.1%) and actually saves more water.

In the final stage, we figure out two schedules to irrigate the field. In one schedule, the field receives water evenly in time during a cycle of irrigation (in our schedule, 4 days), while the other one costs least labor force and time. In this stage, the time and labor force required are the most important factors we considered.

Our suggested solution, which is easy to implement, includes a detailed timetable and the arrangement of the pipes. It costs 12.5 irrigation hours and 6 equipment resets in every cycle of 4 days to irrigate the field with DU as high as 92.1%.

Contents

1 Problem Review

"Hand-move" irrigation system is one of various techniques for irrigating a field. Pipes with sprinkler heads are put in place across fields, and they are moved by hand at periodic intervals to insure that the whole field receives an adequate amount of water. This type of system is cheaper and easier to maintain but requires a great deal of time and effort to move and set up the equipment at regular intervals.

Use this system to irrigate an $80m \times 30m$ field and work out a scheme to minimize the amount of time required by a rancher to maintain the irrigation system and maximize the uniformity. Given a pipe set whose total length is $20m$, try to determine the number of sprinklers and the spacing between sprinklers and find a schedule to move the pipes, including where to move them. Each pipe has a $10cm$ inner diameter with rotating spray nozzles that have a $0.6cm$ inner diameter. At the water source, the pressure is 420kPa and has a flow rate of $150lpm$. No part of the field should receive more than $0.75cmph$ of water, and each part of the field should receive at least 2cm of water every 4 days.

2 Assumptions and Definitions

- The weather is assumed to be "fine" while the influence of wind can be neglected.
- The whole system is assumed to be "ideal" while evaporation, leaking and other ways of water loss can be neglected.

- The water source can be moved and put at any position of the field. In practice, a tube can be used to transport water from the pump to the pipe set.
- No mainline is assumed to exist so that all pipes join together and can be put at any position of the field.
- The time for a rancher to uncouple, move and reinstall the pipe set is assumed to be half an hour.
- The discharge of any sprinkler is assumed to be the same.

- The manufacturer design pressure of sprinklers is assumed to be about 400kPa which is a most appropriate pressure in this problem and the type of rotating sprinkler is impact driven sprinkler (see details in Information Analysis of Sprinklers section).
- The diameter of the riser is assumed to be the same as that of the pipe.
- The water pressures in pipes are assumed to be the same. In practice, there is a slight difference.

Table 1: Variables

Variable	Definition	Units
p_{in}	Water pressure in the pipe before a junction	kPa
p_{out}	Water pressure in the pipe after a junction	kPa
p_{up}	Water pressure at the sprinkler upon a junction	kPa
v_{in}	Water velocity in the pipe before a junction	m/s
v_{out}	Water velocity in the pipe after a junction	m/s
v_{up}	Water velocity at the sprinkler upon a junction	m/s
A_{in}	Section area in the pipe before a junction	cm^2
A_{out}	Section area in the pipe after a junction	cm^2
A_{up}	Section area at the sprinkler upon a junction	cm^2
h	Height of the sprinkler upon the pipe	m
t	Change in time	s
v_{source}	Water velocity of the water source	m/s
n	Number of sprinklers	-
$distr(r)$	Distribution function of precipitation profile	-
p	Precipitation rate	-
R	Sprinkling range	m
r	Distance from a sprinkler	m
r_i	Distance from the ith sprinkler	m
a	Obliquity of the precipitation profile	rad
$pr(r)$	Precipitation function of one sprinkler	cm/min
DU	Distribution Uniformity of an irrigation system	-

Table 2: Constants

Variable	Definition	Value
ρ	Density of water	$1.0kg/L$
g	Acceleration of gravity	$9.8m/s^2$

3 Problem Analysis

Our goal is to determine the number of sprinklers and the spacing between sprinklers and find a schedule to move the pipes, including where to move them.

Our approach can be divided into three stages.

First, determine the number of sprinklers. In order to achieve the goal, we figure out the pressure and velocity of water from each sprinkler and then determine possible sprinkler number according to some engineering data.

Second, determine where to put the pipes. We consider some major factors such as sprinkling time, moving time and distribution uniformity (DU) while DU is especially important for the purpose of saving time. Since the pipe positions depend on the sprinkler number and the precipitation profile, we just work out some problem specific cases. However, our method can be used to solve any practical cases.

Third, determine the schedule to move the pipes. Referring to the water need of the field, a schedule is made to minimize the time cost, which, obviously, is closely related to the positions of the pipes to move.

4 The Development of Models

4.1 Stage1: Water Pressure and Velocity

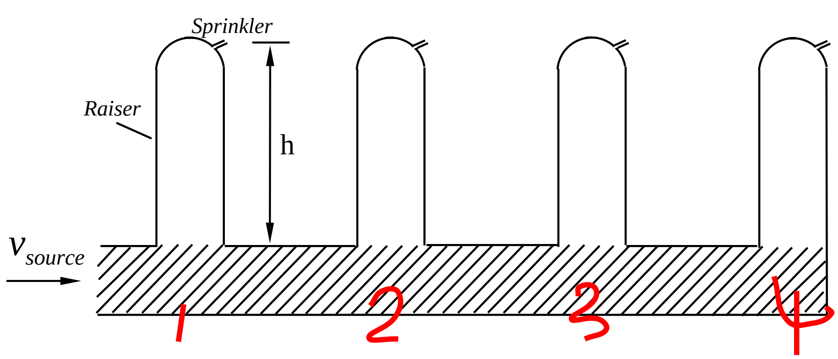

Figure 1: Overall sketch map with 4 sprinklers, 4 junctions numbered from 1 to 4.

The pressure of the shadow area is the same due to the last assumption.

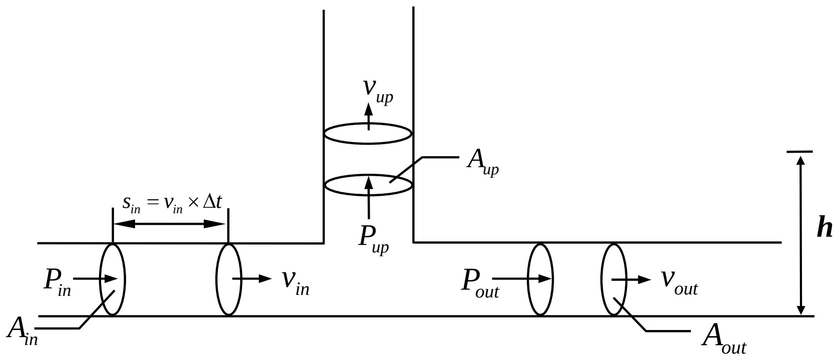

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Figure 2: Sketch map at one junction.

We apply the law of conservation of energy to solve.

The work done by the forces is

$F \times V \times \Delta t = W$

$$F_{in}s_{in} - F_{up}s_{up} - F_{out}s_{out} = p_{in}A_{in}v_{in}\Delta t - p_{up}A_{up}v_{up}\Delta t - p_{out}A_{out}v_{out}\Delta t$$

?

The decrease of potential energy is

$$-mgh = -\rho g A_{up}v_{up}\Delta th$$

The increase in kinetic energy is

$$\frac{1}{2}mv_{up}^2 + \frac{1}{2}mv_{out}^2 - \frac{1}{2}mv_{in}^2 = \frac{1}{2}\rho A_{up}v_{up}\Delta t v_{up}^2 + \frac{1}{2}\rho A_{out}v_{out}\Delta t v_{out}^2 - \frac{1}{2}\rho A_{in}v_{in}\Delta t v_{in}^2$$

Putting these together, because of the law of conservation of energy, gets

$$\begin{aligned} &p_{in}A_{in}v_{in}\Delta t - p_{up}A_{up}v_{up}\Delta t - p_{out}A_{out}v_{out}\Delta t - \rho g A_{up}v_{up}\Delta th \\ &= \frac{1}{2}\rho A_{up}v_{up}\Delta t v_{up}^2 + \frac{1}{2}\rho A_{out}v_{out}\Delta t v_{out}^2 - \frac{1}{2}\rho A_{in}v_{in}\Delta t v_{in}^2 \end{aligned} \tag{1}$$

As the fluid is incompressible,

$$A_{in}v_{in} = A_{up}v_{up} + A_{out}v_{out} \tag{2}$$

The diameters are all the same:

$$A_{in} = A_{up} = A_{out} = \pi * (10cm/2)^2 \tag{3}$$

According to assumptions, at every junction

$$p_{in} = p_{out} = 420kPa \tag{4}$$

$$v_{up} = v_{source}/n \tag{5}$$

when

$$v_{source} = \frac{150L/min}{\pi * (10cm/2)^2} = 0.3183m/s$$

Therefore, from (2),(3),(5), for the ith junction, its

$$v_{in} = v_{source}(1 - \frac{i-1}{n})$$

and

$$v_{out} = v_{source}(1 - \frac{i}{n})$$

Put (1),(2),(3),(4),(5) all together ,we can obtain p_{up} at every junctions.

Table 3: Pressure at every sprinkler when $h = 1m$ and $n = 4$.

Junction No.	$P_{up}(Pa)$
1	410314
2	410257
3	410219
4	410200

In fact, at the last (i.e. the nth) junction,

$$v_{in} = v_{up} = \frac{v_{source}}{n}$$

$$v_{out} = 0$$

Put into (1), we can get

$$p_{up} = p_{in} - \rho g h$$

which means the pressure at the last sprinkler is independent of n.

Commonly, h is about $0.5m$ to $1.5m$, and even if assume $h = 1.5m$, the v_{up} at the last junction will be $405300Pa$, not far from $420kPa$. (if $h = 0.5m$, the last v_{up} will be $415100Pa$)

From these equations, we can also know that the last v_{up} is the v_{up} that differs most from $420KPa$, and the v_{up} at the first junction is the v_{up} that close to $420kPa$ most (and below $420kPa$),the values of v_{up} are decreasing slowly from junction 1 to n.

So we can come to this conclusion: all the values of v_{up} at every junction will be very close (all about $400kPa$, below $420kPa$ and close to $420kPa$), no matter how many sprinklers are. That's why we assume "design pressure of sprinklers is assumed to be about $400kPa$" in assumptions.

4.1.1 Information and Analysis of Sprinklers

Table 4: Data of sprinklers.[2] (Medium pressure sprinklers have the best application uniformity.)

Type	Design Pressure (kPa)	Range (m)	Discharge ($m^3/hour$)
Low Pressure Sprinkler (Low-Range Sprinkler)	< 200	< 15.5	< 2.5
Medium Pressure Sprinkler (Medium-Range Sprinkler)	200-500	15.5-42	2.5-32
High Pressure Sprinkler (High-Range Sprinkler)	> 500	> 42	> 32

There are 5 different types of rotating sprinklers among which the impact driven sprinkler is the most widely used. In this article, we assume that the rotating sprinkler is impact driven sprinkler. Some rotating sprinklers have a sector mechanism that can wet either a full circle or a sector, while rotating sprinklers without sector mechanism can only wet a circle.

There are three main structure parameters of sprinklers: intake line diameter, nozzle diameter, nozzle elevation angle.

An experiential formula is used to calculate the spraying range of an impact driven sprinkler:

$$R = 1.70 d^{0.487} h_p^{0.45}$$

where d is the nozzle diameter, h_p is the operational pressure head.

We have looked up a wide range of different models of impact driven sprinklers, the following are the models with $6mm$ nozzle diameter. The manufactory and some other information are omitted here.[2]

Table 5: Commonly available nozzle types whose diameter is 6mm.

Model	Nozzle diameter (mm)	Design pressure (kPa)	Discharge ($m^3/hour$)	Range (m)
PY$\neg_1$15	6	200	1.23	15.0
		300	1.51	16.5
PY$\neg_1$20	6	300	2.17	18.0
		400	2.50	19.5
PY$\neg_1$S20A	6*4	300	2.99	17.5
		400	3.41	19.0
PY$_1$S20	6	300	2.22	18.0
		400	2.53	19.5
15PY$_2$22.5	6	350	2.40	17.0
		400	2.56	17.5
15PY$_2$30	6	350	2.40	18.0
		400	2.56	18.5

Sprinklers with higher manufacturer design pressure tend to have larger wetted diameters. However, deviations from manufacturer's recommended pressure may have the opposite effect (increase in pressure, decrease in diameter), and uniformity will probably be compromised.

The following picture shows typical precipitation distribution of one sprinkler in low, correct, and high sprinkler pressure.

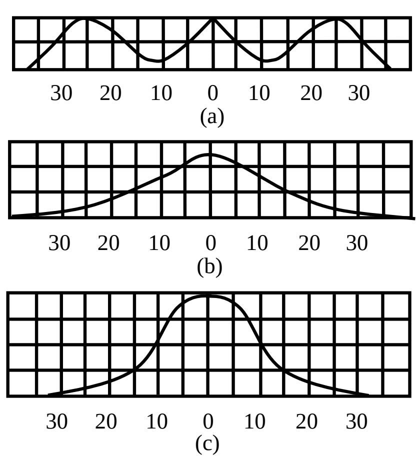

Figure 3: Relation between pressure and precipitation distribution.[2] (a) Pressure is too low (b) Pressure is ok (c) Pressure is too high

In practice, people use catch-can data to generate precipitation profile of a "hand move" irrigation system. That is to put catch-cans evenly in the field, and, after irrigation, the precipitation profile can be portrayed by the amounts of water contained in each catch-can (Figure 4).[3]

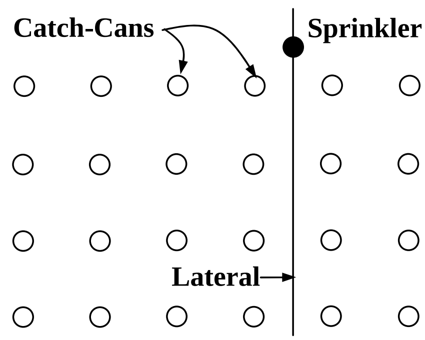

Figure 4: Catch-can test.[3]

One measure of how uniformly the water is applied to the field is Distribution Uniformity (DU), which is defined as:[3]

$$DU = \frac{average\_precipitation\_rate\_of\_low\_quarter}{average\_precipitation\_rate} \times 100\%(*)$$

Usually, DUs of less than 70% are considered poor, DUs of 70 - 90% are good, and DUs greater than 90% are excellent. In short, bad DU means that either too much water is applied, costing unnecessary expense, or too little water is applied, causing stress to crops. There must be good DU before there can be good irrigation efficiency.[4]

To simplify our calculation, we approximate the precipitation profile of a single sprinkler (in Figure 3(b)) to a function: $distr(r)$, which means the relative precipitation rate in the position with a distance r from the sprinkler (Figure 5).

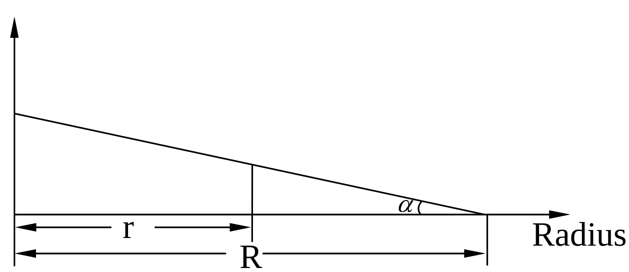

Figure 5: The precipitation rate plotted vs. the distance to the sprinkler.

In this problem's case, surely we should use medium pressure sprinklers (see Table 4).And In Table 5, for those sprinklers with a $6mm$-diameter nozzle and working at $400kPa$ (as we assumed), their discharge is $2.5-3.5m^3/hour$ and spraying range is 18.5,19 or $19.5m$. From now on, we'll use $19m$ as the range of sprinklers concerned.

Note the discharge of the source is

$$150L/min = 9m^3/hour,$$

thus, to fit every sprinkler's actual discharge to the design discharge, the number of sprinklers we'll install should be 3 or 4. It is because $9/3 = 3$ or $9/4 = 2.25$, which is close to or within the range of the $2.5 - 3.5m^3/hour$.

4.2 Stage2: Scheduling the Irrigation

Actually, a schedule to move the pipes includes both where and in how long an interval to move them. For the previous one, we just imagine a fixed irrigation system consisting of several $20m$ pipes. If the system can nicely, i.e. with high Distribution Uniformity (DU), meet the needs of the crops, then the way of moving the pipe in the problem is just to move it from one pipe's position to another in the system. So, we'll determine where to move the pipe by laying out a system of several 20m pipes, and then decide for how long we should water the field before making a next move. First, we use a simulation of catch-can analysis to choose a layout with a high DU.

4.2.1 Catch-can Analysis

Since the water sprayed by a particular sprinkler has a determined distribution: $distr(r)$, as we've already defined, we use the following method to simulate the catch-can test.

For rectangular spacing (Figure 6 Left), we consider the rectangular region between four adjacent sprinklers. In our simulation, we pick 900 positions evenly distributed in the region. For each position, we calculate its relative precipitation rate p:

$$p = \sum_i distr(r_i)$$

r_i is the distance from the position to a sprinkler considered. Thus , for the ith position, we got pi,$(1 \leq i \leq 900)$. With Equation (*), we then calculate the DU of this irrigation system.

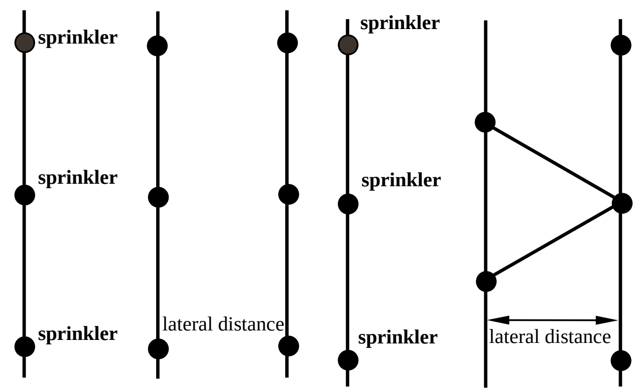

Figure 6: Left: Rectangular spacing; Right: Triangular spacing.

As we've already deduced, the number of the sprinklers should be 3 or 4, thus the sprinkler distance will be $10m$ $(20m/(3-1))$ or $6.67m$ $(20m/(4-1))$[1]. So the DU is a function of the lateral distance. And this can also be applied for triangular spacing (Figure 6 Right). After the simulation, we get:

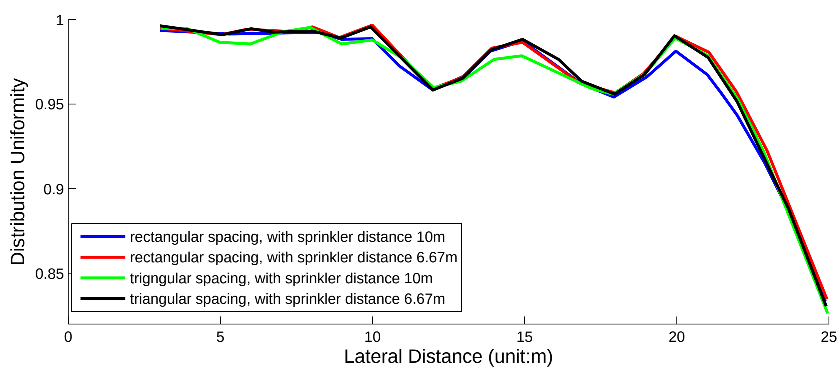

Figure 7: DU plotted vs. lateral distance, in 4 different situations.

The simulation shows that when lateral distance ≤ 20, DU is acceptable $(\geq 90\%)$, regardless of the spacing and whether the sprinkler distance is

[1]That the sprinkler distance is evenly distributed along the pipe is because that it will have a higher DU and it is easy to operate.

6.67m or 10m. But since larger lateral distance will result in smaller amount of time required to irrigate the field (the number of moves to make will be less), we pick 20m as the lateral distance. Figure 8 and Figure 9 show the precipitation profile for the irrigation systems with sprinkler distance 10m and lateral distance 20m.

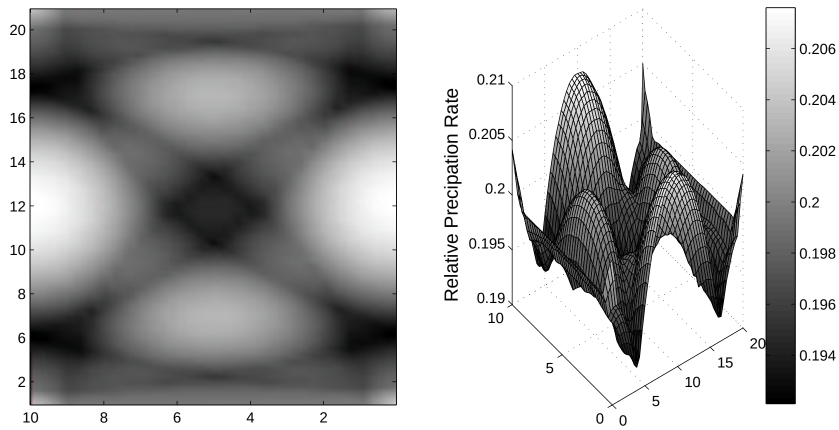

Figure 8: Left: Precipitation profile for rectangular spacing with sprinkler distance 10m and lateral distance 20m; right: the 3D form of the precipitation profile.

$$DU = 98.1\%$$

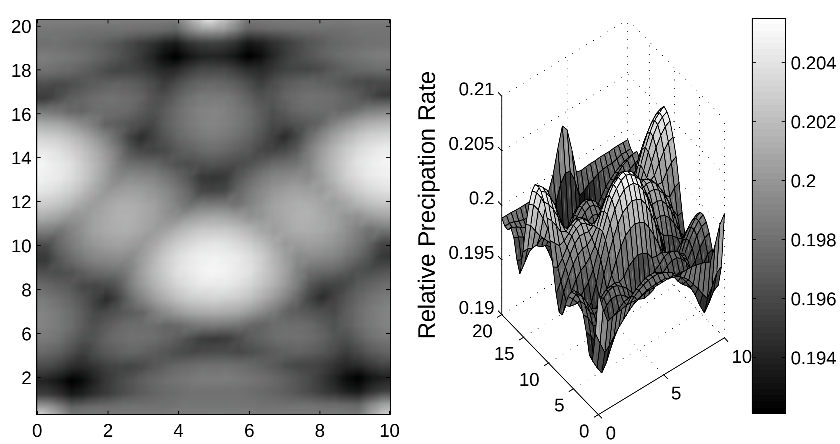

Figure 9: Left: Precipitation profile for triangular spacing with sprinkler distance 10m and lateral distance 20m; right: the 3D form of the precipitation profile.

$$DU = 98.7\%.$$

Considering that the field ($30m \times 80m$) is not relatively large enough to implement triangular spacing when the pipe is $20m$ long, we will use rectangular spacing with an only 0.7% neglectably weaker DU. Before we layout the pipe set, we should first determine the max distance from the rim of the field to the sprinklers satisfying that the DU can be acceptable.

We simulate a catch-can test on the rectangular region on the rim of the field as in Figure 10.

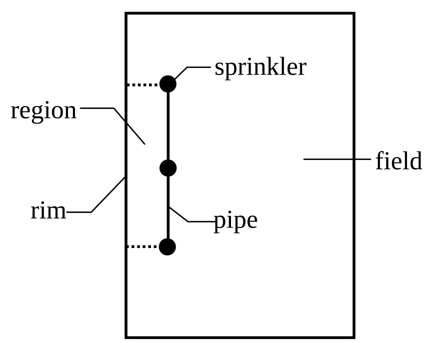

Figure 10: Region to simulate a catch-can test.

The result is in Figure 11. Thus, we can see that, the max length between the rim of the field and the sprinklers is $5m$ with an acceptable DU of 82.7%.

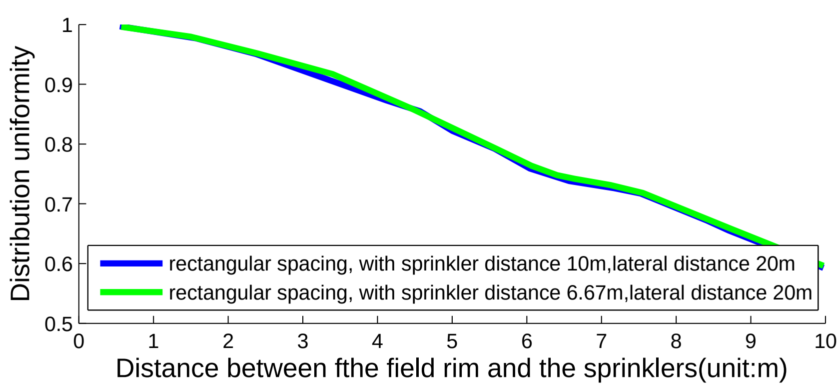

Figure 11: DU plotted vs. distance from the rim to the sprinkler in 2 different situations

4.2.2 Layout of the Pipe Set

According to the analysis above, having 3 or 4 sprinklers along the pipe only results in a slight difference. Considering that the spraying radius (19m) is too large compared with the sprinkler distance 6.67m when having 4 sprinklers, we choose to have 3. Thus the only two feasible layouts of the whole system exist[2] (Figure 12 and Figure 13). Simply speaking, Layout 1 implies that it requires 5 times of moving and setting up the pipes while Layout 2 requires 6. But it's too early to judge which is better.

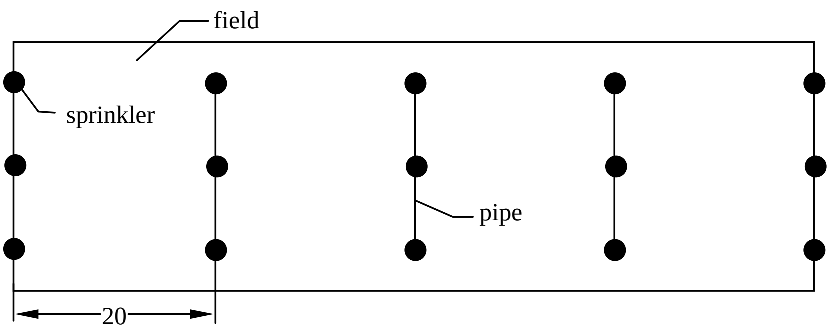

Figure 12: Layout 1.

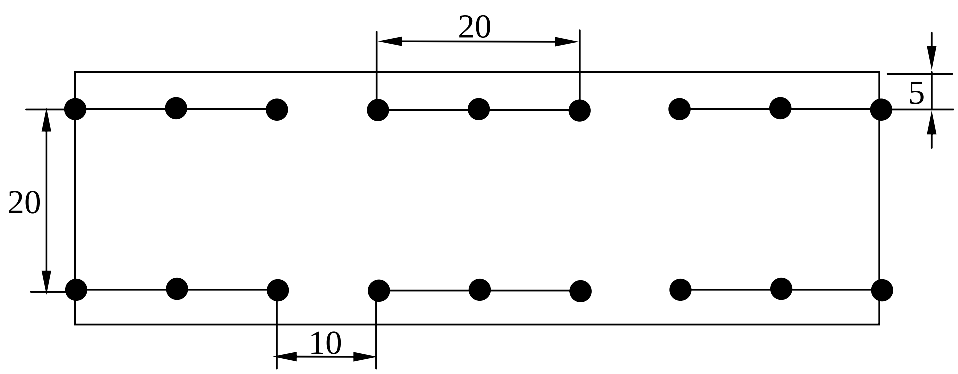

Figure 13: Layout 2.

For further estimation, we should calculate *DU* (Distribution Uniformity) of both layouts. The result from the simulation of catch-can tests is shown in following figures:

[2]We are not considering the situation when the pipes are not parallel to the edge of the field, because layout of this kind is not practical.

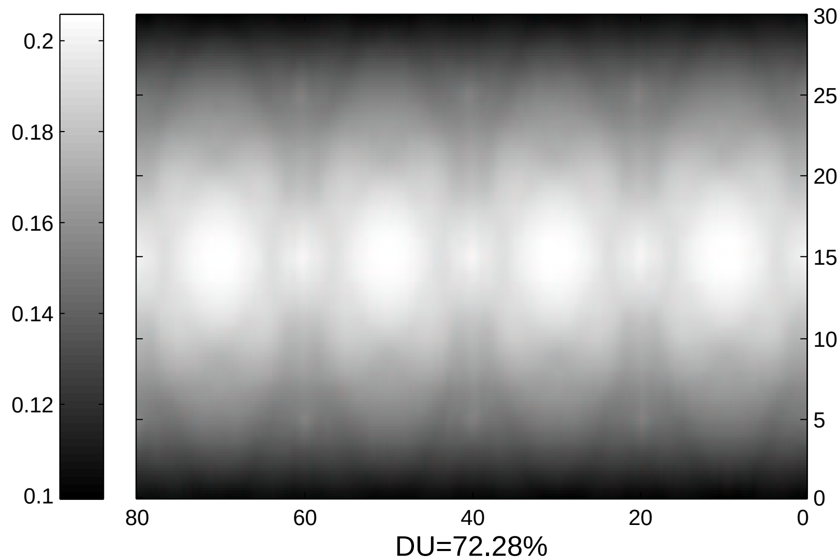

Figure 14: Catch-can test simulation result of layout 1.

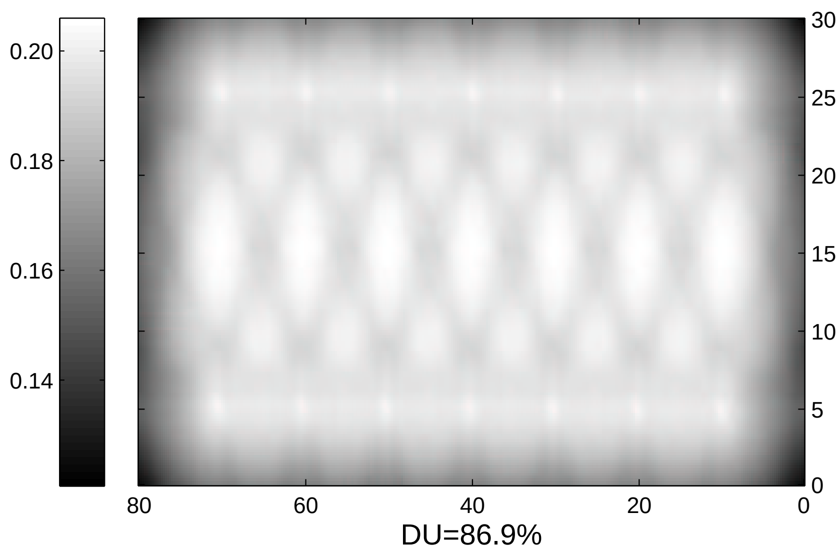

Figure 15: Catch-can test simulation result of Layout 2.

We decide to abandon Layout 1 because it has a very poor DU. After slightly changing the lateral distance in Layout 2, we finally achieve a best DU of 89.5% in Layout 3 (see in Figure 16):

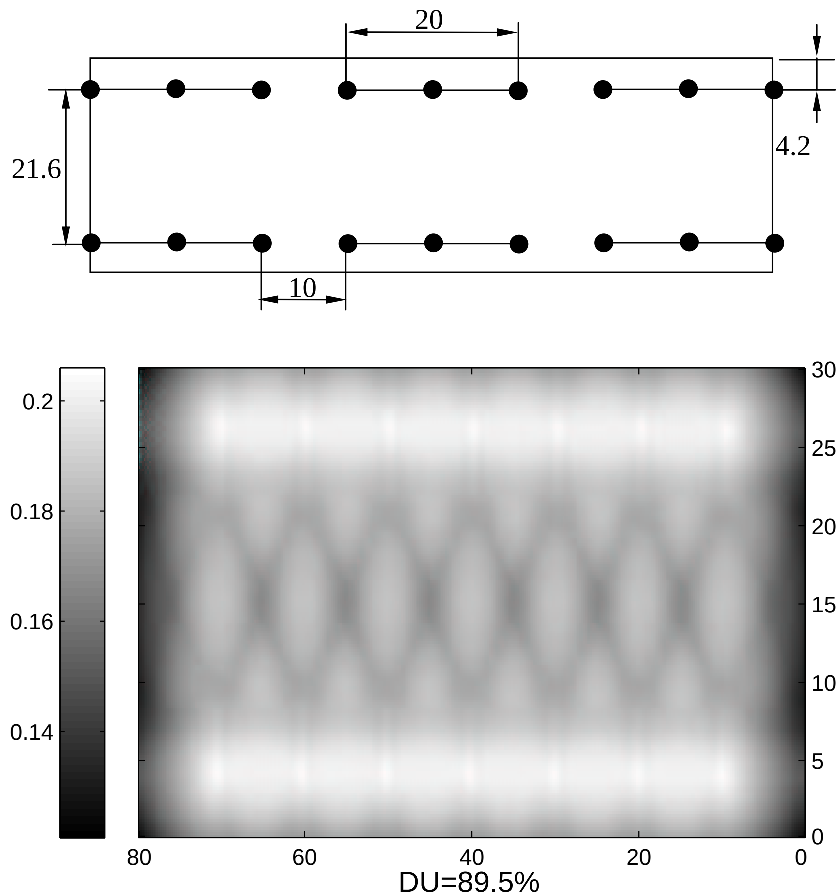

Figure 16: Upper: Layout3; Lower: Catch-can test simulation result of Layout 3.

Then, if we are brave enough to move some sprinklers out of the field, we'll achieve a higher DU in Layout 4 (see in Figure 17):

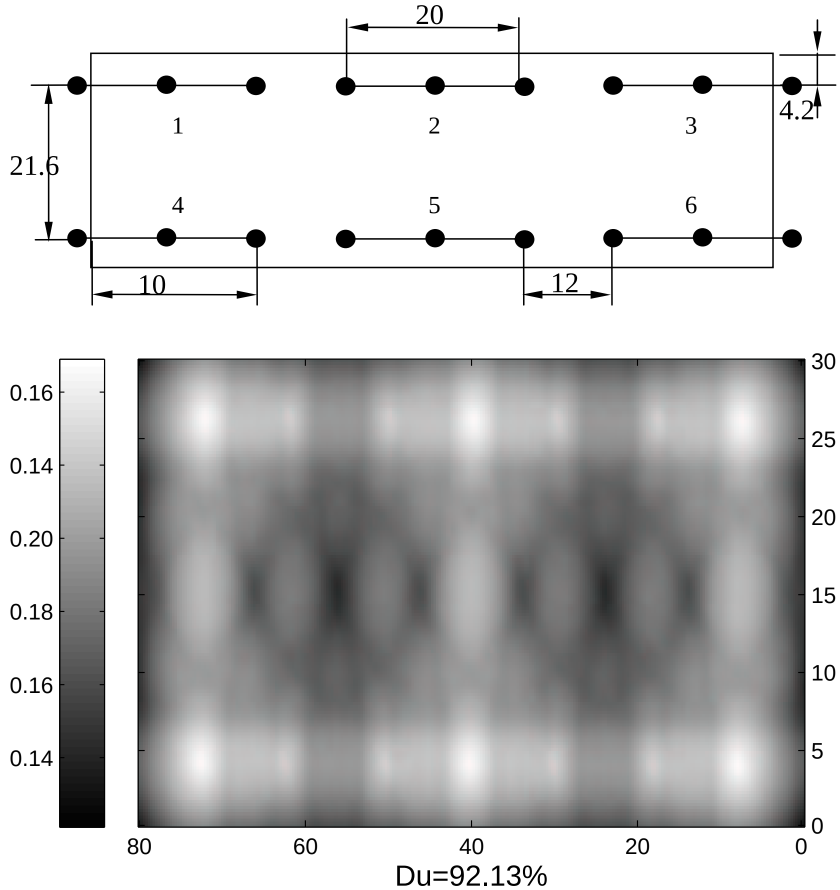

Figure 17: Upper: Layout4; Lower: Catch-can test simulation result of Layout

4.2.3 Calculation of the Precipitation

In order to meet the problem's constraints that in any part of the field,

a) the precipitation rate $\geq 2cm/4days$ ......(Constraint A),

b) the precipitation rate $\leq 0.75cm/hour$ ......(Constraint B),

we should calculate the precipitation rate of the system in Layout 4 before scheduling the interval to irrigating the field and to move the pipe.

The precipitation area of a sprinkler should be a circle with a radius R, as Figure 18 shows. The profile of the precipitation rate distribution is in

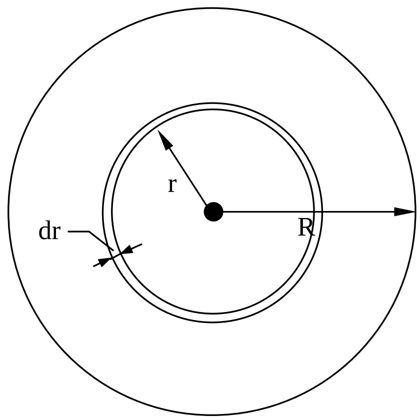

Figure 18: Precipitation area of a single sprinkler.

Figure 5. In order to figure out the precipitation rate at a certain point whose distance from the sprinkler is r, we firstly calculate the angle α in Figure 5. As we normalize the distribution, we get

$$\int_0^R (R-r)\tan\alpha \cdot 2\pi r \mathrm{d}r$$

so

$$\tan\alpha = \frac{3}{\pi R^3}$$

then the precipitation rate

$$pr(r) = v(R-r)\tan\alpha = \frac{3(R-r)}{\pi R^3}v,$$

where $R = 19m$, $v = 50lpm$.

With Matlab, we calculated the precipitation rate at each point in the $80m \times 30m$ field, with the irrigation system working only once (see in Figure 19 Right) and after a complete cycle of moving the equipment and irrigating (see in Figure 19 Left).

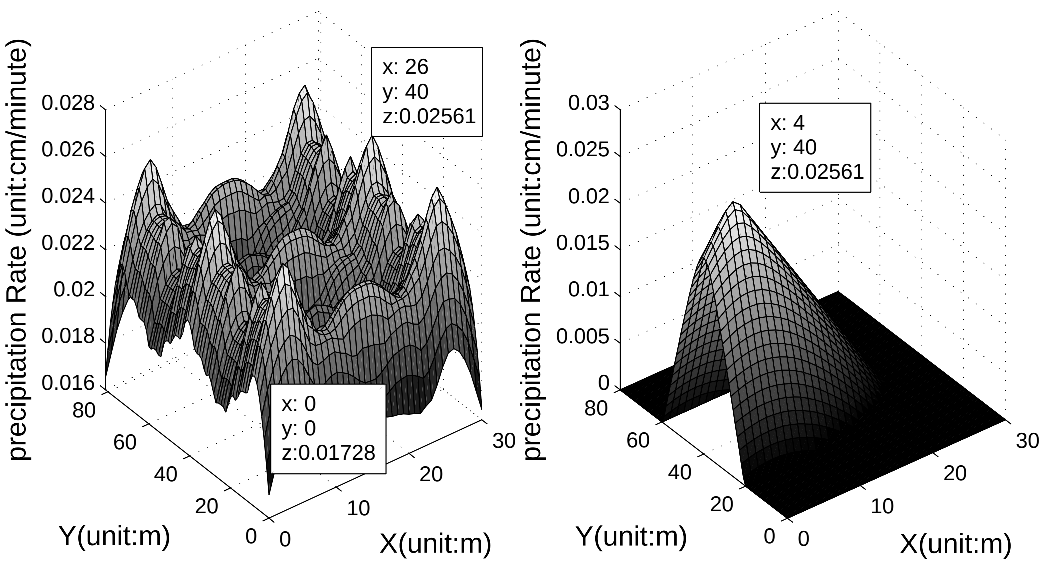

Figure 19: Precipitation rate of water in the field with Layout 4. Left: the whole effect of 6 pipes together; Right: the effect of a 20m pipe working alone.

4.2.4 Scheduling the Irrigation Time

Figure 19 Right shows that when the sprinklers (only one $20m$ pipe at a time) are working, the maximum precipitation rate is

$$0.02561cm/min.$$

To satisfy Constraint A, the period of irrigation should be less than

$$\frac{0.75cm/hour}{0.02561cm/min} = 29.30\text{min per hour}$$

Because the smaller the period of irrigation is, the more frequently the farmer should stop to move the pipe, we thus choose a large but easy to implement one:

$$25\text{min per hour.}$$

Figure 19 Left shows that after a complete cycle of irrigation the whole field, i.e. the equipment has been moved to and irrigated every required place of the field, and the minimum precipitation rate is

$$0.01728cm/min$$

To satisfy Constraint B, the period of irrigation should be longer than

$$\frac{2cm/4days}{0.01728cm/min} = 115.7\text{min every 4 days}$$

To meet this, in every 4 days, we plan to irrigate the same place 5 times, every time lasts 25 minutes, that is 125 minutes, well satisfies Constraint B.

With the same method, we calculate the same parameters for Layout 3, and list the comparison in Table 6:

Table 6: Comparison between Layout 3 and Layout 4.

	Layout 3	Layout 4
Max precipitation rate (cm/min)	0.02561	0.02561
Min precipitation rate (cm/min)	0.01598	0.01728
Total Irrigation time every 4 days (min)	150×6	125×6
DU, Distribution Uniformity	89.5%	92.1%

It is clearly shown that Layout 4 not only has higher DU than Layout 3, but also saves 16.7% of water, in other words, has higher application efficiency, though one of its sprinklers is positioned out of the field in some situation. This is because that Layout 3 has a smaller min precipitation rate which leads to more irrigation time in order to satisfy Constraint A. So we choose Layout 4 as our solution.

4.3 Stage3: Schedule Design

As we've discussed in the previous stage, our schedules will be able to achieve a DU as high as 92.1% after a cycle of 4-day-irrigation. We have two concrete design of irrigation timetable.

The first design make the least moving time but, to some extent, is not so "average" as it gathers sprinkling processes of the same sprinkler together. (Table 7)

Table 7: The first schedule for every four days.('*' means it is required to set up the pipe set in the referred position before irrigation. And the position code refers to pipe's position in Figure 17)

Day	Time	Position code
1	7:00-7:25	1*
	8:00-8:25	1
	9:00-9:25	1
	10:00-10:25	1
	11:00-11:25	1
	13:00-13:25	6*
	14:00-14:25	6
	15:00-15:25	6
2	7:00-7:25	6
	8:00-8:25	6
	9:00-9:25	2*
	10:00-10:25	2
	11:00-11:25	2
	13:00-13:25	2
	14:00-14:25	2
	15:00-15:25	4*
3	7:00-7:25	4
	8:00-8:25	4
	9:00-9:25	4
	10:00-10:25	4
	11:00-11:25	3*
	13:00-13:25	3
	14:00-14:25	3
4	7:00-7:25	3
	8:00-8:25	3
	9:00-9:25	5*
	10:00-10:25	5
	11:00-11:25	5
	13:00-13:25	5
	14:00-14:25	5

The second design need more moving time but, as a kind of compensation, is more "average" (for instance, the field receives water much more evenly in time) than the first design. (Table 8)

Table 8: The second schedule for every four days. (position code refers to Figure 16)

Day	Time	Position code
1	7:00-7:25	1
	8:00-8:25	5
	9:00-9:25	3
	10:00-10:25	4
	11:00-11:25	2
	13:00-13:25	6
	14:00-14:25	1
	15:00-15:25	5
2	7:00-7:25	3
	8:00-8:25	4
	9:00-9:25	2
	10:00-10:25	6
	11:00-11:25	1
	13:00-13:25	5
	14:00-14:25	3
	15:00-15:25	4
3	7:00-7:25	2
	8:00-8:25	6
	9:00-9:25	1
	10:00-10:25	5
	11:00-11:25	3
	13:00-13:25	4
	14:00-14:25	2
4	7:00-7:25	6
	8:00-8:25	1
	9:00-9:25	5
	10:00-10:25	3
	11:00-11:25	4
	13:00-13:25	2
	14:00-14:25	6

5 Evaluation of Results

5.1 Comparison between Two Designs

Table 9: Comparison between Design 1 and Design 2.

Parameters in one cycle of irrigation (4days)	Design 1	Design 2
Number of equipment resets	6	30
Equipment reset time (one reset cost 30min as assumed) (hour)	3	15
Irrigation time (hour)	12.5	12.5
DU, Distribution Uniformity	92.1%	92.1%

Actually, Design 1 is the most time effective and labor saving schedule based on Layout 4. If the water source, i.e. the pump, has a timing mechanism (there is such product in market), the whole irrigation only costs 3 hours labor time every 4 days. But as we've discussed, Design 2 has a more "average" irrigation, which may be better for crops or plants. So it is easy to arrange a more compromising schedule good for plants and with longer but acceptable required labor time.

It is also worthy mentioning that with the sector mechanism, we can control the rotating range of the sprinkler on the edge of or out of the field to reduce the water waste.

6 Strengths and Weaknesses

6.1 Strengths

- We use real data of sprinklers to determine the parameters of the sprinklers we choose and determine the number of sprinklers.
- We establish a model based on the engineering knowledge of sprinklers, and find out the overall precipitation distribution, and then manage to find out an optimal schedule. All the results are based on calculations.
- Our model to analyze the layout of the irrigation system is sprinkler-independent. This means, for whatever kind of sprinkler, if its single

precipitation profile is known (e.g. though a real catch-can test), we can determine the precipitation profile across the whole field.

- The placement and schedule is very clear and easy to implement.

6.2 Weaknesses

- Water pressure in the pipe may diverse, and so the discharge of the sprinklers may not be exactly the same.

7 Further Discussion

The analysis should further include the consideration of wind, evaporation, the characters of the soil type and penetration.

References

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