EFFECTS OF TIME TAKEN TO APPLY AN IRRIGATION ON SEASONAL IRRIGATION REQUIREMENTS

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INTRODUCTION

In developing scheduling procedures for irrigation (4, 5, 7), most authors appear to have assumed that the entire field would be irrigated at once, with full credit being given for rain up to the available water capacity of the soil. Insofar as timing of irrigations and credit for rain are concerned, this could be called "zero" time for irrigation. Except for special cases, the zero time procedure is currently not in use by farmers.

From the time irrigation is started in one section of the field, several days may be required before water will have been applied to the entire field. The actual number of days will depend on the equipment and the size of the field to be irrigated. As reported by Wilcox and Korven (8), greater soil water deficits can occur in the last part of the field to be irrigated than in the first part. They attributed this to weather fluctuations occurring during the course of an irrigation. Further investigation (10) showed that if full credit were given for rain, the subsequent irrigation would be delayed too long, permitting excessive soil drying.

Wilcox and Sly (11) modified the irrigation scheduling procedure originally developed by Korven and Wilcox (3, 8, 10) and presented one that ensures that the required amount of irrigation water is applied to all parts of the field at the proper time. Once the time for the start and end of the irrigation season has been established, this assurance is obtained by using specially developed objective methods of limiting the credit to be given for rain in the daily calculations for determining the soil water balance. This procedure follows closely that recommended for use in the Okanagan Valley of British Columbia. Since full credit is not given for rain in some circumstances and special techniques involving the use of additional water are employed to determine the start of the irrigation season, more water is required than with the method requiring zero time for irrigation.

Interest in saving water will increase as the water becomes scarcer or more costly. This study was undertaken to determine how estimates of supplemental water for irrigation, calculated for selected sites using zero time for irrigation, compare with those obtained when a longer time for irrigation is required.

SCHEDULING PROCEDURES

The basic procedure used for determining seasonal irrigation requirements is the weather-based scheduling procedure developed by Wilcox and Sly (11). In this procedure, an application rate of 4 d for each 2.54 cm of water applied to the entire field was used. This rate has proved satisfactory for conditions in British Columbia (9) and has been used in this study for determining irrigation requirements for other than a zero time of application. For convenience, the procedure using this rate of application will be referred to as method 1.

Before the scheduling procedure developed by Wilcox and Sly can be used with a zero time of application, certain changes must be made to ensure that the same basic benefits from irrigation will be realized. These changes involve the amount of each irrigation, the start and end of the irrigation season, and the credit to be given for rain in the soil water balance during the irrigation season. The scheduling procedure incorporating these changes will be referred to as method 2. Method 1 has been described in detail in reference (11) and only those procedures being changed to provide method 2 need be discussed here.

Amount of Each Irrigation

It is generally believed (6) that the minimum safe water content for most crops is close to 50% of the available water capacity (AWC) within the effective root depth. To maintain this minimum in all parts of the field, under method 1 each irrigation is started when the water content of the soil is about 60% AWC and the amount of each irrigation is 2.54 cm for each 6.35 cm of AWC.

In method 2, water is applied to the entire field when required, so irrigation is delayed until the soil water is 50% AWC. In this case each irrigation is 3.18 cm for each 6.35 cm of AWC.

Start of Irrigation Season

Using method 1, it is obvious that to prevent the soil water at the last setting from dropping too low before being reached by the sprinkler line, it will be necessary to start irrigation at the first setting before the soil there (the last setting) is actually dry enough to require irrigation. The details of the technique employed are given in reference (11).

With method 2, there is only one setting for the entire field, so irrigation begins when the soil water balance is 50% AWC.

Credit for Rain

With method 1, once irrigation has begun, all rain cannot be added to the soil water balance as this could create soil water conditions similar to those at the beginning of the growing season. Then, to avoid retuning to the procedures of the start of the season, the following rules are followed for method 1:

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(1) From the start of the growing season to the start of the irrigation season – give full credit for rain in the soil water balance up to 100% AWC.

(2) During the time water is being applied – give credit for rain only to the amount of potential evapotranspiration for the day.

(3) During the layoff periods (time between irrigations) – give credit for rain in the soil water balance only until this balance comes up to that registered on the last day or irrigation just completed.

In method 2, full credit for rain up to 100% AWC is always given in the soil water balance.

End of Irrigation Season

It is necessary to recognize when to stop irrigation so that water that cannot be used by the crop will not be applied near the end of the growing season. In method 1, this day is determined using a counting back procedure as follows:

(1) Assume the soil water has been reduced to 40% AWC at the end of the growing season.

(2) To this balance add the potential evapotranspiration for the day and subtract the rain to get the balance for the previous day. This balance is never allowed to fall below 40% AWC.

(3) Continue this counting back procedure until the balance exceeds 60% AWC. The day on which this occurs will be the last day of the irrigation season.

This procedure allows for the possibility of soil water lessening in some part of the field to 40% AWC before the end of the growing season, a condition considered desirable to help induce good maturity in perennial plants (Wilcox unpublished).

In method 2, the same procedure is followed. The soil water is assumed to be reduced to 40% AWC at the end of the growing season as before. Because the amount of each irrigation is now 50% AWC, the counting-back procedure will only involve 10% AWC, and the end of the irrigation season will be later than for method 1.

DATA

The scheduling procedures discussed in the previous section involve the balancing, on a daily basis, of incoming water based on estimations for potential evapotranspiration (PET). PET is estimated by using daily weather reports in the equations developed by Baier and Robertson (1) and converting the results (in millilitres) to centimetres of PET by multiplying by 0.0086. In the scheduling procedures, soil water is assumed to be at 100% AWC at the start of the growing season. The daily loss from this will be given by the product of PET and CU, where CU is the consumptive use factor determined by the crop characteristics. In the calculations for this paper, CU is considered to be 1.00 throughout.

Only the standard daily weather observations, as collected by the Meteorological Branch, Canadian Department of Transport (2) (now the Atmospheric Environment Service, Department of the Environment) are required in order to obtain seasonal irrigation requirements for soils of any water-holding capacity with either scheduling procedure. Such data have been used in methods 1 and 2 to obtain irrigation requirements for the standard 20-yr period, 1931-60, for selected stations in British Columbia. Calculations were made for soils with holding capacities for available water of 6.35, 12.70, 19.05, 25.40 and 31.75 cm, respectively.

These represent soil depths and textures ranging from 60 cm of loamy sand to 150 cm of silt or clay loam.

RESULTS AND DISCUSSION

Seasonal irrigation requirements for the period 1931-60, as determined for selected localities in British Columbia by the two scheduling procedures, are presented in Table 1. The five different soil textures under climatic conditions ranging from very dry to wet are represented.

As expected, average irrigation requirements are greatest in the hot dry areas (see rain and PET columns in Table II) with coarse textured soils and least in the wet areas with fine textured soils, ranging from near 50 cm at Kamloops under scheduling method 1 to just under 1.0 cm at Agassiz under scheduling method 2. Irrigation was required in each of the 30 yr at Kamloops, Summerland and Creston for all soils. Saanichpton had a comparatively wet growing season in 1948, and irrigation was not required for the 25.40 and 31.75 cm AWC soils. At Prince George and Agassiz, irrigation was required every year only for the 6.35 cm AWC soils. The number of years in the 30-yr period requiring irrigation dropped off gradually as the finer textured soils were considered, decreasing to 17 at Prince George for soils with AWC's of 31.75 cm under scheduling method 2. At Agassiz, irrigation was required in only 3 yr (1938, 1951 and 1958) for such soils using method 2. These results are

<table>
<thead>
<tr>
<th>AWC (cm):</th>
<th>6.35</th>
<th>12.70</th>
<th>19.05</th>
<th>25.40</th>
<th>31.75</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Method</td>
<td>Saving</td>
<td>Method</td>
<td>Saving</td>
<td>Method</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>(cm) (%)*</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Kamloops</td>
<td>50.1</td>
<td>46.4</td>
<td>3.7</td>
<td>7</td>
<td>46.8</td>
</tr>
<tr>
<td>Summerland</td>
<td>46.5</td>
<td>42.7</td>
<td>3.8</td>
<td>8</td>
<td>42.4</td>
</tr>
<tr>
<td>Creston</td>
<td>40.3</td>
<td>36.1</td>
<td>4.2</td>
<td>10</td>
<td>36.3</td>
</tr>
<tr>
<td>Saanichton</td>
<td>24.1</td>
<td>21.8</td>
<td>2.2</td>
<td>9</td>
<td>20.0</td>
</tr>
<tr>
<td>Prince George</td>
<td>21.7</td>
<td>16.6</td>
<td>5.7</td>
<td>26</td>
<td>16.1</td>
</tr>
<tr>
<td>Agassiz</td>
<td>17.5</td>
<td>13.1</td>
<td>4.4</td>
<td>25</td>
<td>10.8</td>
</tr>
<tr>
<td>Average</td>
<td>33.4</td>
<td>29.3</td>
<td>4.1</td>
<td>12</td>
<td>28.7</td>
</tr>
</tbody>
</table>

* In method 1, 4 d are required to apply each 2.54 cm of water to the entire field. In method 2, water is applied to all the field at the same time.

† Percent of amounts under method 1.
TABLE II. EFFECTS OF SCHEDULING METHOD ON LENGTH OF IRRIGATION SEASON 1931-1960 AVERAGES

<table>
<thead>
<tr>
<th>AWC (cm):</th>
<th>Growing season (d)</th>
<th>Rain† (cm)</th>
<th>PET† (cm)</th>
<th>Irrigation season (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6.35</td>
<td></td>
<td></td>
<td>12.70</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Kamloops</td>
<td>220</td>
<td>14.9</td>
<td>63.3</td>
<td>167</td>
</tr>
<tr>
<td>Summerland</td>
<td>217</td>
<td>17.2</td>
<td>59.9</td>
<td>160</td>
</tr>
<tr>
<td>Creston</td>
<td>198</td>
<td>19.8</td>
<td>54.7</td>
<td>146</td>
</tr>
<tr>
<td>Samichon</td>
<td>256</td>
<td>34.9</td>
<td>37.6</td>
<td>118</td>
</tr>
<tr>
<td>Prince George</td>
<td>176</td>
<td>32.7</td>
<td>41.7</td>
<td>121</td>
</tr>
<tr>
<td>Agassiz</td>
<td>244</td>
<td>81.4</td>
<td>38.6</td>
<td>104</td>
</tr>
</tbody>
</table>

† During the growing season.
* In method 1, 4 d are required to apply each 2.54 cm of water to the entire field. In method 2, water is applied to all the field at the same time.

TABLE III. ANALYSIS OF VARIANCE OF ESTIMATED IRRIGATION REQUIREMENTS

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Mean square</th>
<th>Obtained</th>
<th>Required for P = 0.01</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methods</td>
<td>1</td>
<td>1.796</td>
<td>648</td>
<td>6.64</td>
</tr>
<tr>
<td>Sites</td>
<td>5</td>
<td>8.278</td>
<td>2,987</td>
<td>3.02</td>
</tr>
<tr>
<td>Years</td>
<td>29</td>
<td>261</td>
<td>94</td>
<td>1.69</td>
</tr>
<tr>
<td>AWC’s</td>
<td>4</td>
<td>2,487</td>
<td>598</td>
<td>3.32</td>
</tr>
<tr>
<td>Error</td>
<td>1,760</td>
<td>2.77</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

consistent with those to be expected from the growing season rain and potential evapotranspiration figures in Table II.

In all cases, scheduling method 2 required less water than method 1. At Kamloops, Summerland and Creston, where growing season rainfall is relatively light and PET large (Table II), the water savings of method 2 over method 1 vary little for each soil. They increase as the AWC of the soils increases, and although the savings in the individual years requiring irrigation increase, the total is not enough to show an increase when averaged over 30 yr. However, when expressed as a percentage of the total irrigation requirement under method 1, the figures indicate marked savings, increasing with the AWC of the soils, ranging from 25% for 6.35 cm AWC soils to over 75% for those with a 31.75 cm AWC.

An analysis of variance was carried out to determine whether the differences in the net ET values obtained by methods 1 and 2 were statistically significant. The results are shown in Table III. These differences were found to be highly significant, as were the effects of the differences between sites, between years, and between AWC values.

CONCLUSIONS

It has been found that substantial savings in water can be made if irrigation water is applied to the entire field at the same time, as compared to the usual practice requiring 4 d for each 2.54 cm of irrigation. For the six British Columbia stations considered, the average savings ranged from 4.1 to 5.3 cm for all soils. These amounts represented 12% of the irrigation water for light soils and 28% for the heavy soils. For the three driest stations, irrigation requirements with the 4 d/2.54 cm method averaged over 32 cm, 20% of which would be saved under the zero day method. Against the advantage of saving water, the disadvantage of a higher cost for the irrigation system, due largely to greater pump and delivery capacity, must be weighed. There is also the disadvantage of using a very large flow of water for a short period, and of having this flow available when needed. The question as to whether it will be economically worthwhile to use this water saving method can only be answered in relation to local circumstances. These depend on agricultural returns in relation to the costs of equipment and labor, and the availability of water.

SUMMARY

Daily climatic data for the 30 year period 1931-60 were used in two routine scheduling procedures to estimate seasonal irrigation requirements for soils of different water-holding capacities at six selected localities in British Columbia. The first procedure, described in detail by Wilcox and Sly (11), closely follows the practices recommended for the Okanagan Valley. Four days are required to apply each 2.54 centimeters of water to the field. In the second procedure, equipment was assumed to be such that water would be applied to the entire field at the same time. The same basic principles are followed as with the first procedure, but adjustments were made to ensure that the same availability of soil water to plants prevailed under both methods. Differences in the irrigation requirements resulted from these adjustments.

In every case, and for each water-holding capacity of the soil and each climatic condition, less water was required under the second scheduling method. Savings, related to the water required with the four days per 2.54 centimeters procedure, ranged from 12 percent for coarse textured soils averaged over all six locations, to 28 percent for fine textured soils. In the dry areas,
where requirements averaged over 32
centimeters for fine textured soils, the
savings averaged more than 20 percent.

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