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Water balance studies in jack

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सार — वर्ष 1993 के दौरान, यू०ए०एस०, जी०के०वी०के०, बंगलौर में सिंचित तथा वर्षा पर आधारित कटहल के पेड़ों द्वारा वाष्पोत्सर्जित जल का इसमें अध्ययन किया गया है। प्रेक्षण की अवधि के दौरान वर्षा पर आधारित वृक्षों में 701.3 मि०मी० जल वाष्पोत्सर्जित किया तथा सिंचित वृक्षों ने 1054.3 मि०मी० जल वाष्पोत्सर्जित किया। दो मुख्य बढ़ोतरी अवस्थाओं, नामतः मार्च के अंतिम सप्ताह से मई का प्रथम सप्ताह तथा जून के तीसरे सप्ताह से अगस्त का प्रथम सप्ताह, के प्रेक्षण लिए गए। सभी वृक्षों में प्रथम बढ़ोतरी अवस्था के प्रेक्षण शुष्क अवधि में लिए गए। सिंचित वृक्षों के फल 20 से 30 दिन देर से तैयार हुए।

ABSTRACT. Water transpired by Jack grown under irrigated and rainfed situations at the University of Agricultural Sciences (UAS), Gandhi Krishi Vignana Kendra (GKVK), Bangalore during the year 1993 has been studied. Irrigated trees transpired 1054.3 mm of water and trees grown under rainfed condition transpired 701.3 mm of water during the period of observation. Two main growth flushes were observed, *viz.*, March last week to May first week and June third week to August first week. In all the trees the first growth flush was observed during the dryspell. The maturity of the fruit got delayed by 20-30 days in the case of irrigated trees.

Key words — Soil moisture, Rainfed, Irrigated, Transpire, Vegetative and fruit growth, Flush, Shoot length and girth.

1. Introduction

The present studies were carried out at the University of Agricultural Sciences, Gandhi Krishi Vignana Kendra (GKVK), Bangalore (Lat. 12° 58′ E. Long. 77° 30′ N and Alt. 930 m amsl) during the year 1993. Eight mature jack trees were chosen for the study, out of them, four trees were provided with irrigation. Observations on vegetative and reproductive growth of the trees were recorded on weekly intervals.

Soil moisture status of soil was studied on weekly basis using the potential evapotranspiration (PET) values calculated according to the modified Penman's (Doorenbos and Pruit 1977) formula following the method of Frere and Popov (1979).

Water holding capacity (WHC) of the soil, where the experiment was conducted, is considered as 135 mm for every 100 cm depth of the soil as it has been reported (Anonymus 1985) to lie between 130 and 140 mm, and the permanant wilting point (PWP) as 1/3 of WHC at its field capacity. Therefore, it is estimated that only 90 mm of water will be available (AWC) for every 100 cm depth of the soil for the plant. Considering the maximum root spread of the matured tree up to 500 cm deep (Bose 1985), the total water available to the plant at its root zone at the field capacity is obtained as 450 mm. It can be expressed as,

$$Sa_i = \frac{(S_i - S_w) \times D}{100} \qquad (1)$$

where,

S_i — Soil moisture at field capacity (mm),

S_w — Soil moisture at wilting point (mm) and

D — Normal rooting depth of the tree (500 cm).

2. Data and method

Using the recorded meteorological data from the Meteorological Observatory at this campus, PET has been computed. Maximum evapotranspiration by the trees has been computed using the equation,

$$ET_i = Kc_i \times \text{PET}_i \qquad (2)$$

where,

ET_i — Evapotranspiration by the tree during ith week,

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TABLE 1

Weekly water balance (mm) calculated for jack trees during 1993

Standard weeks	Weekly PET	Weekly rainfall *P*	Crop coeff. *Kc*	Weekly ET crop values ET	Water used by crop AET	Soil moisture storage *Si*	Surplus moisture *E*	Deficit in moisture *D*	*Si/Sai*	AET/PET
				Rainfed						
1	23.1	0.0	0.9	20.8	20.8	150.2	—	—	0.33	0.90
2	23.8	0.0	0.9	21.4	21.4	128.8	—	—	0.29	0.90
3	23.1	0.0	0.9	20.8	20.8	108.0	—	—	0.24	0.90
4	25.2	0.0	0.9	22.7	22.7	85.3	—	—	0.19	0.90
5	27.3	0.0	0.9	24.6	24.6	60.7	—	—	0.13	0.90
6	28.7	0.0	0.9	25.8	25.8	34.9	—	—	0.08	0.90
7	29.4	0.0	0.9	26.5	26.5	8.4	—	—	0.02	0.90
8	31.5	0.0	0.9	28.4	8.4	0.0	—	20.0	0.00	0.27
9	29.4	5.8	0.85	25.0	5.8	0.0	—	19.2	0.00	0.20
10	33.6	0.0	0.85	28.6	0.0	0.0	—	28.6	0.00	0.00
35	23.8	156.4	0.85	20.2	20.2	136.2	—	—	0.30	0.85
36	27.3	13.7	0.85	23.2	23.2	126.7	—	—	0.28	0.85
37	28.0	9.0	0.85	23.8	23.8	111.9	—	—	0.25	0.85
38	24.5	147.4	0.85	20.8	2.0	257.3	—	18.8	0.57	0.08
39	24.5	9.7	0.85	20.8	20.8	246.2	—	—	0.55	0.85
40	23.8	135.2	0.85	20.2	20.2	361.2	—	—	0.80	0.85
41	23.1	95.8	0.85	19.6	19.6	437.4	—	—	0.97	0.85
Total	1258.5	967.7		1080.3	701.3		0.0	378.9		
				Irrigated						
1	23.1	0.0	0.9	20.8	20.8	150.2	—	—	0.33	0.90
2	23.8	0.0	0.9	21.4	21.4	128.8	—	—	0.29	0.90
3	23.1	0.0	0.9	20.8	20.8	108.0	—	—	0.24	0.90
4	25.2	0.0	0.9	22.7	22.7	85.3	—	—	0.19	0.90
5	27.3	0.0	0.9	24.6	24.6	60.7	—	—	0.13	0.90
6	28.7	0.0	0.9	25.8	25.8	34.9	—	—	0.08	0.90
7	29.4	0.0	0.9	26.5	26.5	8.4	—	—	0.02	0.90
8	31.5	0.0	0.9	28.4	8.4	0.0	—	20.0	0.00	0.27
9	29.4	455.8	0.85	25.0	25.0	430.8	—	—	0.96	0.85
36	27.3	13.7	0.85	23.2	23.2	440.5	—	—	0.98	0.85
37	28.0	9.0	0.85	23.8	23.8	425.7	—	—	0.95	0.85
38	24.5	147.4	0.85	20.8	20.8	450.0	103.4	—	1.00	0.85
39	24.5	9.7	0.85	20.8	20.8	438.9	—	—	0.98	0.85
40	23.8	135.2	0.85	20.2	20.2	450.0	103.3	—	1.00	0.85
41	23.1	95.8	0.85	19.6	19.6	450.0	76.2	—	1.00	0.85
Total	1258.5	3667.7		1080.3	1054.8		356.4	20.0		

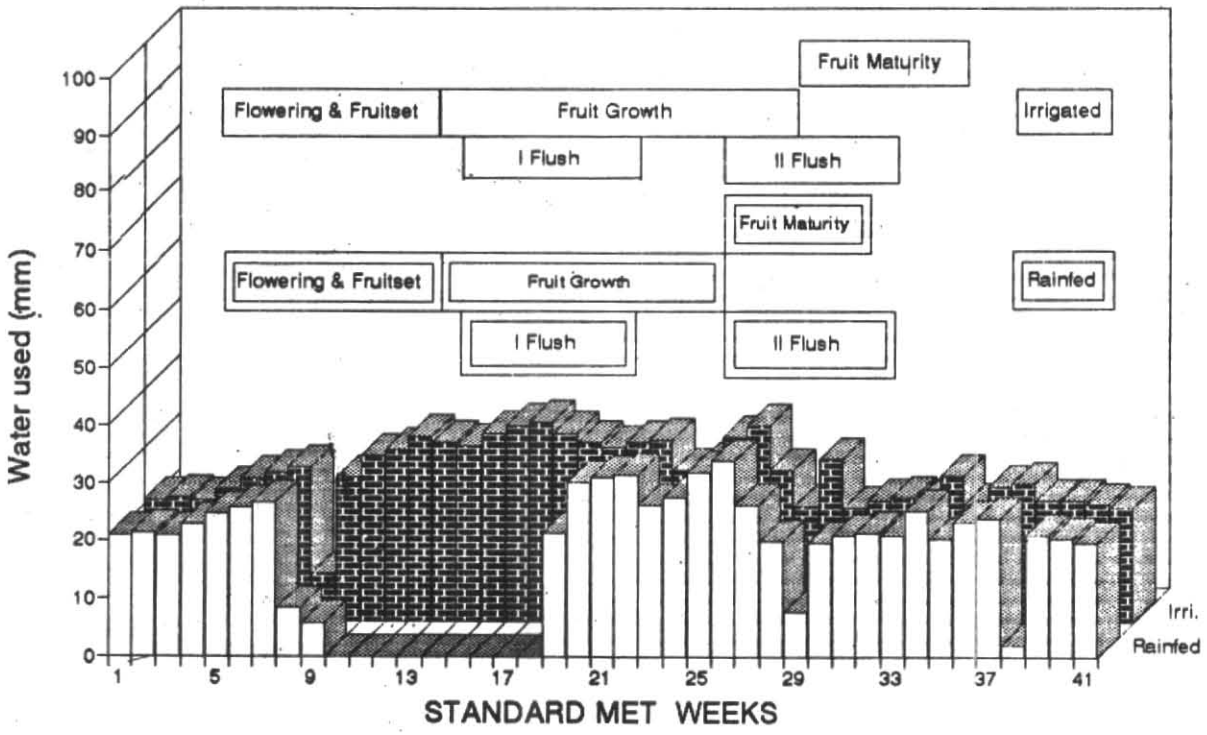

Fig. 1. Water used by jack trees in different conditions and phenological stages

Kc_i — Crop coefficient during ith week and

PET_i — Potential Evapotranspiration during ith week.

Kc_i values provided by Doorenbos and Pruit (1977) for citrus in different seasons of the year have been considered for the tree as the leaf structure and plant geometry are similer in both the plants.

Actual Evapotranspiration (AET) by the plant depending upon the availability of moisture in the soil has been indirectly calculated using the following procedure adopted by Frere and Popov (1979):

Soil water storage (mm) at the end of any week could be calculated using the equation

$$S_i = S_{i-1} + P_i - AET_i \quad (3)$$

where,

S_i = Water retained (mm) in the soil at the end of ith week,

S_{i-1} = Water available (mm) in the beginning of the ith week,

P_i = Precipitation and/or irrigation (mm) during the ith week,

and AET_i = Actual amount of water that plant has transpired during ith week into the atmosphere.

where,

$AET_i = ET_i$, when $S_{i-1} > ET_i$ and (4)

$AET_i < ET_i$, when $S_{i-1} < ET_i$ and (5)

$AET_i = 0$, when $S_{i-1} = 0$ (6)

In Table 1, the meteorological standard weeks, weekly PET, P, *Kc*, ET, AET and *Si* (above wilting point), surplus and deficit in soil moisture for the period of observation have been computed and presented (arbitrarily) for jack trees grown under irrigated and rainfed conditions.

3. Results and discussion

3.1. *Vegetative growth*

In Fig. 1 the water used by plants during the period of observation has been plotted both for

TABLE 2

Total water used (mm) by the plants in different physiological states of growth

Irrigated plants			Rainfed plants		
Stages	Water used	%	Stages	Water used	%
Flowering + Fruit set	203.8	24.3	Flowering + Fruit set	156.0	35.2
Fruit growth	186.1	22.2	Fruit growth + I Flush	114.0	25.2
Fruit growth + I Flush	194.4	23.2	Fruit maturity + II Flush	165.4	37.3
Fruit growth + II Flush	85.5	10.2	II Flush	7.6	1.8
Fruit maturity	62.2	7.4			
Fruit maturity + II Flush	107.6	12.7			
Total	839.6			443.0	

TABLE 3

Increase in shoot length and girth at 15 days' interval after initiation of first flush

Condition	Days after the initiation of the first flush															
	0	14	28	41	56	75	84	97	115	126	140	154	168	179	195	209
	Percent increase in shoot length															
Irrigated	0.69	2.3	7.8	6.7	3.0	2.8	6.3	4.5	3.0	1.10	1.50	1.40	3.60	3.1	2.8	2.3
Rainfed	0.42	1.4	6.8	4.7	2.2	2.8	4.9	4.1	2.5	0.84	0.87	0.86	1.07	1.3	1.1	1.2
	Percent increase in shoot girth															
Irrigated	2.40	3.7	6.6	7.8	3.9	1.4	6.3	2.9	1.9	2.00	4.80	2.20	3.30	2.5	2.3	1.9
Rainfed	2.70	4.2	7.4	4.4	2.4	1.8	3.6	2.2	2.2	4.10	1.90	2.10	2.20	2.1	1.6	1.6

irrigated and rainfed trees. The physiological stages attained by both rainfed and irrigated trees are also given. The amount of water used by plants and their percentage during different physiological stages is given in Table 2. Vegetative growth in jack occurred in growth flushes. Two distinct main growth flushes were observed, *viz.*, March last week to May first week and June third week to August first week. In all the trees the initiation of first growth flush occurred during dry period. This indicates that jack has adapted itself to the prevailing soil moisture status under rainfed condition. The tree stores some amount of water and utilises when there is no supply of moisture from the soil. However, the subsequent flushes coincided with heavy rainfall periods and high soil moisture status.

Under irrigated condition soil moisture status was maximum throughout the growth period. Matured trees were not influenced by the supplemental irrigation. From Table 2, it is evident that during the flowering and fruit setting period irrigated trees transpired maximum amount of water (24.3%) and trees grown under rainfed conditions transpired 35.2% of the total water transpired. Fruit growth period alone transpired 22.2% and shared 23.2% with I flush and 10.2% with II flush in irrigated and rainfed trees fruit

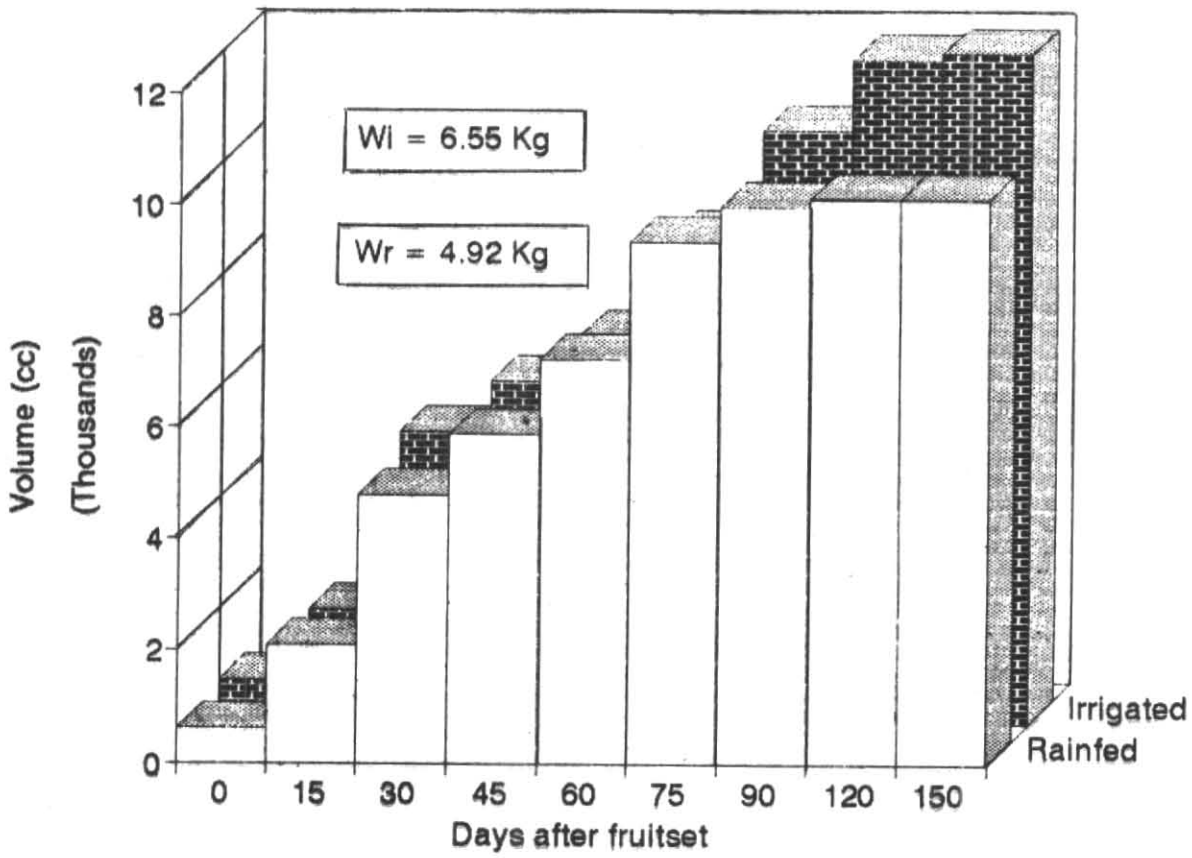

Fig. 2. Volume of jack fruit

growth period alongwith I flush plants transpired 25.7%. During fruit maturity and II flush irrigated plants transpired 12.7% compared to that of 37.8% by the rainfed plants.

The per cent increase in shoot length and girth are given in Table 3. It is observed only during first two growth flushes both under rainfed and irrigated conditions. in rainfed trees, shoot growth was observed during first growth flush inspite of severe soil moisture stress and water absorbed from the soil by the tree was found to be zero. Water absorbed from the soil by the tree was found to be high in irrigated trees compared to trees grown under rainfed situations. Accumulated water utilization by the tree from beginning till the harvest of the fruits was maximum (839.5 mm) in irrigated trees compared to the trees grown under rainfed situation (443.0 mm). Eventhough water utilization by trees was high under irrigated situation the vegetative growth was not influenced proportionally.

The following linear regression equations for shoot growth (dependent) and water transpired (independent) have been obtained for the growth of the shoot length and shoot girth :

(a) for trees grown under rainfed condition,

$$Y = 2.6429 - 0.00930\ X \quad \text{[Shoot length]} \quad (7)$$

$$Y = 4.5128 - 0.04508\ X \quad \text{[Shoot girth]} \quad (8)$$

and

(b) for the trees grown under irrigated condition,

$$Y = -1.842 + 0.00969\ X \quad \text{[Shoot length]} \quad (9)$$

$$Y = -0.972 + 0.00404\ X \quad \text{[Shoot girth]}. \quad (10)$$

The drought tolerance capacity of the jack tree may be attributed to several modifications that occurred during the course of evolution, such as, presence of thick cuticle, extensive root system or tolerance of dehydration which might increase the probability of their survival and growth in dry period.

3.2. *Fruit growth*

There was no significant difference between irrigated and rainfed conditions, pertaining to fruit growth. The rapid fruit growth rate coincided with soil moisture deficit condition. Inspite of unfavourable conditions, growth was observed when the water absorbed from the soil was recorded zero. The per cent increase in the fruit development has been shown in Fig. 2. It is evident from the data that most of the fruit growth coincided with deficit soil moisture status. Though, accumulated water used by the plant from fruit set to fruit maturity was high (553.5 mm) under irrigated condition was compared to rainfed condition (244.7 mm), there was no significant difference in fruit growth rate between irrigated and rainfed trees. This reveals that fruit growth was not influenced much by the supplemental irrigation. However, fruit maturity was delayed in irrigated trees by 20-30 days. The prolonged growth of fruit under irrigated conditions may be due to lack of moisture stress on the plant, which brings about early maturity of fruits. The average weight of the fruit was 6.55 kg in irrigated trees and 4.92 kg in rainfed trees.

4. Conclusion

The development of flushes during dry period shows that jack has adapted itself to the prevailing soil moisture status and stores a small amount of moisture to utilise for its regular growth during non-supply of moisture from the soil. Accumulated water transpired by jack from flower initiation till the harvest of fruit is 839.5 mm in the irrigated trees and 443.0 mm in the rainfed trees. The fruit growth was not influenced by supplemental irrigation, however fruit maturity was delayed by 20-30 days in irrigated trees.

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