Moisture Scheduling for Irrigated Crops

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Irrigation, the process of artificially applying water to the soil for the purpose of supplying the moisture essential to plant growth, has been practiced on the Canadian prairies for many years. In improving any irrigation program two of the most important questions which must be answered are: "When to apply water?" and "How much water to apply?".

The answers to these questions require some consideration as to the type of crop grown, the climate of the area, the moisture storage properties of the soil, and from a practical standpoint, how often the farmer can irrigate a crop and the amounts of water which he can apply.

As part of the research program carried out by the Department of Soil Science on target yields for irrigated crops an attempt was made to develop a rational method of irrigation scheduling which satisfied the above requirements.

This study was carried out with J. L. Henry in co-operation with the Conservation and Development Branch of the Saskatchewan Department of Agriculture on lands donated by various co-operating farmers in the South Saskatchewan River Irrigation Project.

Rationale

A tremendous amount of work has been carried out on the consumptive use of water (evapotranspiration) by various types of crops (cf. Hiler and Clark, 1971 and Jensen *et al*., 1970). In the Canadian prairie region extensive studies by Sonmor, 1963, at Lethbridge, Alberta, and more recently at Outlook, Saskatchewan, have provided a fairly complete picture of the moisture requirements of a variety of crops under these climatic conditions. Figure 1 shows the average consumptive use of water by various crops and also illustrates the deviations from the average for cereals because of the seasonal climatic conditions.

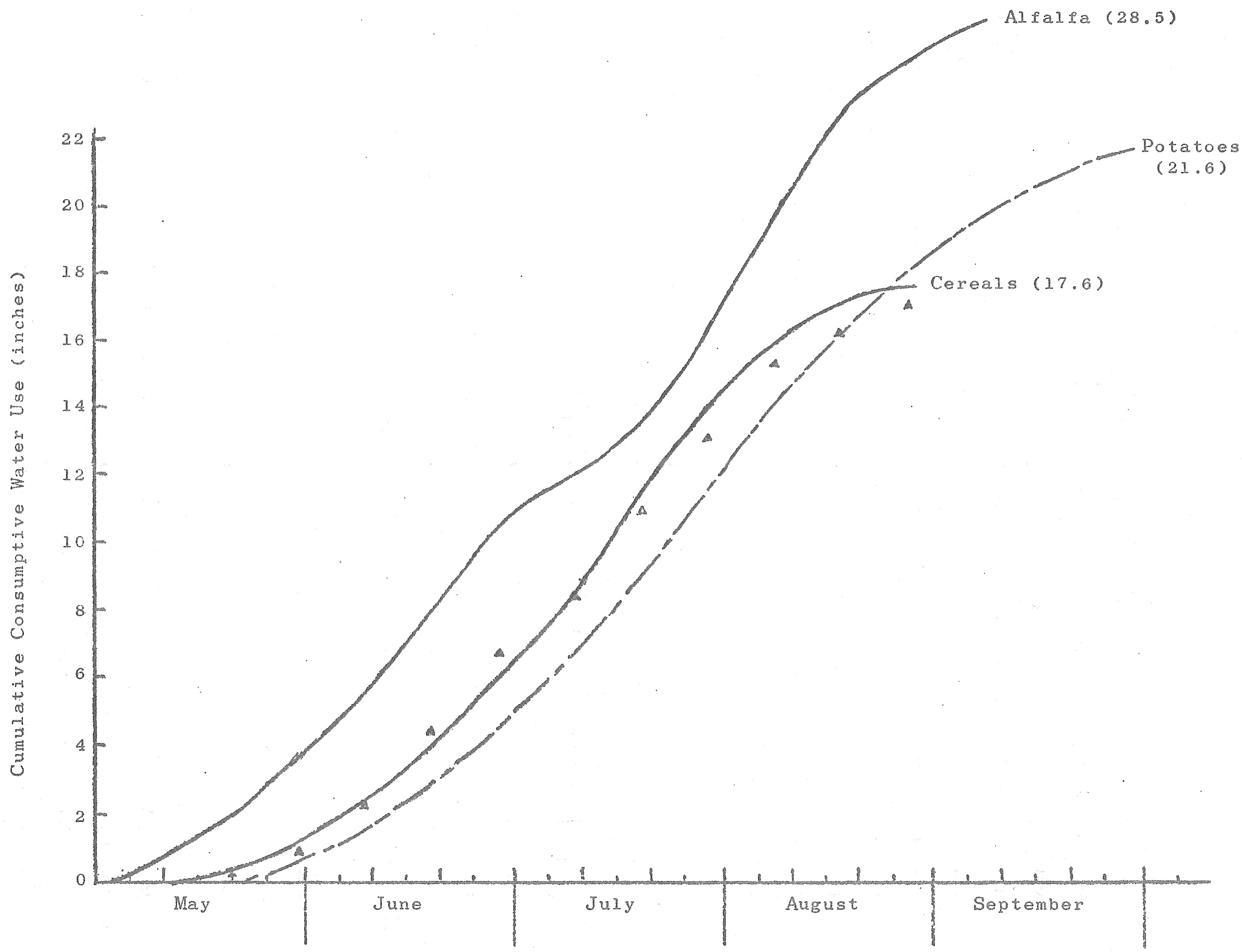

Figure 1: MEAN 1963-1971 COMSUMPTIVE WATER USE 10 DAY INTERVALS, at Outlook, Saskatchewan (from L. G. Sonmor), and variations caused by climate, (▲) cereals for the 1972 season

The approach taken in this study has been to maintain the moisture content of the soil at levels sufficient to supply the requirements of the growing crop. Moisture use by the crop was then approximated by the amount of water added to the soil minus water moving out of the profile by deep percolation.

<u>Methods and materials</u>

For the crops rapeseed, soft wheat, and barley, nutrient response experiments were carried out on two different soils using three different irrigation schedules. In this report the effects of the irrigation schedules on barley and rapeseed will be discussed. Further details on these studies may be found in the Soil Plant Nutrient Research Reports for 1971 and 1972.

Soil moisture levels were monitored in the plots receiving irrigation (Water 1 and 2) by means of tensiometers installed at depths of 9 and 18 inches. The shallow tensiometers were used to obtain an indication of when to irrigate and the deep tensiometers provided information on the amount of water to apply.

The time for applying water to the various treatments was determined as follows:

1. Water 1 Treatment - Irrigation water was applied when the moisture tension in the shallow tensiometers reached 0.5 atmospheres. The Water 1 treatments of the Elstow soil were originally scheduled to take place when the moisture tension had reached 1.0 atmospheres as determined by extrapolation from a plot of tensiometer readings. This schedule resulted in an unplanned moisture stress early in the growing season. Therefore, irrigation at a tension of 0.5 atmospheres was resorted to on the Elstow soil as well as the Asquith.
2. Water 2 Treatment - Irrigation water was supplied when sufficient time had elapsed to evaporate two inches of water, after a tension of 0.5 atmospheres had been reached. Evaporation was determined from Bellani plate readings.
3. Water 3 Treatment - These plots were not irrigated (dryland

controls) except for an initial irrigation at seeding to ensure germination.

The amount of water to be applied was determined after consideration of the readings of the shallow and deep tensiometers, the storage properties of the soils and the limitations of the sprinkler system within which amounts could be controlled. The approximate amounts applied are summarized in Table 1.

Table 1

Depth of Water Required to Replenish Soil Moisture

Water 1

Deep Tensiometer Reading	Depth of Water in Inches	
	Elstow site	Asquith site
0.3	2.5	1.5
0.3 - 0.7	3.5	
Greater than 0.7	4.5	3.0

Water 2

When irrigation was required water was applied to bring the total amount applied to these plots up to 75% of that applied to Water 1.

Water 3

Dryland conditions - no irrigation

Results and Discussion

In assessing the effectiveness of this irrigation program three aspects were considered; that the crop under the Water 1 treatment was supplied with adequate moisture throughout the growing season, that the crop yield reflected conditions of adequate moisture or the effects of imposed stress, and that efficient use was made of the applied water, i.e. that the irrigation water was not being lost by deep percolation out of the profile. These aspects will be considered in turn for the crops barley and rapeseed.

Barley trials

Figure 2 shows the cummulative additions of water to barley for the three water treatments on the Asquith site. For comparison the moisture requirements calculated from the data of Sonmor are included. It is apparent from this figure the applications of water under the Water 1 treatment quite closely followed the calculated consumptive moisture use. Under the Water 2 treatment the crop was stressed from fairly early in the growing season to maturity and on the Water 3 treatment the stress was more severe and began earlier in the season.

On the Elstow site the moisture applied on the Water 1 treatment on barley fell below the calculated moisture requirements in the month of June (Fig. 3). As mentioned earlier this stress in the Water 1 treatment was unplanned. Aside from this stress period the cummulative moisture applied in this treatment runs parallel to the calculated consumptive use. Again the treatments Water 2 and Water 3 applied increasing stress to the crop.

When the yields obtained on these sites are compared, the effects of the various moisture conditions become readily apparent (Table 2). In Table 2(a) the yields from various fertility treatments have been grouped into low fertility levels (0 and 25 lb. of nitrogen applied), recommended range (50, 75 and 100 lb. of nitrogen), and high range (150, 200 and 300 lb of nitrogen).

Considering the yields under conditions of recommended fertility, the most striking effect is the yield difference between the two sites on the Water 1 treatment. On the Elstow site which received a water stress the yield was 58 bu barley/acre compared to a yield of 75

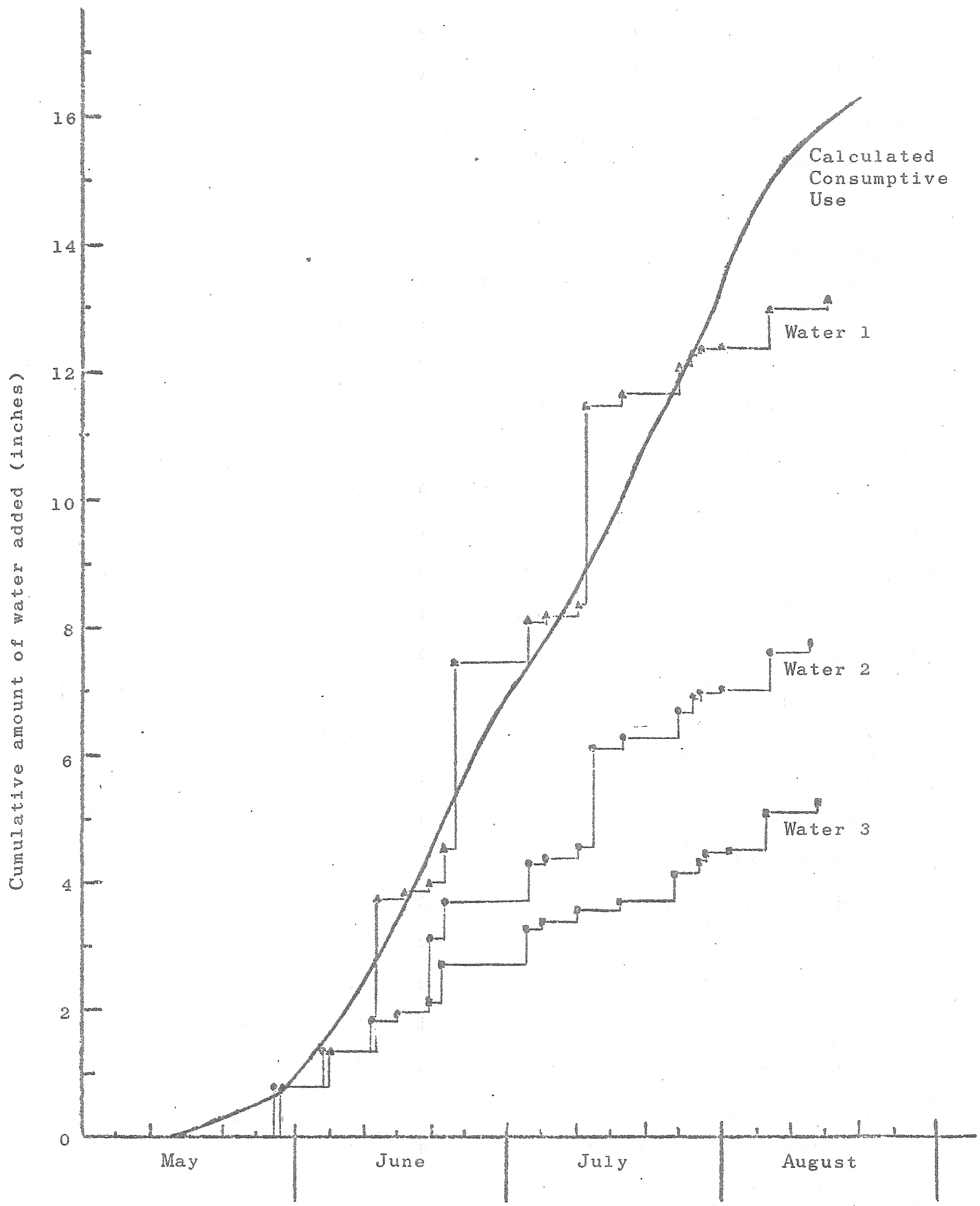

Figure 2: Cumulative amounts of water added to barley plots at the Asquith site under various irrigation schedules. For comparison the calculated consumptive use curve is included.

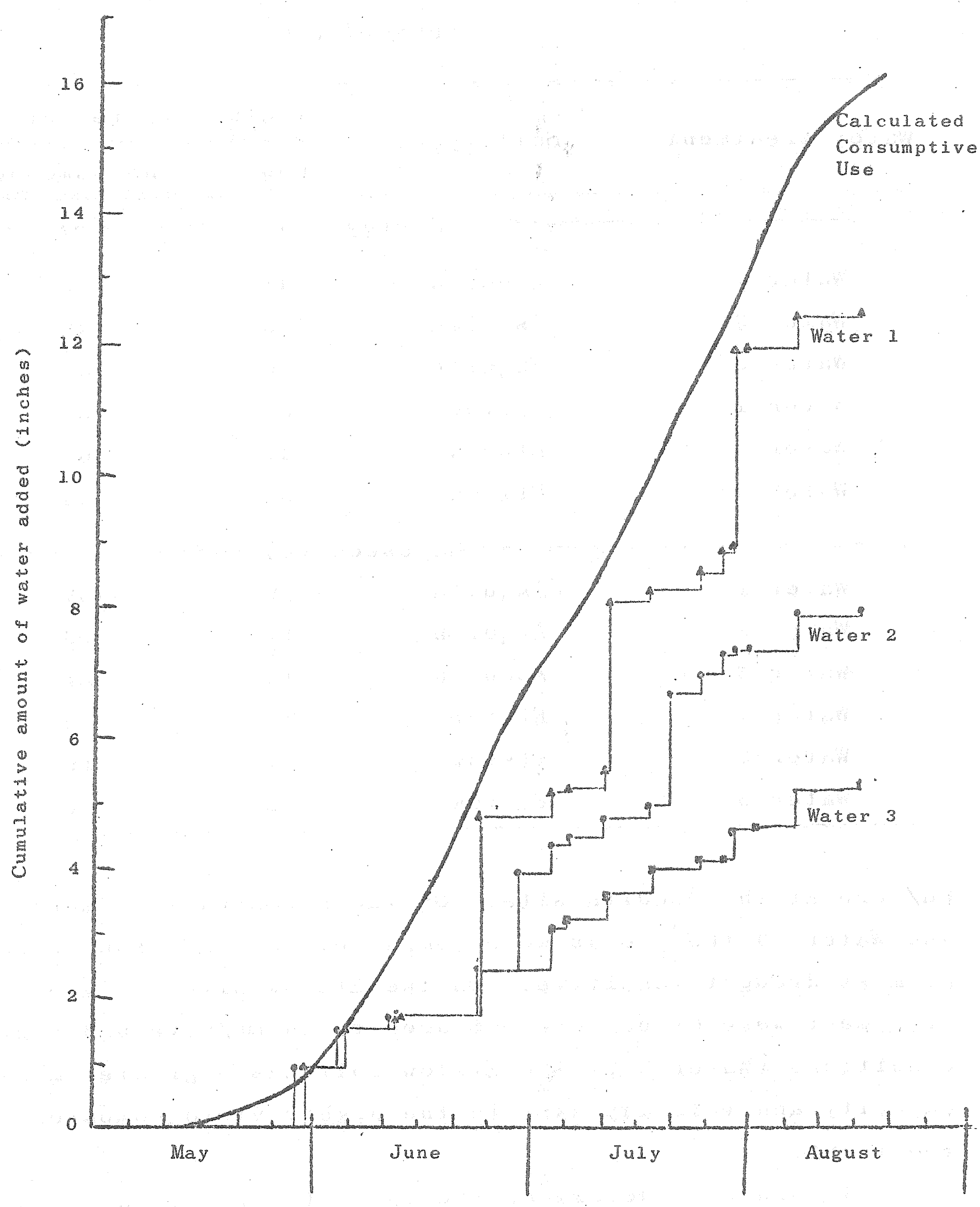

Figure 3: Cumulative amounts of water added to the barley plots on the Elstow site under various irrigation schedules. For comparison the calculated consumptive use curve for cereals is included

Table 2

Yields for 1972 on barley and rapeseed plots

Water treatment	Soil type	Yield bu/acre fertility range		
		Low	Recommended	High
Barley (a)				
Water 1	Asquith	41	75	87
Water 2	Asquith	38	49	65
Water 3	Asquith	49	53	68
Water 1	Elstow	37	58	63
Water 2	Elstow	41	61	71
Water 3	Elstow	32	44	44
Rapeseed (b)				
Water 1	Asquith	20	37	52
Water 2	Asquith	14	26	42
Water 3	Asquith	16	21	21
Water 1	Elstow	19	28	38
Water 2	Elstow	17	19	18
Water 3	Elstow	6	6	6

bu/acre at the Asquith site. On the stressed treatments (Water 2 and Water 3) the yields were comparable on the Asquith soil which would be most drought sensitive. On the Elstow site the yields on Water 2 treatment were 61 bu/acre compared to 44 bu/acre under dryland conditions (Water 3). The Elstow soil has a greater moisture storage capacity and this may explain the higher yield compared to the Water 3 treatment.

In order to determine the fate of the irrigation water applied, soil moisture content was monitored to the four foot depth by means of a neutron moisture meter. Readings were taken prior to and following irrigations to determine the amount of irrigation water which was moving out of the rooting zone and being lost by deep percolation. On both sites barley was irrigated three times during the growing season. The results of these studies are summarized in Fig. 4 which shows the moisture content in the surface foot of soil and in the three to four foot depth throughout the growing season. As expected the moisture levels in the surface foot show marked fluctuations throughout the season. It is interesting to note, however, that there is very little change in soil moisture content at the three to four foot depth. This result strongly suggests that all of the water applied remains in the rooting zone and may be used by the growing crop.

Rapeseed trials

The total amount of water applied to the rapeseed plots was greater than on barley, an additional irrigation being applied later in the season (Fig. 5). As with barley, the water treatments 2 and 3 applied increasing moisture stress to the crop.

The effects of moisture stress on the yields of rapeseed were quite apparent (Table 2(b)). At the recommended fertility levels rapeseed at the Asquith site on the Water 1 treatment yielded 37 bu/acre while on the Elstow site which received a moisture stress in June the yield was 28 bu/acre. Similarly as the extent of stress increased (Water 2 and 3 treatments) the yields were reduced.

When the soil moisture levels were plotted through the growing season (Fig. 6), it was found that the moisture content in the surface foot of soil showed wide fluctuations while the moisture content at the three to four foot depth remained approximately constant. From these data it was concluded that all of the moisture applied had remained in the rooting zone and negligible amounts of irrigation water had been lost through deep percolation.

Summary

The Water 1 treatment appears to provide an optimal irrigation

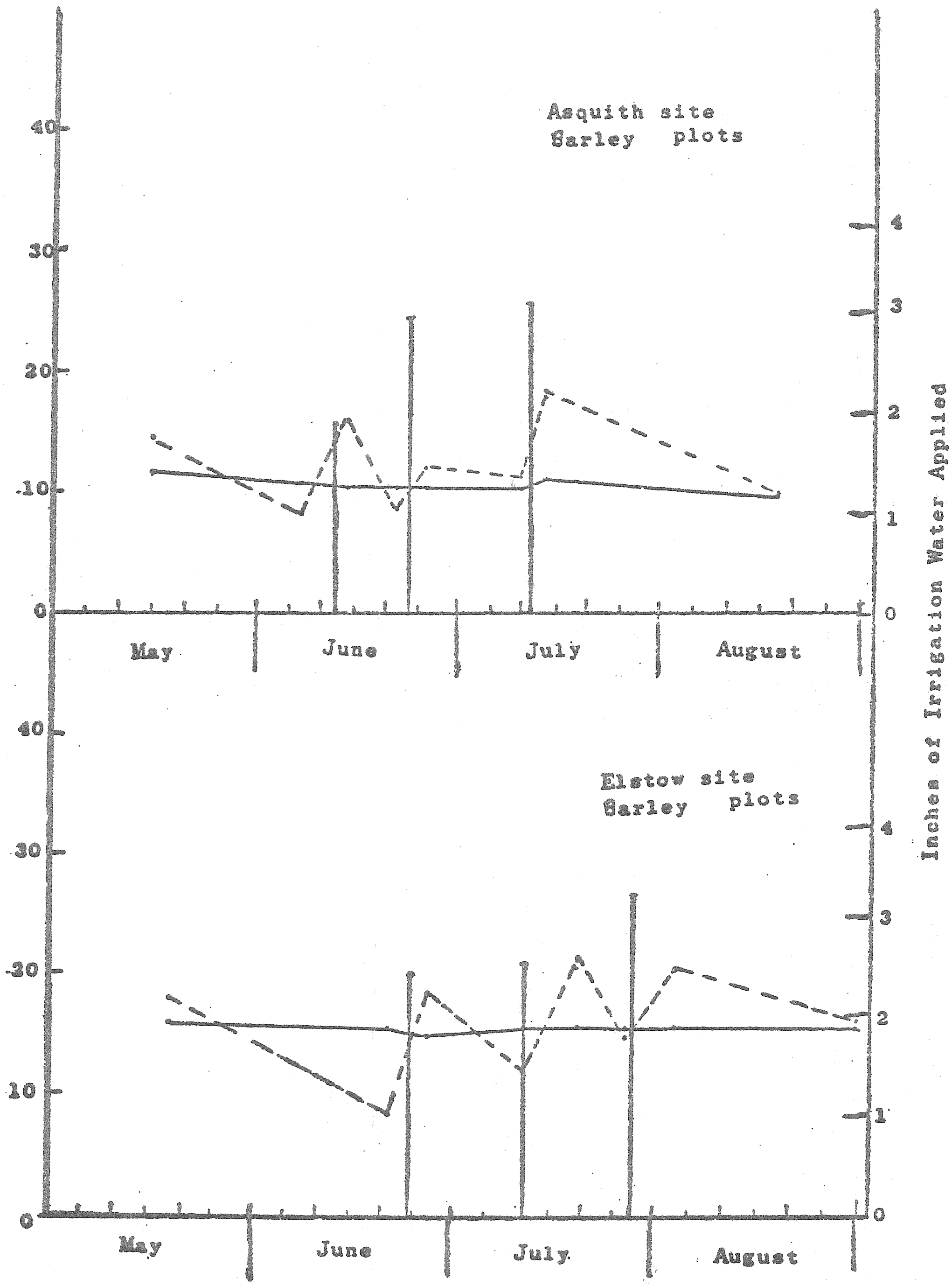

Fig. 4: Soil moisture content through the growing season. ------ surface layer of soil 0-12"; ——— 36-48" soil layer; vertical bars represent amounts of irrigation applied in inches.

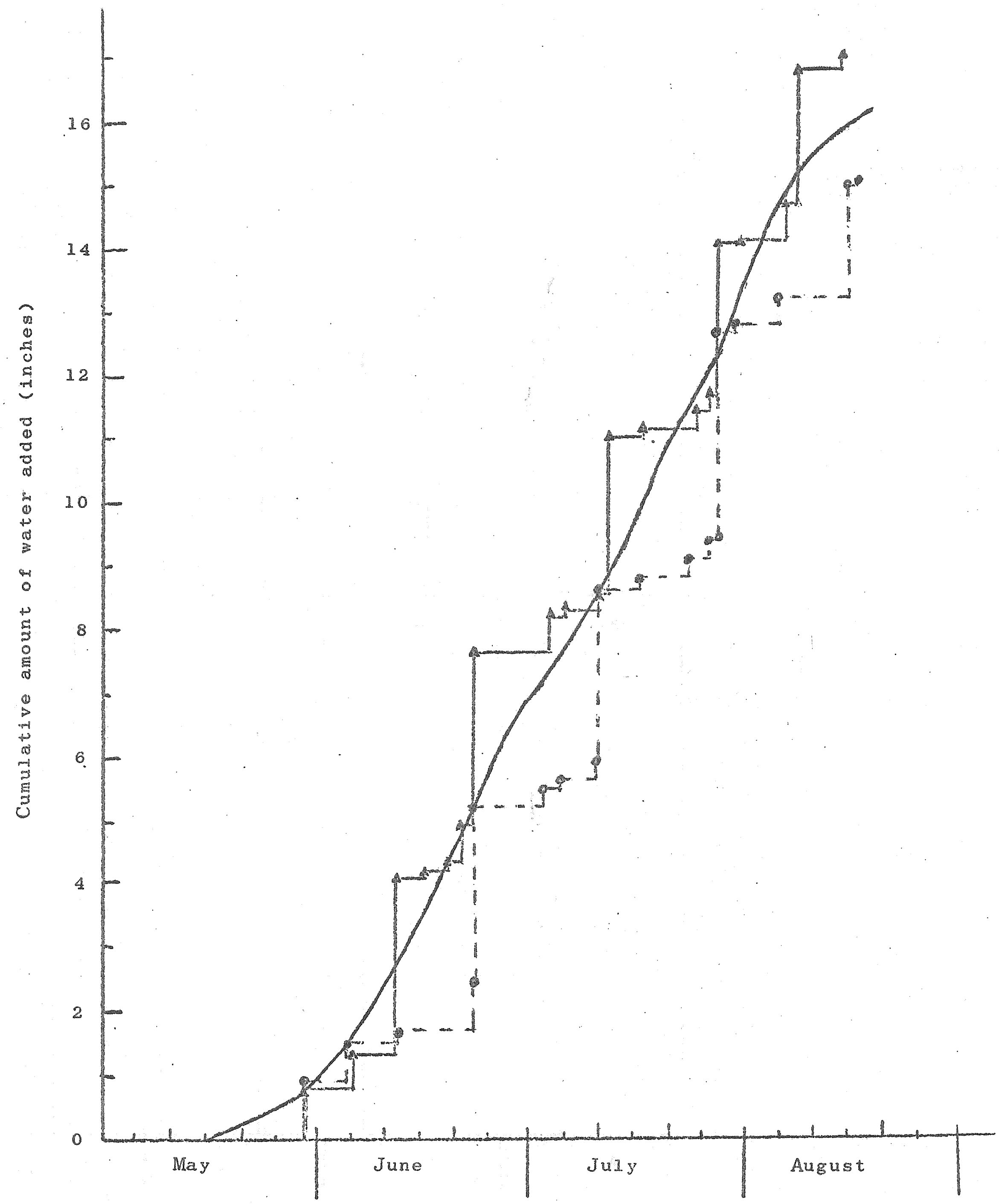

Fig. 5: Cumulative amounts of water added to the rapeseed plots on the Water 1 irrigation schedule, ▲——▲ Asquith site, ●--● Elstow site. The smooth curve represents the calculated consumptive water use for cereals.

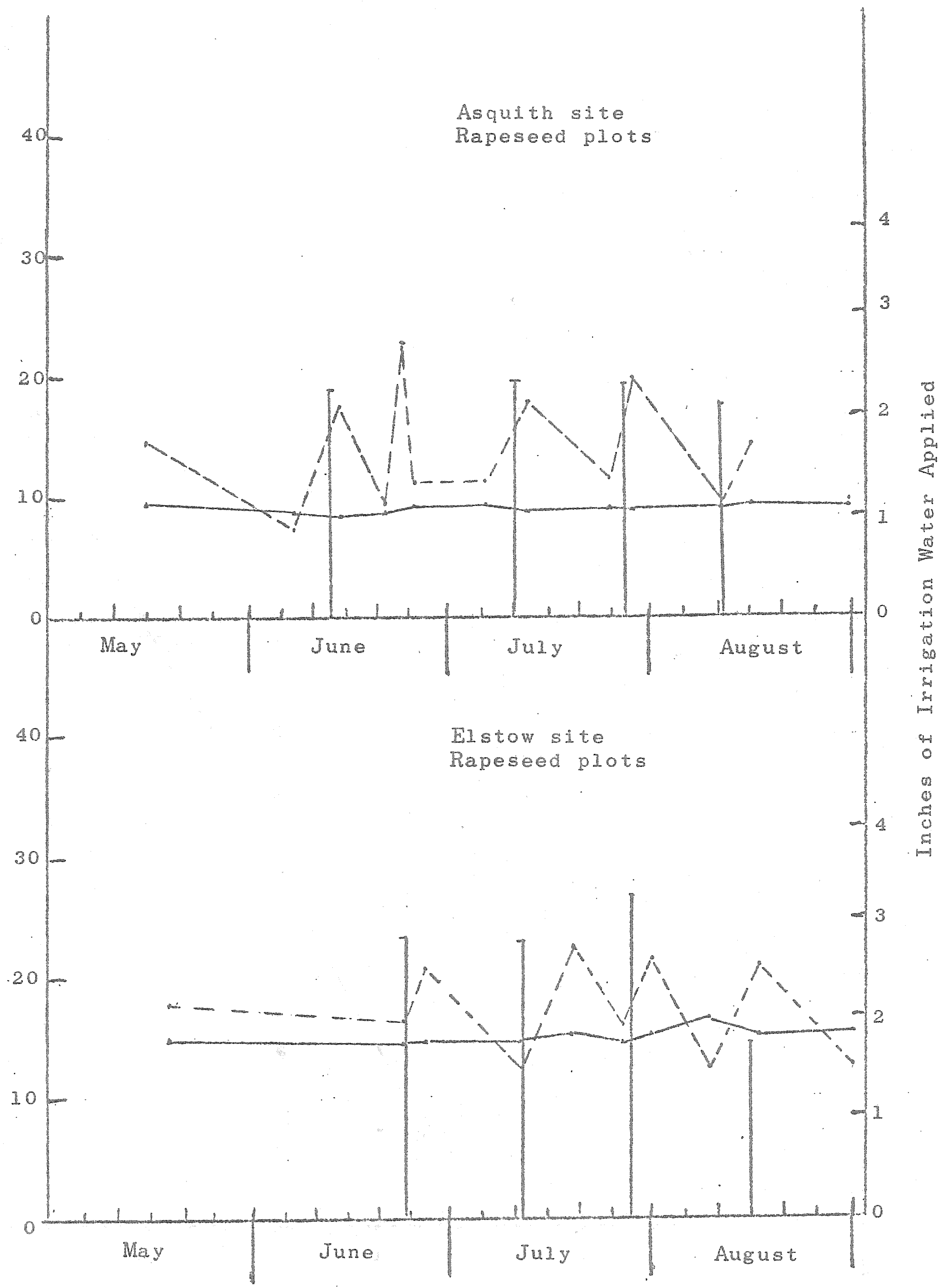

Fig. 6: Soil moisture content through the growing season. ------ surface layer of soil 0-12"; ——— 36-48" soil layer; vertical bars represent amounts of irrigation applied in inches.

schedule. Moisture is supplied to the crop in amounts sufficient to meet the calculated consumptive use requirements. By considering the storage properties of the soil the amounts of irrigation water required were estimated and measurement of the soil moisture levels at depth showed that these amounts of water remained in the soil profile and were not lost through deep drainage.

These studies will be repeated in the coming year to check the results.

One point which is quite clear from these studies is that stress at one point in the growing season (in this case in June) can markedly reduce crop yields. More information is required on the critical stress periods for particular crops and their effects on yields.

On the basis of these studies it is apparent that we are in a position to give the farmer some guidelines for a realistic irrigation schedule. This will require effort on the part of both extension personnel and the farmer to use this information and adapt it to his particular conditions of soil properties and the control available on his irrigation system. If this is done higher yields should be obtained by supplying adequate amounts of irrigation water to the crop when it is required and avoiding periods of moisture stress. This type of extension must be carried out if this research program is to be effective.

Literature cited

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