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CONSUMPTIVE USE OF WATER FOR POTATO

M. Tahir Rashid and Bashir Ahmad*

N.A.R.C., Pakistan Agricultural Research Council, P.O., N.I.H. Islamabad

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Cordinal variety of potato was planted on ridges during three years of experimentation. Actual consumptive use (EtA) of water worked out by gravimetric method was 388, 365, 333 and 288 mm, respectively, and the values by irrigation method were 397, 389, 342 and 289 mm for 40, 55, 70 and 85 % depletion levels respectively.

Maximum tuber yield 19.47 tons ha^{-1} was observed under 40 % depletion level, followed by 17.45, 14.29 and 11.58 tons ha^{-1} respectively for 55, 70 and 85 % depletion of available moisture. Pan evaporation values were higher than EtP during initial stages of crop growth, then EtP exceeded for some time and Pan evaporation values were higher than EtP at the end of the season. The moisture depletion of 40 % was found to be the best level regarding EtA, tuber yield and crop water use efficiency for successfull potato production.

Key words: Potato, EtA, Consumptive use of water.

INTRODUCTION

Potato is one of the world leading food and vegetable crops and is also a cheap source of nutrients rich food. It has attained great importance and the area under crop has increased from 3000 hectares in 1947-48 to adoptability and is being commercially grown under varying agro-metereological conditions. Potato crop requires sufficient water at regular intervals, generally after 7-10 days [1], but irrigation requirements for this crop should be calculated according to the present water resources which are limited as compared to cultivable land.

Considerable work has been done for calculation of consumptive use of water throughout the world. Irrigation water requirements basically depends upon environmental factors such as transpiration, evaporation, solar radiation, minimum and maximum air temperature rainfall and wind velocity [2]. Among all these factors crop transpiration plays an important role and rates of transpiration are controlled by atmospheric demands and area of transpiring crop surfaces as long as water supply is not limited [3]. Govandhari [4] through his lysimeteric studies showed that 80% field capacity [5,6,7]. Poored that increasing rate of nitrogen increased the potato yield regardless of the moisture level. Potato irrigated at commulative evaporation of 25mm proved to the best water level for highest water use efficiency and tuber yield, [8]. Tuber yield increased with water applied upto 70% estimated evapotranspiration (Et) [9]. Han and Pamphrey [10] found that yield and quality of potato was increased as water use increased from 300-600 mm. They further reported that evapotranspiration increased rapidly from emergance until early tuber bulking and then declined gradually. Precise irrigation water management is important to ensure higher tuber yields through economic water use. Keeping in view the importance of this research, experimental work was carried out at MONA Reclamation Experimental Project Bhalwal Distt Sargodha with the collaboration of PARC, for three years.

*Mona Reclamation Experimental Project, WAPDA, Bhalwal.

MATERIALS AND METHODS

The research site was 30 km North east of Bhawal town distt. Sargodha where the ground water table has been recorded to be more than 5 meters. Soil was medium textured, non saline and non sodic (Table 1). Soil available moisture depletion levels tested were 40, 55, 70 and 85%. Two fertilizer levels were tested under all depletion levels.

F_1 = 75 – 50 – 50 kg NPK/ha

F_2 = 150 – 100 – 100 kg NPK/ha

Plots size was 13.12 x 12.19 m (1/60 of hectare) and field was divided into 24 plots. Complete factorial design was followed. Cardinal variety of potato was sown on ridges by using seed rate 3200 kg/ha and field was irrigated just after sowing. A second irrigation was also common to facilitate the germination.

Moisture determination was done by soil sampling from ridge side from the point up to which the soil directly wetted. Soil samples from each depletion treatment were

Table 1. Physico-chemical analysis of experimental site.

Depth	Physical analysis						
	Mechanical analysis			Textural class	Field capacity	Wilting point	Bulk density
	Sand %	Silt %	Clay %				
0 – 15	15	22	23	Sandy clay	15	7.73	1.64
15 – 30	56	22	22	Loam	15	7.88	1.77
30 – 60	53	22	25		15	7.44	1.80
60 – 90	55	22	25		14.5	7.22	1.65
90 – 120	54	25	21		14	7.18	1.63
120 – 150	55	20	25		15	7.65	1.78

Depth	Chemical analysis				
	Salinity	Sodicity	Fertility		
			Total %	Av-P(ppm)	Av–K (ppm)
0 – 15	1.25	1.78	0.045	10.18	55
15 – 30	1.40	1.95	0.041	10.00	57
30 – 60	1.20	1.90			
60 – 90	0.98	2.00			
90 – 120	1.10	1.68			
120 – 150	1.20	1.74			

taken as close as possible before and after irrigation. After each rain exceeding 13 mm soil moisture contents were estimated by taking samples from different depths such as 0 - 15, 15 - 30, 30 - 60, 60 - 90, 90- 120 and 120 - 150 cms respectively.

Soil samples were composited and moisture was calculated on dry weight basis after drying at 105^{o} to a constant weight.

Each plot was irrigated at the time of proper depletion level of available moisture. The irrigation water requirement was calculated in time and good quality water used was controlled by cut throat flume fitted in the channal.

Consumptive use was calculated by two methods:-

1. Gravimetric method
2. Irrigation method

Gravimetrically computed consumptive use was calculated by using the equation.

CuWg = WL + Pe + Er + Et

CuWg – Consumptive use of water by gravimetric method.

WL – Water loss between sampling.

Pe – Pan evaporation

Er – Effective rainfall

Et – Evapotranspiration estimated from soil moisture graphs for the days not otherwise accounted for.

Consumptive use estimated by irrigation method was calculated as follows:

CUW_1 = Td + Er + Md

Where Td – Total delta of water applied

Er – Effective rainfall

Md – Moisture content difference at sowing and harvesting time.

Evapotranspiration was calculated by using the Jensen & Haise equation (1963).

ETP= Ct (T – Tx) Rs

ETP= Potential evapotransporation in mm/day

Ct = Temperature coefficient

Tx = Constant co-relating solar radiation and air temperature

T = Mean daily temperature

Rs = Daily solar radiation.

Crop yield was recorded on whole plot basis and the data was statistically analysed by using the factorial design.

RESULTS AND DISCUSSION

Consumptive use. Consumptive use of water for potato crop was computed by irrigation and gravimetric methods. (Table 2). Consumptive use was found 388, 365, 333 and 288 mm respectively when irrigations were provided on depletion levels of 40, 55, 70 and 85 percent depletion of available moisture in 15 cm surface soil depth as determined by gravimetric method. The consumptive use decreased by 23, 55 and 100 mm respectively when depletion levels were raised from 40% to 50, 70 and 85%.

Consumptive use determined by irrigation method were 397, 389, 342 and 289 mm at 40, 55, 70 and 85% depletion of available moisture respectively. Decrease in consumptive use was 8, 55 and 108 mm when available moisutre depletion levels were raised to 55, 70 and 80% respectively. The schedule of irrigation and effective rainfall is given in (Table 2).

Actual evapotranspiration, potential evapotranspiration and pan evaporation. The daily rates of actual evapotranspiration (EtA) potential evapotranspiration (EtP) are shown in Figs. 1 and 2. The data revealed that EtA was

Table 2. Consumptive use of water for potato by irrigation and gravimetric methods.

Source	Depletion of available moisture (consumptive use in mm)			
	$M_1$40%	$M_2$55%	$M_3$70%	$M_4$85%
Irrigation method	397.0	389.0	342.0	289.0
Gravimetric method	388.0	365.0	333.0	288.0

Delta of irrigation and effective rainfall.

Year	Total irrigation (mm)				Effective
	M_1	M_2	M_3	M_4	rainfall (mm)
1982-83	368	336	202	288	45.4
1983-84	375	353	322	308	13.0
1984-85	453	404	392	315	47.0
Total	1196	1090	1006	911	105.4
Ave.	398.66	364.33	335.33	303.66	35.1

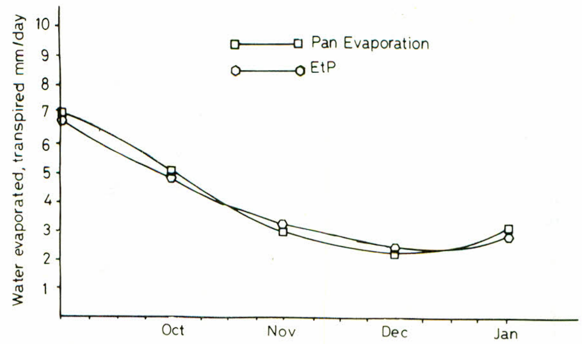

Fig. 1. EtP and Pan evaporation during growing season.

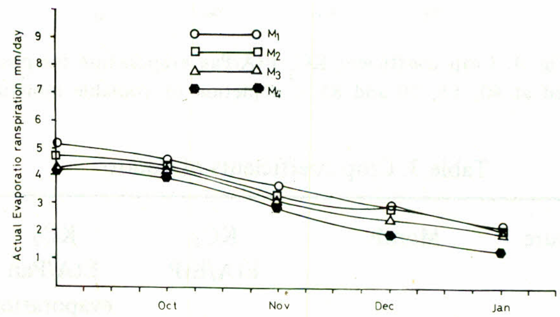

Fig. 2. Actual evapotranspiration for potato irrigated at 40, 55, 70 and 85 % depletions of available moisture.

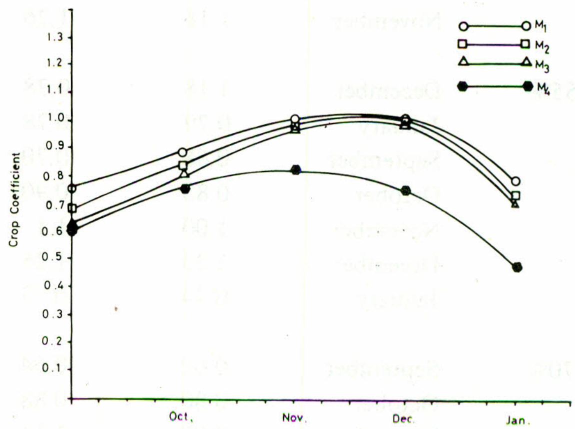

Fig. 3. Crop coefficient KC_1 EtA/EtP for potato irrigated at 40, 55, 70 and 85% depletion of available, moisture.

lower than EtP and panevaporation until the plant cover was increased. Pan evaporation was higher during initial stages of crop growth but as the crop covered the soil surface at its maximum growth stage the evapotranspiration exceeded the pan evaporation. On later stages panevaporation increased from the evapotranspiration till crop harvest.

Crop coefficients. Crop coefficients calculated by (i) EtA/EtP and (ii) EtA/Pan evaporation are reported in Table 3 and illustrated graphically in Figs 3 & 4. Crop coefficient values by EtA/EtP method for M1, M2, M3

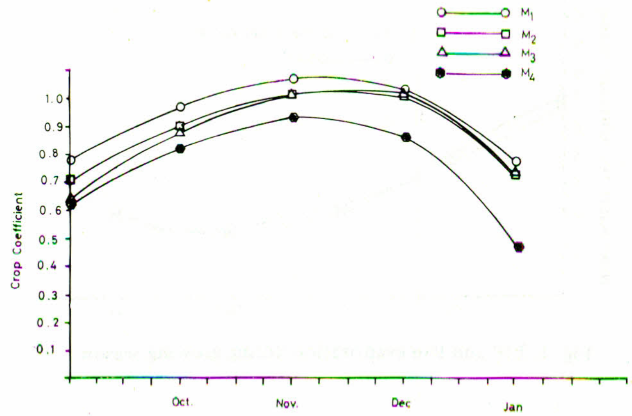

Fig. 4. Crop coefficient KC_2 EtA/Pan evaporation for potato irrigated at 40, 55, 70 and 85 % depletion of available moisture.

Table 3. Crop coefficients of potato

Moisture level	Month	KC_1 EtA/EtP	KC_2 EtA/Pan evaporation
M_1 40%	September	0.75	0.77
	October	0.87	0.97
	November	1.16	1.26
M_2 55%	December	1.18	0.78
	January	0.79	0.78
	September	0.68	0.70
	October	0.83	0.90
	November	1.00	1.1
	December	1.23	1.25
	January	0.74	0.73
M_3 70%	September	0.62	0.64
	October	0.80	0.88
	November	0.97	1.11
	December	0.99	1.10
	January	0.71	0.73
M_4 85%	September	0.61	0.60
	October	0.70	0.78
	November	0.85	0.95
	December	0.75	0.86
	January	0.49	0.47

and M4 were 0.75, 0.68, 0.62 and 0.61 respectively during September which increased upto 1.18, 1.23, 0.99 and 0.75 respectivey for all moisture levels during December. Crop coefficient then decreased to 0.79, 0.74, 0.71 and 0.49

Table 4. Yield of potato tubers

Treatments	Yield tons ha^{-1}			
	M_1	M_2	M_3	M_4
F_1 (75-50-50)NPK kg ha^{-1}	17.94	16.13	12.81	10.53
F_2 (150-75-75 NPK kg ha^{-1}	21.80	18.77	15.78	12.63
Average)	19.47	17.45	14.29	11.58
ANOVA				
	19.47	17.45	14.3	11.67
	a	b	c	d
	F_1 = 14.35		F_2 = 17.1	
	b		a	

LSD 5% Moisture = 3.00
LSD 5% Fertilizer = 1.71

respectively for all moisture levels at harvest during January Crop coefficient values calculated by EtA/Pan evaporation for 40, 55, 70 and 85% depletion of available moisture were 0.77, 0.70, 0.64 and 0.60 during September which were then raised upto 1.28, 1.25, 1.11 and 0.95 respectively in December for M1 and M2 and November for M3 and M4. While compairing the two crop coefficient values the ratios in initial stages were more than that of later stages of crop growth with EtA/Pan evaporation as compared to EtA/EtP.

Crop yield. The tuber yield for different moisture and fertilizer treatments is depicted in Table 4. Maximum yield of 19.47 tons/ha was obtained at 40% depletion level followed by 17.45, 14.29 and 11.58 tons/ha at 55, 70 and 85% depletion level, respectively. The yield decreased significantly when the depletion of available moisture was raised from 55%. These results show that water increase from 288 mm to 388 mm during growing season increased the tuber yield, and are in line with the results obtained by Hane and Pumphrey [10].

The data clearly show pronounced effect of fertilizer, regardless of moisture levels. Increased fertilizer also increased the tuber yield under all moisture treatments. Mould and Ruther Foord [5], Pahuja and Sherma [6], Pandey and Kirtisingh [7], also presented similar results.

Table 5. Crop water use efficiency of potato.

Treatments	Tons ha^{-1}				EtA(mm)				ECWU Kg mm^{-1}			
Moisture	M_1	M2	M_3	M_4	M_1	M_2	M_3	M_4	M_1	M_2	M_3	M4
F_1	17.9	16.1	12.8	10.5	388	365	333	288	46.2	442.	38.5	36.6
F_2	21.0	18.7	15.8	12.6	388	365	333	288	54.1	51.4	47.4	43.9
Average	19.47	17.45	14.29	11.58	388	365	333	288	50.18	47.80	42.94	41.20

Crop water use efficiency. The data for crop water use efficiency are presented in Table 5. Highest value of 50.18 kg/mm was recorded under M1 followed by 47.80, 42.94 and 41.20 for M2, M3 and M4, respectively. It is very clear from data that in terms of efficient use of water, depletion of available moisture up to 40% was desirable. The results are very close to those given by Govandhari [4], who reported that irrigation at 80% field capacity gave highest yield followed by 50% field capacity.

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