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Selective Weed Control In Ornamental Ground Covers

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Many different plants are used as ornamental ground covers in California, and both the kinds of plants and the acreage is increasing. There are at least 100 species and innumerable varieties in current use. It has been estimated that there are some 20,000 acres in ornamental ground cover at the present time. Probably the commonest is Ice Plant which has been estimated to occupy some 75% of the acreage. Ivy, primarily Algerian, occupies perhaps another 10% and Periwinkle is planted on 5% of this estimated acreage. The other 10% is planted to a wide variety of other species. Because of the many different plants that may be used in this manner it is extremely difficult to make recommendations for selective weed control. Most of our herbicidal chemicals are selective only on certain varieties of plants. Thus the first step in a weed control program is to know for sure what the ornamental ground cover is. A particular chemical may be selective on only a few of these and as a result many chemicals may be used but only on certain species or varieties.

As a first approach to this problem of weed control in ground cover let us explore what might be done prior to planting the ground cover. This pre-plant treatment allows much greater latitude because we do not have the problem of selectivity at that time. With the chemicals now available it is possible to treat the area before planting and remove many of the weeds and weed seeds. This would certainly be the desirable approach in new areas that are to be planted. Fumigation of the area with currently available materials will often kill established stands of weeds as well as weed seed that have been pre-moistened. Additional advantages may accrue through insect and disease control obtained from these same fumigant applications. The most effective soil fumigant for use in weed control is methyl bromide. This material presents some difficulties of application since it must be applied under a vapor proof covering to contain the volatile fumes and give the desired kill of weeds and weed seeds. The area to be treated should be pre-irrigated in order that the weed seeds have a chance to either start germination or at least to soak up water. Dry, dormant weed seed will not be harmed even by methyl bromide, the most effective of the fumigant materials. There is more and more use of methyl bromide alone and in mixtures with chloropicrin for both weed and disease control in a number of our crops. I think we should see increased use of the pre-plant fumigation in areas planned for ornamental. Other fumigant materials that are slightly less effective than methyl bromide, but considerably easier to apply, are Vapam and Mylone. Both of these can be applied and followed by an immediate sprinkling or watering to give a water seal in the top few inches of soil. This takes the place to some extent of the plastic tarp that is used with methyl bromide. It is not as effective as the plastic covering would be, but is cheaper and easier to do. A proper application with either Vapam or Mylone will remove a high percentage of the weed seed in the area and insure a good start for a later planting of the desired ground cover. Another possible pre-plant treatment that is often used in turf areas is calcium cyanamid. This material is ordinarily less effective than the soil fumigants but has an additional advantage in that there is a residue of nitrogen that is available to the later planting. The calcium cyanamid is ordinarily applied at a rate of about 50# per 1000 square feet. Twenty-five or thirty pounds is applied first and rototilled into the surface soil. The remainder of the material is then spread on the surface. The treated area must be kept moist by frequent sprinklings for a period of about 30 days before planting. This treatment will result in the elimination of many of the weed seeds that have started to germinate and will leave a residue of nitrogen for the early rapid growth of the planted ground cover. The final method that is used, if there is sufficient time available, is to work up the area to be planted, irrigate it well, and when there is a germination of weed seed kill them off with a material such as weed oil. If there are several months time available before the necessary planting dates it is possible to irrigate and spray several times thus eliminating many of the surface weed seed before the ground cover is planted. The final planting operation, then, should be done with a minimum of soil disturbance in order not to bring up new weed seeds from greater depths. I would emphasize again that we should not overlook these pre-plant treatments in order to get ground covers off to a good start and in a weed free environment. It is much easier to handle at this time before the ground cover is planted than to try to find' selective materials after the ground cover is in.

In some instances weed control has been handled at planting time by the use of weed oils or other contact sprays in and around the newly planted ground cover. Very often the plants are spaced at considerable distance,

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and the bare ground or cleared areas between may be weeded with a weed oil carefully applied with a shielded nozzle to keep it off of the desirable plants. It is also possible to use some of the selective soil sterilants at low rates at this same time by confining them to the areas between the plants and not in the basins or the actual planted area. Simazine and neburon have both been used in this fashion. The procedure usually is to dig the basins in which the plants are to grow and then treat the area with one of the chemicals mentioned above being careful not to spray the chemical into the basin nor to spray it on the piles of soil that are to be used to fill in immediately around the plant. On a newly planted area this would mean weed control on a sizeable percentage of the ground, since ordinarily these ground covers do not cover more than a small percent of the ground when newly set out. There ate certainly other of the new materials that would be promising in this same situation. Amino triazole has been used in the place of the contact spray to kill existing weeds that have started to grow. The newer materials such as Dacthal and Trifluralin also deserve some testing at this time. It is important to remember that in this type of application we are obtaining selectivity by keeping the sprays away from the newly planted ground covers and also out of the root zone of these plants at the time they are getting established.

Treatment in existing plantings requires a material that is selective for the desirable ornamental species and also a material that will kill the weeds that are present. Since these selective herbicides may also be selective against certain weed species, it is important to know what weeds are present or expected to be present. Some of the herbicides are more effective against grasses, others against certain broad leaf weeds; and in order to pick a herbicide that will be effective it is necessary to know what it is expected to kill as well as what it is expected to be selective toward. Let us look at the more important of out ground covers and see what materials have been used and are possibilities for use.

As we mentioned earlier, Ice Plant is one of the commonest of our ornamental ground cover. Unfortunately, there are many different Ice Plants. Probably the commonest of these in California is the large leaf *Mesembryanthemum edule.* However, there ate perhaps 100 genera in the family with *Mesembryanthemum edule,* and there are numberless species. As a result, we can not make a recommendation that would include everything that is sometimes called Ice Plant. The remarks that I will make are primarily based upon *Mesembryanthemum edule.* Many chemicals have been tested against this and other species. Currently, we are using only a very few chemicals on anything like a commercial scale. One that has been used primarily for control of dodder is ammonium sulfate, the common, ordinary fertilizer grade. It is used at the rate of l# pet gallon of water with some wetting agent. It is effective in dry weather when temperatures are 75 to 80 degrees or above, and the weeds are small. The action is purely a contact drying of these small weeds by the concentrated fertilizer solution. In damp weather ot in cold weather results will be poor. Probably the greatest use of chemicals on ice plant is magnesium chlotide.This material is used at the rate of 3# pet gallon of water plus wetting agent and at a rate of something like 200 gallons pet acre. Again the action is a contact burn of small weeds and will be more effective in watm weather. This use developed from the earlier use of a material called bittern which is a by-product of the salt industry. This is a concentrated solution of potassium and magnesium salts which can be used wherever it is conveniently available. Since it is used in its concentrated form, it is necessary *to* haul large quantities of materials in order to get 200 gallons per acre. As a result, the magnesium chloride is often more economical if there is any problem of distance involved.

The new things that are showing promise on Mesembryanthemum include Dacthal at tate of 8 to 12# per acre, Diphenamid at rates of 6 to 10# per acre, and Trifluralin at rates of 2 to 4 # per acre. These materials should all be applied pte-emergence to the weed growth and sprinkled ot rained in so that they may be in the soil in contact with the germinating seed. Let me say again that these should be tried *on* a limited scale because we have only limited information. They have shown some selectivity to some of the species of Ice Plant and in some climatic situations, but they should be tried carefully in any new situation where information is not yet available.

Several chemicals have been used successfully for weed control in Algerian Ivy. Probably the commonest has been IPC at 6#/A. This gives grass control during the winter or early spring season with some stunting of the Ivy. Normally the plants recover however. The ICP is not highly effective in the summer because of the short life in warm soil, but may be more effective in coastal areas where soil. temperatures ate not so high. It is effective against winter annual weeds particularly grasses, although it will get chickweed and certain other of the winter broad leaf annuals. Dalapon has been used in ivy at low rates of 3 to 5 #/A for control of Bermuda grass. This does not eradicate the Bermuda, but repeated treatments keep the Bermuda down until the ivy forms a dense mat. The trifluralin, mentioned before, has also been suggested for use in Ivy, and there is limited information to indicate that it is selective.

The Periwinkle or Vinca is a tough plant that will stand some 2,4-D. The highway people have used a mixtute of Endothal Harvest Aid at 6 gallons, 2,4-D Amine at 8 oz. and wetting agent at 8 oz. This mixture pet 100 gallons of water is applied to give thorough coverage. The Endothal Harvest Aid is the material that is normally used for cotton defoliation and gives contact action on a number of species. The IPC application reported under Ivy can also be used in Vinca for winter weeds. Low rates of TCA in the range of 10 to 15 pounds pet acre have been repotted as have rates of Dalapon up to 10# pet acre. Either of these may give some burn to the Vinca, but on established stands will certainly not kill it out.

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Again I would suggest the possibility of Diphenamide and Trifluralin in this particular ground cover.

This is about the range of materials that are currently being used or ate in the very near future for these more common ground covers. For some of the others perhaps we can best look at some of the chemicals that are available, and make some suggestions of things to try. One of the most selective pre-emergence materials is neburon. It is selective for most woody omamentals on any but very sandy soil. The only injury we have seen has been on sandy soils where the material leaches very readily around the roots. On any of the heavier soils it has been selective and at rates from 2 to 4# has given weed control. A second material with a considerable degree of selectivity is simazine at rates of 2 to 3# per acre. Again, it can not be unconditionally recommended because some plants are more susceptible than others, and again very sandy soils are much more apt to give trouble than clay soils. A mixture of simazine and amino triazole is also effective for weeds that have germinated, but this must be sprayed selectively in and under the established plants since the amino triazole will cause damage if it is sprayed on the foliage of the omamentals. It has been used in plantings of larger ornamentals where it is possible to spray beneath them with some degree of ease. Chloro IPC has a high degree of selectivity, approaching that of IPC, and is somewhat better in warmer soils. It is obtainable as a granular material which can be used over the top of the established plantings perhaps more effectively rhan a spray. Dalapon at low rates is a possibility in a number of the ornamentals, but should be tried first because some of them are susceptible. The amino triazole alone can also be used under the larger ornamentals. A new material diquat has a great potential as a contact spray where it can be applied selectively in and around the woody ornamentals. It has very little effect through the soil but is an excellent contact material, and there is less chance for absorption through the bark than with weed oil which has been a standard for this use for a number of years. This is about the array of materials that we have now, and I am sure there will be others that will show promise. It is necessary, however, to test new materials on each of the species involved because we can not outguess selectivity. Just because the material is selective on one ornamental does not mean it will be on a related one and certainly does not mean it will be on other genera of ornamentals.

These materials that are active through the soil, and this includes trifluralin, diphenamid, dacthal, neburon, simazine, IPC, Chloro IPC, etc., will vary in their action depending on several factors. These include the soil type, the climate in terms of temperature, the rainfall or irrigation pattern, the weed species, and the particular ornamental involved.

In summary weed control in ornamental ground cover is not yet a cut and dried matter of making a recommendation and assuming it will be safe under all sorts of conditions. Nevertheless, we have at the present time a greater array of potential materials than we have ever had before. Our field use of them will depend on exhaustive testing and much of this will be done in the field by people such as you who have the ground covers and the problem. My suggestion is to get the best information you can on the ground cover you are interested in, and try some of these promising materials on a small scale. In this way we will accumulate information that can lead to field practice and to much more economical weed control in ornamental ground covers.

Evapotranspiration – A Guide To Irrigation

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INTRODUCTION

It is well recognized that the climate of most of California is such that irrigation is an absolute necessity for most crops or for proper maintenance of lawns, shrubs and trees. In striving for a neat maximum benefit from irrigation with a minimum of water and labor, the need for a technical approach is obvious. The overall problem of achieving good irrigation practice is not simple and yet there are some technical helps which could be pressed into service both in irrigation management as well as in system design.

DISCUSSION

Factors Affecting Evapotranspiration

The term evapotranspiration (ET) is an expression for the combined water lost by evaporation from the soil and plant surface plus the water lost by plants through transpiration. Many factors affect the rate of ET and although a detailed discussion of the physical processes involved is not needed here, a brief presentation covering some of the factors should be of interest.

For most vegetation which is largely shading the ground, the most important factor by far involved in ET is the amount of solar energy received at the surface. Of this energy received, some 70 to 90% of it is absorbed by the vegetation with only 10 to 30% of it being reflected back out to the sky. There is an additional loss due to the net exchange of long wave radiation between the warm earth and the colder sky. That which is retained we call net radiation (R_n). Of the total energy represented by R_n, some is normally dissipated by a net daytime convective heating of the air mass; some is used in daytime warming of the soil and plant material; most of the rest is dissi-

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pated as the energy required to evaporate the water lost by ET, and very small amounts are used in the plant growth process. The partitioning of R_n between the above depends upon a number of factors such as wind speed, temperature and absolute humidity of the air, roughness of the crop surface, stage of growth, extent of plant control of transpiration losses and soil surface and sub-surface moisture conditions.

The importance of solar and net radiation in the process of evapotranspiration is indicated in Figure 1. The sharp response of ET to sharply increasing or decreasing radiation is very striking. The evapotranspiration data were obtained from a 20-foot diameter weighing lysimeter at Davis which can detect losses or gains equivalent to less than l/1000 of an inch of water from its surface.

In Figure 2 we see that there is a close relationship throughout the year between ET and Rn although a generally smaller percentage of R_n is used as ET in spring months than in fall months.

There ate other factors however which can alter the normally close relationship indicated previously. Again an example is offered in Figure 3 where data are given for two clear days. The solar and net radiation pictures ate almost identical for the two days and yet an ET value of 0.456 inches on June 1, 1960 was almost double the 0.233 inches lost on May 29. It should be mentioned that loss on June I was unusually high for Davis and has been equalled on only one other day in 41/2 years of record.

An examination of the weather data helps explain the difference in ET for the two days. On May 29 it was fairly calm and relatively cool with a maximum temprerature of 80 F. This contrasts to June 1 when 10-18 mph north winds were blowing and the air mass was at 80°F. by 7:00 AM and went to 100°F. by mid-afternoon. Also, relative humidity was considerably lower although this was a less important factor than one might assume. The absolute moisture content of the air was not greatly different, being only 20 – 30% reduced on June 1 from May 29.

From the example in Figure 3 it is obvious that wind velocity, air temperature and humidity can be very important factors in determining the amount of Rn which is used in the evaporative process. There are fairly basic formulas, which include these factors along with radiation. They have been shown, at Davis and elsewhere, to be fairly reliable in predicting ET even on a daily basis.

Evaporation as an index of ET

Although a water surface absorbs 90 – 95% of the incoming solar radiation (70 – 90% for crops); it normally has a smoother surface than crops; and can offer no control over water loss, as can plants; a surprisingly good relationship between evaporation from a watet surface and ET for plants does exist. This was shown in the early work of L. J. Briggs and II. C. Shantz in a number of later studies.

In Figure 4 we see that on a monthly basis there has

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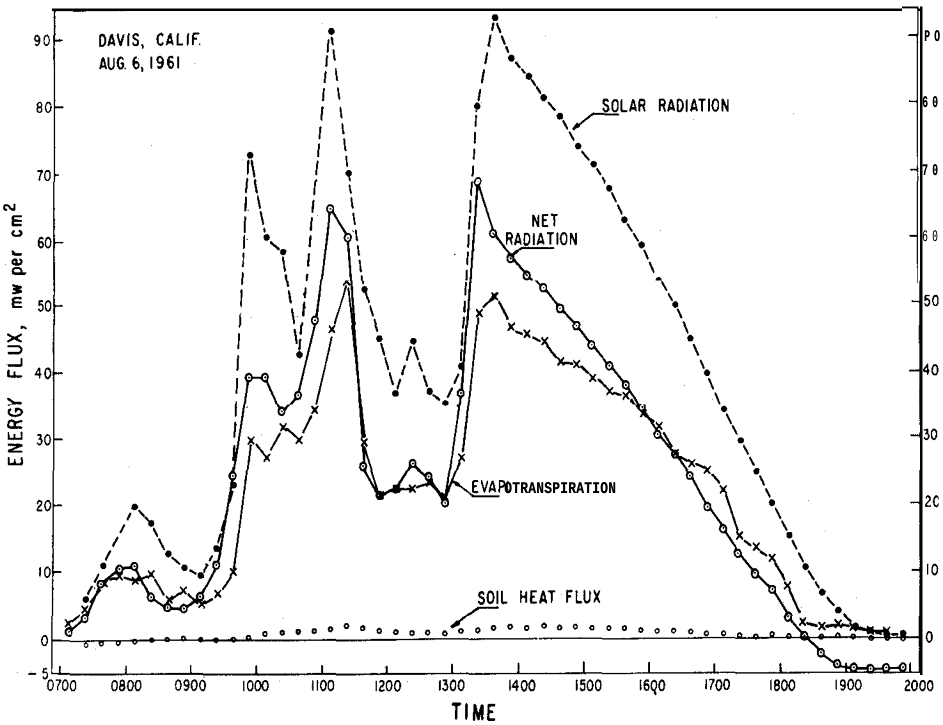

Figure 1. Evapotranspirotion for perennial ryegrass compared with solar and net radiation on a day with highly variable cloudiness up until 2:00 P.M. (1400) and clear thereafter. The peak ET reached. at 11:20 A.M. of 53 milliwatts per square cm of surface represents about O.O3"/hr.; or again in energy terms, the equivalence of 50-watts per square foot. Over an acre this wou ld be equal to the energy used by 43,560 50-watt light bulbs.

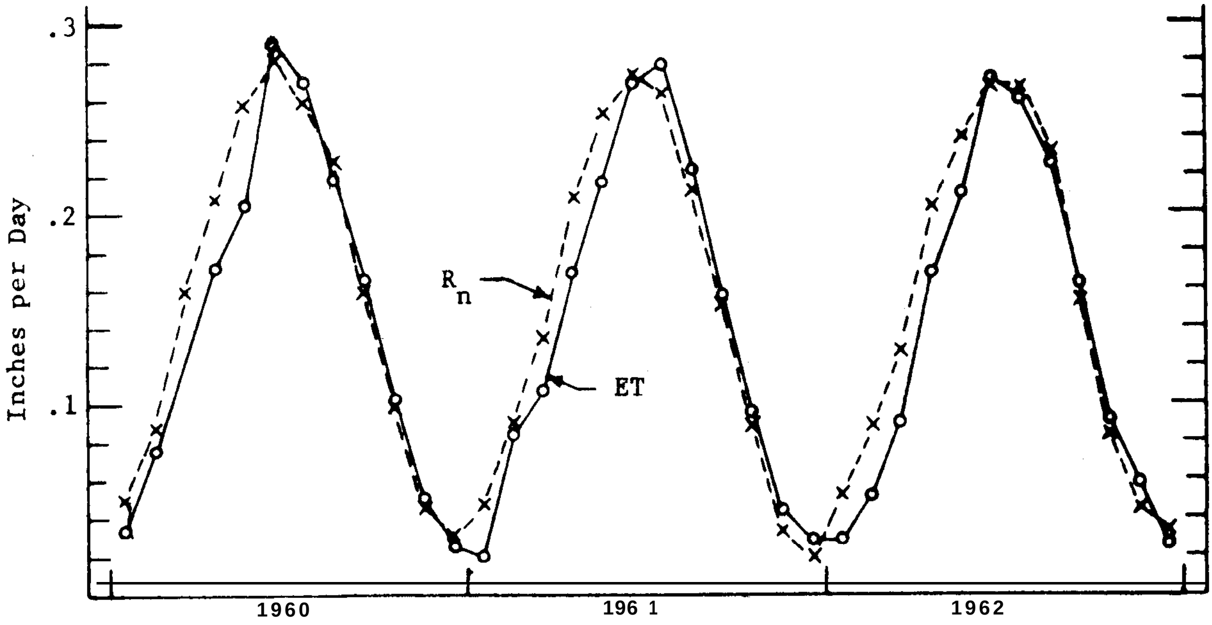

Figure 2. Mean monthlyevapotranspiration (ET) for perennial ryegrass and net radiation (R_n) expressed in equivalent evaporation terms of inches per day. Davis, Calif.

Note: Both ET and R_n values tend to be higher than the true mean during rainy months since the low losses on rainy days were excluded due to a lack of R_n data on such days. For ET data representing both rainy and non-rainy periods see Figure 4.

been a very close relationship for 3 years between ET and evaporation from two different types of pans which are located in the same grass field as the 20-foot lysimeter at Davis. Mean monthly ET for the ryegrass was very close to the loss from the USDA (BPI pan) which is a 6-foot diameter, 2-foot deep pan with the water surface maintained about 4 inches below the rim of the pan at about ground level. ET averaged about 0.7 to 0.8 as much as evaporation from the more exposed 4-foot diameter USWB pan which has its water surface about 14 inches above ground level. During several months with a number of days of dry north winds, this ratio was lower, for example in October 1960, ET/E = 0.58.

In Figure 5 we note a close relationship between ET and E even on a daily basis although the divergence of the two values for three of the days is very striking. This change from a more normal ET/E ratio of around 0.8 to a value less than 0.5 has occurred on almost all of the dry, strong north wind days observed at Davis. It is likely due to several factors including some plant control of transpiration and the generally greater exposure of the pans to advected heat.

The U. S. Weather Bureau proposed a method which may overcome the above problem insofar as the pan exposure is concerned. The method requires wind and water and air temperature data along with the evaporation measurements. Little consideration need be given to this problem in areas like the Sacramento valley where these conditions occur quite frequently. In areas with prevailing strong dry winds the Weather Bureau method of correcting the pan data should be of considerable value, however.

Scheduling Irrigation from ET Estimates

While at the Irrigation Experiment Station in Prosser, Washington the writer developed and used a simple guide for determining the timing of irrigations for a number of different crops on several experimental plots. Subsequently, the Extension Service started a program two or three years ago in that state where daily evaporation data, obtained from modified USWB pans, are now broadcast or published in newspapers in a number of locations. Several hundred farmers are now using this information to help them schedule their irrigations,

A similar guide for use in a park might look something like that pictured in Figure 6. The string stretching between two slides located at either side of the board is used to indicate the current value on any given day of cumulative evaporation (scale at far left) from a suitable pan since the beginning of the season. Each day the string would be moved up an amount equal to the previous day's evaporation.

The slides located in channels 1 through 6 would be prepared taking into account the type of vegetation and whether shaded or not by taller trees; the depth of effective rooting; the moisture holding and infiltration characteristics of the soil; etc. The expected ratio of ET/E would determine the scale used on the left side of each slide (note the differences in scale for slides 5 and 6 as compared to the evaporation scale which indi-

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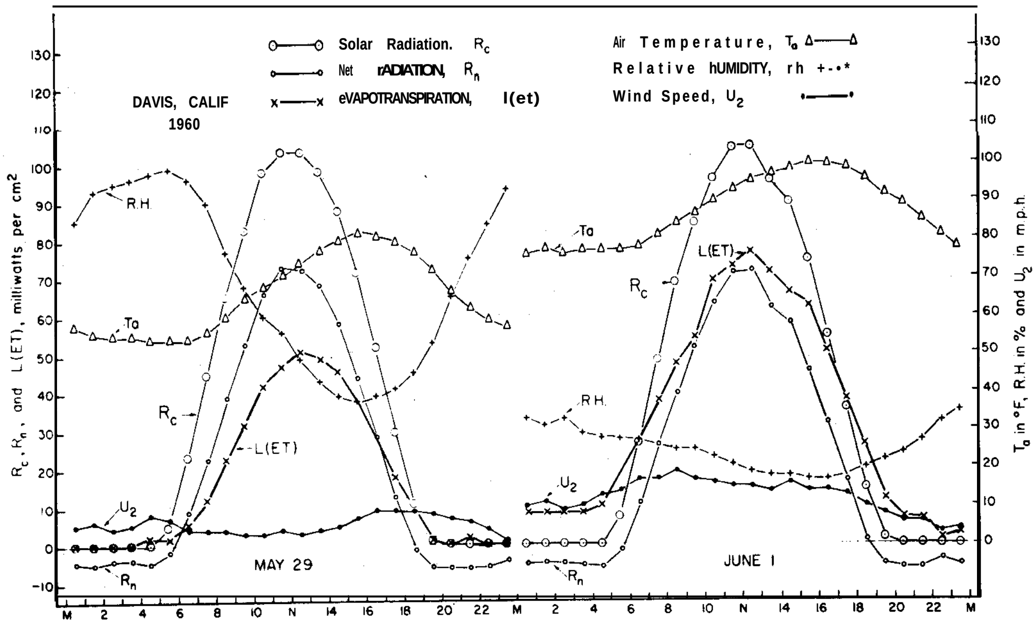

Figure 3. Evapotranspiration for perennial ryegrass, and solar and net radiation, expressed in mw/cm^2 for two clear days at Davis. Air temperature, relative humidity and wind speed are also indicated. Hot, dry winds from the north occurred on June 1 compared with gentle breezes of more moist air on May 29.

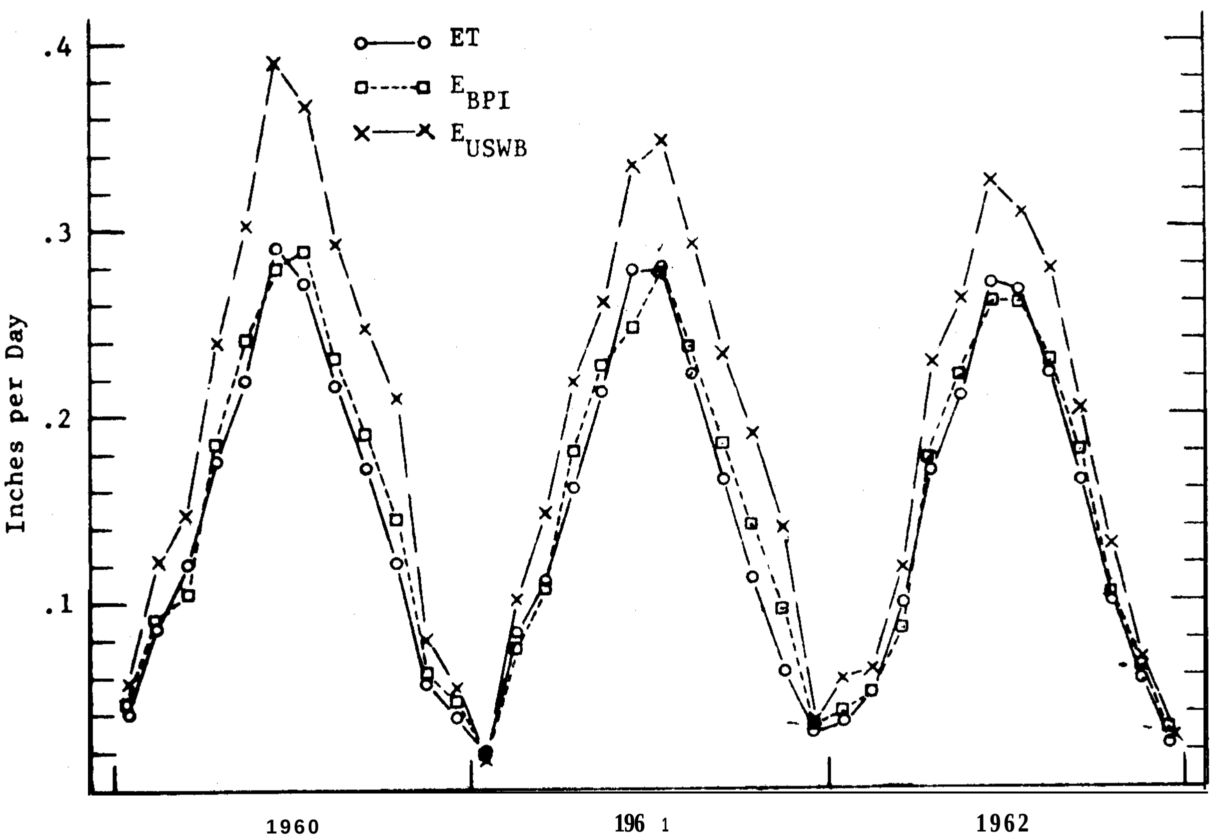

Figure 4. Mean monthly evapotranspiration (ET) for perennial ryegrass compared with evaporation from a U.S. Department of Agriculture pan (E_{BPI}) and a U.S. Weather Bureau pan (E_{USWB}), Davis, California.

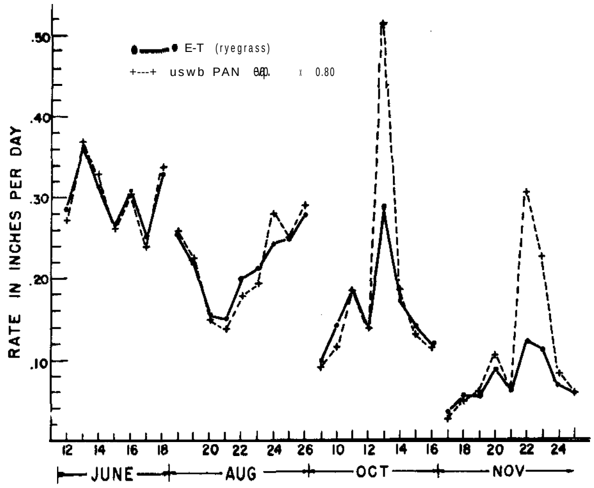

Figure 5. Daily evapotranspiration for perennial ryegrass for selected days during 1959 compared with evaporation from a USWB pan multiplied by a coefficient of 0.80. The extreme departure of the two curves in October and November occurred on days of very dry, strong north winds. Davis, California.

cates an expected ET/E ratio different from 1.0). A ratio of 1.0 was used for the grass area which is the approximate ratio found at Davis between ET for grass and E from the 6-foot USDA (BPI) pan, The higher ratio for slide 5 was used since it is likely that small groves of tall trees would use more water than grass. Thus a 1 inch travel of the string on the board would indicate 1.25 inches of ET. For shrubs partially shaded by trees to the south an ET/E ratio of 0.7 was assumed.

The desired soil moisture depletion between irrigation determines the length of the slide. This amount in inches is indicated on the left side of each slide. The scale on the right gives the number of hours of sprinkling involved, assuming certain application rates, which would have to be equal to or lower than the average infiltration rate of the soil for the total amount applied. Other factors could be taken into account for example, as in slide 4 where a combination of slope and soil type precludes the application at any one time of more than 2 1/2 inches of water. The convenience in time of day for moving sprinklers could also be accounted for by increasing or decreasing the length of the slides.

As the string is moved up daily (or at convenient longer intervals) its position over each slide would indicate the estimated depletion of moisture since the last irrigation. As it approached the top of any slide the need for irrigation would be indicated. Following irrigation of an area the slide representing it would be moved up an amount equal to the number of hours of sprinkling. For example, in Figure 6 area number 1 has just been irrigated. The need of an immediate irrigation for area number 2 is indicated. The next field needing irrigation would be area number 4 followed by areas number 5 and number 3.

Rainfall during the season would be taken into account by moving each slide upward an amount equal to the rain although none should be moved up so far that the bottom of the slide was above the level of the string.

An approach like that used in Washington State could be used to provide the necessary data on cumulative evaporation, or if the operation was large enough a pan could be maintained for example in some open spot in a park or a golf course.

Use of ET Estimates in System Design

It is obvious from the monthly ET data given in Figures 2 and 4 that the months of June and July are peak demand months at Davis with the average daily use for these months averaging around 0.27 to 0.29 inch/day. In sprinkler system design however these values would need to be increased by 5 to 10% to allow for years of higher than normal use. Even then this value would only apply for a case where a 6- to 8-inch depletion could be allowed each irrigation.

The moisture use for any one day or small groups of days can be considerably higher than the monthly mean. Jensen and Criddle in Bulletin No. 291 of the Idaho Agricultural Experiment Station proposed a preliminary curve for determining peak evapotranspiration for irrigation system design. This curve is reproduced in Figure 7 along with data for June and July for 4 years lysimeter results at Davis for comparison, A proposed curve based on the Davis results is also given. This curve would give somewhat lower peak design rates than the Jensen-Criddle curve except for depletion values greater than 5.5 inches. It is realized that such a curve based on only four years of data may be misleading as to extremes

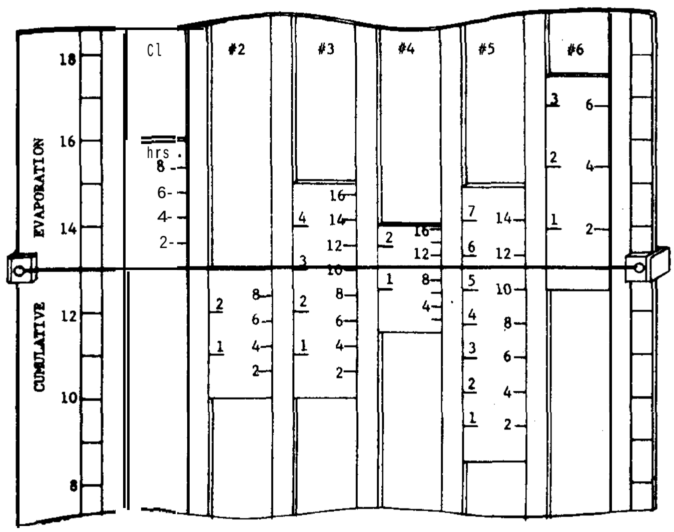

Figure 6. A portion of a suggested Irrigation Scheduling Guide for six areas in a pork as described below:

1. Bluegrass in open playfield, slit loam soil, 24" effective rooting dsph, 3.0" usable water storage in root zone, ET/E = 1.0, and 0.3"/hr. sprinkler application rate.
2. Same as for #1.
3. Bermuda grass in open playfield, silt loam soil, 42" effective rooting, 5.0" usable water ET/E = 1.0, and 0.3*,/h, application rote.
4. Same as #3 except poor infiltration on hillside location restricts total application of water to 2.5". A rate of 0.l5"/hr is needed to prevent surface runoff.
5. Grove of deciduous trees, sandy loam soil, 84" effective rooting, 8.0" usable water, ET/E 1.25, and 0.5"/hr. applic. rate.
6. Shrubs partially shaded on south by tall trees, randy loam soil, 36" effective rooting, 3.5" usable water, ET/E = 0.70, and 0.5"/hr applic. rate.

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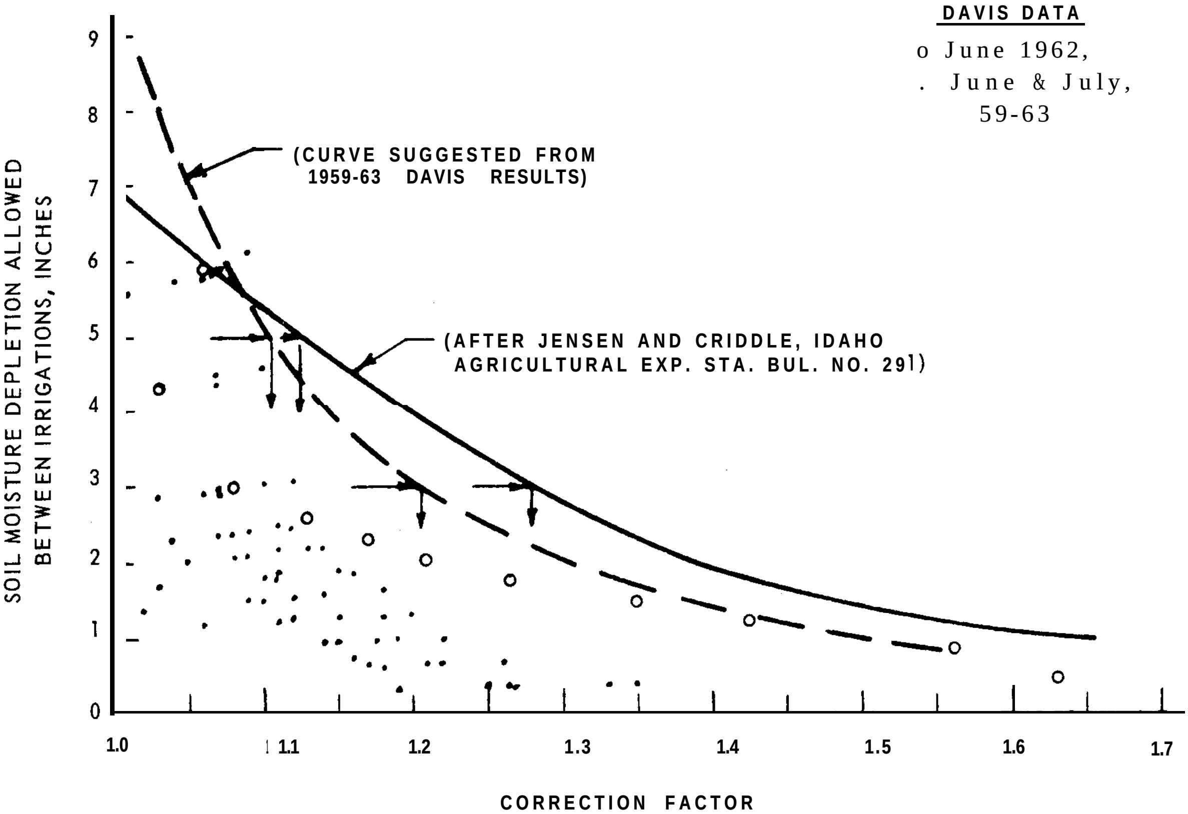

Figure 7. Prelminary curves for determination of a correction factor to estimate peak design ET for given depletions of soil moisture. Data points indicated were obtained by dividing mean daily ET for consecutive l-20 day periods of maximum use by a mean monthly ET of 0.28"/day. June 1960 data are indicated by open circles. This was the mostextreme month of high potential ET in 5 years at Davis.

which might occur. In areas where on an occasional year, strong dry winds can prevail for a week or more, the Jensen-Criddle curve might be safer to use in determining possible peak demands.

To use the curves in Figure 7 a mean monthly estimate of ET for the peak month is needed (for example, at Davis the value of 0.28 inch/day for June and July). For a shallow rooted situation such as that illustrated by slides 1 and 2 in Figure 6, we would enter on the ordinate at the 3.0 inch level, project horizontally to the curves and then down to the abscissa. Using the Jensen-Criddle curve we would get a peak design rate of 1.28 x 0.28 = 0.36 inch/day or with the Davis curve a design rate of 1.20 x 0.28 = 0.34 inch/day. For a 5-inch depletion we would find multiplying factors of 1.12 and 1.10 using the Jensen-Criddle curve and the Davis curve respectively or a peak design rate of approximately 0.31 inch/day for both.

Suggested peak design rates for various climatic zones of California are as follows:

AREA	INCHES PER DAY	INCHES PER WEEK
Coastal fog belt	0.15	1.0
Coastal valleys	0.20 – 0.27	1.5 – 1.9+
Delta region	0.25 – 0.30	1.9 – 2.1
Sacramento Valley and San Joaquin Valley	0.30 – 0.35	2.1 – 2.4
Desert	0.32 – 0.42	2.3 – 3.0

(10 miles from fog belt summer use may not differ appreciably from the Central Valley)

The rates given for the Sacramento Valley appear to agree quite well with those discussed earlier for a 3 to 5-inch depletion. Somewhat higher peak rates might be encountered on an occasional year for depletions of only 1 to 2 inches. For an excellent discussion on this, the reader is referred to a recent paper by Dr. John Madison, "Irrigation Systems and Procedures," in the ***California Turfgrass Culture,*** January 1964 issue.