

Design ceriteria of sprinkler irrigation for the dry zone

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SUMMARY

Considering the great loss of irrigation water in the Dry Zone of Sri Lanka through the use of traditional systems of irrigation, an experiment was conducted at the Maha Illuppallama Research Station to determine the criteria for the application of water to crops by sprinkler systems. Different operating pressures, nozzle spacings and droplet sizes were tested in relation to soil infiltration and wind velocities. It was found that sprinkler equipment performed effectively in the Red Brown Earths, characteristic of the region, within a maximum wind velocity of 10 mph at an operating pressure of 35 psi nozzle pressure and a spacing of 40 feet between sprinkler heads.

INTRODUCTION

Recently irrigation water has become an expensive commodity under the major schemes. Even in small holdings with well-lift irrigation systems water has become expensive, because of the energy crisis. Under these circumstances it is time to consider adoption of sprinkler irrigation in areas where the irrigation losses are very high.

Presently the irrigation efficiency in farmer's fields is about 30 to 40 percent. The water losses, not available to crops, is about 60 to 70 percent. Apart from being a wasteful system, it causes ill drained conditions in the lower aspects of the landscape. In a sprinkler system, efficiencies could be as high as 80 to 90 percent. However, the system should be designed for the crop, soil and climate of the area. In order to adopt a sprinkler equipment to suit the local conditions, tests should be conducted to obtain the best performance. The investigations on sprinkler at Maha Illuppallama were conducted with a view to obtain relevant design criteria for the dry zone.

MATERIALS AND METHODS

The system was composed of 1,330 feet 3" portable main line and 2 of 340 ft 2" laterals, 18 Rainbird 30 sprinkler heads with 11/64 x 5/32 inch nozzles.

The pump selected was capable of discharging 136 gpm against a total head of 170 feet at 3000 RPM. Pressure gauges were installed in the main line of the pumps. Different pressures were obtained by throttling at the main line.

Since the decision was to find out how best this equipment could be laid out and operated, some basic information was necessary before carrying out irrigation trials. The data which had to be determined are listed below:

1. Water pressure required to operate the system so that it will sprinkle a droplet size which will not adversely affect the infiltration characteristics of the soil, and at the same time maintain an efficient distribution, not distorted much by the prevailing winds.
2. Direction of laterals in relation to the wind and also the spacing of laterals to satisfy the irrigation requirement for mixed cropping.
3. Efficiency parameters calculated from (1) and (2).
4. Crop effects such as flower drop in chillies, damage to onion seedlings, incidence of pest and diseases due to a change in the humidity close to crop environment.

Operating Pressure

Three different operating pressures, 25, 35 and 45 psi at the nozzle were tried. Different droplet sizes were obtained by varying the pressure, to compare the infiltration characteristics of the soil and the pattern of distribution of water affected by the wind.

The pattern of distribution was evaluated in the same manner as in the US Department of Agriculture i.e. by measuring the precipitation in catch cans at different points in the sprinkled area. The low catch area amounts to insufficient irrigation. Pattern efficiency equals low catch/average catch multiplied by 100.

The results of sprinkling at the 3 different pressures are given in Table 1.

Table I — Sprinkling at Different Pressures

Operation pressure in psi.	Nozzle discharge rate in/hr.	Infiltration	Wind velocity mph, 22' above G.L.	Pattern efficiency
25	0.34	Ponding after 60 minutes	10—12	93%
35	0.40	Ponding after 100 minutes but no run-off	10—12	85%
45	0.43	Ponding not very visible	10—12	78%

Although the discharge rate at 25 psi was low the soil was unable to take in the water because the droplet size was large and created a sealing effect on the bare surface of the soil. At the highest pressure of 45 psi the ponding was not very significant. However, it was affected by

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the winds and hence a low pattern efficiency was observed. The pressure of 35 psi at the nozzle was found to be suitable for the prevailing winds and soil conditions.

Lateral Pipes and Nozzle Spacings

Lateral pipe spacing is very much dependent on the effect of wind on the sprinkling. Three different spacings were tried at 20, 40 and 60 feet. Evaluation was based on the pattern efficiency. The results of the experiments are given in Table 2.

Table 2 — Sprinkling at Different Spacings

Spacing Lateral	Spacing Nozzle	Wind Speed at 22' (mph)	Pattern Efficiency	Observation
20'	20'	10—12	97.5%	Heavy sprinkling. Ponding in 20 min.
40'	40'	10—12	90 %	Ponding not very visible.
60'	60'	10—12	66 %	No ponding

At 20 x 20 feet spacings the distribution of sprinkling was excellent. However, there was a heavy rate of irrigation and the laterals had to be shifted quite often. This was inconvenient. At 60 x 60 feet there was much distortion by wind. Hence spacing at 40 x 40 feet was considered suitable for the efficient distribution of sprinkling.

Capability of Equipment

After having determined the operating pressure and spacings the capability of the system was computed with the aid of the manufacturers performance chart. The discharge capacity of the system was 120 gpm, 18 Rainbird sprinkler heads with 11/64 x 3/32 inch nozzle will discharge 6.57 gpm (0.4"/hr.) at a pressure of 35 psi and a spacing of 40 x 40 feet. There were two laterals with 9 heads in each.

Pressure loss along the lateral was 6.1 psi which is a drop of only 17.4 percent, well within the 20% limit set by the manufacturer. Applying a factor of three-quarter of the loss due to friction along the lateral and considering a two feet riser a main line pressure of 40.5 psi was provided at the lateral junction.

Soil Moisture Data

Soil infiltration tests were done for the Red Brown Earths characteristic of the area by standard infiltrometers. The basic intake rate was 0.2 inches per hour, the moisture to be replaced at each irrigation 0.75 inches per foot depth. This is compatible with daily peak consumptive use of 0.25 inches if irrigated once in 4 days. Assuming a root zone depth of 1½ feet in mixed cropping, the irrigation requirement will be 1.1 inches.

Operation of the System

Each set will sit for 2.5 hours at a place. Six sets per day with 30 minutes for moving will require 17 hours per day of operating time in the period of peak consumptive use. The extent irrigated per day during this period is 4.3 acres. If irrigated once in 4 days this set can irrigate an area of 12 acres.

Irrigation Trials

The sprinkler set was laid out in Catchment F, Maha Illuppallama. The operation of the system was according to the specifications given above. The crops grown in this area were chillies, onions, green gram and vegetables. The sprinkler precipitation for the irrigation trials was measured in catch cans. The cans in close proximity to the sprinkler head had more precipitation catch than the ones further away. The wind velocity was measured with anemometers. In Table 3 the results of 3 irrigation trial runs are given.

Wind

It is observed in Table 3 that wind velocities higher than 10 mph at a height of 4-8 feet distorted the distribution. The pattern efficiency in Trial No. 3 of 72% was considered low i.e., about 30% of the area did not have adequate irrigation and this can cause much damage to the crops. Hence, this equipment is quite effective when the wind velocities do not exceed 10 mph. In Figure 2 wind velocities at a height of 6.6 feet are given during the months of July and August. It is observed that during late evenings and early mornings the velocities are less than 10 mph. Therefore, it is recommended that irrigation by sprinkling should be undertaken during these hours in the months of July and August.

Soil Infiltration

In Figure 2 cylinder infiltrations of water in the Red Brown Earths are given. Infiltration rates before sprinkling are greater than the rates after 5 sprinklings. The system operated at 35 psi and issued a droplet size of 1.25 mm. This is equivalent to 70 ft lb of energy expended per inch of rain on each square foot of soil. The energy thus expended by falling droplets dislodged the surface soil aggregates and created a surface sealing. Under this condition the infiltration rates were considerably reduced. For the germination of seed, it is important that surface sealing be kept to a minimum. Therefore, breaking the surface with a light hoe is recommended.

Crop Growth

Chillies, onions and some vegetables were grown under sprinkler irrigation. The sprinkled droplets did not have any adverse effect on the crop. It was observed that on very windy days there was inadequate wetting in the low catch areas and the plants were stressed. The yields were considerably reduced. Therefore, it is suggested that during the months of July and August sprinkling should be confined to either late evenings or early mornings.

Table 3—Performance of Sprinkler Irrigation (Catchment 'F' Maha Illuppallama)

Trial No.	Date	Time	Humidity	Temp. °F	Wind speed at 4-8 ft. mph.	Wind speed at 22 ft. mph.	CV Uniformity of Coef. of trial in %	Pattern efficiency in %	Irrigation application efficiency in %	System efficiency in %
1	11.7.70	4.30 a.m. to 8.00 a.m.	72%	78	4.0	10.2	92	87.5	89	86
2	6.7.70	11.30 a.m. to 2.00 p.m.	54%	87	10.6	13.3	87	78	92.5	72
3	3.8.70	1.00 p.m. to 5.00 p.m.	52%	87	13.0	18.5	78.5	72	88.5	61.7

Uniformity Co-efficient $CV = 100x (1X/Mn)$

M = Average precipitation catch

n = Total number of catches.

X = Deviations from M.

Pattern Eff: Av. of low catch/Av. catch x 100

Application Eff: Irrigation Requirement/Amount applied x 100

It has been determined 80% is the minimum coef. of uniformity acceptable (Canada Dept. of Agriculture).

System Eff: Application Eff: x Pattern Eff: 75% is considered good

CONCLUSION

The sprinkler equipment performed effectively within a maximum wind velocity of 10 mph at an operating pressure of 35 psi nozzle pressure and 40 x 40 feet spacing of sprinkler heads. At each setting the laterals have to sit for 2.5 hours to give the required irrigation depths for mixed cropping. The equipment can command an area of 12 acres if used for 17 hours a day sprinkling during peak consumptive use. Relevent local data on sprinkler, droplet size, operating pressure, soil infiltration characteristics, evapotranspiration rate and wind velocities should be included in the specifications for sprinkler equipment.

REFERENCE

1. U.S. Department of Agriculture 1955 Water, the Year Book of Agriculture 1955, p. 751.

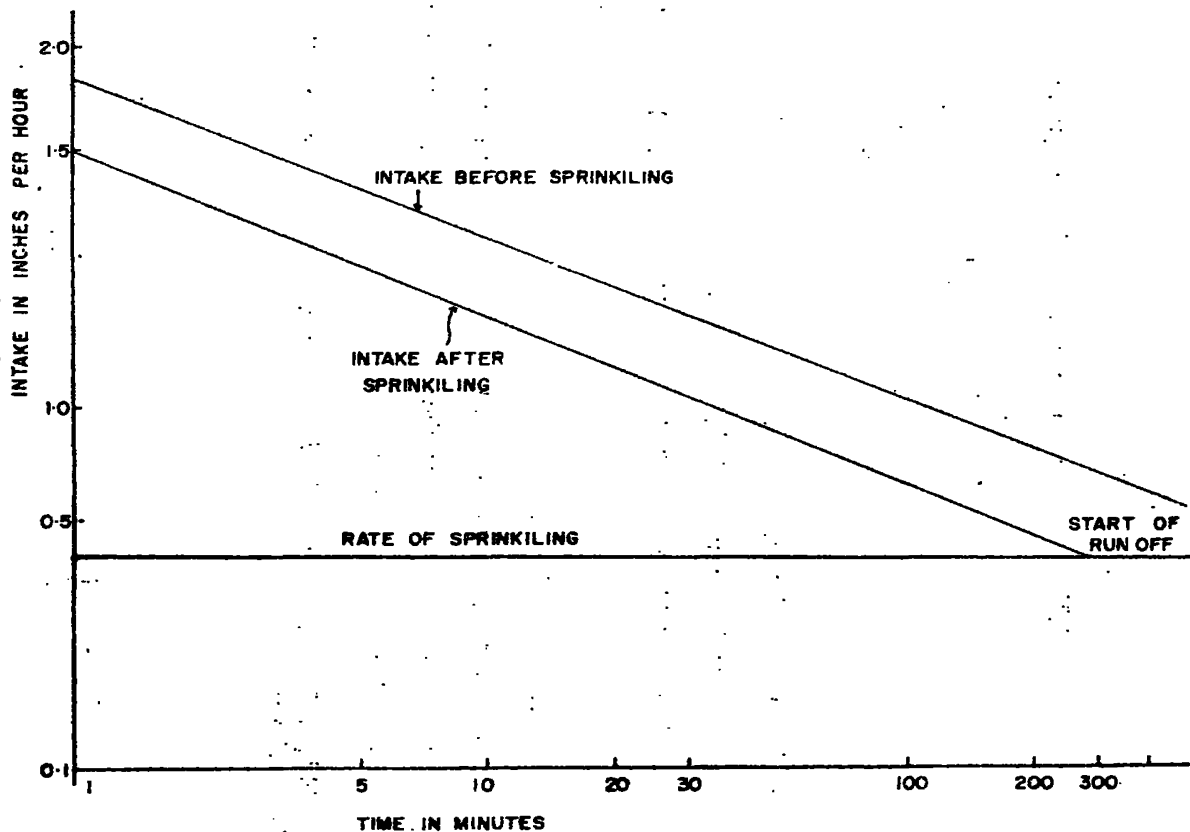


FIGURE 1. CYLINDER INFILTROMETER TEST (MAHA - ILLUPPALLAMA)

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FIGURE 2.

WIND VELOCITY AT DIFFERENT TIMES OF THE DAY AT 8' HEIGHT - YALA

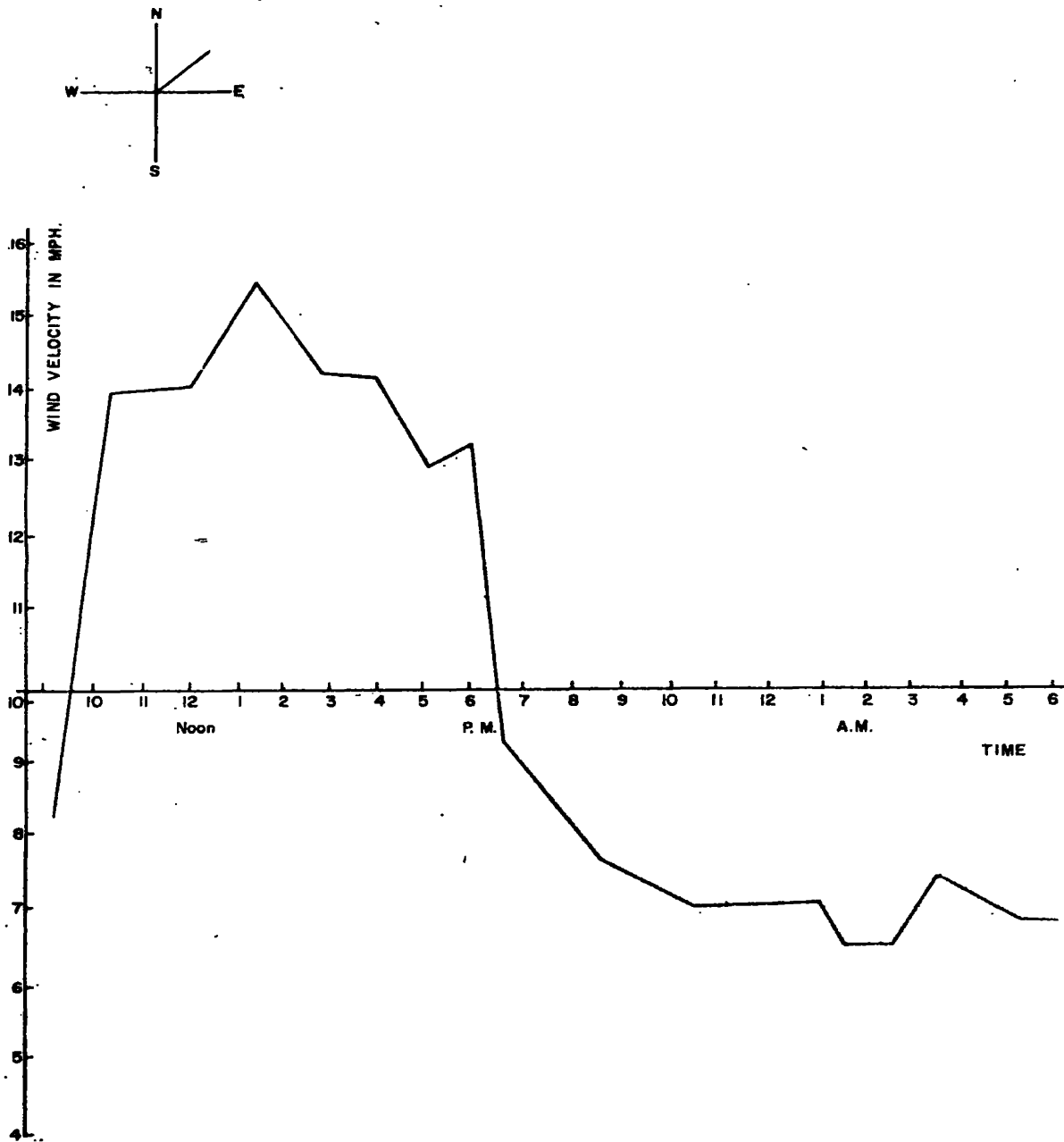
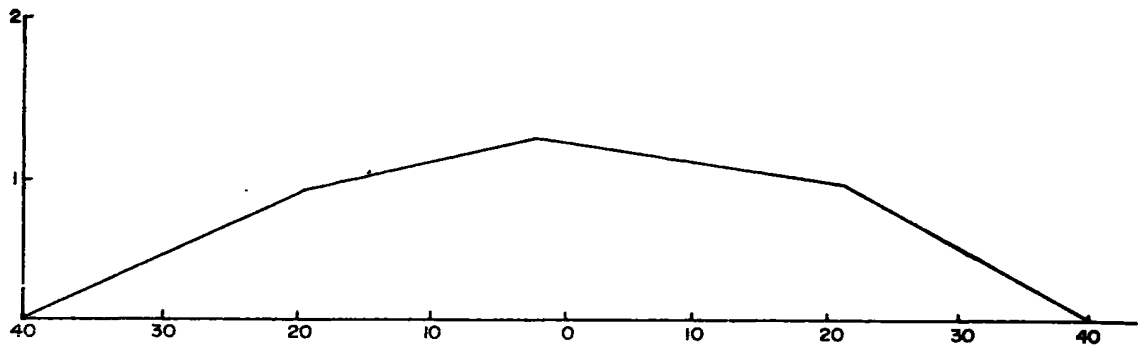
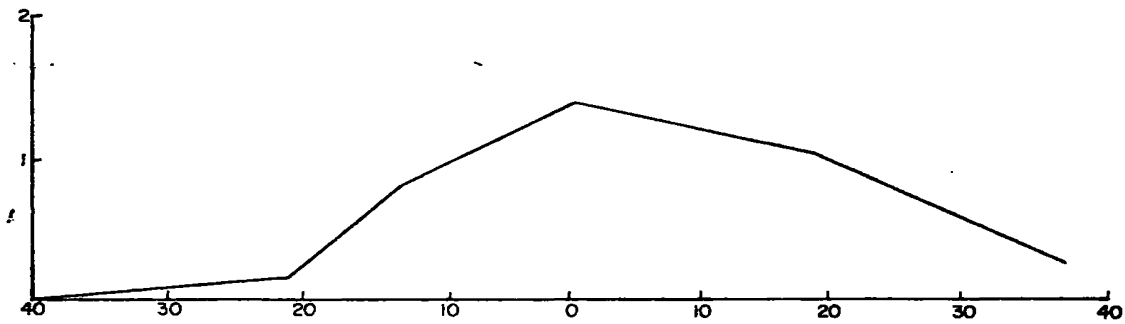


FIGURE 3.

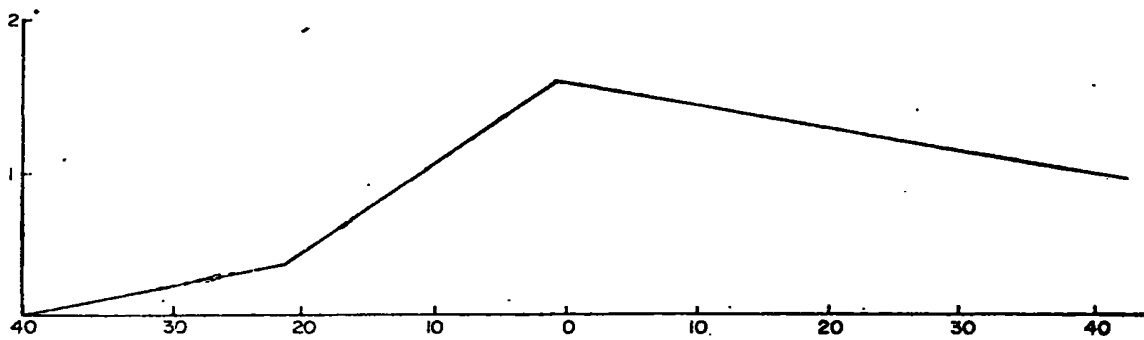
GRAPHICAL REPRESENTATION OF WETTING PATTERN OF SPRINKLER IRRIGATION



DISTANCE FROM SPRINKLER IN FEET. WIND SPEED AT 4MPH. AT 8' HEIGHT.



DISTANCE FROM SPRINKLER IN FEET. WIND SPEED AT 10MPH. AT 8' HEIGHT.



DISTANCE FROM SPRINKLER IN FEET. WIND SPEED 13 MPH. AT 8' HEIGHT.