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Effect of Deficit Drip Irrigation and Mulching on Mango Hybrid 'Amrapali'

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An investigation was carried out at ICAR-IIHR-Central Horticultural Experiment Station, Bhubaneswar, India during 2010-14 to standardize deficit drip irrigation scheduling and mulching for mango hybrid 'Amrapali' in a split plot design with nine treatment combinations and four replications. Main plot treatments consisted of three drip irrigation schedules, *viz*., 25, 50 and 75% pan evaporation replenishment (PER) whereas, subplots comprised of three levels of mulching, *viz*., no mulch, organic mulch (10 cm thick layer of paddy straw) and inorganic mulch (100 μ thick UV stabilized black polythene sheet). Drip irrigation was provided daily through hydrogol system having four drippers of 8 liter per hour (lph) discharge capacity during fruit setting to fruit maturity (February to May). Drip irrigation at 75% PER recorded the maximum annual canopy area increment (2.64 m^2), fruit retention (25.42%), yield (21.22 kg $tree^{-1}$) and number of fruits (123.81 fruits $plant^{-1}$), that was *on par* with 50% PER. Fruit quality parameters, *viz*., pulp, peel and stone contents, TSS and acidity did not show significant differences with change in PER levels. Application of organic and inorganic mulches not only enhanced the fruit retention and yield but also, improved fruit quality in terms of TSS.

*(**Key words:** Amrapali, Deficit irrigation, Drip, Mango, Mulching)*

Mango (*Mangifera indica* L.) belonging to family Anacardiaceae, is the leading fruit crop of eastern India. Among eastern states, Odisha has the highest acreage (1.98 lakh ha) whereas, Bihar ranks first in production (1.27 million tonnes). The eastern region experiences a wide variation in productivity levels with the lowest of 3.9 t ha^{-1} in Odisha and the highest of 10.1 t ha^{-1} in Jharkhand. Low productivity of mango in Odisha is primarily attributed to the prevalence of rain-fed orchards. Owing to light texture and poor water holding capacity of soil, scarcity of water is the normal phenomenon during post monsoon season, especially during February to May which coincides with the critical stages of water requirement, when fruit setting and development occur in mango. Water deficit in the soil profile during this period leads to poor fruit set, dropping of fruits and reduction in fruit size, yield and quality. Irrigation during critical stages of water requirement is essential to avoid drought stress and to ensure higher fruit yield and quality.

As irrigation water is becoming scarcer and scarcer due to various reasons, there is an urgent need to develop appropriate crop specific, deficit irrigation management technique that could be adopted to get optimum yield. Drip irrigation and mulching offer great savings of water on account of precise and direct application of water to the root zone of plant and soil moisture conservation, respectively. The present investigation was therefore, initiated to know the effects of mulch on growth, yield and fruit quality in mango and to identify threshold level of drip irrigation below which, optimum fruit yield could not be achieved.

MATERIALS AND METHODS

The experiment was conducted at ICAR-IIHR-Central Horticultural Experiment Station, Bhubaneswar, Odisha during 2010 - 2014 on high density orchard (5 x 5 m^2) of mango hybrid 'Amrapali' planted in the year 2005. The experimental site is situated at an altitude of 25.5 m above mean sea level between 20°15′ N latitude and 85°40' E longitude. The climate is hot and humid with average relative humidity of 75-85% and average minimum and maximum temperature of 22.2 and 33.7°C, respectively. The soil of the experimental site was sandy-loam (77.9% sand, 9.6% silt and 12.5% clay), strongly acidic (4.5 pH) and low in organic carbon (0.2%), available N, P and K (197.2, 9.7 and 148.5 kg ha^{-1}, respectively).

The experiment was laid out in split plot design with nine treatment combinations and four replications. Main plot treatments consisted of drip irrigation at three levels,

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viz., 25, 50 and 75% pan evaporation replenishment (PER) whereas, sub plots comprised of three levels of mulching, *viz.*, no mulch, organic mulch and inorganic mulch. Irrigation was provided daily through hydrogol system of drip irrigation from fruit setting to maturity, i.e., from February to May. Hydrogol having four drippers of 8 liter per hour (lph) discharge capacity was placed around the tree trunk at 50% distance of canopy radius. The water requirement in respective treatment was determined by multiplying the canopy area (m^2) x monthly mean pan evaporation (mm) x pan evaporation replenishment (%) as used by Kumar *et al*., 2008. The time of drip operation was determined by the total quantity of water required (l) divided by total discharge rate (lph). A 10 cm thick and uniform layer of paddy straw was applied in tree basin as organic mulch whereas, 100μ thick UV stabilized black polythene sheet was used as inorganic mulch. Mulch was applied after monsoon in the month of October-November after cleaning the tree basin. Black polythene mulch sheet was placed beneath the soil near the tree trunk and at the periphery of tree basin to prevent being blown with wind. Plastic mulch was removed during rainy season and imposed again during October- November.

Observations were recorded on soil moisture content (%), vegetative growth parameters, *viz.,* canopy area (m^2) and scion girth (cm), flowering characteristics, *viz*., % of floral, vegetative and dormant shoots, fruit retention (%), yield (kg $tree^{-1}$), yield contributing parameters, *viz.,* average fruit weight (g) and no. of fruits, and on fruit quality parameters, *viz.,* pulp, peel and stone contents (%), fruit size (length and width), TSS (^{o}B) and acidity (% equivalent of citric acid). For determination of soil moisture content, soil samples (0-30cm depth) at monthly interval were collected at 5 cm away from the hydrogol right from February to May under different treatments by gravimetric method. Initial growth parameters, *viz*., canopy area and scion girth was recorded during November-December, 2010. Thereafter, annual increments in vegetative growth parameters were noted for three consecutive years, *i.e*., from 2011 to 2013. The girth of scion was recorded at 5 cm above the graft union with the help of measuring tape. Canopy area was computed by multiplying canopy diameter of plant recorded in east-west and north-south directions.

Vegetative, dormant and floral shoots were counted in four directions of canopy using quadrate of 1m^2 area, averaged and expressed in %. Fruit retention was computed by counting the number of fruits on 20 panicles (five panicles in each direction) per tree at pea stage thereafter, at an interval of 15 days till fruit harvesting and expressed in %. Fruits were harvested at full maturity, weighed with physical balance and yield was expressed in kg $tree^{-1}$. Average fruit weight was computed by dividing the fruit yield by the number of fruits $tree^{-1}$. Ten mature fruits from each tree were taken randomly for recording observations on fruit quality attributes. Fruit and its fractions namely, peel and stone were weighed and expressed in %. Fruit size was measured with the help of vernier caliper. For determination of TSS and acidity, fruit juice was extracted from uniformly ripened fruits. TSS was determined using hand held digital refractometer (Hanna make) whereas, acidity was estimated by titrating the fresh fruit juice with 0.1N NaOH using phenolphthalein as indicator. The data generated on various parameters were tabulated and statistically analyzed using OPSTAT package of Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana for interpretation of results and drawing conclusion.

RESULTS AND DISCUSSIONS

The data recorded on annual increase in vegetative growth, flowering and fruit retention, yield and fruit quality parameters are summarized in Table 1, 2, 3 and 4, respectively. The interaction between the two factors was not significant at P= 0.05 for all the characters studied and hence is not included in the Tables.

Effect of drip irrigation on growth, yield and fruit quality

In present study, scion girth, intensity of floral, vegetative and dormant shoots and average fruit weight did not show significant difference with change in level of PER (Table 1, 2 and 3). However, levels of irrigation were found to have significant influence on canopy area, fruit retention, yield and number of fruits. These parameters showed an increasing trend with increase in levels of irrigation as reported by Mishra *et al.*, 2008 and Gajbhiye *et al.*, 2017 in cashew. The irrigation treatment 75% PER registered better plant growth in terms of annual increment in canopy area (2.64 m^2), and gave the highest fruit yield (21.22 kg $tree^{-1}$) and number of fruits at harvest (123.81 fruits $tree^{-1}$). These results were on par with irrigation level of 50% PER. Significant increase in yield and number of fruits per tree by 50 and 75% PER irrigation levels over 25% PER could be due to favourable moisture regime in the soil profile which, in turn might have resulted into more fruit retention in these treatments (Fig.1 and Table 2).

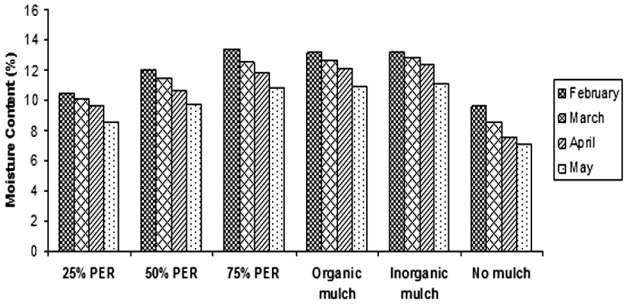

Fig. 1. Soil moisture retention under different drip irrigation regimes and mulching

As far as fruit quality is concerned, scheduling drip irrigation at 75% PER level produced big sized fruits (10.37 cm length and 6.65 cm width) with more pulp content (68.73%) whereas, 25% PER irrigation treatment recorded the maximum TSS of fruits (Table 4). The differences for these fruit quality parameters and other studied parameters, *viz*., peel and stone content and acidity were found to be at par in all the drip irrigation treatments. The results are in conformity with the findings of Dixit *et al*. (2003) and Kumar *et al*. (2008).

Effect of mulching on growth, yield and fruit quality

Perusal of pooled data presented in Table 1, indicated that the growth of mango in terms of canopy area and scion girth was not significantly influenced by the application of mulches. However, application of mulch in mango showed significant improvement in yield (Table 3). Organic mulch produced the highest yield (20.80 kg tree^{-1}) which was at par with the yield recorded in inorganic much (19.48 kg tree^{-1}). The

Table 1. *Effect of drip irrigation regimes and mulching on annual increase in vegetative growth of mango hybrid 'Amrapali'*

Treatment	Annual increase in vegetative growth							
	Scion girth (cm)				Canopy area (m^2)			
	2010-11	2011-12	2012-13	Pooled	2010-11	2011-12	2012-13	Pooled
Drip irrigation								
25 % PER*	9.99	8.64	3.50	7.38	1.67	2.18	1.81	1.88
50 % PER 11.53	6.18	4.42	7.38	1.81	3.24	2.84	2.63	
75 % PER	11.62	7.40	5.01	8.01	1.63	3.67	2.61	2.64
CD *(P=0.05)*	NS	NS	NS	NS	NS	0.62	0.67	0.47
Mulching								
Organic mulch	11.37	7.84	4.94	8.05	1.71	3.34	2.50	2.52
Inorganic mulch	10.42	7.75	4.01	7.39	1.50	3.24	2.66	2.47
No Mulch	11.34	6.64	3.98	7.32	1.90	2.50	2.10	2.17
CD *(P=0.05)*	NS	NS	NS	NS	NS	NS	NS	NS

*PER: Pan Evaporation Replenishment

Table 2. *Effect of drip irrigation regimes and mulching on flowering and fruit retention in mango hybrid 'Amrapali'*

Treatment	Flowering characteristics			Fruit retention (%)					
	Floral shoot (%)	Vegetative shoot (%)	Dormant shoot (%)	15 March	30 March	15 April	30 April	15 May	30 May
Drip irrigation									
25 % PER*	43.58	20.42	36.01	47.08	26.42	20.83	19.13	16.50	16.50
50 % PER	45.98	24.57	29.45	59.42	35.17	28.33	25.42	22.00	22.00
75 % PER	48.25	23.23	28.52	65.50	40.67	33.00	28.42	25.42	25.42
CD *(P=0.05)*	NS	NS	NS	7.54	5.63	3.85	3.4	3.88	3.88
Mulching									
Organic mulch	46.61	23.54	29.85	60.92	36.33	29.46	25.75	22.67	22.67
Inorganic mulch	45.75	23.23	31.01	61.83	36.25	29.00	26.13	22.88	22.88
No Mulch	45.45	21.44	33.11	49.25	29.67	23.71	21.08	18.38	18.38
CD *(P=0.05)*	NS	NS	NS	5.11	3.59	3.39	3.30	3.66	3.66

*PER: Pan Evaporation Replenishment

Table 3. *Effect of drip irrigation regimes and mulching on fruit yield in mango hybrid 'Amrapali'*

Treatment	Fruit yield																	
	No. of fruits tree^{-1}						Average fruit weight (g)						Weight of fruits (kg tree^{-1})					
	2010	2011	2012	2013	2014	Pooled	2010	2011	2012	2013	2014	Pooled	2010	2011	2012	2013	2014	Pooled
Drip irrigation																		
25% PER*	26.75	95.00	41.46	166.79	115.98	89.20	125.12	255.86	163.87	161.60	159.37	173.17	5.75	23.03	6.71	26.61	18.40	15.60
50% PER	51.50	110.75	59.75	204.04	144.25	114.06	117.61	237.31	165.01	162.70	162.57	169.04	6.23	23.85	9.94	32.96	23.32	19.26
75% PER	27.83	145.42	65.84	223.74	156.23	123.81	108.13	214.81	173.00	161.59	167.22	164.95	3.01	30.74	10.61	35.77	25.98	21.22
CD *(P=0.05)*	9.86	NS	17.06	30.50	26.94	19.05	NS	NS	NS	NS	NS	NS	NS	NS	2.19	4.81	3.22	3.29
Mulching																		
Organic mulch	47.33	129.25	59.92	215.14	148.15	119.96	110.30	251.83	173.24	157.93	163.76	171.41	7.79	30.89	10.08	33.67	24.08	20.80
Inorganic mulch	23.17	126.92	62.71	208.23	149.35	114.08	122.39	229.38	159.73	167.07	166.33	168.98	2.84	25.61	9.88	34.36	24.73	19.48
No Mulch	35.58	95.00	44.42	171.21	118.96	93.03	118.17	226.77	168.90	160.90	159.07	166.76	4.36	21.12	7.301	27.31	18.90	15.80
CD *(P=0.05)*	6.46	NS	NS	35.09	27.01	13.94	NS	NS	NS	NS	NS	NS	NS	NS	NS	4.39	3.97	2.62

*PER: Pan Evaporation Replenishment

Table 4. *Effect of drip irrigation and mulching on fruit quality of mango hybrid 'Amrapali'*

Treatment	Physical quality attributes					Chemical quality attributes	
	Pulp (%)	Peel (%)	Stone (%)	Fruit length (cm)	Fruit width (cm)	TSS (°B)	Acidity (%)
Drip irrigation							
25 % PER*	66.00	15.32	18.69	10.20	6.57	21.17	0.36
50 % PER	67.06	14.81	18.13	10.23	6.63	20.62	0.37
75 % PER	68.37	14.39	17.24	10.37	6.65	19.52	0.39
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS
Mulching							
Organic mulch	67.82	14.43	17.75	10.32	6.66	21.19	0.35
Inorganic mulch	67.94	14.34	17.73	10.35	6.61	20.82	0.4
No mulch	65.66	15.76	18.58	10.13	6.55	19.29	0.37
CD (P = 0.05)	NS	NS	NS	NS	NS	1.27	NS

*PER: Pan Evaporation Replenishment

increase in yield under organic and inorganic mulches was due to significant increase in number of fruits over no mulch treatment as reported by Samant *et al*., 2015. Soil under mulching treatments retained more moisture as compare to un-mulched (Fig. 1) which in turn might have attributed to improvement in fruit retention and yield (Table 2). These results are in line with the findings of Das *et al.* (2010) and Polara *et al.* (2013) who also reported improvement in yield of guava and custard apple, respectively due to better conservation of soil moisture following mulching.

Mulches were found to have positive impact on TSS of fruit over no mulch. The maximum value for TSS was recorded in organic mulch (21.19°B) followed by inorganic mulch (20.82°B). However, other fruit quality parameters (pulp, peel and stone contents, and acidity) recorded under organic and inorganic mulches remained at par with no mulch (Table 4). Improvement in TSS by mulching might be due to soil moisture conservation and increased soil water availability (Fig. 1) which ultimately might have caused mobilization of soluble carbohydrates to the fruits. Improvement in fruit quality due to application of mulches has also been reported in guava by Singh *et al*. (2015) and Samant *et al*. (2016).

CONCLUSIONS

Based on the results obtained from five years long study it is concluded that under hot and humid climate of Odisha, mango hybrid 'Amrapali' may be drip irrigated during fruit setting to fruit maturity period, *i.e*., from February to May at least at 50% pan evaporation replenishment to get optimum yield. Irrigation below this threshold level may affect production adversely. Further, mulching either with 10 cm thick layer of paddy straw or 100 μ UV stabilized black polythene could be very helpful in conserving the soil moisture and sustaining the yield with improved fruit quality.

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