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Water requirements of maize (*Zea mays* L.) as influenced by planting dates in Kuwait

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ABSTRACT

Crop water and irrigation requirements of maize in relation to planting dates have been estimated using the FAO CROPWAT model and an irrigation schedule was developed for the loamy sands of Kuwait. Weather data for 43 years recorded at the International Airport Kuwait was used for this purpose. The crop water requirement (ETc), irrigation water requirement (IR) and net irrigation requirement (NIR) of maize varied with planting dates; the lowest values were observed with planting date November 5. The period between October 25 and December 5 is ideal for planting grain maize in Kuwait. For planting date November 5, the ETc requirements were 210, 244 and 273 mm, respectively, for maize of 90, 100 and 110 days duration. For the planting date of January 5, ETc of maize increased to 323, 398 and 470 mm respectively for maize of 90, 100 and 110 days duration. The study clearly suggests that grain maize planting in Kuwait may not be delayed beyond 5th December, in order to economize on the water use. Irrigation schedules were also developed for grain maize for the loamy sands of Kuwait.

Keywords : Irrigation requirement, Kuwait, scheduling, water

Kuwait (30° 27' N, 48° 46' E) is one of the smallest countries of the Middle East with a large proportion of land under sandy desert containing oil fields. Soils are mostly entisols with low water holding capacity and susceptible to wind erosion. The clay and organic matter content is low indicating poor soil fertility. Kuwait Institute of Scientific Research (KISR), after a detailed soil survey reported that only 2.71 percent of the total land area located at Al Wafra, Al Abdali along the western margin of Kuwait city is considered suitable for agriculture (KISR 1999). Currently limited area is under agriculture. Date palm, potato, barley, maize and vegetables form certain important irrigated crops grown under open field conditions. Being an extremely dry environment with harsh climate and poor soils, agriculture without irrigation is rather impossible. Water use efficiency assumes significance particularly in semi-arid environments with increasing pressure on water resources from competitive users (Hatfield *et al.* 1996).

Information on irrigation scheduling is meager for crops of Kuwait.

Different approaches are there in developing irrigation schedule. In many parts of the world, irrigation is scheduled by use of class 'A' evaporation pan (Doorenbos 1976). But the pan evaporation may be 25 to 100 percent more than potential evapotranspiration (ETo) depending on location of the pan and the weather conditions. A computer program (Hess 1996) or a spreadsheet (Hess & Stephens 1993) can be used to calculate ETo using the Penman or Penman-Monteith equation. This method has been shown to be reliable (Allen *et al.* 1994), in a wide range of environments. Hess (1996) reported that Penman-Monteith equation should give the best estimate of ETo where daily weather data are available. Allen *et al.* (1998) reported guidelines for computing crop water requirements based on evapotranspiration.

Salam and Mazrooe (2006a, b) have reported the normal weather conditions and evapotranspiration estimates of Kuwait. Research attempts are inadequate to standardize the agronomic water requirements of maize in Kuwait. The objective of this investigation is to assess the effect of planting dates on the water requirement of maize (90 to 110 days duration) and to develop an irrigation schedule for this crop in the loamy sands of Kuwait.

MATERIALS AND METHODS

The 43 years (1962-2004) of climatic data and its analysis are reported by Salam and Mazrooe (2006 b). Same data series have been used in the present investigation. Soil properties required for this study were collected from the soil survey report (KISR 1999). The surface soil depth varies from 40 to 60 cm. The clay content varies from 4.1 to 10 percent, silt from 2.7 to 21 percent and sand from 87.9 to 93.2 percent. The bulk density of the soil ranges from1.83 to1.88g cm^{-3}. The moisture content of the soil at field capacity is 9 to 10 percent and at permanent wilting point 3 to 4 percent. The available water holding capacity varies from 5 to 7 percent. The pH of the soil varies from 7.8 to 8 and the electrical conductivity varies from 0.3 to 1.5 dS m^{-1}.

The data regarding cropping practices such as varieties grown, crop duration, planting time, irrigation and other agronomic practices were collected by conducting field survey in the Wafra region of Kuwait, during October 2005 to March 2006 cropping period.

Crop coefficients of maize

The duration of crop growth stages along with crop coefficient (Kc) as given by Allen *et al* 1998 are presented in Table 1. The reference crop evapotranspiration (ETo), crop water requirement (ETc), irrigation requirement (IR), net irrigation

requirement (NIR), the effective rainfall (ER) and the irrigation schedule (IS) of maize (Tables 2 to 4) were estimated following the FAO Penman-Monteith method using the CROPWAT decision support system. Irrigation requirement (IR) is the amount of water that the irrigation system must provide to the crop root zone to meet the crop evapotranspiration and is estimated as the difference between ETc and effective rainfall (ER). Effective rainfall is that part of the total rainfall that forms the part of ETc and is measured by USDA method (Allen et.al. 1998). As in CROPWAT, net irrigation requirement is the irrigation depth applied and no kind of losses were accounted. Irrigation schedule involves information regarding the quantity of water to be applied along with time and frequency of application. Time of irrigation was taken as time at which 50 percent depletion of readily available soil moisture occurs. The quantity of irrigation water applied at each irrigation was enough to restore the soil moisture level, to field capacity.

Nine planting dates from 15th October to 5th January (Table 4) at an interval of 10 days were chosen to estimate the ETo, ETc, IR and NIR. This season was selected for the study since this is the main planting season suitable for agricultural activities in Kuwait. The development of irrigation schedule is based on a daily soil-water balance following methodologies presented in FAO Irrigation and Drainage Papers No. 56 (Allen *et al.* 1998).

RESULTS AND DISCUSSION

Maize evapotranspiration (ETc)

The ETc of maize, calculated by FAO CROPWAT method (Tables 2 to 4) varied with planting dates and crop durations. Between planting dates from 5th October to 5th January, the ETc varied from 210 mm (5th November planting) to 323 mm (5th January planting) for a 90-day crop. The ETc of a 110-day crop varied from 273 mm (5th November planting) to 470 mm (5th January planting). As the planting dates got delayed beyond 15th November, the ETc goes on increasing. This pattern of change in ETc in relation to planting dates was consistent with the crops of all durations. The ETo values were low during December to January and increased there after. The crop with planting date 5th January enjoys the period with low ETo and as such the ETc values were also low. The values of seasonal water use of maize as influenced by planting dates and crop durations, varied from 210 to 470 mm.

Maize irrigation requirements

As in the case of ETc, the irrigation requirements also varied with the planting dates. They were low with the crop planted on 5th November and the highest with 5th January planting (Tables 2 to 4). For the 5th

Table 1: Crop data

Particulars	Initial	Development	Mid	Late	Total duration (d)
Growth stages (days)	20	20	20	30	90
	20	25	25	30	100
	25	25	30	30	110
Crop coefficients (Kc)	0.30	1.20	1.20	0.50	
Rooting depth (m)	0.30	0.30	1.10	1.10	
Depletion levels (P)	0.50	0.50	0.50	0.80	
Yield factors (Ky)	0.40	0.40	1.30	1.50	

Table 2 : ETo, ETc, IR and NIR of maize (90 days)

Date of planting	Eto mm/period	ETc mm/period	Rainfall mm/period		IR mm/period	NIR mm/period
			TR	ER		
15th October	362	254	70	67	187	177
25th October	323	228	81	77	152	140
5th November	292	210	89	84	126	123
15th November	287	211	88	83	129	127
25th November	282	215	87	82	137	114
5th December	291	228	83	79	155	149
15th December	320	254	76	73	187	173
25th December	349	285	70	67	224	206
5th January	390	323	62	59	270	267

Table 3 : ETo, ETc, IR and NIR of maize (100 days)

Date of planting	Eto mm/period	ETc mm/period	Rainfall mm/period		IR mm/period	NIR mm/period
			TR	ER		
15th October	389	277	82	78	199	169
25th October	351	254	92	87	167	163
5th November	330	244	93	89	155	151
15th November	325	247	92	88	159	164
25th November	328	258	91	87	174	173
5th December	348	281	88	84	203	179
15th December	377	311	82	78	239	228
25th December	412	348	74	71	283	255
5th January	468	398	66	63	341	333

Table 4 : ETo, ETc, IR and NIR of maize (110 days)

Date of planting	Eto mm/period	ETc mm/period	Rainfall mm/period		IR mm/period	NIR mm/period
			TR	ER		
15th October	418	292	93	88	203	187
25th October	390	277	96	92	185	190
5th November	368	273	98	93	179	190
15th November	371	284	97	92	194	178
25th November	385	305	96	92	219	201
5th December	404	332	93	89	259	224
15th December	440	370	86	82	295	280
25th December	491	417	78	75	349	354
5th January	547	470	69	67	411	408

ETo = Reference crop Evaporation - mm
ETc = Crop Water Requirement - mm
TR = Total Rain fall - mm
IR = Irrigation Requirement - mm
NIR = Net Irrigation Requirement -mm
ER = Effective Rainfall - mm

Table 5 : Irrigation schedule for maize (90 days) : planting date - 5th November

Date of irrigation	Irrigation interval (days)	NIR (mm)
19/11	14	13.7
9/12	20	24.1
19/12	10	26.2
29/12	10	27.5
14/1	16	31.1
3/2	20	Date of harvest
Total	90	122.6

Table 6 : Irrigation scheduling for maize (100 days): planting date - 5th November

Date of irrigation	Irrigation interval (days)	NIR (mm)
19/11	14	13.7
9/12	20	20.9
22/12	13	27.1
3/1	12	25.8
15/1	12	27.7
3/2	19	35.8
13/2	10	Date of harvest
Total	100	150.9

Table 7 : Irrigation scheduling for maize (110 days): planting date - 5th November

Date of irrigation	Irrigation interval (days)	NIR (mm)
18/11	13	12.4
19/12	31	25.3
29/12	10	26.5
10/1	12	28.0
20/1	10	27.2
2/2	13	32.6
17/2	15	37.9
23/2	6	Date of harvest
Total	110	189.8

Note : For calculating irrigation schedules, the initial soil moisture depletion level was taken as zero.
Application time: Irrigate when 50 percent of readily available moisture depletion occurs
Application depth: Refill to 100 percent readily available soil moisture
Date of start of scheduling: 5/11
Net irrigation requirements: The irrigation depth applied and no kind of losses are taken into account in the calculation

November planting, the IR and NIR were 126 and 123mm respectively for a 90-day crop. The total rainfall during this cropping period was 89 mm of which 84 mm formed effective. But, in the case of 5th January planting, the IR and NIR were 270 mm and 267 mm respectively for the 90-day duration. Here, the contribution of rainfall to ETc was less (59 mm), and the 5th January planting completes its lifecycle only by 5th April. The ETo values of February and March are relatively high. Thus the decreased quantity of effective rainfall coupled with the increased ETo during the crop period resulted in an increased ET demand and thus irrigation requirements. It is clear that the maize planted on 5th November gained the best advantage of rainfall as well as the cool season. As in the case of ETc, the irrigation water requirement was also low with the 90-day crop and high with the 110-day crop.

Irrigation scheduling

An attempt was made to develop irrigation schedules for the planting date with the lowest water demand (5th November) for maize of duration 90, 100 and 110 days (Table 5 to 7). A 90day crop planted around 5th November requires 5 irrigations at an interval ranging from 10 to 16 days; in total, 123 mm of water per season as net irrigation (Table 5). Similarly, a 110 day crop requires 7 irrigations at an interval of 10 to 31 days with a total water requirement of 190mm per season (Table 7). The maize culture in Kuwait is for grain

production, and used as sweet corn as well as fodder. The results of the present study will enable the growers to rationalize maize irrigation on scientific lines and to economise water use.

CONCLUSIONS

From the present study it is clear that evapo-transpiration demands of maize differ considerably between the planting dates from 15th October to 5th January. ET demand of maize was the lowest with planting dates 5th November and the highest with 5th January. Depending on planting dates and crop duration, the seasonal ETc of maize varies from 210mm to 470 mm. A planting window from October 25 to December 5 is considered ideal for planting maize in Kuwait.

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