

Low Precipitation Rate System for Moisture controlled Depth

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ABSTRACT

Moisture control level at given soil profile is an issue that concerns every one who deals with irrigation management.

There are two aspects involved in solving this target

- a. sensors to measure and guides
- b. The irrigation system that is used

Over head irrigation is one of the popular systems that required a new close look to achieve better control of moisture controlled depth.

Low precipitation rate is a feature that has a few aspects that are involved directly with moisture control depth.

- Droplet size and soil crusting
- Air-water ratio in soil pores
- Matched soil infiltration rate
- Water percolation control
- Nitrate leaching prevention
- Under ground water pollution prevention
- Water saving

Studies of Soil crusting due to water droplets impact show plant emergence drop.

Air and oxygen level in soil and in soil solution reduce growth stress.

Infiltration rate of a given soil is reduced gradually from one irrigation to the next by droplets impact and crust formation.

Lost of water by deep percolation out of the effective root system is in the range 20-40% due to heavy precipitation rate, heavier water dose and poor water distribution uniformity.

Water saving according to field reports and calculation are in the range of 15-30 %

Introduction

Moisture control level and soil profile is an issue that concerns every one who deals with irrigation management.

There are questions such as when to initiate the irrigation, at what moisture tension and what water volume to apply.

There are many concepts and sensors to guide us in the most efficient way.

Tensiometers, Class A pan Evaporation, Dendrometers, Infra Red, Pressure cell and a few more.

This is one side of the picture to achieve good Irrigation Management.

The other question is how practically we can apply it in our field and soil.

The task is different from one irrigation system to another:

Furrow irrigation, Sprinkler system Drip or Micro sprinklers system.

The manner of the water distribution pattern is different from one system to another:

- The forces operate on the water movement and direction in the soil
- The salt moves with the soil solution
- The air and soil aeration during the irrigation and immediately after is affected by the irrigation system.
- Water percolation under the root system

The question is whether we find the tools to come as close as possible to a control on the irrigation management we are required to execute?

In this work we would like to examine the Low Precipitation Rate (PR) as the easy, simple and practical tool for achieving maximal control on the soil moisture levels and moisture profile depth. In the past 40 years a lot of researches were done on these subjects, each of them relating to single aspect.

Based on those scientific works and vast field experience we developed the low precipitation overhead irrigation solution to achieve full control on the desire wetted profile.

Over head irrigation is one of the common systems used world wide

Flood & Furrow- 84.5%

Sprinklers - 12%

Drip & Micro sprinklers – 3.5%

The method

Traditional Over- head irrigation system P.R is in the range of 6-20mm/hr

High P.R. is evolving in many undesired symptoms:

- Run –off
- Soil erosion
- Deep percolation
- Nitrate & other minerals leaching
- Reduced oxygen in the root system
- Soil compaction
- Germination difficulties

Why Low P.R?

To be able to match Infiltration rate

No run –off

Irrigation duration is 3-7 times longer, contributes to:

- Continuous oxygen supply (fresh water can hold 8 ppm oxygen compare to standing water that will have 0-2 ppm)
- Increased lateral water movement
- Maximal Moisture control on water front movement

Soil particles and structure are kept stabilized

Soil aeration level is higher

What is the technology required?

- Low precipitation rate Over- Head Sprinkler System
- High water distribution uniformity above the crop and in the soil
- Small Droplet size (2-3.0 mm)

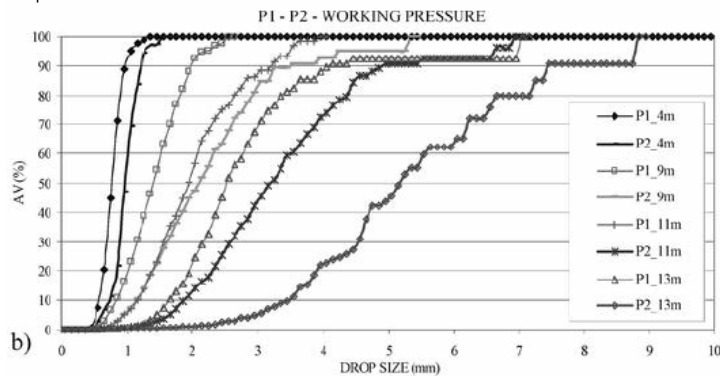
Droplet energy and soil compaction

The Water droplet impact energy on the soil surface contributes to several phenomena:

- Soil crust
- Reduced infiltration rate
- Run off
- Soil erosion
- Difficulties of achieving control on soil moisture depth.
- Reduce plant germination
- Reduced soil aeration

Droplets sizes distribution tests and droplets energy calculations show the direct effect on soil sealing and crust formation. The droplets sizes depend on nozzle size & design, operating pressure and sprinkler operating mechanism.

Figure 1
Droplets distribution curve
of standard 4.8 mm sprinkler
At P1-2.0 and P2-3.0 bar



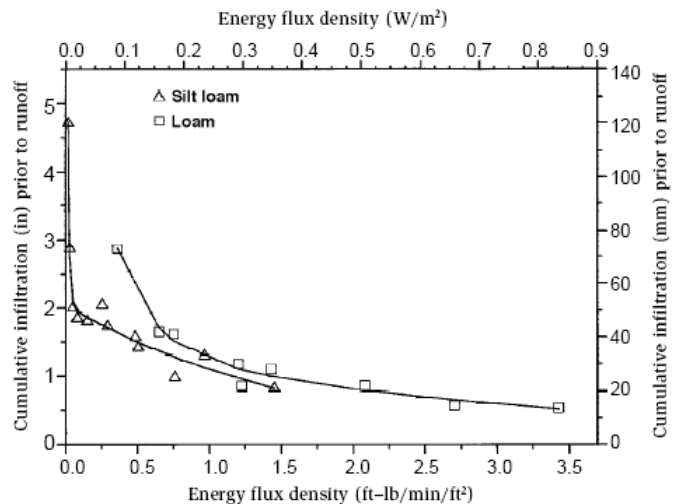
The effect of particular sprinkler droplet impact on I.R. of particular soil must be measured. However the general trend shown in figure 2 is applicable to any soil and useful in the selection of suitable sprinkler.

Energy flux density

combines the effects of sprinkler droplet kinetic energy and water application rate into a single parameter that is expressed as power per unit area (feet-pounds per minute per square foot or watts per square meter). It correlates very well with infiltration rate.

The relationship between energy flux density and depth of infiltration prior to runoff is illustrated in figure 2 for two different soils under dry, bare conditions.

Figure 2
Infiltration rate (I.R.) reduction by
energy density flux of sprinkler
droplets for two soils. Adapted from
Thompson and James(1985)and
Mohammed and Kohl (1987)



Trend analysis of soils data from 1998 through 2001 revealed that DEs is greater than or equal to 10.6 J per kg decreased MWD (mean weight diameter) most.

(Lehrsch, Gary A.; Kincaid, D. C 2006)

Producers should reduce sprinkler droplet kinetic energy to less than 10.6 J per kg to minimize surface structural breakdown of recently tilled soil.

(G.A. Lehrsch and D.C. Kincaid)

A study of plants emergence comparing sprinklers with 105 ft-lb/ft and 315 ft-lb/ft³ of droplet kinetic energy found a 13 % increase for the lower droplets size (Lehrs et al.)

Numerous studies in the past have been made of the effects of soil compaction on potato yield. Oxygen diffusion rate (ODR), however, was determined at a moisture content of field capacity. The study indicates that the ODR of subsoil is a useful criteria to diagnose the prevailing physical condition of the soil which, in turn, could be related to the relative productive capacity of soil for potato production in New Brunswick, Canada (G. R. Saini 1976)

Reduce oxygen, surplus irrigation, nitrate leaching and water waste

The moisture control depth is involved with oxygen level in the same profile.

Wide range of research and work in green- houses, orchards, plantation and vegetables correlate the oxygen level to fresh water supply, soil aeration, soil compaction etc.

The vigorous growth and better fruit production of plants in the SRI-EGS (growing substrate) might be attributable to the better root zone environment conditions in the SRI growth substrate than that in rockwool. One measured benefit of using SRI-EGS was that the root zone oxygen level was higher, especially during the afternoon hours, in the SRI growth substrate than that in the rockwool (Fig. 1). The oxygen level was as low as 3.6 ppm in rockwool, while remained ≥ 7.5 ppm in the SRI-EGS substrate. The measurements were made on a mild April day. During hot summer days, root zone DO levels can go as low as 1.8 ppm in some greenhouses as mentioned before. (Youbin Zheng, Ping Zhang and Dr. Mike Dixon 2006)

Development of irrigation best management practices for potato

From a research perspective in the United States (1) *A. B. Pereira(A,C) and C. C. Shock(B)* (2005)

Solomon (1984) pointed out that since no irrigation system is perfectly uniform, application uniformity should be quantified in order to measure irrigation system efficiency, because an irrigation must continue long enough to adequately water plants receiving the least water. The scale of the uniformity measurement should be related to the soil volume occupied by potato roots (Letey, 1985). Because potato is grown in hilled rows, there is a micro-topographic influence on water distribution uniformity. Saffigna et al. (1976) measured sprinkler water application to potato and found that water runs down stems and down the sides of the potato hill, saturating the soil in the center of the hill and below the furrows. Yoder et al. (1991) studied water movement in potato hill topography and found that most of the water applied by sprinklers ran off the hills and infiltrated below the furrows. In contrast, solid set sprinkler irrigation results in uniform wetting of potato hills at Ontario in silt loam (Steiber and Shock, 1995). The more uniform water distribution noted at Ontario, Oregon, which is not noted elsewhere, may be caused by better lateral transmission of water in these specific silt loams.

Since potato economic yield is so sensitive to soil water stress, there is a strong financial incentive for growers to simplify management by over-irrigating their potato crop.. Not all the water applied in a saturating irrigation is available to the plants, since some is lost to deep infiltration past the root zone and some water is lost to surface runoff. The crop survey by Jensen and Simko (1991) revealed that potato irrigation substantially exceeded potato crop evapotranspiration.

The role of sprinkler irrigation efficiency for the reduction of nitrate leaching to groundwater had not been evaluated in eastern Oregon or southwestern Idaho. Recent research in Malheur County, Oregon, placed emphasis on nitrogen fertilization efficiency for onion (*Allium cepa*) (Shock et al., 1991) and improved recovery of residual soil nitrogen by deep-rooted crops (Miller et al., 1991; Stieber and Shock, 1991; Shock et al., 1998b, 2000). Feibert et al. (1998) demonstrated that N fertilizer applications for potato could be reduced with careful sprinkler irrigation

Mark talham Cambridge University(2001) relates to over irrigation with Traveler Irrigator.

Applications of irrigation exceeding 30 mm are to be avoided as this may result in restrictions to growth caused by temporary water logging, physical damage to both soil and canopy and lead to quality defects such as erupted lenticels.

Watering control depth

The low precipitation rate (P.R) sprinkler system design to match the two soil characteristics:

1. Infiltration rate
2. The time to fill up the depleted moisture

An Example: Available to sprinkler systems

1. Traditional P.R.- 10mm/hr
2. Low P.R - 3.0 mm/hr

According to the tables 1, 2 we can learn that low P.R. system can cover any soil type while the traditional one will create run-off after short time in most loam to clay soils.

The other examination is the water percolation under root system of 30-40 cm

Assuming a watering dose of 15 mm (150m³/Ha) every 3 days for loamy sand field.

For the 10 mm/hr system it will take approximately 90min.

Any minor deviation in irrigation duration will result in significant increase of the required dose.

Extra of 10 minutes equivalent to 11% deviation. Causing waste of water and fertilizers by deep percolation. At the same time the Low P.R. system will have to run 5.0 hr and 10 min deviation will result with only 3% extra watering (no run off and better water distribution uniformity).

Table 1. Approximate available soil water in variously textured soils.

Soil Texture	available moisture mm/30 cm
Coarse sand and gravel	13.0
Sands	20.0
Loamy sands	28.0
Sandy loams	38.0
Fine sandy loams	48.0
Loams and silt loams	61.0
Clay loams & silty clay loams	53.0
Silty clays and clays	48.0

Table 2. Infiltration rates of variously textured soils.

Soil Texture	Inf.Rate mm/hr
Coarse sand	19.0-25.0
Fine sands	13.0-19.0
Fine sandy loams	9.0-13.0
Silt loams	6.5-10.0
Clay loams	2.5-7.5

Conclusion

The moisture depth control is a combination of various elements.
It was showed that a low precipitation irrigation system can implement the required solutions in a very economical and practical manner.
It's a supplement to all the existing tools that are used for better irrigation management.

Sprinklers with low application rate not only prevent soil surface seal formation that affects infiltration rate but has other agronomic implications such soil erosion prevention ,improve water application efficiency and fertilizers distribution in the soil profile.

A range of low volume low pressure sprinklers have been developed to deal with these aspects by NaanDanJain Irrigation.

Delivering low precipitation rate and small droplet sizes preventing any of the above mentioned phenomena.

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