Journal of AgriSearch 1(4): 216-220
Peer Reviewed Quarterl
ISSN : 2348-8808 (Print), 2348-8867 (Online)

Effect of Irrigation and Fertigation Scheduling under Drip Irrigation in Papaya

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ARTICLE INFO

Received on	: 16.09.2014
Revised received on	: 01.10.2014
Accepted on	: 12.10.2014
Published online	: 05.12.2014

ABSTRACT

A field experiment was conducted for three consecutive years from 2011 to 2013 to study the effect of different irrigation scheduling through drip irrigation on papaya (*Carica papaya Linn.*) production in sandy loam soil. The experiment comprised of nine treatments under drip method of irrigation with combination of three irrigation regimes viz. 60%, 80% and 100% of cumulative pan evaporation (CPE), three different levels of fertilizer, and conventional irrigation at 50 mm CPE as a control treatment. The results showed that drip irrigation resulted in 45 to 66 % water saving with 21 to 36 % increase in papaya yield as compared to conventional method of irrigation. The water use efficiency was found maximum (3.39 t/ha/cm) in drip irrigation with 60 per cent cumulative pan evaporation (CPE) on daily basis. The drip irrigation at 100% CPE with 100% recommended dose of fertilizer (RDF) was found to be optimum for growth (139.17 cm), and papaya production (112.55 kg/plant)..

Keywords: Drip irrigation, irrigation interval, papaya, water use efficiency

INTRODUCTION

Papaya (*Carica papaya* Linn.) has long been known as a wonder fruit of the tropics and grown primarily for its delicious test and for extraction of its digestive constituent papain. It gives one of the highest productions of fruits per hectare and an income next to banana. Papaya is grown in India mainly Maharashtra, a leading state which produces papaya mainly for papain production. The present area under papaya cultivation is about 70 thousand ha and production is around 1.5 million tonnes.

Fertigation is a technology for distributing fertilizers to the crop along with water through drip irrigation on a continual basis in controlled manner so as to allow for steady flow of nutrients by plants and to effect inputs of both water and fertilizer (Pandey *et al*., 2013). Fertigation uses either granular or liquid fertilizers, which are dissolved in water, and injected into the irrigation system. Nutrients can be applied through drip system, and can vary in concentration and composition (Pandey *et al*., 2012). Fertigation provides uniform and relative ease of distribution of nutrients and can be fine tuned to the nutritional requirements of a particular crop. In general, application of fertilizer with irrigation water gives a better crop response than either broadcast or foliar application (Pandey *et al*., 2013). Making a right decision about water and nutrient application is the key for high crop yield and its quality. Singh and Singh (2011) in the experiment conducted to study the effect of fertigation on papaya (Pusa delicious) at the experimental farm of Horticultural Research Station, Birauli (RAU, Bihar) reported that fruit characteristics of papaya were found superior with 100 per cent fertigation followed by 80 per cent, the control treatment and 60 per cent fertigation treatment. The highest value of fruiting length was recorded as 0.88 meter and number of fruits per plant was 39 under 100 percent fertigation treatments. Studies conducted by Sadarunnisa *et al.* (2010) indicated that 75% N and K when applied through drip recorded a yield of 100.42 kg/plant which was at par with the yield of plants supplied with 100% RDF

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(102.60 kg/plant). Similarly, Jeyakumar *et al* (2010) studied the influence of fertigation on nutrient use and yield improvement in papaya. Application of 100% recommended dose of N and K_2O (50 g N and 50 g K_2O) through drip irrigation resulted in flowering at the shortest height (96.32 cm).

Fertigation decision involves kind of fertilizer (solid/ liquid), dose of fertilizer, selection of the most effective formulations, proper preparing solutions for injection and scheduling injections to ensure that essential nutrients are made available to the plant as needed. In view of above facts studies were undertaken to assess the effect of irrigation scheduling through drip on papaya.

MATERIALS AND METHODS

A field experiment was conducted to study the influence of drip fertigation on moisture regime, growth and yield of papaya (*Carica papaya* Linn.) crop in Chhindwara district of Madhya Pradesh. The experiment was laid out during May 2011 and continued upto to September 2013 under drip irrigated condition at JNKVV Zonal Agricultural Research station, Krishi Vigyan Kendra, Chhindwara District of MP. Chhindwara has a sub tropical climate. It has a hot dry summer (April–June) followed by monsoon rains (July–September) and a cool and relatively dry winter. Average annual rainfall is 1183 mm. Minimum temperature during winter is 4 degree Celsius while maximum temperature during summer is 42^0 C. Initial soil samples were collected from a depth of 0 to 15 cm before start of the experiment, for analyzing various physico-chemical properties of soil. The plot size was 60 X 20 m, and total area was 1200 square metres. The soil characteristics are presented in table1.

Irrigation treatments for papaya crop

The following three treatments were taken for the experiment

I_1-Drip irrigation with IW/CPE (Irrigation water/ cumulative pan evaporation ratio of 0.6 (I_1)

I_2-Drip irrigation with IW/CPE (Irrigation water/ cumulative pan evaporation ratio of 0.8 (I_2)

I_3-Drip irrigation with IW/CPE (Irrigation water/ cumulative pan evaporation ratio of 1.0 (I_3)

Fertigation treatments for Papaya crop

The following three fertigation treatments were taken

F_1- 60% of recommended dose of fertilizer

F_2- 80% of recommended dose of fertilizer

F_3-100% of recommended dose of fertilizer

Control plot treatments

The control plot was irrigated by furrow method and fertilizer was manually applied as 100% as recommended doses.

F–100% recommended dose of fertilizer_

Table1: Physical and chemical characteristics of soil

Properties		Methodology
Soil Texture	Sandy loam	Piper (1966)
Sand (%)	68.5	
Silt(%)	16.3	
Clay(%)	15.2	
Bulk density (g/cm^{-3})	1.48	Black (1975)
Specific gravity	2.41	
pH	7.5	Jackson (1973)
Electrical conductivity (dS/m)	0.12	
Organic carbon (%)	1.05	
Available nitrogen (kg/ha)	328	
Available phosphorus (kg/ha)	18.5	
Available potassium (kg/ha)	570	

The experimental soil was sandy loam with medium in available N and P and high in available K. Planting of papaya seedlings (cultivar: Taiwan 786) was done on raised beds at spacing of 2.5 m x 2 m distance (2000 plant /ha) on 45 cm raised strip of 100 cm width. The recommended dose (Chadha, 2002) of fertilizer 250:250:500 N:P:K, g/plant was used. The basal dose of phosphorous, potassium and half dose of nitrogen (as basal) were applied at the time of planting. The field experiment was conducted in a randomized block design (RBD) with ten treatments combinations replicated thrice. The main plot treatments comprised of three depth of irrigation viz. 60, 80 and 100 % of cumulative pan evaporation values. The three sub-plot treatments comprised of different fertilizer levels viz. 60, 80 and 100 recommended dose of fertilizer (RDF). The surface irrigation was also included in the experiment as control. The irrigation was applied as per treatment on the basis of climatologically approach. The daily pan evaporation data was recorded from USWB class A Pan. The quantity of water applied through drip irrigation as per treatment was calculated by following formula (Doorenbos and

Pruitt, 1976).

$ET_c = E_p \times K_p \times K_c$ [Eq.1]

$V = (ET_c \times W_a) / E$ [Eq.2]

Where,

ET_c = Evapotranspiration of papaya

E_p = Cumulative pan evaporation (mm)

K_p = Pan coefficient (0.7)

K_c = Crop coefficient (Allen *et al.* 1994)

V= Crop water requirement/emitter

W_a = Wetted area

E = Efficiency of the system (considered as 90%)

The application of irrigation water for each plant, two on-line drippers with 8 liters per hour discharge was fitted on 16 mm laterals. The spacing between two adjacent laterals and emitter within plot was 1.0 m and 0.6 m, respectively. The average emission uniformity (efficiency of the system) of drip irrigation system was estimated as 90 per cent for all treatments. In surface irrigation, 5 cm depth of irrigation was applied at 50 mm cumulative pan evaporation using relationship given below (Michel 2008).

Net depth of irrigation= (FC-PWP)/100 x Bulk density x root zone X MAD) [Eq.3]

Where,

FC = Field capacity of soil, % by weight

PWP = Permanent wilting point, % by weight

MAD = Maximum allowable deficiency, %

Bulk density = g/cm^3

Root zone = m

The effective root zone was considered as 0.8 m and maximum allowable deficiency (MAD) was considered as (50%). In surface irrigation, the water was carried to the respective plots using PVC pipes. Observations were recorded on various parameters on moisture regime, growth and yield. Data thus collected were analysed statistically to draw inference (Panse and Sukhatme, 1989).

RESULTS AND DISCUSSION

Growth Attributes

There was overall significant effect of different treatments on yield attributes of papaya. The growth parameters viz. Plant height, number of leaves, number of fruit per plant, fruit weight per plant, diameter of fruit, length of fruit diameter and yield were found maximum in drip irrigation equal to 100% of CPE applied daily (Table 1). The maximum yield (112.55 kg/plant) were fund under 100% of treatment. However, these values were at par when irrigation quantity of 60 and 80% of CPE was applied. The data also indicated that decrease in irrigation water and fertilizer decreases the plant height, number of fruit per plant as well as fruit diameter. Fruiting length also affected by decreasing water and fertilizer quantity. The data revealed that drip irrigation with fertigation in papaya crop has better vegetative growth as well as yield as compared to conventional method of irrigation. Fruiting length was

Table 2: Growth and yield of papaya as influenced by irrigation scheduling (Pooled data of 3 years)

Treatments	Plant height (cm) at 90 days of transplanting	Number of fruits per plant	Fruit diameter (cm)	Fruit length (cm)	Yield (kg/plant)
60% CPE and 60% RDF	133.80	24	23.76	24.65	84.55
60% CPE and 80% RDF	136.33	27	23.40	24.75	83.85
60% CPE and 100% RDF	139.20	30	24.85	25.55	85.00
80% CPE and 60% RDF	138.27	24	23.55	26.60	88.85
80% CPE and 80% RDF	140.00	28	24.55	26.60	82.45
80% CPE and 100% RDF	140.00	29	25.65	26.65	85.65
100% CPE and 60% RDF	138.33	26	24.45	27.90	90.85
100% CPE and 80% RDF	138.00	31	24.95	27.85	98.65
100% CPE and 100% RDF	139.17	35	26.85	29.50	112.55
Surface irrigation and 100 RDF	120.67	22	22.85	20.15	69.65
SEm±	0.43	0.16	0.37	0.13	0.33
CD (P = 0.05)	1.07	0.41	0.92	0.33	0.82

CPE = Cumulative pan evaporation, RDF = Recommended dose of fertilizer

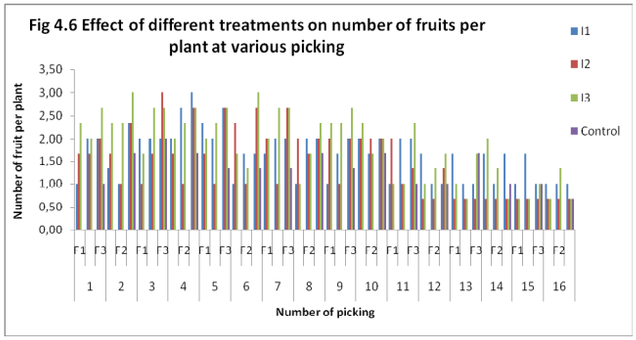

Fig 1: Effect of irrigation and fertilizer levels on number of fruits per plant of papaya at various picking

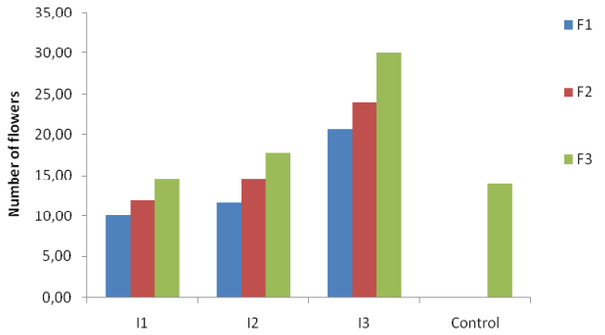

Fig 2: Effect of irrigation and fertilizer levels on number of first flowers on papaya plants

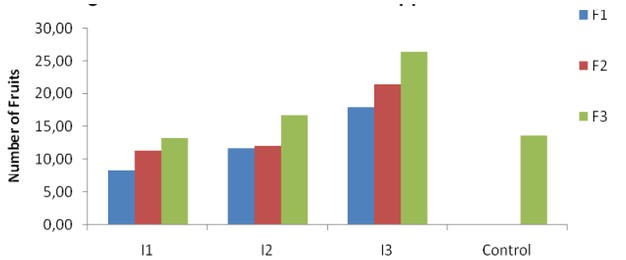

Fig 3: Effect of irrigation and fertilizer levels on number of first fruiting numbers

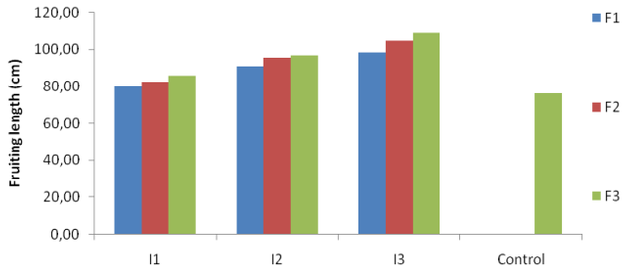

Fig 4: Effect of irrigation and fertilizer levels on fruiting length of plant

Table 3: Water used by papaya under different irrigation scheduling of drip (Pooled data of 3 years)

Treatments	Papaya yield (t/ ha)	Water applied (cm)	Field water use efficiency (t/ha/cm)	Water saving (%)	Increase in yield (%)
60 % CPE and 60% RDF	149.10	50.04	2.97	54.46	7.03
60 % CPE and 80% RDF	161.70	50.04	3.23	54.46	16.08
60 % CPE and 100% RDF	170.00	50.04	3.39	54.46	22.03
80 % CPE and 60% RDF	177.70	66.73	2.66	39.28	27.56
80 % CPE and 80% RDF	164.90	66.73	2.47	39.28	18.37
80 % CPE and 100% RDF	171.30	66.73	2.56	39.28	22.97
100 % CPE and 60% RDF	181.70	83.41	2.17	24.1	30.43
100 % CPE and 80% RDF	197.30	83.41	2.36	24.1	41.63
100 % CPE and 100% RDF	225.10	83.41	2.69	24.1	61.59
Surface irrigation and 100 RDF	139.3	109.90	1.26	-	-
SEm±	3.05	-	-	-	-
CD (P=0.05)	7.48	-	-	-	-

found maximum (29.5 cm) in drip fertigation equal to 100% CPE and 100 RDF.

Fruit Yield

The results revealed that drip irrigation gave significantly the higher yield as compared to conventional method of irrigation (Table 2). The daily application through drip equal to 100 % CPE gave maximum yield (225.10 t/ha). It indicated that with reduction of irrigation and fertigation, water saving is more but yield were not increased significantly. Data showed that up to 61.59% more yield was found with drip fertigation system as compared to conventional method of irrigation.

Water Use Efficiency

The seasonal water requirement was higher in surface irrigation at 50 mm of cumulative pan evaporation (109.9cm) as compared to irrigation applied by drip irrigation treatments (Table 2). The overall water saving in drip irrigation ranged from 24.1 to 54.46 %. The lowest water use efficiency was recorded1.26 t/ha/cm in conventional method of irrigation. The highest water use efficiency was found (3.39 t/ha/cm) when drip irrigation equal to 60 % of cumulative pan evaporation was applied daily. The water use efficiency increased when drip was applied for papaya cultivation.

CONCLUSION

The drip fertigation application equal to 100 % of cumulative pan evaporation at 100% RDF was best to obtain better growth, quality of fruits and yield of papaya cultivar Taiwan 786 under sandy loam soil conditions of Chhindwara district of Madhya Pradesh.

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Correct Citation:

Deshmukh G and Hardaha MK. 2014. Effect of irrigation and fertigation scheduling under drip irrigation in papaya. *Journal of AgriSearch* **1**(4): 216-220.