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A lysimetric study at Ludhiana for weather based irrigation scheduling for kharif maize — Variety Vijay

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ABSTRACT. The seasonal march of evapotranspiration (ET) of kharif maize, in relation to pan evaporation (EP), rainfall and irrigation at Ludhiana in 1977 and 1978 are presented. The quantum of easily available field moisture for potential ET is seen to be 12 cm. The crop shows physiological senescence about 15 days from harvest. Peak consumption is from 5th to 12th week after sowing and the peak rate is 1.5 0.2 times that of EP. An irrigation schedule based on evaporimetry is indicated.

1. Introduction

Maize is reported to do well in regions where the natural vegetation is of tall grasses. This shows a preference of the crop for a high soil water status. Because of lack of photo-respiration maize is one of the best trappers of solar radiation under good moisture supply. It is also suited for maximisation of yield in assured rainfall zones where it can be sown to an initial high population density and thinned in mid-season for harvest of green cobs. The availability of short-duration hybrids have increased the versatality and potential of maize for being fitted into a wide variety of cropping practices and rainfall situations. For making full use of solar energy, rainfall and irrigation, thereby realising maximum gross yield of the crop from a given area, crop-planning based on data of field-water-needs of the maize crop is a must.

The field-water-needs referred to as 'Consumptive use' by irrigation engineers relate to the crop-water requirements for transpiration and the inevitable evaporative loss of water in surface applications. This combined loss is known as Evapotranspiration (ET). Thus consumptive use is synonymous with ET. In light of the above the daily measurements of ET of maize-variety Vijay-recorded at Ludhiana at the research farm of the Agronomy Department of the Punjab Agricultural University assumes significance.

2. Material and method

In the kharif season of 1977 and 1978 maize crop, variety Vijay, of about 3½ months' duration, had been sown in late July and harvested by early November. Two units of the gravimetric lysimeter system, described by Venkataraman *et al.* (1976) were used for making the daily ET measurements. Care had been taken to ensure that there was (*i*) a good fetch of maize of the same variety, stand and age for the lysimeter crop, (*ii*) no non-croped area around the lysimeters, (*iii*) proper alignment of the field and tank rows and (*iv*) no difference in cultural treatments between the lysimeter and field crop. The agronomic practice was to have the crop rainfed in the first half of the crop season and to resort to irrigation when the rains withdraw. The spacing adopted was 60 cm between rows and 22 cm between plants in rows.

3. Results and discussion

To understand the influence of crop and weather factors on consumptive use, values of ET and pan evaporation (EP) for 3-day periods commencing from sowing to harvest were taken. The 3-day period was marginally adjusted during dates of irrigation or significant rain. The 3-day mean ratios of ET to EP were tabulated. The march of the 3-day mean values of ET/EP for 1977 and 1978 are shown respectively in Figs. 1 and 2. The age of the crop, its phenophases,

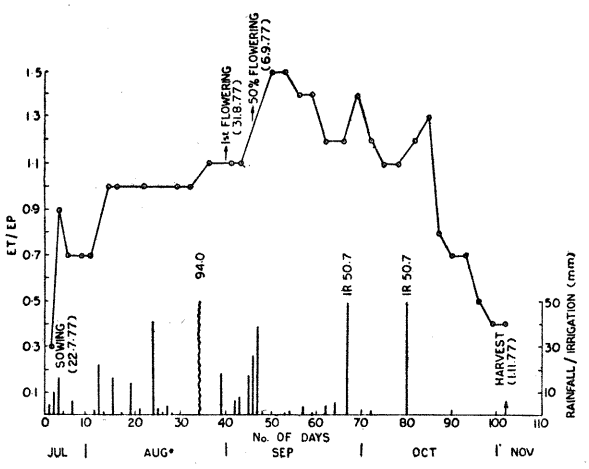

Fig. 1. Relative evapotranspiration (ET/EP) maize-variety Vijay — Ludhiana, 1977

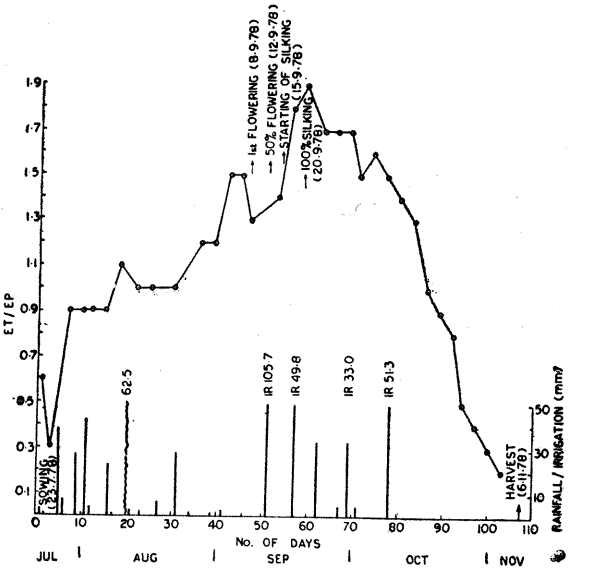

Fig. 2. Relative evapotranspiration (ET/EP) maize-variety Vijay — Ludhiana, 1978

daily falls of rain and dates and amount of irrigation are also indicated in the figures. The features emerging from Figs. 1 and 2 are discaused below :

1977 Crop (Fig. 1)

There was good rainfall in the week preceding sowing, leading to good moisture recharge. It can be seen from Fig. 1 that rainfall activity was quite good and sustained till beginning of 2 September. The rain-out period necessitated irrigation of 5 cm on 27 September and 10 October :

Immediately after sowing, the ET/EP ratio is about 0.30. At the end of the first dry spell the ET/EP ratio is about 0.70. The time when ET equals EP is obscured by rains. ET equals EP definitely from 19 August. In the wake of rains, ET equals EP from 11 to 14 August. So one could guess that ET equals EP in about 3 weeks after sowing.

The ET/EP ratio rises to a value of 1.4 by end of 1st week of September, *i.e.,* about 45 days after sowing and is maintained there till October, *i.e.,* about 30 days from harvest. In the period between the end of significant rains on 7 September and the first irrigation on 27 September the total ET loss was about 90 mm and rainfall was 20 mm. Amount of irrigation on 27 September was about 51 mm. In the irrigation interval from 28 September to 10 October total ET was 62 mm and rainfall only 2mm. Amount of irrigation was 51 mm. Thus the moisture status after irrigation on 10 October was nearly the same as on 7 September. Therefore, the steady drop in ET/EP ratio from a value of 1.3 from mid-October is not due to soil moisture stress. Thus maize variety Vijay can be deemed to show physiological senescence about a fortnight from harvest or 3 months after sowing.

1978 Crop (Fig. 2)

The total rainfall in the crop period in 1978 was only 180 mm compared to about 420 mm in 1977. In 1978 the last significant rain was on 23 September, *i.e.,* about a fortnight later than in 1977. However, prior to this there had been no significant falls of rain for a month. So the rainy season can be deemed to have ended a fortnight earlier than in 1977.

Here significant rains have occurred a week after sowing. The ET/EP ratio immediately before onset of rains is 0.30. This is in conformity with the 1977 finding. Due to good distribution of rains the ET/EP ratios are about 1.0 subsequently. In the dry spell from 15-18 August the ET/EP ratio is 1.0. This indicates that the stage of equivalence with EP is reached about 3 weeks after sowing. This substantiates the assumption made in the 1977 experiment.

The peak consumption of 1.6 $\pm$ 0.1 sets in by 30 August, *i.e.,* after about 35 days after sowing. On 12 October, *i.e.,* about 80 days after sowing there is a drop from the peak ratio and ET becomes less than EP from 22 October, *i.e.,* about 90 days after sowing and 15 days before harvest. The time of attainment of peak consumption and the drop in consumption below EP are similar to that of the 1977 crop. The gradual drop in peak values is similar to that of the 1977 crop. Due to copious irrigation of 106 mm on

TABLE 1

Weekly march of evapotranspiration (ET) of maize variety Vijay, Pan Evaporation (EP) and Rainfall (RR)

Period	ET (mm)	EP (mm)	Average EP (mm)	ET/EP	RR (mm) & Irrigation	Crop growth stage
			1977 Crop			
22-28 Jul	22.6	30.5	33.6	0.74	38.0	Germination
29-4 Aug	18.2	24.8	30.1	0.73	26.6	Seedling establishment
5-11 Aug	25.8	27.0	32.9	0.95	33.3	Elongation
12-18 Aug	32.3	29.0	31.5	1.11	53.3	Do.
19-25 Aug	30.0	30.0	32.9	1.00	94.9	Do.
26 Aug-1 Sep	43.7	37.2	35.0	1.17	19.0	Do.
2-8 Sep			Data missed			Flowering & silking
9-15 Sep	29.8	21.4	31.5	1.39	4.8	Do.
16-22 Sep	33.0	26.4	32.9	1.25	9.2	Maturation
23-29 Sep	38.5	29.5	31.5	1.30	6.0 (Irri. 5cm)	Do.
30 Sep-6 Oct	31.6	26.2	32.2	1.21	2.4	Do.
7-13 Oct	29.7	28.4	32.2	1.05	0.0 (Irri. 5cm)	Incipient drying
14-20 Oct	24.7	26.8	32.2	0.92	0.0	Do.
21-27 Oct	16.7	26.4	29.4	0.63	0.0	Leaf withering
28 Oct-1 Nov	6.0	14.1	19.0	0.53	0.0	Do.
			1978 Crop			
23-29 Jul	18.6	32.1	33.6	0.58	52.0	Germination
30 Jul-5 Aug	24.7	24.7	30.1	1.00	74.1	Seedling establishment
6-12 Aug	22.5	23.8	32.9	0.95	87.2	Elongation
13-19 Aug	25.4	24.3	31.5	1.05	12.7	Do.
20-26 Aug			Data missed		31.4	Do.
27 Aug-2 Sep	38.6	29.5	35.0	1.31	3.9	Do.
3-9 Sep	50.9	38.4	30.1	1.33	1.3 (Irri. 10.6cm)	Do.
10-16 Sep	40.1	30.9	31.5	1.30	0.0	Flowering & silking
17-23 Sep	48.0	26.4	32.9	1.82	33.2 (Irri. 5cm)	Do.
24-30 Sep	44.0	26.3	31.5	1.67	5.2 (Irri. 5cm)	Maturation
1-7 Oct	45.0	29.9	32.2	1.51	0.0	Do.
8-14 Oct	43.6	30.0	32.2	1.45	0.0 (Irri. 5cm)	Do.
15-21 Oct	26.1	25.8	32.2	1.00	0.0	Incipient drying
22-28 Oct	13.6	24.0	29.4	0.57	0.0	Leaf withering
29 Oct-4 Nov	5.6	17.3	19.0	0.32	0.0	Do.

12 September followed by one of 50, 33 and 51 mm on 18 September, 30 September and 9 October respectively the moisture status on 9 October was very good. Therefore, the decline in moisture consumption in the fortnight before harvest and after 90 days of sowing is due to physiological senescence. This also is in conformity with the finding of 1977.

In the dry spell from 23 August to the time of first irrigation on 12 September 1978 the ET/EP ratios show a sharp decline from 10 to 12 September. The moisture status was quite good on 24 August. The cumulative ET from 24 August till 10 September was about 115 mm and rainfall was about 6 mm only. This shows that the quantum of field moisture that is available with ease for ET can be taken as 120 mm.

The maximum values of ET/EP ratios, *viz.*, 1.6 are 15 per cent higher compared to the values of 1.4 in 1977. This can be attributed to lesser rainfall and earlier end of monsoonal rains in 1978 leading to same macro-scale advection.

Weekly march of ET/EP

The above discussions are based on the march of 3-day mean values of ET/EP. As EP values are available for weekly periods at most places it would appear that better use of the information can be made if the data are given for weekly periods indicating the growth stage of the crop and the average EP value corresponding to each week. Therefore a table giving weekly values of ET, actual EP, average EP, ET/EP rainfall and/or irrigation and crop growth stage for weekly periods from sowing to harvest for the 1977 and 1978 crop are given in Table 1.

Irrigation scheduling

Application of Irrigation Water (IW) on the basis of cumulative pan evaporation (CPE) is being advocated for scheduling of irrigation. Now immediately on sowing the moisture need of the crop for transpiration is 1/3 of EP. In 3 weeks time ET equals EP. The evaporation component of maximum ET is 20 per cent (Venkataraman *et al.* 1976, 1977). Therefore, at the end of 3 weeks of sowing the transpiration need will be 80 per cent of EP. For the 3-week period after sowing mean transpiration need will be 50 per cent of EP. Irrigation to be applied ahead of consumption. The water uptake and hence the moisture need for transpiration of the crop in the first 3 weeks of sowing is 50 per cent of pan evaporation (EP). Average cumulative EP in 3 weeks of sowing is 100 mm. So moisture need for crop transpiration is 50 mm. When water is applied as surface irrigation there is loss of applied water as evaporation from soil surface. This is about 20 mm per irrigation. So moisture need of the crop in 3 weeks of sowing when it reaches the grounding stage is 70 mm. In other word pre-sowing application of 70 mm will meet crop-water needs till ground shading. Beyond 3 weeks applications of 120 mm when CPE reaches 100 mm would be a sound irrigation practice. Any rain in excess of 10 mm per day in the first 3 weeks of sowing and all rain after that must be deducted from CPE to allow for contribution of rain to crop water needs.

4. Conclusions

(1) The ET of maize crop would equal that of pan evaporation (EP) in about 3 weeks of sowing.

(2) The moisture requirements for crop transpiration would be 50 per cent of EP in the first 3 weeks.

(3) The peak period of water consumption is from 6th to 12th week of sowing and would equal 1.5 ± 0.2 of EP.

(4) About 120 mm of water would be available with ease for Potential ET for a crop with full canopy.

(5) The water consumption rapidly departs from equivalence with EP about 15 days prior to harvest.

(6) Pre-sowing application of 70 mm of water followed by applications of 120 mm of water when cumulative pan evaporation (CPE) reaches 100 mm would be a sound irrigation practice.

(7) In computing CPE any rain in excess of 10.0 mm/day in first 3 weeks and any rain after that has to be minimised from CPE.

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