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Short Communication

Water Requirements of Qat (*Catha edulis*) Cultivation in the Central Highlands of Yemen

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Abstract

Water requirements of qat (*Catha edulis*) under irrigated and rainfed production systems in the central highlands in Yemen were studied during 2003 and 2004 at 6 sites. The crop evapotranspiration of qat was calculated by balancing method, where the sources of evapotranspiration were irrigation water and rainfall. The amounts of crop evapotranspiation of qat during winter months were less than other months of the year under both irrigated and rainfed conditions. The maximum daily evapotranspiration was 2.5 mm during summer season. The annual crop evapotranspiration for the irrigated qat in the Yemeni central highlands was 602.8 to 786.7 mm and 412.8 to 506.2 mm for the rainfed qat. The average annual crop evapotranspiration of qat for both production systems (irrigated and rainfed) was about 553.6 mm/year**.**

Keywords: Crop water requirement; Evapotranspiration; Qat; Central highlands; Yemen.

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1. Introduction

Qat belongs to the family *Celstraceae*. It is divided into two species: *Catha edulis* and *Catha spinosa*, the latter does not exist in Yemen. Qat is mainly chewed through grinding and squeezing the soft leaves and branches in one side of the mouth, then the extracted juice is absorbed to achieve stimulation. In some African countries, qat dry leaves are utilized as tea. The Red Indians used qat leaves as a medicine for some sexual disease.

Qat is chewed to achieve humor and many of chewers believe that qat is a source of energy and encourage the chewer to work hard. Qat chewing is a sociable occasion and be chewed a lot in marriage festivals and other occasions instead of alcohol that is consumed in the same occasions in most of the countries in the world.

Qat is a major agricultural crop that achieves a high return for the producers of this crop in Yemen. In the last few years, qat cultivated area has rapidly been increased, the

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growing rate of area planted by qat is estimated by 3.4% and according to the 2009 census, the area planted by qat occupied about 63.8% of the cash crop area , and about 11.3% of the total cultivated lands during 2009 [1]. From economic point of view, qat is estimated to contribute 41% of the total prices of agricultural products in Yemen [2].

This paper presents the actual water requirement of qat in some selected farms in Dhamar governorate which is located in the central highlands of Yemen.

2. Material and Methods

This study was carried out over two years (2003 and 2004) at 6 farms belonging to Dhammar Governorate as representative to the Central Highland which is located between 14^{o} and 15^{o} north latitude and between 43^{o} 30" and 44^{o} 50" east longitude, where is characterized by elevation ranges from 2000 – 2400 meter above sea level. The climate is generally mild summers and cold winters, where the average temperature in summer is between 20 and 28 ^{o}C, while falling in winter between -1 and -18 below ^{o}C during the night an early morning. Two of these farms were under irrigated and 4 were under rainfed production system. The soil texture of the studied fields was clay loam to sandy clay loam with bulk density ranging from 1.4 to 1.6 g/cm^{3}.

The irrigation water was added through the Parshall flume. The time required for irrigation water was recorded. The measurements covered also the area of the plots and the time required to fill each plot.

For estimation the moisture content and bulk density, soil samples were taken before irrigation and after 24-hour of irrigation from the depths (0 – 0.20, 0.20 - 0.40 and 0.40 - 0.60 m). As well as samples were taken by Auger intensity to estimate the bulk density. The moisture content (%) is calculated from the sample weight before and after drying as the following equation:

$$MC\% = \frac{W_2 - W_3}{W_3 - W_1} \, x \, 100$$

where:
W_1 = Weight of tin (g),
W_2 = Weight of moist soil + tin (g),
W_3 = Weight of dried soil + tin (g).

Samples of soil were collected to measure the soil moisture before and after each irrigation to estimate the amount of water stored after each irrigation and the time required to irrigate one ha throughout the whole year. The soil water content was followed every month of the year. By calculating the difference between the average of moisture content before and after each irrigation, the volume of each stored irrigation in the soil was estimated.

The actual crop evapotranspiration of qat was estimated by using the water balance equation as the following:

$$ETC = SW_{in} - SW_E + I_{rr.} + R_{ef}$$

where, ETC = actual crop evapotranspiration, SW_{in} (mm) = soil moisture at the beginning, SW_E = soil moisture at the end (mm), $I_{rr.}$ = amount of irrigation water (mm), $R_{ef\,=}$ effective rainfall. Calculations were made by using FAO CROPWAT software - equation of USDA soil conservation service.

The Genstat 5 software program was used for statistical analyses.

3. Results and Discussions

Tables 1 and 2 show the irrigation frequency for the two irrigated qat fields during the period of study, which shows that the numbers of irrigation in the Alqalah and Almashwaf sites for the year 2003 were 7 and 4, for the year 2004 were 6 and 2 respectively. These findings agree with the statement reported by Qassem [3]. The amount of applied water were 522, 323 mm during 2003 and 380, 170 mm during 2004 in the both fields respectively but the stored irrigation water in the root depth was 425, 273 for 2003 and 303, 136 mm during 2004 in Alqalah and Almashwaf respectively. The water requirements of qat are documented in other reports [4-7]. The application efficiency was around 80 - 92 % in both the fields that shows the irrigation efficiency was the highest in the studied field because of using the pipes for water conveyance and siphons for water application. These results also confirm the findings of A. Al-Thawr *et al.* [8].

Table 1. Applied irrigation water and application efficiency in the irrigated qat field in Alqalah.

Years	Date of irrigation	Irrigation water, mm		Application efficiency, %
		deilppA	derotS	
	06/05/2003	68	54	80
	14/06/2003	113	93	82
2003	29/05/2003	57	50	88
	15/09/2003	68	54	80
	30/09/2003	60	50	83
	09/10/2003	78	62	80
	28/11/2003	78	62	80
	10/02/2004	68	54	80
	17/03/2004	68	54	80
	13/06/2004	40	33	82
	02/08/2004	68	54	80
2004	17/10/2004	68	54	80
	23/10/2004	68	54	80

Table 2, Applied irrigation water and application efficiency in the irrigated qat field at Almashwaf.

Years	Date of irrigation	Irrigation water, mm		Application efficiency, %
		Applied	Stored	
2003	03/01/2003	74	68	92
	21/02/2003	70	59	84
	25/05/2003	94	78	83
	05/11/2003	85	68	80
2004	15/10/2004	85	68	80
	15/11/2004	85	68	80

The crop evapotranspiration of qat was calculated by balancing method, where the sources of evapotranspiration were irrigation water and rainfall. The amounts of daily crop evapotranspiation during the winter months were less than the other months of the year at the both irrigated and rainfed qat fields. The results obtained in this study show that the greatest values of daily crop evapotranspiration of qat in all the studied fields is between 2 - 2.5 mm during the months from July to September with the exception of a field Zawyat Alhalah, where the maximum rate of daily crop evapotranspiration has been recorded during August and September ranged from 2.4 to 2.8 mm / day, due to the high rate of rainfall during these months in this site (Table 4).

Tables 3 shows the average values for elements of crop evapotranspitation of qat for 2003-2004, where it was noted that the rainfall occupies about 47- 72% of the total crop evapotranspitation of irrigated qat at Alqalah and Almashwaf respectively, On the other hand, rainfall occupies 100% of the total crop evapotranspitation of rainfed qat.

Table 3. Average values for elements of actual evapoteranspiration during 2003-2004.

Elements	Irrigated qat		Rainfed qat			
	Alqalah	Almashwaf	Almashwaf	Gabal Aljamoh	Gabal Alothmani	Zawyat Alhalah
Initial soil moisture, mm	113.5	204.0	230.5	91.0	155.5	126.5
Soil moisture at the end, mm	142.5	191.5	253.0	66.0	112.0	105.0
Effective rainfall, mm	451.5	385.5	419.5	387.0	460.5	484.5
Applied irrigation water, mm	451.0	246.5	-	-	-	-
Stored irrigation water, mm	364.0	204.5	-	-	-	-
Crop evapotranspiration, mm	786.5	602.5	459.0	412.0	506.0	506

Usually at the beginning of the winter season, the farmers stop irrigation and make oppressive cutting of qat shrubs over the ground to protect it from the frost, for that the amount of evapotranspiration was decreased in the winter. The farmer have got 3-4

cutting qat and every each period of cutting consumes 1-2 irrigating depend of amount of rainfall.

The results of statistical analysis for the average of two years of study 2003 and 2004 shows that the actual average crop evapotranspiration (ETc) of qat (Table 4). The results obtained during the study indicate that the average crop evapotranspiration of irrigated qat ranged between 602.8 in the Almashwaf field to 786.7 mm/year in the Alqalah field, and the average crop evapotranspiration of rainfed qat ranges between 412.8 in Gabal Aljamoh to 506. 2 mm/year Gabal Alothmani and Zawyat Alhalah. Results of statistical analysis explained that the average annual crop evapotranspiration of qat in the all studied fields irrigated and rainfed was 553.6 mm/year, where the value of the standard deviation (SD) was 148.01, standard error of means (SE) 66.19, the coefficient of variation (C.V.) 26.73% and the value of t-test is 8.36 (Table 4).

Table 4. Average monthly evapotranspiration of qat in the different sites of study.

Month	Irrigated qat		Rainfed qat			
	Alqalah	Almashwaf	Almashwaf	Gabal Aljamoh	Gabal Alothmani	Zawyat Alhalah
Jun.	60.5	43.4	24.8	23.25	27.9	21.7
Feb.	54.6	40.6	22.4	21	28	19.6
Mar.	60.5	58.9	31	23.25	31	24.8
Apr.	60.0	57	54	34.5	30	27
May	62.0	63.55	62	46.5	58.9	37.2
Jun.	67.5	61.5	63	58.5	60	48
Jul.	77.5	60.45	46.5	60.45	77.5	49.6
Aug.	76.0	62	46.5	48.05	77.5	74.4
Sep.	75.0	49.5	36	37.5	51	84
Oct.	65.1	38.75	24.8	20.15	21.7	58.9
Nov.	63.0	33	24	19.5	21	30
Dec.	65.1	34.1	24.8	20.15	21.7	31
Total	786.7	602.8	459.8	412.8	506.2	506.2

Mean = 553.6; Standard deviation (SD) = 148.01; Standard error of mean (SE) = 66.19
Coefficient of variation (C.V.) = 26.73; t-test = 8.36

4. Conclusions

Irrigated qat gets 2 -7 irrigation water supply as a supplemental irrigation and depends on amounts of rainfall in the central highlands. The actual crop evapotranspiration of irrigated qat ranges between 602.8 to 786.7 mm per year while the evapotranspiration of qat under rainfed system is between 412.8 and 506.2 mm per year. The average actual crop evapotranspiration of qat is 553.6 mm/year. Qat is drought-tolerant and cannot resist extreme cold and frost conditions.

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