J. Indian Soc. Coastal Agric. Res. 34(2): 55-60 (2016)

In-situ Moisture Conservation for Rain-fed Cultivation of Guava Hybrid 'Arka Amulya' in Indian East Coast

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Received: 07.05.2016 Accepted: 11.10.2016

A field experiment was carried out at Central Horticultural Experiment Station, Bhubaneswar, Odisha during 2007-12 to find out the effects of various *in situ* moisture conservation methods on growth and yield of guava hybrid 'Arka Amulya' under rain-fed conditions of east coast India. Four *in-situ* rain water harvesting structures (cup and plate, half-moon, full moon and trench) in combination with three levels of mulching (no mulch, inorganic mulch and organic mulch) were evaluated employing split plot design. Each treatment combination was replicated five times. Among four *in situ* rain water harvesting structures, cup and plate system resulted in maximum annual increments in vegetative growth parameters, viz., plant height (36.01cm), canopy diameter (47.65 cm), scion girth (6.05 cm), and also fruit yield (5.63 kg plant^{-1}). Both organic (10cm thick layer of grass) and inorganic (UV stabilized black polythene of 100μ thickness) mulches significantly improved vegetative growth, yield and total soluble solids of fruit over no mulch.

(***Key words:*** *Arka Amulya, Guava, Mulching, Rain water harvesting*)

Guava (*Psidium guajava* L.) is grown throughout the tropical and sub-tropical parts of India due to its hardy nature and wider adaptability to varied soil and climatic conditions. Since its introduction in the country during 17th century by Portuguese, it has naturalized so well that there has been a shift in its production from subsistence to commercial cultivation. Over the past 13 years (2001-2013), area under guava cultivation has increased 1.73 times from 155 to 268 thousand hectares with 2.13 fold increase in production from 1.72 to 3.67 million tonnes. However, its productivity has not yet increased significantly because most of the orchards in the country are rain-fed. Though considered hardy, guava suffers in terms of growth and production under rain-fed conditions due to low water availability in the soil profile during February to May even in heavy rainfall zones, viz., Odisha which receives 75- 80% of annual rainfall (1400 mm) during June to September. This is critical as it adversely affects the fruit yield due to more flower and fruit drop, and reduced fruit growth. Therefore, appropriate measures of soil moisture conservation are needed to ensure consistent cropping and optimum yield in rain-fed areas.

In rain-fed areas of humid tropics of eastern India with poor quality lateritic soils, especially in the coastal tract, where majority of the farmers are either small or marginal, *in-situ* rain water harvesting and mulching could help in augmenting guava production. Badhe and Magar (2004), Khola and Sastry (2005), Manivannan and Desai (2007) and Panigrahi *et al.* (2008) reported that *in-situ* rain water harvesting by trenching, bunding, circular basins can increase soil water content by reducing surface runoff and encouraging infiltration in different fruit crops. Mulching is also an important soil moisture conservation technique that reduces evaporative loss of soil moisture. Besides, it plays important role in reducing soil erosion, improving soil structure, organic matter (organic mulch), microbial flora, soil aeration, regulating soil temperature, controlling weeds and reducing nutrient removal by weeds (Lal *et al*., 2003). Hence, an experiment was laid out to standardize *in situ* moisture conservation methods for guava.

MATERIALS AND METHODS

The study was carried out at ICAR-IIHR-Central Horticultural Experiment Station, Bhubaneswar, Odisha during 2007-2012 to find out suitable techniques of *in situ* rain water harvesting and mulching for cultivation of guava hybrid 'Arka Amulya' (Allahabad Safeda x Triploid) under rain-fed conditions of east coast India. The experimental site lies at 20°15' N latitude to 85°15' E longitude and 25.5m above mean sea level. The climate of the experimental farm is hot humid tropical which receives on an average 1400 mm annual rainfall between June to September. The climate between October to June remains dry. The meteorological information of the experimental site has been given in Table1.

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Table 1. *Meteorological data of experimental site during the study period (2007-2012)*

Month	Average of weather parameters (2007-2012)				
	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)
	Max.	Min.	Max.	Min.	
July	33.85	25.48	93.45	80.80	319.70
August	33.45	25.95	94.35	82.95	415.05
September	32.25	23.88	93.25	74.90	229.65
October	31.73	23.58	90.55	66.45	64.90
November	30.95	19.10	90.40	59.05	48.38
December	28.98	14.65	88.25	50.25	0.00
January	29.40	14.60	77.05	46.10	11.10
February	33.85	17.15	89.85	38.25	6.15
March	36.13	21.88	88.90	37.20	2.95
April	36.65	24.75	88.80	47.10	44.53
May	37.90	26.33	89.75	57.50	91.30
June	37.53	26.83	89.50	69.75	181.88

The soil of the experimental site is sandy loam (81.8% sand, 9.72% silt and 8.48% clay) and strongly acidic (pH 4.35) with low organic carbon (0.20%) and available N, P and K (162.8, 7.5 and 106.58 kg ha^{-1}, respectively). The site has very low soil depth (5-10cm) and sub-soil is characterized by *morrum*/stone blocks and hard pan due to which planting pits of 1m x 1m x 1m size were prepared at 5m x 5m spacing by JCB (Hitachi make) so that, the root system of the plant grows properly. *In-situ* orchard of guava was developed by sowing the seeds in the pits with the onset of monsoon in 2007 and top grafting the seedlings so raised with scion of guava hybrid 'Arka Amulya' a year after in 2008.

The experiment was laid out in split plot design with 12 treatment combinations and five replications. The treatments consisted of four *in-situ* rain water harvesting structures, *viz*., half-moon (semi-circular basin), full moon (circular basin), cup and plate (circular pit of 0.50m width and 0.50m depth around the tree) and trench system (2m length, 0.50m width and 0.50m depth) at 1m distance from trunk, as main plot and three levels of mulching, *i.e.,* no mulch, organic mulch (10cm thick layer of grass) and inorganic mulch (UV stabilized black polythene of 100μ thickness) around the tree at 1m radius as sub-plot treatments (Fig. 1). Plastic mulch was removed during rainy season and imposed again during

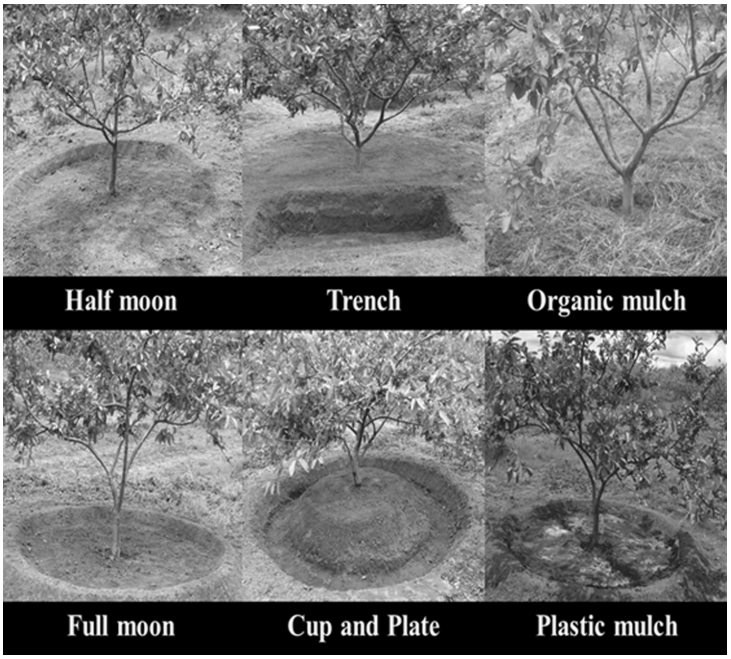

Fig. 1. *In situ moisture conservation for rain-fed cultivation of guava*

Table 2. *Effect of in situ moisture conservation methods on annual increase in growth parameters of guava hybrid 'Arka Amulya'*

Treatment	Annual increase in growth parameters (cm)											
	Plant height				Canopy diameter				Scion girth			
	2010	2011	2012	Mean	2010	2011	2012	Mean	2010	2011	2012	Mean
***In-situ* rain water harvesting structures**												
Half- moon	21.17	28.13	29.60	26.30	31.63	39.76	29.09	33.49	4.14	4.79	3.80	4.24
Full moon	21.42	28.85	31.94	27.40	35.25	41.08	30.53	35.62	4.31	4.92	4.03	4.42
Cup and plate	27.04	40.42	40.58	36.01	37.00	55.96	49.99	47.65	6.03	6.45	5.63	6.05
Trench	28.25	36.77	37.38	34.13	36.21	47.08	42.25	41.85	5.32	6.15	4.88	5.45
CD (P=0.05)	4.34	7.48	4.8	3.81	NS	6.28	6.18	5.11	0.79	0.98	0.69	0.37
Mulching												
No mulch	20.84	27.75	28.92	25.84	33.31	41.84	30.92	35.36	4.31	4.81	4.00	4.37
Inorganic mulch	26.44	36.56	37.47	33.49	35.81	46.84	41.17	41.28	5.20	5.95	4.89	5.35
Organic mulch	26.13	36.31	38.23	33.56	35.94	49.23	41.81	42.32	5.35	5.98	4.85	5.39
CD (P=0.05)	4.54	6.1	6.34	3.19	NS	4.49	5.86	3.47	0.65	0.88	0.51	0.31

Table 3. *Effect of in situ moisture conservation methods on fruit yield of guava hybrid 'Arka Amulya'*

Treatment	Fruit yield												
	No. of fruits plant^{-1}				Average fruit weight (g)				Weight of fruits (kg tree^{-1})				
	2010	2011	2012	Mean	2010	2011	2012	Mean	2010	2011	2012	Cumulative	Mean
***In situ* rain water harvesting structures**													
Half- moon	22.71	24.04	35.96	27.57	116.82	119.07	118.64	118.18	2.60	2.85	4.26	9.71	3.24
Full moon	24.29	26.08	37.42	29.26	116.22	120.98	116.46	117.89	2.79	3.15	4.31	10.25	3.42
Cup and plate	33.96	50.63	58.71	47.77	113.63	121.29	118.94	117.95	3.79	6.13	6.98	16.9	5.63
Trench	30.63	38.75	47.38	38.92	110.80	121.23	115.33	115.79	3.37	4.64	5.45	13.46	4.49
CD (P=0.05)	NS	10.78	8.78	6.97	NS	NS	NS	NS	NS	1.15	1.04	2.32	0.77
Mulching													
No mulch	24.50	27.50	36.63	29.54	112.49	121.05	114.90	116.15	2.73	3.31	4.19	10.23	3.41
Inorganic mulch	28.41	37.28	47.44	37.71	114.96	122.11	120.34	119.14	3.22	4.56	5.65	13.43	4.48
Organic mulch	30.78	39.84	50.53	40.39	115.65	118.77	116.79	117.07	3.46	4.71	5.91	14.08	4.69
CD (P−0.05)	NS	6.24	6.23	3.84	NS	NS	NS	NS	NS	0.7	0.67	1.29	0.431

October- November after cleaning the tree basin. The trees were maintained under rain-fed condition since the inception of the experiment.

Initial growth parameters (plant height, canopy diameter and scion girth) were recorded in 2009. Annual increments in vegetative growth parameters were noted for three consecutive years thereafter, from 2010 to 2012. The height of plant was measured with the help of graduated pole from ground level to top of plant. Scion girth was recorded at 5cm above the graft union with the help of measuring tape. Canopy diameter of plant was recorded in east-west and north-south directions with the help of measuring tape and mean value was computed. The first fruiting was in 2010. Fruits were harvested at full maturity and observations were recorded on fruit yield and quality parameters (pulp and seed contents, total soluble solids and titratable acidity). Fruit pulp and seed were weighed (in grams) using electronic balance and expressed in %. The TSS was determined using hand held digital refractometer (Hanna make). Acidity was estimated by titrating the fresh fruit juice with 0.1N NaOH using phenolphthalein as indicator and expressed as per cent citric acid equivalents. The data 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 observations recorded for three consecutive years from 2010-2012, on growth and yield are presented along with pooled data in Table 2 and Table 3, respectively. The interaction between the two factors was not significant at P=0.05 for all the characters studied hence not included in the Tables.

Effect of *in situ* rain water harvesting structures on growth, yield and fruit quality

From the perusal of pooled data, it is clear that cup and plate system of *in-situ* rain water harvesting had significant impact not only on growth parameters (plant height, canopy diameter and scion girth) but also on yield. In the present study the maximum fruit yield recorded by 4 years old plant under cup and plate system was 6.98kg/plant. Fruit quality parameters (pulp and seed%, TSS and acidity) were at par in all the treatments (Table 4).

Better vegetative growth and yield in cup and plate system, might be due to more rainwater harvesting by this structure and the resultant increased soil water availability to plants for longer duration as compared to other structures. Negi *et al.* (2013); Polara *et al*. (2013) and Patil *et al*. (2005) have reported the similar beneficial effects of *in-situ* rain water harvesting techniques on plant growth and fruit yield in *aonla*, custard apple and mango, respectively.

Effect of mulching on growth, yield and fruit quality

The growth of guava in terms of plant height, canopy diameter and scion girth was improved by organic and inorganic mulches, over no mulch. Similar effects of mulching have been reported earlier by Das *et al*. (2010) for guava in West Bengal. Enhanced plant growth might be due to sufficient moisture availability and enhanced lateral growth of the roots in upper layers of soil which in turn might have resulted into better nutrient uptake as reported in citrus and mango by Panigrahi *et al*. (2008) and Singh *et al*. (2009), respectively.

Table 4. *Effect of in situ moisture conservation methods on fruit quality of guava hybrid 'Arka Amulya'*

Treatment	Fruit quality			
	Pulp (%)	Seed (%)	TSS (°B)	Acidity (%)
***In situ* rain water harvesting structures**				
Half-moon	96.96	3.04	11.28	0.23
Full moon	97.11	2.89	11.21	0.26
Cup and plate	97.33	2.67	10.89	0.27
Trench	97.05	2.95	10.86	0.28
CD (P=0.05)	NS	NS	NS	NS
Mulching				
No mulch	97.0	3.00	10.78	0.27
Inorganic mulch	97.13	2.81	11.19	0.26
Organic mulch	97.14	2.86	11.23	0.25
CD (P=0.05)	NS	NS	0.37	NS

Organic mulch produced the highest fruit yield which was at par with the yield recorded in inorganic much. The increased yield under organic and inorganic mulch was due to significant increase in number of fruits over the no mulch treatment which might be due to better conservation of soil moisture, improved availability of soil moisture, suppression of weed growth and decrease in soil temperature which in turn might have resulted into more fruit retention and reduced fruit drop. Similar results of increased yield due to mulching have been reported by Shukla *et al*. (2000); Ghosh and Tarai (2007); Joolka *et al*. (2008) and Sharma (2009) in other fruit crops.

In the study mulches were found to have positive effect on TSS (Table 4). However, other fruit quality parameters (pulp%, seed% and acidity) were not influenced significantly. Improvement in TSS by mulching treatments may be due to soil moisture conservation which ultimately might have caused mobilization of soluble carbohydrates to the fruits as reported by Nath and Sharma (1994). Improvement in fruit quality due to application of mulches was also observed by Ghosh and Bauri (2003); Ghosh and Tarai (2007) and Joolka, *et al*. (2008) in mango, ber and apple, respectively.

CONCLUSIONS

From the results of six years long study, it may be inferred that cup and plate system of *in situ* rainwater harvesting and mulching either with 10cm thick layer of grass or black polythene of 100μ thickness could be adopted for better growth, fruit yield and quality of rain-fed guava.

ACKNOWLEDGEMENT

Authors are thankful to the Director, IIHR, Bengaluru and Head, Central Horticultural Experiment Station (ICAR-IIHR), Bhubaneswar for providing facilities, and to Mr. A. Kanhar, Technical Assistant, CHES, Bhubaneswar for the help rendered during data collection and physico-chemical analysis of fruit samples.

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