



IJEAST

INTERNATIONAL JOURNAL
OF ENGINEERING APPLIED SCIENCE
AND TECHNOLOGY



VOLUME : 4 ISSUE : 06 Print / Issue Publication Date: 06-Dec-2019



ISSN : 2455-2143



DOI : 10.33564/IJEAST.2019.v04i06.031

Indexed In



WWW.IJEAST.COM

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DRIP IRRIGATION SYSTEM IS BEST IRRIGATION SYSTEM UNDER HIGH DENSITY ORCHARDS

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Abstract-Water is the most critical input in successful cultivation of fruits and for getting higher yield; however, its deficiency is one of the most important restricting factors in crop production in the world ^[1]. The most important natural influences which affect the water quantity are climate, water supply, soil and topography ^[6]. The water requirements of temperate fruit plantation have been reviewed ^[9]. There are many irrigation systems that are used for water management in high density fruit crops but drip irrigation system is most commonly used in high density orchards due to its high water saving efficiency i.e. about 60-70 per cent. Reported that under sprinkler irrigation system 5616.8 L of water was required by a 6-year old apple tree for two years however it was only 2921.1 L under drip irrigation system ^[5]. Equilibrium between water irrigation and fertilization determines good conditions of growth to avoid excesses of vigor and physiological disorders that could affect fruit yield and quality ^[7]. Many researchers have reported the higher application efficiency of drip irrigation system over the conventional basin irrigation systems as well as other traditional irrigation systems. Compared drip and basin irrigation systems in fruit orchards and found that there was water savings of 40 –60 % in drip irrigation system than basin irrigation method ^[14].

Keywords: ETc, High Density Orchard, Irrigation Methods and Water.

I. INTRODUCTION

Traditional orchards based on wide plantings yielded 5t per ha, whereas modern orchards based on close plantings, dwarfing

rootstocks and effective canopy management yield upto 100t per ha ^[8]. The canopies of most orchard crops including those from temperate and tropical areas capture less than 70% of radiated light and intensive canopy management is required to maximize light interception and productivity ^[15]. The development of high-density orchards in temperate fruits are dependent on the development of small trees than can be pruned to maximize light interception and still remain productive. Early and higher yield is possible only due to high density plantation ^[11].

II. IRRIGATION SYSTEMS

Irrigation systems are most suitable for their particular orchard with maximizing their efficiency. Two types of irrigation systems are available for irrigation in high density orchards.

Different types of Irrigation system

High Flow (Macro)	Low Flow (Micro)
Flooding	Sprinkler
Border Strip	Drip
Check Basin	-
Furrow	-

Drip Irrigation

- Drip irrigation is defined as the frequent application of small quantities of water directly above and below the soil surface; usually as discrete drops, continuous drops or tiny streams through emitters placed along a water delivery line.
- To apply sufficient moisture to the root of the crops- prevent water stress.
- A major difference between drip system and most other systems is that the balance between crop evapotranspiration and applied water.
- Also known as Trickle Irrigation.

Need of drip irrigation

- To make fruit crops productive.
- Help produce more from the available land, water and labor resources without either ecological or social harmony.
- Generate higher farm income, On-farm and off-farm employment.
- To use water efficiently.
- No water to runoff or evaporation and soil erosion.
- It reduces water contact with crop leaves, stems, and fruits.
- Agrochemicals can be applied more efficiently.

III. BENEFITS OF DRIP IRRIGATION



Figure 1 Benefits of drip irrigation
Influence of various factors are used to water

- Evapotranspiration
- Temperature
- Relative humidity
- Wind
- Radiant energy

Evapo-transpiration

Loss of water through living (plant part) or non-living surface (soil) is called as evapo-transpiration.

Temperature

The degree or intensity of heat present in a substance or object. Depends on temperature, high temperature may cause high evapo-transpiration (high loss of water) while low temperature cause less evapo-transpiration (less water).

Relative humidity

Amount of water vapour present in air.

.Wind

Movement of air

Water loss depends on wind speed

Wind speed measure by- Anemometer

How to calculate of water requirement to the plant

Evaporation is the principle way of loss of water from the soil as well as plants. The evapo-transpiration loss of water is treated as total water requirement of the plant. The requirement of water for a particular fruit crops is calculated using formula:

Table 1 Calculation of water requirement for fruit crops under high density orchards

Age of the plant	Spacing (m)	Daily Water Uses in litres per Day			
		E.T. 0.10"/day Cool day, early spring Late fall, foggy	E.T. 0.20"/day Warm day in spring or fall; some fog	E.T. 0.25"/day Hot day, mid-summer No fog	E.T. 0.30"/day Very hot (100°F) Windy, mid-summer
1 year old	3 x 1	0.960	1.920	2.40	2.88
	3 x 1.5	1.44	2.88	3.60	4.32
	3 x 2	1.92	3.84	4.80	5.76
	3 x 3	2.88	5.76	7.20	8.64
5 year old	3 x 1	4.8	9.6	12	14.4
	3 x 1.5	7.2	14.4	18	21.6
	3 x 2	9.6	19.2	24	28.8
	3 x 3	14.4	28.8	36	43.2

Compared two micro sprinkler irrigation systems in mature 'Fuji' trees in Washington State (Table 2). This difference is perhaps largely the result of the higher ETr and ETc values in Idaho than Washington [5].

Table 2 Precipitation, evapo-transpiration and total volume of applied water per tree in Pacific Gala apple from 2004 to 2007

Year	2004	2005	Mean	2006	2007	Mean
Precipitation (mm)	64.9	67.2	66.0	54.4	55.9	55.1
ETc (mm)	846.3	930.7	888.7	1022.8	1077.7	1050.3
Water applied by sprinkler (lt./tree)	5399.8	5833.8	5616.8	6249.9	6673.5	6461.7
Water applied by drip (lt./tree)	2404.2	3438.0	2921.1	3872.0	4121.2	3996.0

Four year cumulative yield was recorded higher in drip system (66.16 kg/tree) as compare to sprinkler (64.25 kg/tree) (Table 3). Maximum yield



efficiency has reported in drip system (0.77 kg cm^{-2}) as compare to sprinkler system (0.72 kg cm^{-2}). Average fruit weights of four year in drip irrigation is 205.7 g while in sprinkler irrigation as 198.5 g. 'Pacific Gala' fruit from trees with sprinkler consistently had better color than those with a drip system every year that could be the result of the cooler temperatures that prevailed under trees with an sprinkler system. Also 'Pacific Gala' leaves from trees with sprinkler irrigation always had significantly lower magnesium (Mg) than those on drip every year. Soluble solid concentration has no difference between both irrigation systems ^[5].

Table 3 Effect of irrigation system on yield and physio-chemical characters during different age of tree in Pacific Gala/Bud.9

Characters	Year	Irrigation methods	
		Sprinkler	Drip
Yield (kg/tree)	2004	7.7	9.0
	2005	6.2	9.8
	2006	15.4	16.4
	2007	35.2	30.3
	Cumulative	64.2	66.1
Yield efficiency (kg/ cm)	2004	0.52	0.69
	2005	0.34	0.55
	2006	0.63	0.73
	2007	1.32	1.14
	Mean	0.72	0.77
Average fruit weight (g)	2003	206.8	219.1
	2004	198.9	214.8
	2005	199.0	198.2
	2006	182.7	177.3
	Mean	198.5	205.7
Color	2004	3.9	3.5
	2005	3.1	2.7
	2006	4.0	3.7
	2007	3.8	3.3
	Mean	3.69	3.27
Soluble solids (%)	2004	13.9	14.1
	2005	14.5	14.0
	2006	14.0	14.4
	2007	13.5	13.2
	Mean	14.0	14.0

Table 5 Effect of drip irrigation treatments and rootstocks on physical quality parameters in apple cv. Red Fuji

Characters	Year	Rootstocks	Treatments				
			100 % ETc	80 % ETc	60 % ETc	40 % ETc	Control (Basin Irrigation)
Fruit length (cm)	2002-2003	EMLA 106	5.87	5.27	5.06	4.90	4.57
		EMLA-7	5.57	5.3	4.78	4.60	4.27
		EMLA-111	5.84	5.49	5.12	4.74	4.25

A significantly greater volume of water is required for trees under full micro-sprinkler systems than those with drip systems. Application of water through a drip system, based on full ETc rate and adjusted by percentage of GS, can result in major water savings and often improves yield and fruit quality.

Compared four drip irrigation treatments (100 % ETc, 80 % ETc, 60 % ETc or 40 % ETc) at weekly intervals ^[12]. The drip irrigation treatments were compared to basin irrigation (control) at 100 % ETc. Two apple cultivars under study were Red Fuji and Scartlet Gala grafted on three rootstocks viz. EMLA-106, EMLA-7 and EMLA-111.

Table 4 Volume of water applied (in liters) various treatments during 2002-2003 and 2003-2004

Water Applied (Litre)	Varieties			
	Red Fuji		Scarlet Gala	
	2002-2003	2003-2004	2002-2003	2003-2004
100 % ETc	1144	1041	881	796
80 % ETc	852	831	705	635
60 % ETc	689	625	528	478
40 % ETc	460	476	352	378
Control (Basin Irrigation)	1144	1041	881	796

Yield and Physical quality parameters

The highest yield in Red Fuji was reported 12.95 kg/tree during 2003-2004 whereas 13.06 kg/plant reported in Scartlet Gala during 2003-2004. The effect has been widely referenced in literature ^[3]. Reported an increase of 40 to 60 percent in fruit size under high quantity of water applied through drip ^[2]. The scion grafted on EMLA-106 produced fruits with highest fruit length, diameter, weight and volume.

Biochemical quality parameters

During both the years of study, the plants under basin irrigation (control) produced fruits which were more firm and had highest total soluble solids than drip irrigation treatments except for 40 % ETc which was at par with it. The TSS content in treatments 100 % ETc, 80 % ETc and 60 % ETc was statistically at per during both the years.



Fruit diameter (cm)	2003-2004	EMLA 106	6.2	5.85	5.22	5.13	4.74
		EMLA-7	5.96	5.53	4.93	4.69	4.32
		EMLA-111	5.69	5.01	4.90	4.35	4.26
	2002-2003	EMLA 106	7.41	7.06	6.47	5.91	5.45
		EMLA-7	7.24	6.90	6.39	5.84	5.23
		EMLA-111	7.11	6.59	6.03	5.46	5.08
	2003-2004	EMLA 106	7.54	7.11	6.57	6.13	5.63
		EMLA-7	7.32	6.9	6.24	5.86	5.36
		EMLA-111	7.34	6.87	6.16	5.89	5.36
Fruit weight (g)	2002-2003	EMLA 106	144.0	97.95	91.37	78.75	67.0
		EMLA-7	108.7	99.25	83.75	76.12	67.0
		EMLA-111	109.9	100.0	86.75	77.75	66.87
	2003-2004	EMLA 106	117.8	109.7	98.14	87.20	77.90
		EMLA-7	113.1	101.2	93.46	82.40	74.66
		EMLA-111	112.3	105.2	94.19	85.40	74.30
TSS (°B)	2002-2003	EMLA 106	15.60	16.76	16.65	17.59	18.24
		EMLA-7	16.39	17.37	17.60	18.44	18.51
		EMLA-111	16.41	16.69	17.41	17.52	17.72
	2003-2004	EMLA 106	16.14	16.41	16.66	16.90	17.48
		EMLA-7	16.41	16.58	16.79	17.19	17.67
		EMLA-111	16.47	16.63	16.89	17.27	17.65
Acidity (%)	2002-2003	EMLA 106	0.35	0.37	0.40	0.42	0.45
		EMLA-7	0.34	0.33	0.35	0.38	0.42
		EMLA-111	0.27	0.32	0.32	0.37	0.42
	2003-2004	EMLA 106	0.36	0.40	0.42	0.44	0.47
		EMLA-7	0.43	0.44	0.46	0.46	0.54
		EMLA-111	0.41	0.42	0.47	0.49	0.51
Total Sugar (%)	2002-2003	EMLA 106	7.29	7.34	7.49	7.95	7.97
		EMLA-7	7.26	7.26	7.38	7.84	7.84
		EMLA-111	7.20	7.27	7.39	7.83	7.85
	2003-2004	EMLA 106	7.47	7.61	7.95	8.11	8.10
		EMLA-7	7.37	7.53	7.81	7.91	8.00
		EMLA-111	7.33	7.51	7.79	7.89	7.90

The possible reasons for higher TSS content in 40 % ETc and control may be the lower moisture level at root zone which caused lower fruits size and consequently higher proportion of sugars. Higher fruit firmness in the trees receiving low volume of water was also reported [10] and [4]. Reported that acidity in fruit juice increased by applying irrigation [13]. There was a little difference among varieties for biochemical parameters except for TSS and Total sugars which were higher in Scarlet Gala.

IV. CONCLUSION

High density orchards require less irrigation water as compared to the traditional system of planting which is to be supplied either by drip irrigation system or micro sprinkler irrigation system. Due to shallow root system of the clonal rootstock frequent water is needed to obtain optimum fruit yield and quality. Permanent drip irrigation system in high density orchards during the growing seasons distinctly increases tree vigour and fruit yield and quality. Application of water through

a drip system, based on full ETc rate and adjustment in G_w , A_w and P_e can result in major water savings. With an increase in area in high density orchards, use of drip irrigation system and new clonal rootstocks have profound effect on fruit quality and yield of fruit plants which further needs to be studied.

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2455-2143