An International Multidisciplinary e-Magazine
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SABUJEEMA

Volume 2 | Issue 3 | March, 2022

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Volume 2 - Issue 3 – March, 2022
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DRIP IRRIGATION AND MULCHING SAVES WATER AND ENHANCES YIELD IN FRUIT ORCHARDS

[Article ID: SIMM0157]

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INTRODUCTION

Fruits are commonly cultivated using surface irrigation (furrow or basin method) in India (Panigrahi and Srivastava, 2011). Groundwater is the major source of irrigation in many regions of the country. Recently, water table is declining in wells creating water shortage in summer for sustaining the crop production. Therefore, every year substantial area under fruit orchard is permanently wilted due to shortage of water, causing economical loss. Water management studies in orchards show that optimum soil water regime under drip irrigation can increase growth and yield of the crops (Barua *et al*., 2000). Mulching is another technique of water conservation by covering the plant basins in the orchards. Mulches reduce the water use of the crops by reducing the evaporation loss from soil surface. Plastic films have been used as mulch which has proved its effectiveness in conserving the soil moisture and increasing the growth, yield and quality of different crops (Shukla *et al*., 2000; Lal *et al.,* 2003). The present study has been presented on the combined effects of drip irrigation and mulch in orchards in a dry sub-humid region of India. The crop under the study was citrus.

METHODOLOGY

The experiment was carried out at Research farm of National Research Center for Citrus, Nagpur, India. The citrus plants taken under the study were six year old which was planted at 6 × 6 meter spacing. The alternate day irrigation treatments imposed were:

T_1 = Irrigation at 40% of pan evaporation with plastic mulch,
T_2 = Irrigation at 60% of pan evaporation with plastic mulch,
T_3 = Irrigation at 80% of pan evaporation with plastic mulch,
T_4 = Irrigation at 100% of pan evaporation with plastic mulch, and
Control (C) = Basin irrigation at 50% depletion of available soil moisture.

The study consisted of randomized block design with 3 replications and 3 plants per replication. The black linear low density poly ethylene (LLDPE) plastic mulch having thickness 100 micron was used. Mulching was 1.0 × 1.0 m size polythene sheets on each tree basin keeping the tree at the center. The experimental soil type was clay loam with field capacity and permanent wilting point of 24.8% (weight basis) and 15.7% (weight basis), respectively. Recommended dose of fertilizers and irrigation water through two dripper (4 lph) / tree were used.

The volume of water requirement was computed using the equation (Panigrahi *et al*., 2009):

$$V = Ep \times Kc \times Kp \times Wp \times D$$

Where, V = Volume of water (liter/tree/day), Ep = cumulative pan evaporation for two consecutive days (mm), Kc = crop factor,

Kp = pan factor, Wp = wetting factor, and D = canopy diameter observed at noon. The crop factor was taken as 0.6 and pan factor was 0.7 in winter and 0.8 in summer (Doorenbos and Pruitt, 1977).

The moisture content at 0-15 cm depth was estimated by gravimetric method, whereas at 0-30 cm depth it was recorded by neutron moisture probe (Troxler model-4300) once in a week. The leaf physiological parameters such as photosynthesis rate (P), transpiration rate (E) and stomatal conductance (C) were recorded fortnightly and the seasonal pooled data was compared for different treatments. The vegetative growth parameters (tree height, stem height, canopy diameter, stock and scion girth) were measured and the incremental magnitudes under different treatments were compared. Analysis of leaf samples for macro-nutrients (N, P and K) and micro-nutrients (Fe, Mn, Cu and Zn) were also done under different levels of irrigation with mulch and control.

RESULTS AND DISCUSSION

Irrigation water

Drip irrigation scheduling based on cumulative pan evaporation on alternate day under plastic mulching from November to June (Table 1) indicates that the maximum water was applied at 100% of pan evaporation with mulch, which varied from 42.1 to 160.2 mm during different months. On the whole, the total amount of water applied was 262.34, 396.62, 524.68 and 655.85mm at irrigation levels 40%, 60%, 80% and 100% of pan evaporation, respectively. The amount of water applied was maximum in the month of May and lowest in the month of December due to highest and lowest evaporation demand in these months, respectively. This result corroborates the finding in citrus (Panigrahi et al., 2006).

Table 1. Irrigation water applied under different irrigation treatments with plastic mulch during November to June in citrus

Treatment	Irrigation water applied (mm)								
	Months								
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr	May	June	Total
Irrigation at 40% E_p + Mulch	18.	16.	17.	20.	41.	51.	64.	32.	26
Irrigation at 60% E_p + Mulch	27.	25.	25.	30.	62.	76.	91.	51.	39
Irrigation at 80% E_p + Mulch	36.	33.	34.	40.	83.	83.	12	69.	50
Irrigation at 100% E_p+Mulch	46.	42.	43.	50.	10	10	16	86.	63
Irrigation at 50% ASMD through Basin irrigation	39.61	37.67	39.5	47.84	96.5	103	128.9	70.5	563.52

*E_p : Class-A pan evaporation rate

Soil moisture

The soil moisture values at different depths (Table2) indicates that the irrigation at 100% of pan evaporation and 80 % of pan evaporation with mulch maintained the soil moisture nearly or more than field capacity during the study period. There were less fluctuations of soil moisture at 0.3m depth in different months. But there was a significant effect of irrigation and mulch on soil moisture at 0.15 m depth, whereas at 0.3 m depth it was non-significantly affected.

Table 2. Average soil moisture content (v/v) in different months at 15 cm and 30 cm depths under different irrigation regimes with plastic mulch in citrus

Treatment	0.15 m				MEAN	0.30 m				MEAN
	Nov-Dec	Jan-Feb	Mar-Apr.	May-Jun.		Nov- Dec.	Jan-Feb	Mar-Apr.	May-Jun.	
Irrigation at 40% E_p+ Mulch	27.1	27.4	28.4	29.6	28.4	31.4	32.5	32.0	31.9	32.0
Irrigation at 60% E_p + Mulch	28.6	28.6	29.6	29.8	29.4	31.7	32.6	32.1	32.0	32.2
Irrigation at 80% E_p + Mulch	30.5	30.1	31.0	31.4	30.9	32.2	33.2	31.9	32.6	32.6
Irrigation at 100% E_p + Mulch	32.3	34.0	34.1	34.9	33.5	33.1	33.1	32.1	33.0	33.0
Irrigation at 50% ASMD through Basin irrigation	25.4	25.1	27.3	27.9	26.5	31.5	32.5	32.1	32.1	32.1
CD (0.05)	-	-	-	-	0	-	-	-	-	N

*E_p : Class-A pan evaporation rate

Leaf physiology

The physiological parameters such as photosynthesis rate (P), transpiration rate (E) and stomatal conductance (C) were recorded by CO_2 gas analyser CI-301PS (CID,Inc) during December to March from 11:00 AM to 3:00 PM in one hour interval twice in a month (Table 3). It was observed that P was highest in IW/CPE = 0.6with mulch in winter. Leaf water use efficiency (LWUE) in IW/CPE = 0.6 with mulch was highest in both winter and summer. It was also observed that all the parameters were affected significantly in both summer and winter, with exception to transpiration and stomatal conductance in summer. Earlier, Ghali and Nakhlla (1996) and Panigrahi et al. (2019) observed higher leaf physiological parameters due to higher soil moisture content under increased irrigation level in citrus and banana, respectively.

Table 3. Photosynthesis rate (P), transpiration rate (E), stomatal conductance (C) and leaf water use efficiency (LWUE) of Nagpur mandarin under different irrigation regimes and mulch in winter and summer.

Treatments	P (µmol/m²/s)		E (mmol/m²/s)		C (mmol/m²/s)		LWUE	
	*Win.	+Sum.	Win.	Sum.	Win.	Sum.	Win.	Sum.
Irrigation at 40% E_p + Mulch	3.931	3.794	2.342	2.434	69.6	46.1	1.609	1.630
Irrigation at 60% E_p + Mulch	4.935	4.312	2.746	2.467	57.8	51.6	1.829	1.880
Irrigation at 80% E_p + Mulch	3.923	3.938	2.753	2.723	77.4	71.9	1.484	1.418
Irrigation at 100% E_p + Mulch	2.021	2.163	2.004	2.736	38.1	74.8	0.896	0.980
Irrigation at 50% ASMD through Basin irrigation	3.152	1.712	2.324	1.891	76.1	31.5	1.123	0.961
CD (0.05)	0.39	0.62	0.28	NS	3.03	NS	0.18	0.09
Win.: winter; and Sum: summer								

*E_p : Class-A pan evaporation rate

Leaf nutrient composition

Leaf samples were collected and analyzed for macro-nutrients (N, P and K) and micro-nutrients (Fe, Mn, Cu and Zn) under different levels of irrigation with mulch and basin irrigation (Table 4). A highly significant response was found in case of nitrogen, potassium and iron due to

irrigation and mulching. The highest leaf - N (2.41 %), - K (1.97%), - Fe (122.6 ppm) were observed in irrigation level at 60 % pan evaporation under mulch, whereas lowest values were found at irrigation at 40 % pan evaporation treatment. These results are in agreement with the findings of Shukla et al. (2000).

Table 4. Leaf nutrients of citrus under different irrigation regimes with plastic mulch.

Treatment	Macro-nutrients (%)			Micro-nutrients (ppm)			
	N	P	K	Fe	Mn	Cu	Zn
Irrigation at 40% E_p + Mulch	1.23	0.073	1.22	99.6	48.5	11.2	10.2
Irrigation at 60% E_p + Mulch	2.41	0.209	1.97	122.6	61.6	12.4	14.7
Irrigation at 80% E_p + Mulch	1.77	0.167	1.77	105.7	58.5	15.8	15.5
Irrigation at 100% E_p + Mulch	1.67	0.075	1.26	101.3	49.3	12.3	22.9
Irrigation at 50% ASMD through Basin irrigation	1.22	0.092	1.24	99.8	49.66	8.5	10.3
CD (0.05)	0.4	NS	0.28	5.3	NS	NS	NS

*E_p : Class-A pan evaporation rate

Plant growth and yield

The tree growth parameters (average tree height, stock and scion girth and canopy spread) and yield are presented in Table 5. It was observed that all the growth parameters and yield were highest in irrigation at 60% pan evaporation with mulch followed by irrigation at 80% pan evaporation with mulch. All the growth parameters except stock girth affected significantly by different treatments. The fruit yield was highest under irrigation at 60% pan evaporation with mulch. This may be due to optimum soil moisture supply and favorable soil temperature under mulch, which resulted in better availability and uptake of nutrients by the plants.

Table 5. Incremental vegetative growth of citrus under different irrigation regimes with plastic mulch

Treatments	Tree height (m)	Stock girth (mm)	Scion girth (mm)	Canopy volume (m^3)	Yield (t/ha)
Irrigation at 40% Ep + Mulch	0.48	42	40	0.582	6.5
Irrigation at 60% Ep + Mulch	0.62	52	49	0.988	8.9
Irrigation at 80% Ep + Mulch	0.53	48	45	0.661	8.2
Irrigation at 100% Ep + Mulch	0.45	40	38	0.503	7.3
Irrigation at 50% ASMD through Basin irrigation	0.43	36	36	0.451	5.7
CD (0.05)	0.06	ns	6.3	0.07	0.21

SUMMARY AND CONCLUSION

A field experiment was carried out to study the effects of alternate day irrigation levels (40% of pan evaporation, 60% of pan evaporation, 80% of pan evaporation and 100% of pan evaporation) under black linear low density polythene mulch (100 micron) in citrus orchards. The results were compared

with conventional irrigation (Basin irrigation at 50% depletion of available soil moisture). It was found that the irrigation at 60% of pan evaporation under plastic mulch gave the best growth and yield along with 29.63% of irrigation water saving compared to control. The study concludes that optimum drip irrigation scheduling (60% of pan evaporation) along with plastic mulch improved the vegetative growth and yield of Nagpur mandarin plants and enhances nutrient uptake efficiency, besides conserving a good quantum of irrigation water against basin irrigation. Thus, adoption of drip irrigation under plastic mulch is the most suitable approach for cultivation of citrus in Central India. The study also reveals that there was a significant effect of drip irrigation and mulch on soil moisture at 15 cm depth, whereas at 30 cm depth it was non-significantly affected. It was also observed that all the physiological parameters (photosynthesis rate (P), transpiration rate (E) and stomatal conductance (C) were affected significantly in both summer and winter with the exception of transpiration and stomatal conductance in summer. Analysis of leaf samples for macro-nutrients (N, P and K) and micro-nutrients (Fe, Mn, Cu and Zn) under different levels of irrigation with mulch and control indicated a highly significant response in case of N, K and Fe that is correlated well with all the growth parameters.

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