The Need to Water Plants in the UK

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WHAT IS THE POINT OF INSTALLING A PROPER IRRIGATION SYSTEM IN THE UK?

It all comes down to ensuring value for the money (and effort,) expended in the landscape development; and the soil-water-plant relationship. Any landscape, be it a window box, urban or suburban garden, public park or open space, industrial development or recreation facility is the result of an investment in time, money and personal effort and, contrary to popular perception, it is not necessary for it to die back every summer.

The purpose of this booklet is to illustrate the need for watering plants in the summer, by one means or another and to put some figures on the quantities of water involved.

PLANTS & EVAPOTRANSPIRATION

Generally, plants are comprised of 85 - 90% water held together by a tissue structure. Through the process of photosynthesis, powered by solar energy, plants (apart from some oddballs such as Xerophytes) grow and build cells and structure by taking up water and nutrients from the soil. Water from the soil not only goes to build new cells as the plant grows, but also drives the process by passing through the plant into the atmosphere, via the leaves in the process called transpiration. The total amount of water consumed by a plant, (called **evapotranspiration**, or **ET**,) is the sum of the amount transpired in the process of growing plus that evaporated from the surface of the plant.

The power source behind this is the sun and, generally, for any given species, the more solar energy that goes into the plant, the higher the temperature, the higher the rate of ET. High winds and low humidity levels in the surrounding air increase surface evaporation, (also affecting ET.) The higher the rate of ET, the more the plant uses and (generally,) the more it grows.

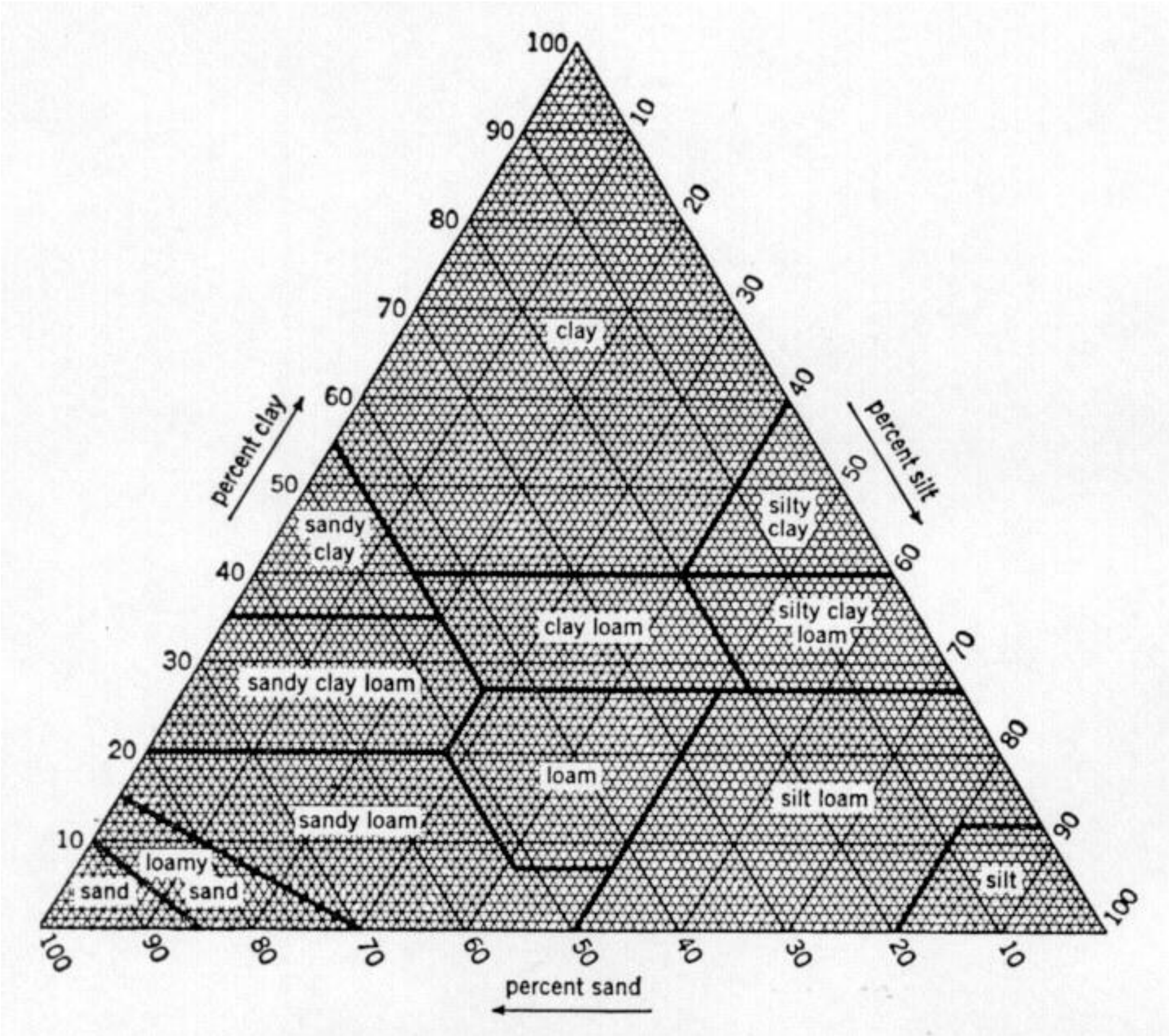
Of course, the higher the rate of ET, the more water is used, and, outside of hydroponics, which is not a technique widely used in landscape, that water has to come from the soil.

SOIL MOISTURE: AVAILABILITY OR OTHERWISE

Soil is made up from individual particles. They can be coarse (sands,) fine (clays,) in-between (silt,) or mixed (loam.) or anything combination of the above and almost invariably, it includes bits of dead plant material (organic content.) Various classifications of soils are defined in the diagram overleaf.

When water is added to dry soil of any type, it doesn't just fill up the voids between the particles. Water molecules are mutually attractive by strong bond called **"surface tension."** Surface tension is what holds the weight of a droplet of water before it gets too big and falls. It is what supports pond skippers and other insects that scuttle over the surface of a pool, or holds air in place to form bubbles in water.

When mutually attractive water molecules are added to soil particles, the water first of all forms of fine layer around the individual particles bonded together by surface tension. As more water is added the layers thicken and join together, particles to particle. If then more water



is added, the stable state will be exceeded and the voids between the particles start to fill. Eventually, all the voids between the particles fill, all air is expelled and the water starts to run straight through the soil.

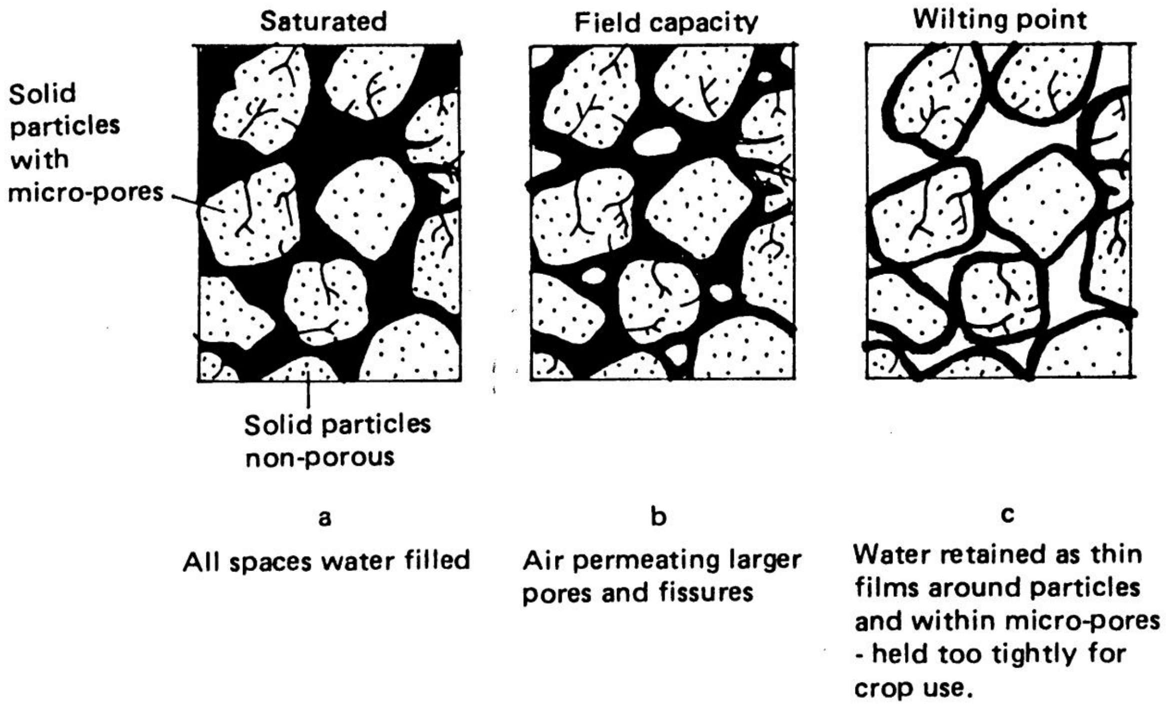
This is the point of **"saturation".** The soil can take no more water; there is no air available in the soil, all gaps being filled with water (and of course, non-specialist plants will die under these conditions.)

Soil saturation is, however, a non-stable condition. Left to drain, some of the water will run away until it reaches a stable condition where the weight of water left is equalled by the surface tension of the water bonding it to the soil particles. At this point the layer of water bonded to each soil particle is at its thickest but there is air in the voids between particles. This condition is known as **"field capacity."**

It is at this point that a plant can obtain water from the soil with the minimum of effort. The pull exerted by the surface tension is at its lowest as the layers are at the extreme of their of stability. This is where **"soil moisture tension"**, a measure of the amount of PULL or EFFORT required of a plant to get hold of moisture, is at its lowest. Plants love soils at field capacity and it is when soils are in or around that condition, that plants make maximum growth.

Soil moisture tension (**SMT**) is usually expressed in terms of pressure. At field capacity (**FC**), SMT is at its lowest, varying with the type of soil, but generally in the region of 0.5 Bar, or 7½ psi in old money..

When a plant starts to extract moisture from the soil, and that moisture is not replaced by rainfall or irrigation, the amount of water held in the soil is reduced below field capacity, the thickness of the water layers around the soil particles is



reduced, and SMT rises. In other words, as water quantities in the soil are reduced by the process of evapotranspiration, the plant has to work harder for that water and, as a result, the actual levels of ET are reduced, leading to reduced rates of growth and, in most plants, loss of condition.

There then comes a point where the attraction of the water layer to the particle is so strong (and the water layer probably around half as thick as at its optimum,) that the plant runs out of puff and cannot get at the water. This is known as the "**temporary wilting point**." It is temporary because although the plant will be showing visible signs of stress, it will make a complete recovery given an application of water.

At this point, SMT will have gone up from around half a Bar at FC to around 14 Bar, (or 210 psi.). To put this effort by the plants into context, non-smoking human lungs can produce 0.2 Bar (2 - 3 psi.) Car tyres run at around 2 Bar (30 psi.) 14 Bar or 210 psi. would support a column of water five hundred feet high; one and a half times the height of Nelson's column, or as high as the London Eye. "Respect" as the younger generation would say!

Although at t the Temporary Wilting Point, if the plant is given water it will recover, there will be a loss of growth and condition. However, If a plant at TWP is then not watered, after a while, with the top end still transpiring away, the cell structure of the plant will be damaged and that's it; the state of "**permanent wilt**" and a dead plant. Of course, most plants are not willing to die and take defensive action long before the temporary wilting point is reached. Transpiration is reduced by dropping leaves and many species will produce flowers and seeds in anticipation of the need to kick start the next generation.

Water holding capacity of soils can vary from less than 10% on a coarse sand to more than 45% on a very squidgy (and useless) fine clay. So, for example, at the sandy/loamy end of the scale, for a soil with a moisture holding capacity of 20%, at field capacity 20% of the volume of soil is actually water. In the same example, 10 centimetres of soil contain a maximum of 2 cm. of water. **"Available water capacity"**, the amount of water available to plants (being the difference between field capacity and the temporary wilting point,) as a percentage, varies from less than 12.5% by volume on sands, to between 12.5% and 20% on medium capacity loamy sands, to a bit above 20% for fine and clay soils.

The **"soil moisture deficit"** is the difference, at any one time, between field capacity and the actual amount of moisture available in the soil. It is usually expressed in millimetres, and so is related to a finite depth of soil determined by the rooting depth of the plants concerned. For any given active root depth in a given soil, field capacity and the soil moisture deficit can be measured, monitored and reduced through rainfall and through irrigation , controlled.

The terms defined above can be summarised as follows:

Field Capacity	FC	The maximum amount of water that a soil can hold, allowing free drainage, expressed as a percentage, or in mm. for a given depth of soil.
Temporary Wilting Point	TWP	The amount of water left in the soil when surface tension has reached such a level that the plants cannot make use of it, again expressed as a percentage or in millimetres.
Saturation		The point at which soil can hold no more water with drainage prevented, and at which there is no free air left in the soil.
Soil Moisture Tension	SMT	The measure of the amount of pressure required to make use of available water in the soil, usually expressed in Bars or psi.
Soil Moisture Deficit	SMD	The difference between Field Capacity (FC) and the actual level of soil moisture, usually expressed in mm. and referring to a finite depth of soil as determined by the plants under consideration.

SOIL MOISTURE DEFICIT AND THE ACTIVE ROOT ZONE

Like people, most plants will actually benefit from a little stress in their lives. It adds strength to branches and can help induce flowering in some species. It can prevent overgrowing and reduce maintenance. After all, the idea behind a landscape is not to get the most tonnage of green growth per acre in a season, but to keep the planting active, well presented and capable of restoring the effects of wear and tear. If, for example, grass was given all the water it could take (by maintaining the soil moisture level at

field capacity at all times,) it would need cutting several times a week, be very soft and green and easily scuffed and have a ground surface which would be moist at all times and therefore ideal for people to skid and slip all over it. A little, managed, soil moisture deficit will reduce overall growth rates whilst still keeping the grass green, toughen the plant structure and keep the ground surface dry most of the time.

But, allowing a lots of stress induced through a low soil moisture level will stunt growth, prevents recovery of wear and tear damage and lay plants open to disease. Stressed plants, half alive plants, are not a good return for the effort of gardening.

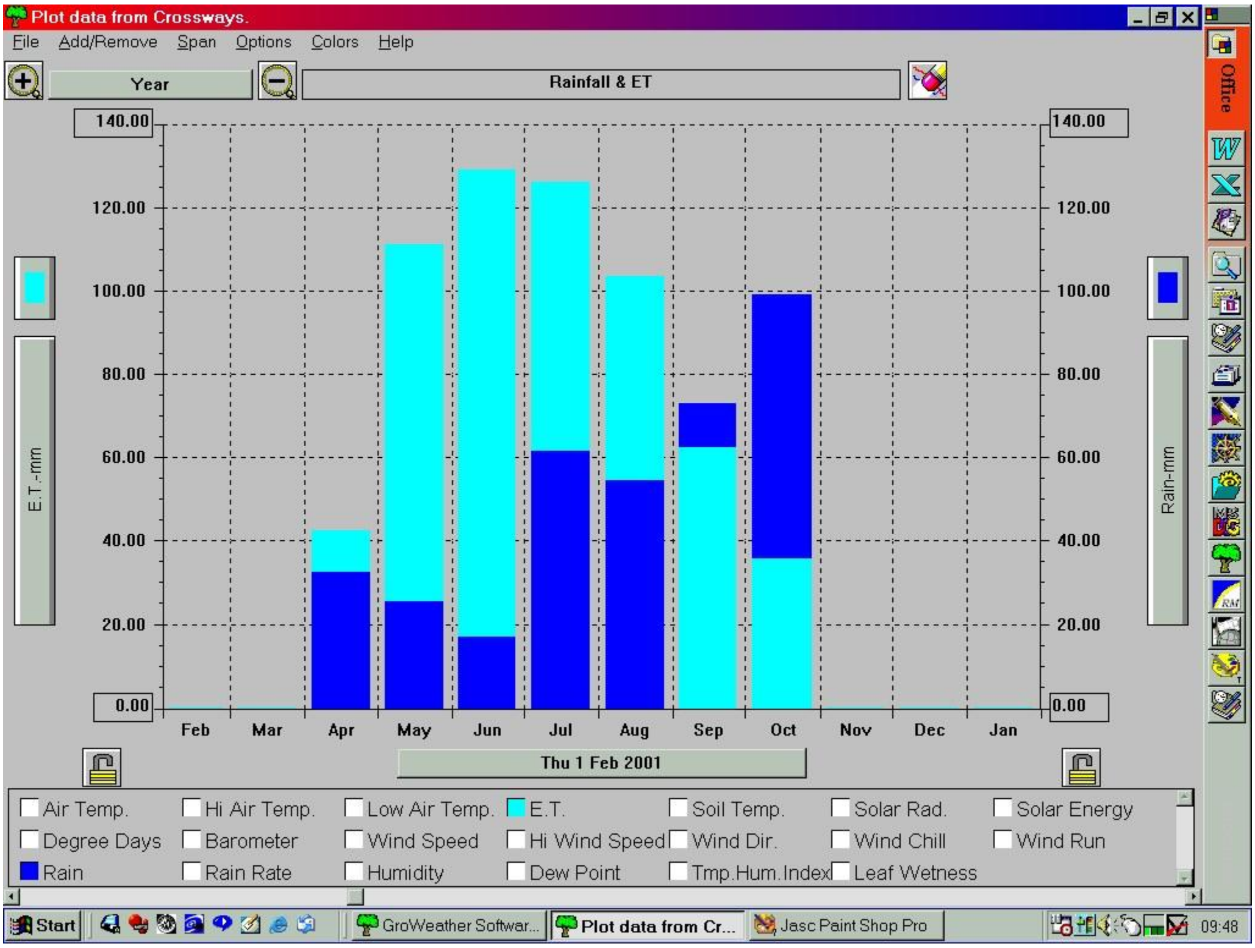
So a bit of soil moisture deficit is fine; even useful. Research into the ideal amount for landscape planting is very sparse to say the least, but agricultural work suggests an SMD maintained at around 20 - 25 millimetres is in the right ball park..

The active root depth of a plant depends upon its size and its species. Active roots are the ones that pull up the water and nutrients from the soil and they generally account for about the top third of the root structure of a plant. The rest just hold things up. There are species that put down tap roots, but these are generally arid area specialist and so not too common in the UK.

AVAILABLE MOISTURE

The amount of water available to a plant is a function of the water holding capacity of the soil, the active root depth and the extent to which a soil moisture deficit can be tolerated.

Grasses and bedding are usually shallow rooted with maybe only 50 - 75 mm. of active root zone. The way dandelions and other deep rooted weeds take over a lawn under stress shows how little soil depth is of any use to grass. At the other end of the scale, large trees can root down two or three metres but even they, once only the top



third of the root zone is taken into account with about 15% available moisture in that soil, has very little water to play with through a drought.

POTENTIAL EVAOPTRANSPIRATION IN THE UK

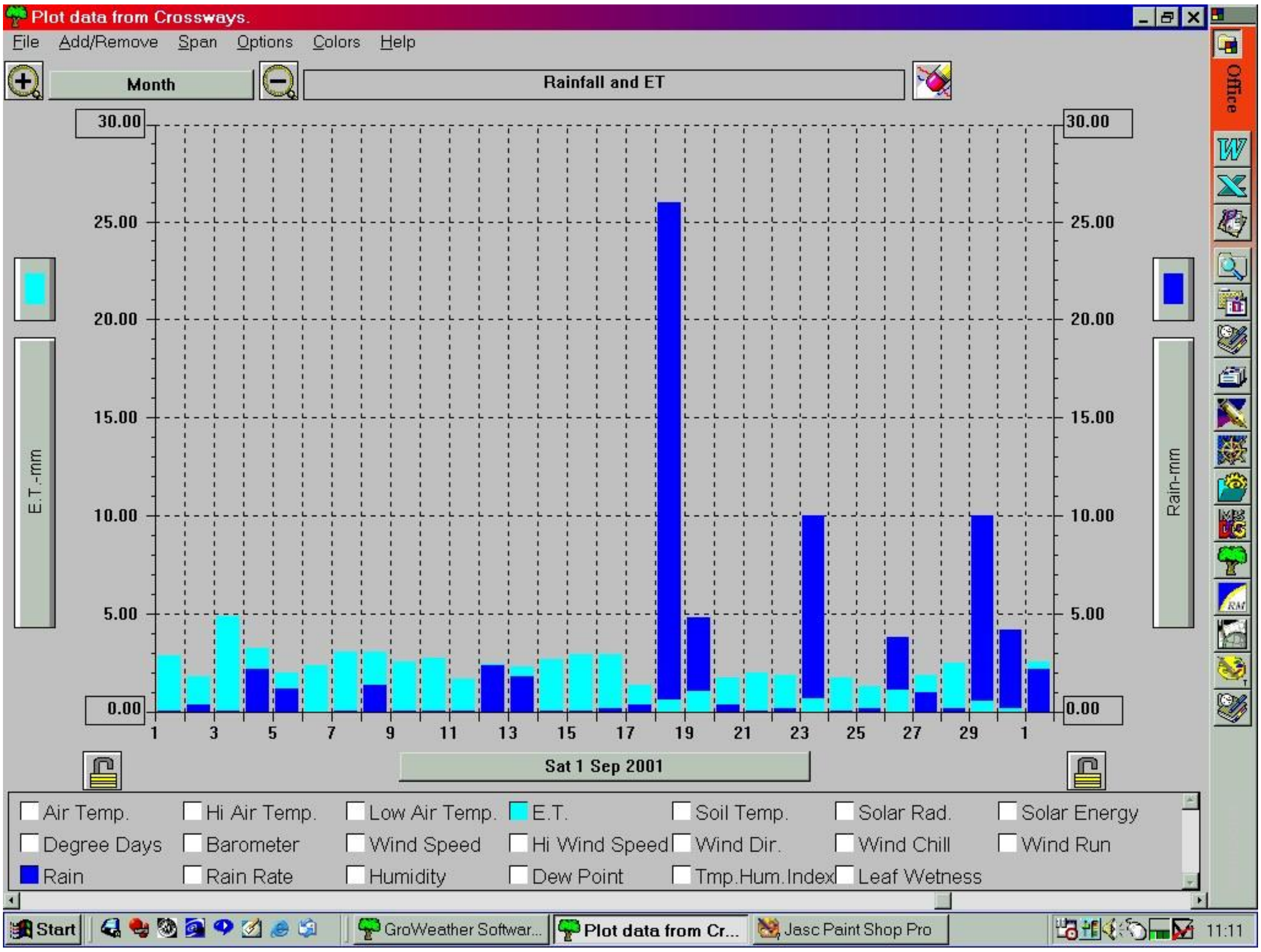
Taking an average English summer is there less rainfall than is needed to take planting through it in good condition? The answer to that is, surprisingly maybe in view of recent conditions, yes. In the east of the country, summer rainfall is less than that of Morocco. There is, on average, an annual shortfall which needs to be made up with a hose pipe or watering system of some sort. The extent of the seasonal deficit can be quantified by measuring **potential evapotranspiration.**

Potential evapotranspiration is that amount of ET that a plant would be expected to use given ideal growing conditions and no soil moisture eficit. Potential ET can be calculated and is the same, in theory, as ET for a plant sitting in soil at field capacity.

Potential ET is a complex function of most climatic parameters, solar energy, temperature, wind, humidity, etc., and positional parameters such as latitude and altitude. Various equations have been developed and, at a given latitude, some work better than others. The most common is called the Modified Penman, but the The FAO of the United Nations developed version by Pruitt & Doorenbos is also widely used.

Luckily, historic potential ET data is available, otherwise there would be quite a lot of calculating to do. Good old MAFF, (Ministry of Agriculture, Fisheries & Food,) in the days before it was turned into a glorified consumer group headquarters, did a lot of measuring up and down the country and produced definitive figures for the whole of the UK.

These show that, in an AVERAGE year, not an exceptional hot and dry year, the deficit between



rainfall and ET through the summer, June onwards, runs up to around 2.5 to 3 mm. a day and that over an average summer, the total SMD will be in the region of 300 - 340 mm.

Figures for 2,001, which hardly ranked as a record hot summer, taken from a full USDA (US department of Agriculture) specification weather station installed on a large ISC landscape project in Dartford, Kent, (illustrated on the previous page,) confirm this. The following SMD levels were recorded:

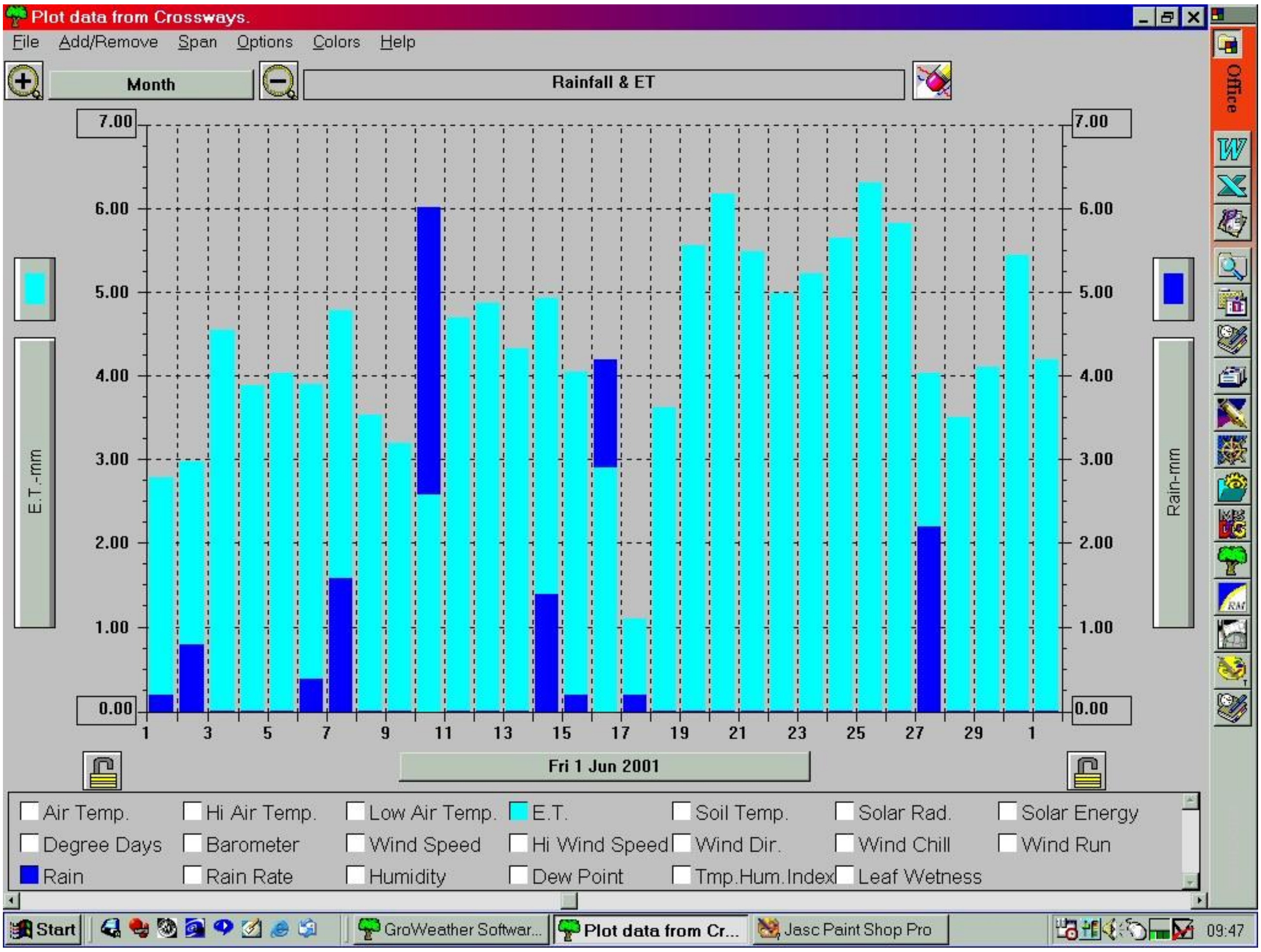
April	10 mm. deficit
May	85 mm. deficit
June	110 mm. deficit
July	65 mm. deficit
August	45 mm. deficit
September	10 mm. surplus

(This weather station is downloaded daily over the telephone to ISC's offices where the data is used to adjust the irrigation on the site, again over the 'phone, to minimise the use of water and power.)

Closer examination of the figures for September (above) show that, even through there was an overall surplus of rainfall over ET, it was necessary to run the irrigation for the first two weeks of the month, the rainfall being mainly confined to the latter half of the month.

This illustrates that overall figures are not necessarily an accurate guide to irrigation need. Rainfall as a form of irrigation is of use only when the pattern of frequency and intensity equates to that of the use of water by plants and the holding capacity of the soils.

A close examination of the figures for June (which are illustrated overleaf and which are on a different vertical scale,) is interesting in that, with high barometric pressure long day length and lots of sunshine, ET rates peaked at over 6 mm./day, in excess of TWICE the average. Even so, using the weather station daily data, it can be seen that the irrigation system could either be tuned off over the 10th. and 11th., and the 16th. and 17th. of the month or, as was actually the case, left on to



make up the SMD which had been rising due to the very hot conditions.

THE BASIC OPTIONS

The existence of a large annual deficit in soil moisture leaves the landscape or garden developer with two basic options; put up with the effects of the deficit on planting or supplement the amount of water available through some form of irrigation, be it by hose or something a little fancier.

For the first option, the question that has to be asked is can the soil moisture content take the plants through? Well for there to be no permanent adverse effect, at 350 mm. of summer deficit and an available soil moisture content of 15% assuming active roots of 33% of the total, the surviving plant would have to have a root system 7 M. (24 feet) deep. (That rules out grass and roses then.) To avoid adversely affecting the growth and appearance of the plant, the SMD would have to be kept to well above the temporary wilting point, making for a total rooting system an awful lot deeper than 7 M. This is obviously never going to happen.

What does happen, as soil moisture tension rises, is that grass and annual bedding (baskets, pots and containers would have long since died off if not watered,) and other things that are shallow rooted, begin to stress and wilt, brown edges, and then patches, appear through the lawn. Bits of lawn that get scuffed by the kids don't grow back and the whole landscape starts to look like a poor return for the effort and cash invested in it. However, deep rooting weeds keep on going of course and even prosper through lack of competition and the need to regularly mow grass.

An unwatered lawn always stands out through the number of dandelions, thistles and other tap rooted weeds that populate it through the summer. It does not matter how well it is cared for. With water remaining in deficit, annual bedding will wilt and die; possibly throwing up a lot of short lived blooms first in an effort to get the next generation on its way. Then. maybe herbaceous plants under-planting a few mature trees will be the next to die back; and the vegetables will be looking a bit sick with the leaf crops and beet running to seed, potatoes like marbles (and few of them,) covered with scab, (water induced stress leaves many plants, even mature trees, open to invasion by disease and pests of one sort or another. Scab on potatoes can be controlled by careful manipulation of the soil moisture deficit using a form of drip Irrigation laid in the crest of each ridge.

The fact that, in the main, the garden or landscape comes back to some semblance of respectability come the autumn rains is no real recompense for all inputs of effort and money.

Leaving things be is therefore only a practical option for the established landscape (it is no option at all for a newly planted landscape,) if it is acceptable to the client or developer for the grass to go brown and not regenerate over worn areas, for general plant growth to be reduced to very low levels and appearance to be compromised: a sort of scruffy Mediterranean effect.

If this is unlikely to be acceptable, or if the landscape is anything other than completely established, then the second option, watering the garden or landscape, has to be the one to go for.

HOW MUCH WATER?

The average summer deficit amounts to about 340 mm., or 340 litres per square metre of planting. To put that in realistic terms, it equates to 302,800 gallons of water on an acre of planting, or 3,400,000 litres on water on a hectare of planting. By careful management and control of its application, the total can be reduced without an overly detrimental effect on the landscape, but it is still a lot of water.

FREQUENCY OF WATERING

Putting all the water on in one go is not an option. Only that free moisture in the active root zone is available to the plants and so, for example, shallow rooted grass with a 75 mm. active root zone and 15% available moisture in the soil will only have 11 mm. (or 11 litres/square metre) of water to use; equivalent to less than four days ET in the summer.

The limited holding capacity of soil within the active root zone is also the reason why a heavy rainstorm in summer will have limited effect. In the above example, if the soil moisture level is at its lowest acceptable level, only 11 mm. of a 1" (25 mm.) rainstorm would be of use to the grass, the rest will drain away to waste. If the soil moisture level is nearer field capacity, then even more of the rainfall will drain to waste. In an ideal world, through the summer, the soil would be kept close to field capacity but with enough deficit to take advantage of the occasional showers.

GETTING OUT THE HOSE PIPE

Taking the not unusual scenario of 1 acre of supermarket car park planting served by a ½" hose tap, what chance is there of keeping up with the demand for water through the summer? An average hose might discharge around 3 gallons of water every minute (14 lit./min.) Therefore it would take seventy days, running

day and night to make up the deficit that occurs, in the main, over a period of pretty much the same time!

The 70 days also assumes that the water is applied with 100% efficiency, (no application losses,) and 100% uniformity over the whole area: not a very likely scenario.

Apart from the labour involved, the inconvenience (hoses running all round the landscape during the day when people are trying to use it,) the main problem with using hose pipes to water plants is a complete lack of control.

How much water is needed at any one time? How much is applied through the hose pipe? How uniform is the application? Has too much water been applied allowing it to drain through the root zone to waste? These are all questions that the user of the hose pipe cannot answer, and cannot be expected to answer. Not much research has been carried out into the efficiency of using hose pipes to water landscapes, but on the agricultural side it has been found that the overall efficiency of similar manual techniques can be as low as 20% (that is 80% of the water applied is wasted in one way or another,) and hardly ever reaches 50%.

Hose pipe watering is also time consuming and, if an attempt is made to do the job properly, very expensive.

And, of course, every time it really gets hot and the sun shines for more than a week, hose pipes get banned.

THE ALTERNATIVE

The alternative to hose pipes is to install a proper automatic watering system. The main advantage of using pop-up sprinklers or drip equipment, or a combination of both, is that (assuming the system is designed and installed properly,) water can be applied uniformly and at a known rate so that the amount applied at any one time is easily controlled. The fact that the systems are all but invisible (when not in use,) and all but free of any labour input is a bonus.

Properly designed, automatic systems can also take into account the different water requirements of different types of planting and cater for variations in soils, aspect, exposure to sunlight and wind, slopes, etc.

Automatic control systems can vary from the simple setting of system run times to apply an average amount of water connected to a rain-stat which shut the system down after rainfall, through systems running rain gauges that automatically adjust irrigation in response to the amount and frequency of rain, through to computerised systems fully integrated with a weather station as mentioned above. The level of control coupled with the efficiency of the overall design of the system determines the overall efficiency of water use.

COSTS

Automatic watering systems are not cheap but the system cost can be offset by savings in potable water infrastructure, labour and even planting costs. An automatic system will give stronger initial growth and vastly reduce (if not eliminate,) replanting during the landscape contract maintenance period.

A study carried out a few years ago by ISC, looking at the potential for using irrigation throughout the parks and gardens of a city in the

UK showed that, compared with hand watering and assuming that the intention was to achieve the best result in both bases, automatic watering system had a pay back period of less than two years.

In addition, it is possible, (subject to approval) through a leasing arrangement made by ISC for the cost of a watering system to be carried onto the operating budget of the landscape rather than the capital budget. This suits the operating regimes of some developers.

WHO ARE ISC

Over the last twenty-five years or so, the company has worked on projects ranging in size and scope from a single window box in Knightsbridge to the landscapes of a whole city or two in Saudi Arabia, to sugar estates in West Africa to reclaiming a 700 foot high quarry face in Hong Kong to the West Course at Wentworth, to landscapes such as Crossways at Dartford, sections of Heathrow, the Barbican, Chiswick Park, various National Trust properties, and many private gardens. The company has worked in something in excess of 100 countries round the world and irrigated just about everything that grows.

MORE INFORMATION

If you would like to know more about irrigation systems or our Company, we have various booklets available including a full company Projects List. Please contact us.

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