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Consumptive Use of Water and NP Doses on Grain Yield of Maize

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Three moisture levels viz. 70, 80 and 90% soil moisture depletion (SMD) and two NP levels i.e. 75-50 and 150-75 kg ha^{-1} were studied for maize crop. Irrigation water was computed by gravimetric measurement and irrigation method applied. The consumptive use of water (551 mm) gave the highest grain yield of 4.66 tons ha^{-1} when irrigated at 80% SMD with high fertility level i.e. 150-75 kg ha^{-1}. Grain yield was significantly affected by soil moisture and fertility levels. The highest water use efficiency (ECWU) was 8.45 kg mm^{-1} when crop was irrigated at 80% SMD. The average evapotranspiration per day (Eta day^{-1}) for the whole growing season was 4.93, 4.34 and 3.87 mm at 70, 80 and 90% SMD, respectively.

Key words: Irrigation, Fertilizer, Maize,

Introduction

Water and fertilizer are vital but necessary inputs in irrigated farming. Presently, large guantities of water are lost during conveyance to fields and field applications. Horning (1972) reported a 10% water loss during conveyance and another 20% during field applications under the best management. Under fair and poor management 20% to 50% of water is lost in conveyance and 40% to 60% during field applications. Ahmed and Ahmed (1971) reported that with the rise of water table in many areas in Pakistan, irrigation schedule for different crops may have to be adjusted according to the depth of sub-soil water.

Adverse effects of short availability of water on crop plants have been reported by Terry *et al* (1983). Water stress prohibits leaf expansion. The deficiency of major nutrients i.e. NP leads to stunted growth and consequently low yield of any crop.

The improper use of chemical fertilizers and irrigation without considering the consumptive use of water is common practice in Pakistan agriculture. This study was conducted at the Experimental Farm of Sindh Agriculture University Tandojam. The objectives were to determine the water requirements at various soil moisture stresses for saving irrigation water through timely application, to determine the relationship between fertility and soil moisture and lastly to use evapotranspiration to schedule irrigations.

Materials and Methods

The soil of the experimental land was clay loam down to 120 cm and sandy clay loam below 120 cm depth. The water table was below 6 m, leaving no chance for the crops to make use of ground water. Three soil moisture depletion levels viz. 70, 80 and 90% in combination with two fertility doses, 75-50 and 150-75 kg NP ha^{-1} were applied with four repeats having individual plot size 9.5 x 6.5m. Potassium (K) was at 30 kg ha^{-1} for all treatments. Akbar variety of maize was used. Nitrogen was applied in two doses, half of N and full dose of P and K were applied at the time of seed bed preparation, while the remaining half of N was applied at the time of first irrigation.

Irrigations were applied at the soil moisture depletion of 70, 80 and 90% on the basis of moisture contents in the top 30 cm depth. This corresponds to 15.12, 13.60 and 12.07% available moisture on dry-weight basis. The depth of irrigation water applied to each treatment was calculated from pre-irrigation soil moisture contents in the effective root zone (0-150 cm soil depth). Each irrigation restored the moisture level of soil down to 150 cm depth to field capacity mainly to avoid loss of water through leaching. The moisture status of the soil was monitored by taking samples before and after every irrigation down to a depth of 150 cm i.e. from 0-15, 15-30, 30-60, 60-90, 90-120 and 120-150 cm. The quantity of each irrigation applied was calculated on the basis of moisture deficit of the soil as indicated by pre-irrigation soil sampling, using cut-throat flume (10.2x91.4 cm size). The quantity of water applied was calculated according to the following relationship:-

$$t = \frac{dxa}{q}$$

where t = time required to irrigate (in hours)

d = depth of water to be applied (in cms)

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a = area of plot (in ha)
q = discharge of water (in lit sec^{-1})

Consumptive Use Computations. The consumptive use of water for maize was determined by two independent methods. First, using gravimetric measurements of soil moisture depletion consumptive use was calculated by adding the water loss determined by soil sampling after and before each irrigation and rainfall (assuming all rainfall effective). Second, using irrigation measurements, the estimation of consumptive use for each moisture stress was made by adding the total quantity of irrigation to the rainfall received during the growth period of crop and the difference in soil moisture content at sowing and harvest time.

Crop Coefficients. Crop coefficients (Kc) estimates for different periods were calculated using the data of actual evapotranspiration (Eta) and pan evaporation (Epan) for the particular growth period using the following relationship (Anon 1982):

$$Kc = \frac{Eta}{Epan}$$

Where Kc = crop coefficeint for a specified crop for a particular growing period

Eta = actual crop evapotranspiration for a specific crop for a particular period (in mm day^{-1})

Epan = open pan evaporation for specific period (in mm day^{-1}).

Table 1
Average evapotranspiration (Eta) value for maize crop from soil moisture data (by gravimetric measurement)

Period	Eta (mm)		
	70%SMD	80%SMD	90%SMD
1. Sowing to first irrigation	110	122	138
2. Interval between first and second irrigation.	131	140	130
3. Interval between second and third irrigation	135	144	—
4. Interval between third and last irrigation.	121	—	—
5. Last irrigation to harvest	130	145	175
Total	627	551	495
Eta day^{-1} (mm)	4.93	4.34	3.89

SMD, Soil moisture depletion.

Results and Discussion

The average consumptive use of water by gravimetric measurement is given in Table 1. The results indicate that average total consumptive use of water by maize was 627, 551 and 495 mm at 70, 80 and 90% soil moisture depletion, respectively. Average total consumptive use values (Table 2) based on the irrigation method was almost same as that of gravimetric measurements. These results are in agreement with Ali *et al* (1973), Melhotra *et al* (1977), Arshad (1978) and Haider (1978).

The consumptive use (Eta) decreased as the moisture stress increased from 70 to 90% and consequently the number of irrigations decreased with the increase in moisture stress Table 3). The Eta rates per day were low at early stage of the crop as well as at maturity. At early and late stages of growth of maize, the Eta was lower which could be expected because at early stages the plants are small and the crop cover is incomplete. Similarly, near maturity, the plants dry up and transpire less water because the main source of water loss during these stages is through evaporation. The Kc values were between 0.35 to 0.91. The growth season average of Kc at all moisture levels was 0.64 (Table 3).

The analysis of variance as presented in Table 4 shows that moisture and fertility levels were effective in increasing grain yield ($P> 0.01$). Moisture and fertility interactions were also significant ($P> 0.05$) which indicated a consistency in performance of each soil moisture level across different fertilizer treatments.

The yield obtained under different moisture and fertility treatments (Table 5) indicates that the highest grain yield was 4665 kg ha^{-1} when the irrigation was applied at 80% soil moisture depletion (551mm) with high fertility level (150-75 kg NP ha^{-1}). The lowest yield of 3510 kg ha^{-1} was recorded at 90% soil moisture depletion (495 mm) with low fertility level (75-50 kg NP ha^{-1}). These

Table 2
Average Eta values for maize crop from irrigation data (by irrigation method)

Source	Eta (mm)		
	70%SMD	80%SMD	90%SMD
1. Irrigations	513	433	361
2. Rainfall	097	097	097
3. Difference at sowing and harvesting	020	025	041
Total	630	555	499

SMD, soil moisture depletion.

Table 3
Crop coefficient values (Kc = Eta/Epan for maize crop) from sowing to harvest period

Moisture levels	Period	Days	Kc
7% SMD	1. Sowing to first irrigation	28	0.35
	2. Interval between 1st and 2nd irrigation	22	0.69
	3. Interval between 2nd and 3rd irrigation	20	0.84
	4. Interval between 3rd and last irrigation	18	0.91
	5. Last Irrigation to harverst	40	0.75
80% SMD	1. Sowing to 1st irrigation	36	0.36
	2. Interval between 1st and 2nd irrigation	26	0.68
	3. Interval between 2nd and 3rd irrigation	26	0.86
	4. Last irrigation to harvest	40	0.74
90% SMD	1. Sowing to 1st irrigation	40	0.35
	2. Interval between 1st and last irrigation	35	0.68
	3. Last irrigation to harvest	53	0.62
	Average	Kc	0.64

results are in agreement with Arshad (1978) and Haider (1978).

The results indicated that the amount of water used by the crop during the growing season can be reduced without any significant reduction in yield. However, if the stress is too much, the yield must suffer. Under low fertilizer conditions the average grain yield in all the three moisture treatments was 3947 kg ha^{-1} as compared to 4257 kg ha^{-1} obtained at high fertility treatment with a difference of 310 kg ha^{-1}.

The objective of consumptive use data is to provide crop coefficients using weather record for irrigation scheduling. This will help to determine the amount and frequency of irrigation for crop requirements, saving water and labour. The growth stage of a crop has considerable influence on its consumptive use rate. This is particularily true for annual crops e.g. maize, which generally has three distinct stages of growth. These are: i) emergence and development of complete vegetative cover during which consumptive use rate increases rapidly from a low value and approaches its maximum ii) the period of maximum vegetative cover during which the consumptive use rate may be maximum if sufficient soil moisture is available and iii) crop maturation stage when for most crops the consumptive use rate begins to decrease.

Table-4
Analysis of variance for grain yield of maize

Source of variation	DF	SS	MS	F-Value	Remark
Moisture	2	4640.35	2320.1	577.20	**
Fertility	1	310.27	310.27	77.18	**
MxF	2	40.89	20.45	5.09	*
Error	15	60.30	4.02	—	

Significant at 0.05 (*) and 0.01 (**) levels.

Table 5
Grain yield (kg ha^{-1}), estimated evaportranspiration (Eta) by gravimetric measurement and crop water use efficiency (ECWU)

Fertility levels (NP kg ha^{-1})	Grain yield (kg ha^{-1}) SMD			Eta SMD			ECUW (mm day^{-1}) SMD		
	70%	80%	90%	70%	80%	90%	70%	80%	90%
75-50	3995	4335	3510	627	551	495	6.44	7.89	7.08
150-75	4420	4665	3685	627	551	495	7.08	8.45	7.16
Mean	4207	4510	3547	627	551	495	6.76	8.17	7.16

SE, standard error of means, SE Moisture = 0.236 SE Fertility = 0.354 SE MxF = 0.7
Lsdi, least significant differences at 0.05 level, Lsdi = 0.87 Lsdi = 1.61
Lsdii, least significant differences at 0.01 level, Lsdii = 1.50 Lsdii = 3.07

References

Ahmed S, Ahmed R 1971 Water requirement of wheat soil with varying water table depths under arid conditions. In: *Proceeding of Wheat Producing Seminar,* Lahore, Pakistan, p 117.

Ali M S, Hussain M A, Asghar M, Hussain G 1973 Studies on consumptive use of water by crops. *Bull IDFCR Council* **3** (2) 49-60.

Anonymous 1982 *Consumptive use of water for crops in Pakistan.* Final Technical Report, PARC, Islamabad. p18

Arshad A 1978 Efficient methods and system for utilization of irrigation water to maximize crop productivity. In: *Proceedings Soc FAO/SI Seminar on Field Crops in Africa and Near East,* pp 135-40.

Haidar G 1978 Conumptive use requirements for wheat, maize, cotton and sugarcane under optimum management conditions. In: *Proceeding Soc FAO/SIDA*, pp 141-145.

Horning G M 1972 *The role of effective irrigation water management at the farmers field.* Rep. FAO/UNDP, Damascus, Syria, December 7-13, 1971 pp 10-21.

Melhotra O N, Mahesh P, Singh G S 1977 Impact of investigation methods on the yield performance of wheat. *Indian J Agri Res* **11** 247-253.

Terry N L, Waldron J, Taylor S E 1983 Environmental influences on leaf expansion. In: *The Growth and Functioning of Leaves*, eds Milthrope J E, Camb Univ Press, Cambridge, UK, pp 179-295.