WATER IN THE BANK

TREATING SOIL MOISTURE LIKE MONEY IN THE BANK CAN PROVIDE A SIMPLE TOOL FOR IRRIGATION MANAGEMENT

Water in the soil can be treated in the same way that money is managed in a bank account. This simple approach can be used to guide your daily decisions on irrigation, or to provide a rational basis for setting longer-term policies regarding water restrictions during periods of water shortage.

In this approach, the deposits to the soil water account are made by precipitation or irrigation. Therefore, it's necessary to know the amount of precipitation that falls and to calibrate your irrigation system so that amounts of water applied per hour are well known. Withdrawals from the water bank account are caused by evapotranspiration, runoff or drainage below the root zone. Just like our bank account, we'd like to minimize these withdrawals as much as possible (Figure 1).

We want to keep a satisfactory balance in the soil water bank so that the turf growing on this soil is not suffering from unhealthy water stress.

Figure 2. Relationship of clay content to water content of soil.

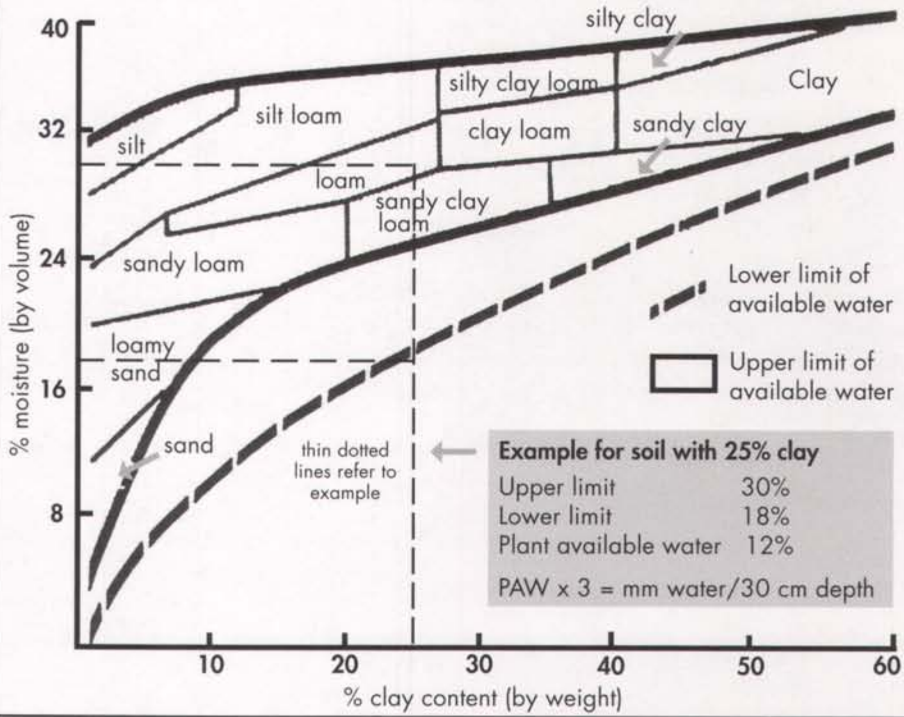
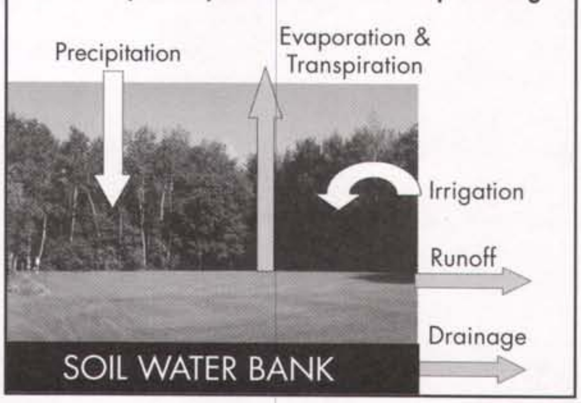


Fig 1. Water in the Soil Bank = Precipitation + Irrigation – Evapotranspiration - Runoff - Deep Drainage



How do we decide what is a "satisfactory balance" of water in the soil? First, the texture of the soil must be determined by sampling and submission to a soil testing laboratory or by consulting a soils map. Each soil type has an upper limit to its water-holding capability when all the soil pores are full. There is also a lower limit to the availability of soil water to plants – when the moisture content is low enough that the water is held very tightly in the smallest soil pores and roots cannot extract it. The difference between the water content at the soil's upper limit and the content at its lower limit of availability to roots is the *plant available water* or PAW. Typically, light sandy soils would have 20-25 mm of available water per foot of root zone, while the PAW for loams would be 40-45 mm per foot and 25-30 mm per foot for clays. Note that clays can have the greatest total soil moisture, but they don't have the biggest PAW because they keep much of this water in their very small pores, out of reach to plant roots. To estimate the upper and lower limits of PAW, it is necessary to know the clay percentage in the soil on your sports field (see Figure 2).

The second thing to decide is what fraction of the PAW can be used up before the turf begins to suffer stress. Experience suggests that it is best to keep the available water above the 50% mark. After a little practice with this idea and your own observations of turf behaviour, you might adjust this percentage to satisfy your own needs.

Let's illustrate these ideas with an example. We'll choose a light soil with a PAW of 24 mm per foot of rooting and assume a 1-foot rooting zone. We'll assume that we have 17 mm in the bank on Day 1, which means the account is 71% full (17/24 x 100 = 71%). On Day 2 there is warm, sunny, dry weather causing a withdrawal of 5.5 mm due to evapotranspiration from the turf and soil. An estimate of daily ET can be obtained from Table 1 and Table 2, from an on-site weather station that measures temperature, humidity, sunshine and wind; or from private companies that provide such information for turf management. Table 1 uses visual observations of four weather factors – sun, temperature, wind and humidity to give an estimate of pan evaporation (tech speak for evaporation from a water surface). Pan evaporation is adjusted to turf evapotranspiration by multiplying by a correction factor for plant species and time of the year (Table 2).

These data can be entered into a spreadsheet (Table 3). We can see that the percent available water at the end of Day 2 is only 48%. Taking the guideline mentioned earlier, that turf will start to suffer stress when the soil available water drops below 50%. Thus, we need to irrigate on Day 3. Knowing that the weather forecast is suggesting some light rain on Day 4, we cleverly apply only 12 mm (about 1/2 inch) of irrigation water. This partly refills the soil water bank to 73% and leaves

Table 1. Estimators for pan evaporation based on observed weather conditions.

	One pm weather observations for:			Estimated Pan Evaporation (mm)
Sunshine	Temperature (C)	Humidity *	Wind**	
Full	Greater than 23	Low	High	8.0
Full	Greater than 23	Low	Low	7.5
Full	Greater than 23	High	High	7.0
Full	Greater than 23	High	Low	6.5
Full	Less than 23	Low	High	6.5
Full	Less than 23	Low	Low	6.0
Full	Less than 23	High	High	5.5
Full	Less than 23	High	Low	5.0
Cloudy	Greater than 23	Low	High	5.0
Cloudy	Greater than 23	Low	Low	4.5
Cloudy	Greater than 23	High	High	4.0
Cloudy	Greater than 23	High	Low	3.5
Cloudy	Less than 23	Low	High	3.5
Cloudy	Less than 23	Low	Low	3.0
Cloudy	Less than 23	High	High	2.5
Cloudy	Less than 23	High	Low	2.0

* Low = clear sky, unlimited visibility; High = smog, haze, fog
** Low = leaves and small branches moving; High = tree tops moving

Tables 1 & 2 reproduced from *Understanding Turf Management*, R.W. Sheard, 2005

Table 2. Correction factors for adjusting pan evaporation to grass ET.

Month	Correction Factor
April	0.45
May	0.55
June	0.65
July	0.75
August	0.75
September	0.55
October	0.45

some room to store the coming rain. About 6 mm of ET also occurs on this warm, sunny, windy day (Table 4). On Day 4 we receive 10 mm of rain and lose only 1.8 mm of ET due to cool, cloudy and windy conditions.

Why did 1.7 mm of runoff occur on Day 4? At the end of Day 3, we had 17.5 mm in the soil water bank. On Day 4, we had a 10 mm rain deposit and a 1.8 mm ET withdrawal, for a net income of 8.2 mm. Therefore our bank balance should be 17.5 + 8.2 = 25.7 mm. But our soil has an upper water holding limit of just 24 mm, so 25.7 - 24 = 1.7 mm must run off, and the soil bank is left 100% full at the end of Day 4.

The loss of 1.7 mm of rain to runoff can be used to illustrate an important point. If we had irrigated to completely refill the soil reservoir on Day 3, we would have lost much more of the natural rainfall to runoff. Therefore the practice of replacing yesterday's ET by irrigating every day will not make best use of natural rainfall. In an experiment on a simulated golf green at the Guelph Turfgrass Institute, we found daily irrigation to replace ET used about 25% more water over the growing season than irrigation when the available soil water bank became 50% empty.

To finish a week on the spreadsheet (Table 5), Day 5 is cool and sunny (ET = 3.5 mm); Day 6 is cloudy and humid (ET = 2.5 mm); then hot, sunny, windy and humid weather arrives on Day 7 (ET = 5.0 mm).

Now we find that we are approaching 50% available water in the bank again and need to be planning another deposit by irrigation. Even though our week's weather has contained some rain and some cloudy or cool days, turf on this soil could not remain stress-free if regulations permitted, for example, only weekly irrigation. When we run similar simulations for loam soils (recall that loams have the highest available water capacity of all soil types), we often still cannot keep them stress-free with only weekly irrigation in the summer.

In summary, treating soil moisture like money in the bank can provide a simple tool for daily irrigation management and

Table 3. Example Spreadsheet.

Day	Rain	Irrigation	ET	Available Water	Percent Available	Runoff or Drainage
1				17 mm	71%	
2	0	0	5.5 mm	11.5 mm	48%	0

Table 4. Example Spreadsheet Continued.

Day	Rain	Irrigation	ET	Available Water	Percent Available	Runoff or Drainage
2	0	0	5.5 mm	11.5 mm	48%	0
3	0	12 mm	6.0 mm	17.5 mm	73%	0
4	10	0	1.8 mm	24 mm	100%	1.7 mm

Table 5. Example Spreadsheet Continued.

Day	Rain	Irrigation	ET	Available Water	Percent Available	Runoff or Drainage
4	10	0	1.8 mm	24 mm	100%	1.7 mm
5	0	0	3.5 mm	20.5 mm	85%	0
6	0	0	2.5 mm	18 mm	75%	0
7	0	0	5.0 mm	13 mm	54%	0

a simple way of providing rational advice to policy makers who are dealing with water regulations. Such analyses suggest that daily irrigation to replace yesterday's evapotranspiration is not the most efficient water management procedure. This keeps the soil water reservoir too full and causes unnecessary losses of natural rainfall by runoff or drainage.

On the other hand, it is often not possible to keep turf fields in top quality, stress-free shape when irrigation is restricted to weekly intervals during the summer. There is a "happy medium" somewhere between these two limits. Turf managers can apply the principles of water budgeting described in this article to utilize an allotment of water in the most efficient way. This approach, rather than the imposition of a fixed time interval between allowed irrigation events, could have a positive impact on sports turf health during the summer season. ♦

~ Prof. Terry Gillespie, Department of Land Resource Science, University of Guelph