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Response of Sapota Productivity to Conjunctive Stimulus of Irrigation Regimes and Mulching

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An experiment was carried out to assess the combined impact of irrigation regimes (40%, 60%, 80% and 100% of crop water requirement), mulch material (wheat straw, black plastic mulch and no mulch) on sapota crop during the year 2010-11 to 2015-16 (up to 9 years of age). FRBD with three treatment replications was adopted. Crop water requirement was estimated using reference evapotranspiration data using FAO-56 Penman Monteith approach and crop co-efficient for different crop growth stages. Irrigation water was applied at 40%, 60%, 80% and 100% of the crop water requirement. Maximum crop water requirement was observed 4.29 mm (88.67 L) per day during 19th week (May month) and minimum of 1.60 mm (12.34 L) per day during 51st week (December month) for 100% crop water requirement at peak growth stage. Black plastic mulch yielded 23.38% higher yield compared to no mulch treatment followed by wheat straw mulch (12.21%) at irrigation regimes 60% of crop water requirement. Water use efficiency and water productivity were 51.27% and 51.29% higher compared to no mulch.

Key words: Sapota, Black plastic mulch, Irrigation regimes, Water use efficiency

Sapota fruit contains high degree of nutrients which makes it delicious and a good dessert fruit. It can also grow on water logged and saline soils as it can tolerate salinity and alkalinity upto some extent. Drip irrigation is a viable option when water availability is scarce and for attaining more water productivity than surface irrigation. A considerable saving in water, increased growth, development and yield of vegetables under drip irrigation has been reported (Bhella 1988; Bafna *et al.* 1993; Raina *et al.* 1999 and Imtiyaz *et al.* 2000). Studies on drip irrigation in combination with plastic mulch carried out at Junagadh Agricultural University, Junagadh on cotton crop showed an increase in yield, saving in water, higher water use efficiency and increase in net profit (Prajapati *et al.* 2016).

It is necessary to irrigate the crop based on water demand under drip irrigation with plastic mulch for appropriate water management (Peter *et al*. 2003 and Patel and Rajput 2007). Drip irrigation in combination with plastic mulch achieves additional benefits of water saving besides greater yield. Murugan and Gopinath (2001) studied the efficacy of organic mulches and inorganic mulches on growth of crossandra cv "Saundrya" at Bangalore. The growth attributes were significantly influenced by organic and inorganic mulches. The black polyethylene mulch was found to be superior to other mulches.

Relatively, few studies were conducted to analyze the conjunctive performance of drip irrigation with plastic mulch and organic mulch on productivity of sapota under variable irrigation regimes. Hence, the present investigation was aimed at studying the techno-economic feasibility of drip irrigation with various irrigation regimes and mulch material on productivity of sapota.

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Material and Methods

A field experiment was conducted at Junagadh Agricultural University (21°30' N, 70°27' E and 77.5 above mean sea level) for six consecutive years from 2010-11 to 2015-16 to study the conjunctive impact of irrigation regimes i.e 40% (I_1), 60% (I_2), 80% (I_3) and 100% (I_4) of crop water requirement and mulch material i.e wheat straw mulch (M_1), black plastic mulch (M_2) and no mulch (C) as control on sapota. Experiment was conducted using Factorial RBD with twelve combinations. Each treatment was replicated thrice. The temporal variation of morphological parameters and yield attributes at the end of experiment were monitored. Sapota was planted during 2008-09 and the experiment was under taken after 2 years with the above treatments. Crop water requirement was estimated using reference evapotranspiration data using FAO-56 Penman Monteith approach and crop co-efficient for different crop growth stages. Irrigation water was applied every alternate day at 40%, 60%, 80% and 100% of the crop water requirement.

Results and Discussion

Crop morphological (plant height, stem girth and canopy) and yield attributes under different treatments were recorded during the years 2010-11 to 2015-16 and sapota yield was recorded after setting of fruits i.e from year 2013-14 to 2015-16. Results revealed that drip irrigation with plastic mulch had significant

influence on the plant growth and yield in comparison to wheat straw mulch and no mulch treatment because water was released strictly in the root zone maintaining soil: air ratio at an optimum level for plant growth and development.

Table 1. Morphological and yield attribute of sapota

Treatments	Plant height (m)	Stem girth (cm)	Canopy (sq mt)	Yield (kg plant^{-1})
I_1M_1	2.49	26.2	11.58	35.64
I_1M_2	3.93	35.2	14.56	40.28
I_1C	2.28	24.9	9.60	21.01
I_2M_1	2.93	28.4	12.57	47.29
I_2M_2	4.54	34.9	16.13	59.27
I_2C	2.48	25.4	10.51	28.86
I_3M_1	2.59	27.0	11.46	37.04
I_3M_2	3.21	33.0	14.17	37.83
I_3C	2.67	27.9	10.93	38.17
I_4M_1	2.36	25.9	9.85	28.08
I_4M_2	2.84	30.5	13.12	31.28
I_4C	2.91	30.0	10.86	41.14
S.Em.±	0.09	0.7	0.3105	1.15
C.D.at 5%	0.25	1.9	0.8696	3.23

Morphological attributes

The highest average plant height (4.54m) of sapota was attained by I_2M_2, followed by I_1M_2 and I_3M_2 (3.93m and 3.21m) respectively. I_2M_1 was at par with

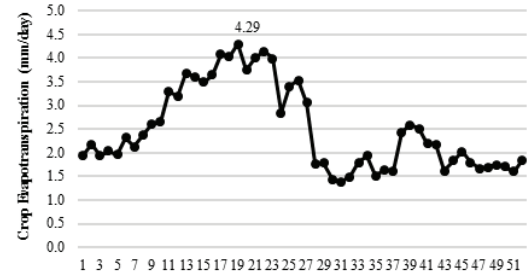

Fig. 1. Weekly average ETc of sapota at 100% irrigation fraction

I_4C. Black plastic mulch performed well as compared to organic mulch i.e wheat straw mulch and control. Significant difference was observed among all the treatments (Table 1). Enhanced morphological attributes might be due to better partitioning of

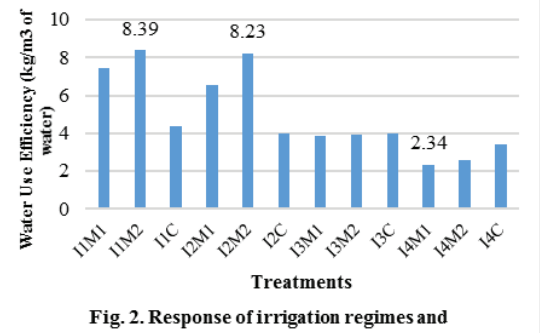

Fig. 2. Response of irrigation regimes and mulching on water use efficiency of sapota

assimilates towards reproductive parts as the source was not limiting under mulching. Better root growth and assimilation of photosynthates under mulching caused highest stem girth of 34.96cm in I_2M_2 followed by I_3M_2 (33.0cm). Highest plant canopy (16.13 sq.mt.) was attained in I_2M_2 followed by I_2M_1 and I_1M_2 (47.29

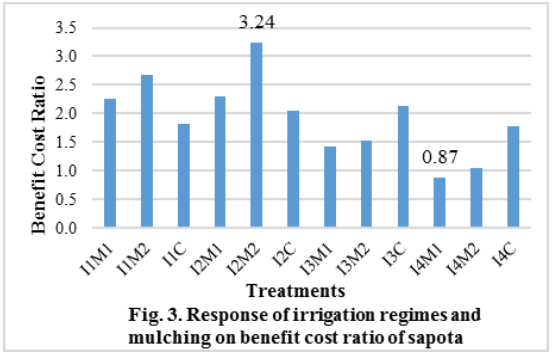

Fig. 3. Response of irrigation regimes and mulching on benefit cost ratio of sapota

kg plant^{-1} and 40.28 kg plant^{-1}) respectively (Tiwari *et al.* 2014). Treatment I_1M_2 was at par with I_4C This indicates that lower irrigation regimes with plastic mulch performed better as compared to higher irrigation regimes without mulch.

Water requirement of sapota crop

Weekly crop evapotranspiration was estimated and presented in Figure 1. The maximum weekly crop evapotranspiration was found as 30.04 mm in 19th

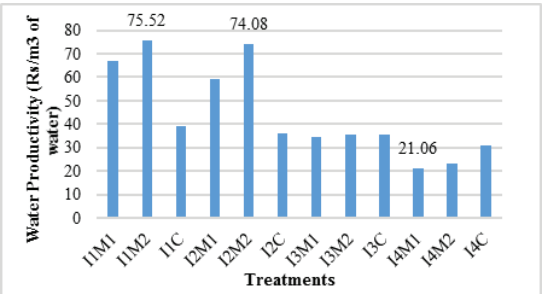

Fig. 4. Response of irrigation regimes and mulching on water productivity of sapota

week and the minimum value as 11.20 mm in 51st week. The crop water requirement was estimated for 52 weeks for different treatments. The maximum crop water requirement was 4.29 mm (88.67 L) per day during 19th week (May month) and the minimum of 1.60 mm (12.34 L) per day during 51st week (December month) for 100% crop water requirement.

Water use efficiency

The mean irrigation water use efficiency for different treatments is shown in Figure 2. The values ranged from 8.39 kg m^{-3} of water to 2.34 kg m^{-3}of water. The highest WUE was found in black plastic mulch scheduled at irrigation regimes I_1 (8.39 kg m^{-3} of water) at par with I_2 (8.23 kg m^{-3} of water) and the lowest was at I_4M_1 (2.34 kg m^{-3} of water).

Economics

Economics of drip at variable irrigation regimes with different mulch material was estimated based

on prevailing rate of year 2015. The highest benefit cost ratio was found to be 3.24 for I_2M_2 whereas the lowest B:C was found to be 0.87 at I_4M_1 (Figure 3). The system cost can be covered within a year. Even if the interest was worked out, the payback period of the system remains invariant because of the additional revenue from saved irrigation water and the cost saved in weeding.

Water productivity

Corresponding merits of mulching with drip irrigation was weighed against no mulch in terms of water productivity. It was calculated using black plastic mulch treatment at I_1 which resulted in higher water productivity of ₹75.52/m^3 of water used which was at par with I_2 (₹74.08/m^3 of water used) and was nearly 2.5 times of no mulch with I_4 (Figure 4).

Conclusion

Drip irrigation coupled with black plastic mulch scheduled at irrigation regimes 60% crop water requirement resulted in better performance of morphological variables, yield attributes, and WUE than wheat straw mulch and no mulch. Drip irrigated black plastic mulch yielded 23.38% higher yield compared to no mulch treatment followed by 12.21% higher yield with wheat straw mulch at irrigation regimes 60% of crop water requirement. Higher water use efficiency (8.23 kg/m^3 of water), benefit cost ratio (3.24) and higher water productivity (₹74.08/m^3 of water used) were found for drip with black plastic mulch scheduled at irrigation regimes 60% of crop water requirement. Drip irrigation with black plastic mulch scheduled at irrigation regimes 40% of crop water requirement was at par with no mulch treatment scheduled at irrigation regimes 100% crop water requirement. This indicates that lower irrigation regimes with black plastic mulch performed better as compared to higher irrigation regimes without mulch.

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