Angewandten Biologie Forschung
www.ctbscience
ISSN: 2321-1733
Vol-1: No-2: 2013: 29-33

Study of applications of a modernized sprinkler irrigation system

Mohd. Hudzari Haji Razali[1*], Syazili Roslan[1], Nur Sakinah Mohamad[2]

[1]Department of Agriculture Science, Universiti Sultan Zainal Abidin, 21300, Terengganu, Malaysia.
[2]Pahang Skills Development Centre, Kampus PSDC, 25350, Pahang, Malaysia.

Abstract

This study introduced the application of sprinkler in irrigation for farm mechanization practical. Sprinkler Irrigation is a method of applying irrigation water which is similar to rainfall. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air and irrigated entire soil surface through spray heads so that it breaks up into small water drops which fall to the ground. It provide efficient coverage for small to large areas and are suitable for use on all types of properties and also adaptable to nearly all irrigable soils since sprinklers are available in a wide range of discharge capacity. With careful calculation and selection showed in this paper through nozzle sizes, operating pressure and sprinkler spacing the amount of irrigation water required to refill the crop root zone can be applied nearly uniform at the rate to suit the infiltration rate of soil.

Keywords: Sprinkler system, Irrigation System, Farm Mechanization, application of sprinkler

Cite this article as
Mohd. Hudzari Haji Razali, Syazili Roslan, Nur Sakinah Mohamad. Study of applications of a modernized sprinkler irrigation system. Angewandten Biologie Forschung. 2013; 1(2): 29-33.

The four basic methods of irrigation are: subsurface irrigation ("sub irrigation," which uses tile drain lines), surface or gravity irrigation, trickle irrigation (also called drip irrigation) and sprinkler irrigation. Of the acres currently irrigated in agriculture area, a big percentage uses some type of sprinkler system. State wide, the centre pivot is the most popular sprinkler system [1].

When many sprinklers are used, they are attached to a pipeline at a predetermined spacing to achieve a uniform application amount. When selecting a sprinkler system, the most important physical parameters to consider are: the shape and size (acres) of the field and he topography of the field. The centre pivot system is very adaptable but does not fit very well on irregularly shaped fields; long, narrow fields; and fields that contain some type of obstruction (trees, farmsteads, etc.). In these situations, other sprinkler systems may be used more effectively [2,3].

The sprinkler system capacity is the flow rate needed to irrigate an area adequately and is expressed in gallons per minute per acre (g/m/acre). The system capacity is dependent on the peak of crop water requirements during the growing season, an effective crop rooting depth, texture and infiltration rate of the soil. The available water-holding capacity of the soil also affects the system capacity. If the water source is a one or more wells, the well or wells' pumping capacity

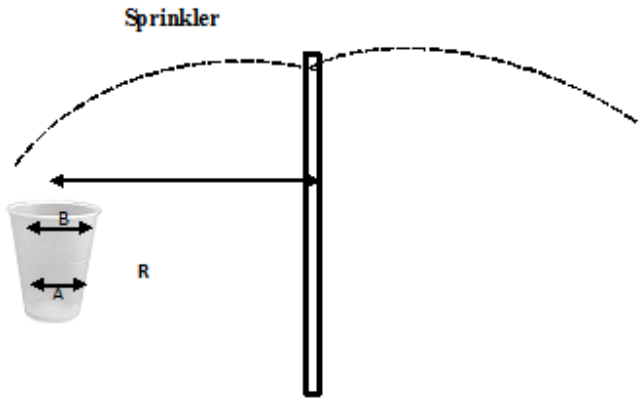

Figure-1:Experiment setup for sprinkler

In this practical the participants are required to choose any sprinkler nozzle and collect irrigated water that run on such period. Calculate the power of pump requires, net/gross irrigation and state assumption where necessary and lastly the participants are require calculating basic irrigation system. For the crop evapotranspiration under standard conditions, denoted as ETc, is the evapotranspiration from disease-free, well-fertilized crops, grown in large fields, under optimum soil water conditions, and achieving full production under the given climatic conditions.

Net Irrigation Requirement (Nir)

The net irrigation water requirement (Nir) is the net amount of water that must be applied by irrigation to supplement stored soil water and precipitation and supply the water required for the full yield of an irrigated crop. Nir does not include irrigation water that is not available for crop water use such as irrigation water that percolates through the crop root zone or that runs off of the irrigated field. Nir as used in this application is the annual amount of water and is expressed in units of acre-inches of water per acre of irrigated land for a year.

Nir = ET + WI – Ws – Re
ET is evapotranspiration
WI is leaching requirement
Ws is off season soil moisture carry over
Re is water leftover

Radius (r)	Area round = πr^2	Volume=area sprinkler/area glass x L	Volume
r1	$\pi ((0.04+0.042)/2)^2$=0.021 m^2	19.63/0.021x2ml=1869.524ml	1869.524ml
r2	$\pi ((0.04+0.045)/2)^2$=0.023 m^2	19.63/0.023x10ml=8534.783ml	8534.783ml
r3	$\pi ((0.04+0.043)/2)^2$=0.022 m^2	19.63/0.022x3ml=2676.818ml	2676.818ml
Average			**(v1+v2+v3)/3 =4360.375ml**

Table-1: Calculation of water sprayed

Table-1 depict the data obtained for the calculation of water sprayed for this experiment while table-2 show the average Eto For different agro climatic regions in mm/day

Gross Irrigation Requirement (Gir)

The gross irrigation requirement (GIR) is the amount that must be pumped. GIR is greater than NIR by a factor which depends on the irrigation efficiency (EFF):

GIR = NIR / EFF

- GIR = gross irrigation requirement (inches),
- NIR = net irrigation requirement (inches)
- EFF = irrigation efficiency (decimal fraction)

Calculation of area of sprinkler

The diameter, D = 5 meter, R = 2.5 meter, so the Area round = πr^2
Area sprinkler = $\pi 2.5^2$ = 19.63 m^2
Flow rate or discharge= 4360.375ml / (20 minute x 60)
=3.634 ml/s
Assumptions are made for calculation this sprinkler including as below;
Root zone = 0.9 m
Field capacity soil = 30%
Permanent wilting point by weight = 15%
Soil bulk density = 1.36 g/cm
Water application efficiency = 70%
Depletion of water irrigation = 50%
System runs for 20 minutes in days
Application efficiency = 0.7
Irrigation efficiency = 0.78
Kc sweet corn is 1.0513 based on the FAO Mean Crop Coefficients, Kc for Sub-humid Climates and the ETo is assumed as 5 mm/days for Sub-humid Climates based on the table-2.
Crop ET under standard conditions, Etc= Kc.ETo

Etc= 1.0513 x 5 mm/days
= 5.257 mm/days
Available moisture = 30% - 15% = 15%
Depth of available moisture = Pm x Db x D
= 0.15 x 1.36 x 900 mm = 183.60 mm
Depth readily available moisture= 0.5(from 50% depletion) x 183.60 mm = 91.80 mm
Net irrigation depth = Depth of available moisture = 183.60 mm
Gross irrigation= Net irrigation / application efficiency = 183.60 mm / 0.7 = 262.286 mm
Irrigation interval= Net irrigation depth / peak ET = 183.60 mm / 5.257mm/day (from ET crop that planting there)
= 35 days
∴ Irrigation period is 35 day
Total area to be irrigate = 19.63 m^2
Area to be irrigate per day= Total area / irrigation period
= 19.63 m^2 / 35 days = 0.561 m^2/day
System capacity, Qc= A.d/F.H.Ea
= (19.63 m^2 x 0.184 m)/(35days x 20 minutes/day x 0.78
= 0.007 m^3/minutes
= (0.007 m^3/ minutes x 10^3) / 60 s = 0.117 L/s =117ml/s

Table-2: Average Eto For Different Agro Climatic Regions In Mm/Day

Regions	Mean daily temperature (°C)		
	Cool ~10°C	Moderate 20°C	Warm > 30°C
Tropics and subtropics			
humid and sub-humid	2 - 3	3 - 5	5 - 7
arid and semi-arid	2 - 4	4 - 6	6 - 8
Temperate region			
humid and sub-humid	1 - 2	2 - 4	4 - 7
arid and semi-arid	1 - 3	4 - 7	6 - 9

Calculate power of the pump, Net Irrigation Requirement (NIR) and Gross Irrigation Requirement (GIR)
Field capacity = 8%
Permanent wilting point = 4 %
Available moisture = field capacity – permanent wilting point
= 8-4% =4%
Time of irrigated water = 30 minutes
Area of irrigated water = 341.90 cm^2
Depth available moisture = available moisture x bulk density x root zone depth
= 0.04 x 1.6 x 500 mm
= 32 mm
Depth of readily available moisture (NIR)
= Depletion of available moisture x depth of available moisture

= 0.5 x 32 mm
= 16 mm
Gross Irrigation Requirement (GIR) = $\frac{\text{Net Irrigation Requirement (NIR)}}{\text{Application efficiency}}$
= 16 mm/0.7
=22.857 mm
System capacity, Qc = $\frac{\text{Area of irrigated water x NIR}}{\text{Time x Application Efficiency}}$
= 341.90 cm^2 x 16 mm/ 30 min x 0.7
= 0.054704 m^3/21 min
= 0.002605 m^3/min
1m^3=1000 L; 1 min= 60 s
If 0.002605 m^3 = 2.605 L
If 30 min = 1800 s
Thus; 0.002605 m^3 /min = $\frac{0.002605\ m^3}{30\ \text{min}}$
= 2.605 L/ 1800 s
=0.0014 L/s
By taking the Root zone depth = 0.5 m
Bulk density = 1.6 g/cm^3 (sandy soil)
Application efficiency = 0.7
Depletion of available moisture = 50%
As the conclusion, the collected amount of irrigated water by one sprinkler is about 11 ml with running time of 30 minutes. By this amount, the power of pump that is required to supply water to the sprinkler can be calculated by calculating NIR and GIR. The calculated power of the pump or the system capacity, Qc, is 0.0014 L/s. therefore, the pump to be purchase for sprinkler irrigation must have capacity equal to or greater than 0.0014 L/s.

Acknowledgement
Thanks to my supervisor, Dr. Mohd Hudzari Razali for his guidance and also for those who help me directly or indirectly.

Reference

1. Mohd Hudzari bin Haji Razali. .Automation and Mechanization in Agriculture, Lambert Academic Publishing, Saarbrucken, Germany. 2012. 64.
2. Mohd Hudzari Razali. Sprayer Technology for Farm Mechanization Course. Tech J Eng App Sci. 2012; 2(5):107 – 112.
3. Mohd Hudzari Haji Razali. A Novel Technology Application In Agriculture Research. Int Res J App Basic Sci. 2011;2(11): 408-417.