IRRIGATION SCHEDULING REFINING THE WHEEL NOT REINVENTING IT

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OBJECTIVE

To develop an inexpensive, simple to use, reliable method or combination of methods which will increase the use of irrigation scheduling in Saskatchewan

BACKGROUND

A survey of growers indicated that very few practice any formal irrigation scheduling. There are several reasons that irrigation scheduling is not implemented:

Low crop value
Low water costs
Inconvenience and/or high cost of labor
High cost of instrumentation
Inconsistent response to applied water since factors such as disease, lodging, lack of optimum temperature and weed control often affect yield as much as water.

Irrigation scheduling information is aimed at individuals who use the soil to soil moisture and then allow the crop to deplete this moisture. When irrigation is done with a center pivot soil moisture can not be depleted since once depleted the irrigation system can not apply sufficient water to bring the soil back to field capacity.

There are four basic methods of scheduling irrigation:
1. Soil moisture content
2. Direct measurement of plant response
3. Estimation of ET from weather information
4. Direct measurement of water use (Lysimetery)

This project examined several systems which purport to have value in managing irrigation water applications.

MATERIALS AND METHODS

1. Soil moisture content

The following new soil moisture measurement devices were compared to tensiometers and neutron probe readings:
Watermark - An improved electrical resistance block
Hydrovisor -In the 25cb sensor a thermister is used to sense when the soil matrix potential pulls moisture away from the 50 micron glass spheres in the sensor tip
Hydromanager -Claims to measure hydrogen ions
Aquamiser -An electric resistance system using AC current
Aqwa-II -The sensors contain a small heater and a temperature sensor in a ceramic block and estimates soil moisture tension by measuring the rise in temperature in the block
Aquaterr -A probe which uses RF capacitance

The Hydrovisor, Aquamiser, Aqwa-II and Hydromanager were compared to tensiometer readings in 2 boxes of 1 m^3. One box contained fine sandy loam at a density of 1.4 while the other contained a silt loam soil at a density of 1.3. Winter rye was planted in the spring to use water and readings were taken twice a week for 12 weeks. The Watermark sensors were compared to tensiometers in a silt loam soil only.

The Aquaterr was inserted into the soil and soil moisture determined by using a soil probe to sample the soil in the zone around the probe tip.

The Aqwa-II was not evaluated since after purchase of the sensors it was found that the Civil Engineer Department of the U of S had just released a comprehensive report on these sensors. In addition we had considerable problems hooking the sensor to our datalogger.

2. Direct measurement of plant response

CWSI- Crop water stress index using Scheduler which senses air temperature, humidity and canopy temperature and calculates an index of stress.
The CWSI of Global canola was measured after full canopy formation in 1989 and 1990 and water was applied when the index calculated on the low setting exceeded 2.5. There were occasions where cloud cover prevented readings from being taken and the crop was irrigated based on tensiometers in the plot.

3. Estimation of ET from weather information

Modified atmometer - A ceramic plate was covered by green canvas to better simulate a leaf. Global canola was irrigated when reading *crop coefficient indicated that 50% of the available moisture in the root zone had been used.

Modified Jensen-Haise -This equation uses solar radiation, temperature and wind to calculate potential evapotranspiration. The model evaluated was provided by the Lethbridge Research Station and no new crop coefficients were developed for our area.

4. Direct measurement of water use (Lysimetery)

Modified Lysimeter -An inexpensive (<$4) Irristat is used to maintain the soil at field capacity. The Irristat uses a polyacrylamide gel contained by a porous polyester membrane to open and close a simple valve. The gel expands greatly when it absorbs water and pushes a piston against a rubber tube closing the tube and preventing water from flowing until the gel shrinks. The modified lysimeter used in the test was a 20 L container buried in the soil. Canola planted in the containers at the same time as the remainder of the field and the soil surface was covered to exclude irrigation and precipitation.

Results and Discussion

WATERMARK

Under controlled conditions this sensor was strongly related to tensiometer readings (r^2=.95 df=64) and was more responsive to changes at lower tensions than standard gypsum blocks (Fig 1). Under field testing the relation between Watermark and conventional tensiometer readings was often not very close. This may be due to installation, tramping of vegetation around the sensor or soil variability. In 1988 canola was irrigated in small basins and within less than 1 ha of land the same irrigation treatments had conventional tensiometer readings which varied widely (CV's of 25-35%). The high degree of variability causes producers to distrust the readings since 3-5 sets would be required in a field to get accurate estimate of soil moisture status. The Watermark sensors cost about $20 and the reader about $250 making this a cost effective system.

HYDROVISOR

This device turned the switch on at the moisture levels indicated but will be of limited value except in landscape and solid set irrigation systems due to the single reading and relatively high cost ($100).

AQUATERR

The Aquaterr probe was extremely difficult to insert into the soil. Soil density had a major impact on readings. The relationship between Aquaterr reading and % moisture by volume was poor (Fig 2). The probe has been redesigned and further work with this device may be warranted since it is portable and available at a low cost (<$500). However, accuracy must be greatly improved before the use of this device can be recommended under Saskatchewan conditions.

HYDROMANAGER

This sensor did not give appreciably different readings even with wide swings in moisture tension as indicated by the tensiometer (Fig 3). The line which represents the "trend" really indicates that even on the sand there was no useful relationship. The results were even less useful on the silt loam soil. This sensor requires AC power making it difficult to use under field conditions.

AQUAMISER

The Aquamiser was strongly related to tensiometer readings on sand (r^2=.85 df=26) on sand but until a different resistor was placed on the circuit board the unit was off scale on the loam soil (Fig 4). The relationship between tensiometer readings and Aquamiser readings was not as good in two other tests. The fact that a new setting had to be used for each soil makes implementation somewhat difficult but with further development the unit may have potential.

MODIFIED ATMOMETER

The modified atmometer tended to underestimate the crop water use unless very high crop coefficients are used. Also the relationship between crop water use, as estimated by soil moisture extraction, and atmometer readings differed between growing periods even when crop canopy was full (Table 1). Other authors have found a strong relationship between this atmometer and locally calibrated Penman equations but in our test this device has not given values which are reliable. It is not known if this was due to failure of the backflow valve or the high winds creating a different evaporation pattern than in other areas.

MODIFIED LYSIMETER

The modified lysimeter estimates of crop water use were very close to water use as estimated by soil moisture depletion (Table 1). A more work must be done since the covers did not exclude moisture as well as possible. In addition the 20 L containers used in this study were small enough that edge effects occurred. This could be improved by constructing a 2 x 2 x 0.6 m "lysimeter" where rainfall would be allowed to drain out the bottom of the area. Water use is based on water depleted from a reservoir prorated for the area of transpiring crop. The system is simple, inexpensive and since the crop integrates the all environmental factors no assumptions on crop coefficients need to be made.

Table 1. Water use (mm) of canola as estimated by soil moisture depletion, atmometer and modified lysimeter

Time Period		Moisture use Depletion+irrg	Atmometer Raw	Atmometer *1.6	Modified Lysimeter
June 26-July	9	77.66	41	65.6	---
July 10-Juyl	19	73.44	34	54.4	69.9
July 20-July	30	61.88	28	44.8	61.0
July 31-Aug	13	69.55	55	88.0	70.9
Aug 14-Aug	20	14.88	10	16.0	

Total use for season 455 mm includes use prior to June 26

SCHEDULER

Although this device is quite complex electronically it is simple to learn to operate. The major disadvantages of this system are: high cost, readings must be taken frequently on cloudless days near solar noon and readings are difficult to interpret until a full crop canopy has been formed. When a lower cost unit is available canopy temperature differences from just before the center pivot has applied water and where the system had applied water the previous evening could provide a good reference as to whether the crop is under stress.

CONCLUSIONS

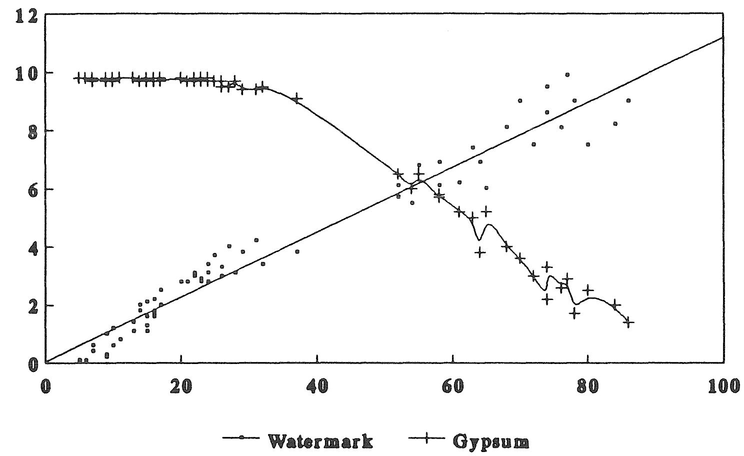
1. Soil variability is often too large to effectively use soil moisture tension or volumetric soil measurements as the sole indicators of when to schedule irrigation.

2. The Watermark soil moisture sensor could be used in place of tensiometers in nonsaline soils. This sensor is lower cost and requires less servicing than standard water filled tensiometers.

3. The Aquamiser and Aquaterr devices require more development before they can be effectively used in this environment.

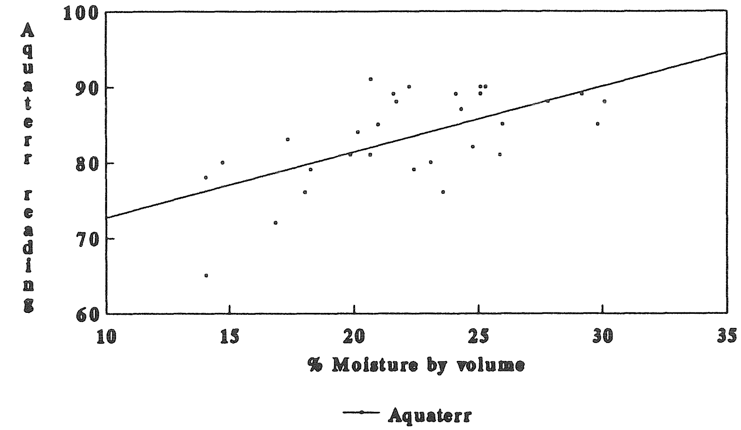
4. Direct estimation of crop water use using the Modified lysimeter appears to be a simple and effective manner of determining crop water requirements in widely diverse areas without the need to define crop coefficients for the region in question.

Fig 1. Watermark and Gypsum vs Tensiometer



r2=.95 df=64

Fig 2. Aquaterr vs Volumetric soil moisture



r2=.34 df=28

Fig 3. Comparison of Tensiometer with Hydromanager Readings

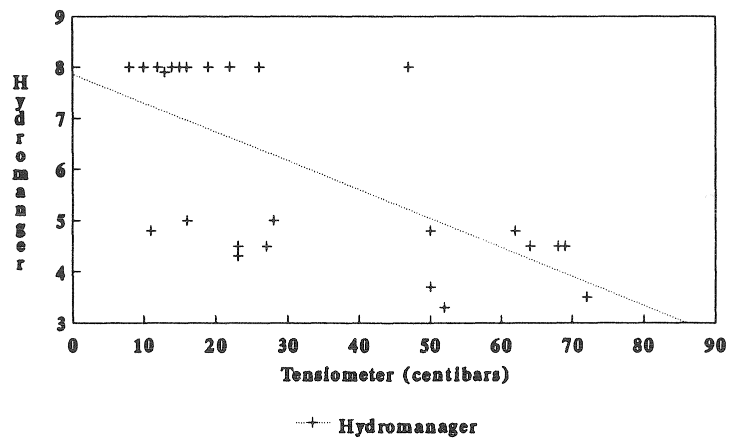
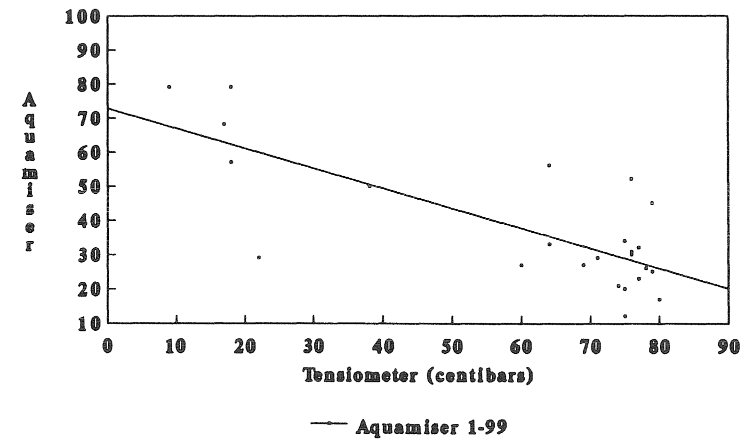


Fig 4. Tensiometer vs Aquamiser Sandy soil 1989



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