DOI : 10.5958/0974-0112.2016.00006.2

Indian J. Hort. 72(4), December 2015: 479-484

Effect of drip irrigation and polyethylene mulching on fruit yield and quality of guava cv. Allahabad Safeda under meadow orcharding

V.K. Singh*, M.K. Soni and Anurag Singh

Division of Crop Production, ICAR-Central Institute for Subtropical Horticulture, Rehmankhera, P.O. Kakori, Lucknow 226101, Uttar Pradesh

ABSTRACT

A field experiment was conducted during 2009-2012 with an objective of improving yield and quality of guava under drip irrigation and polyethylene mulching in ultra high density planting (2.0 m × 1.0 m). The experiment plot of guava (four-year-old) was irrigated with a drip irrigation system having two emitters per plant of two LPH capacity based on four irrigation levels (40, 60, 80 and 100%) of pan evaporation (PE) replenishment and one ring basin irrigation method (control). UV stabilized black polyethylene mulching (100 µ thickness) was done during October-November (2009). Higher fruit number (27.3), fruit weight (107.3 g) and fruit yield (16.92 kg m^{-3}) were recorded by application of irrigation at 80% PE (T3) per day per plant coupled with black polyethylene mulching. Maximum water saving (47.52%) was recorded through drip irrigation and polyethylene mulching as compared to control (unmulched basin irrigation). Fruit yield varied from a maximum value of 16.92 kg m^{-3} canopy volume in drip irrigation 80% PE level with black polyethylene mulching as compared to minimum in control (8.21 kg m^{-3}). Drip irrigation coupled with polyethylene mulching resulted in better quality of fruits in terms of increased TSS (12.1°Brix), total sugars (6.61%), ascorbic acid (169.2 mg 100 g^{-1}) and reduced acidity (0.27%) as compared to the minimum TSS (10.1°Brix), total sugars (6.12%), ascorbic acid (159.6 mg/100 g) and increased acidity (0.34%) in control.

Key words: *Psidium guajava* L., drip irrigation, plastic mulching, meadow orchard.

INTRODUCTION

Guava (*Psidium guajava* L.), a member of Myrtaceae family is an important fruit crop of tropical and subtropical regions. It is fifth most important fruit crop in production after banana, mango, citrus and papaya with a total production of 1.68 million tonnes. The fruit is rich source of vitamin C, pectin and minerals like calcium, phosphorus and iron and is mainly used as a table fruit. Comparatively, good quality fruits are available only in winter season, whereas the rainy season fruits are poor in quality as well as insipid in taste (Singh, 16) due to poor water management. As the global water consumption is doubling every 20 years (Vorosmarty *et al.*, 21) and projected increase in food demand will have to be met by irrigation. Appropriate scheduling of irrigation increases the water use efficiency along with water saving for other purposes. The surface irrigation system is most common method of irrigation.

The guava fruits exhibits marked decline in quality due to indiscriminate irrigation and erratic rainfall pattern (Singh, 16). It is therefore, essential to formulate an efficient and economically viable water management strategy in order to irrigate more land area with existing limited water resources and enhance economic returns. It is established that drip irrigation and plastic mulching improves the fruit quality in many other crops (Singh *et al.*, 18). Many workers have reported that there is 50 to 70 percent saving in irrigation water and 10 to 70 percent increase in yield of fruit and vegetable crops through drip irrigation (Cetin *et al.*, 3; Ramniwas *et al.*, 12; Singh *et al.*, 17). The drip irrigation systems also provide opportunity to apply appropriate amount of nutrients and chemicals along with water, which reduces leaching losses and enhances soil temperature, yield, quality, water and nutrient use efficiency (Sulochanamma *et al.*, 20). Mulching has been found beneficial in improving physical and biological health of soil (Garg *et al.,* 7). The response of guava to the combined effect of drip with different levels of irrigation in conjunction with polyethylene mulch and their economic feasibility are not well known. The water requirement through drip has been little studied in high density planting in guava (Singh *et al.*, 15). However, water requirement under meadow orchard (5,000 plants ha^{-1}) has not been worked out. Hence, an experiment was conducted to evaluate crop water requirement and improving yield and quality of guava under drip irrigation and polyethylene mulching.

*Corresponding author's E-mail: singhvk_cish@rediffmail.com

MATERIALS AND METHODS

A field experiment was conducted at ICAR-Central Institute for Subtropical Horticulture, Lucknow located at a latitude of 26°54'N and longitude of 80°45' E with an altitude of 127m above mean sea level, having typical subtropical climate with dry hot summer and cold winters. Observations on meterological parameters, *viz*. pan evaporation, temperature, relative humidity and soil moisture were recorded by the weather station located adjacent to the experimental plot during 2009-2012. Plant growth parameters, *viz*. tree volume (m^3), yield (kg m^{-3}), fruit weight (g) and quality attributes, *viz*. TSS (°Brix), acidity (%), vitamin C (mg/100 g) and total sugars (%) were recorded at appropriate stages. The soil is mixed hyperthermic family of Typical Ustochrepts with sandy loam texture. Ultra high density plantation of guava cv. Allahabad Safeda at a spacing of 2.0 m × 1.0 m (5,000 tree ha^{-1}) was maintained since 2008. Soil nutrient and moisture level at different depth (0-100 cm) of the root zone of the trees was recorded under mulched and unmulched condition. The moisture (%) was measured up to 50 cm depth only as there was no difference in its level after 50 cm depth. The plants were irrigated through drip irrigation system having 2 emitters per plant of 2 lph capacity and UV stabilized black polyethylene mulching (100 micron thick) was done during month of October-November. Each tree was pruned uniformly at a height of 40 cm during the first year for maintaining the height and inducing flowering. In the experiment, the drippers were placed equidistant in at 50% distance of canopy radius. There were four irrigation levels (40, 60, 80 and 100% PE replenishment), one basin irrigation with (100% PE) under mulch and unmulched conditions. The treatments were replicated three times in a randomized block design making ten treatments in all. The water received through rain was accommodated in irrigation schedule in successive days in all treatments but ignored in control plants. The volume of water required was computed by using the following equation:

Daily water requirement = r × f × k × c × Kc

Where, r = pan reading in mm; f = plant area / spacing (2 m × 1 m = 2 sqm); k = area of plant canopy; c = % Canopy area covered by the on an aerial view; Kc = Crop factor (for guava is taken as 0.8)

One square metre canopy area with one mm evaporation replenishment was equal to one litre of drip irrigation (Dinesh *et al.*, 5). The time of drip operation was determined by the total discharge rate. Canopy volume of tree was calculated using the formula devised by (Westwood *et al.*, 22). The fertilizer was applied as urea 130 g + single super phosphate 185 g + muriate of potash 50 g per plant. This dose was increased every year up to three years in the multiple of first year's dose. Thus, a plant aged three years and above should get 385 g urea + 555 g single super phosphate + 150 g muriate of potash along with 20 kg of FYM. The single super phosphate was applied as soil application in September and urea along with muriate of potash was applied through fertigation in 10 split doses.

Total soluble sugars was estimated following the method of Alcoverro *et al.* (1) based on Yemm and Willis (23) spectrophotometrically by an anthrone assay using glucose as a standard. The total soluble solids in fresh pulp were recorded by using hand refractometer (Erma, Japan) in fresh pulp. Ascorbic acid was estimated by 2,6-dichlorophenol-indophenol visual titration method as described by Ranganna (13) and its content was expressed by mg 100 g^{-1} of fresh fruit pulp. The acidity was determined by the method of AOAC (2). The soil moisture at different depth was measured by soil moisture measurement system (Delta Devices Ltd. U.K.). The data on moisture level at different depth was presented only for 80% PE as it was at par with 100% PE and best among other treatments. The organic carbon, pH, available P, K, exchangeable Ca and chloride content in soil at different depth were estimated as per standard procedure (Jackson, 9). The water saving percent was expressed as the percent reduction in the quantity of water (mm ha^{-1}) applied under drip irrigation as compared to basin irrigation with and without polyethylene mulching (INCID, 8). Sigma plot and SAS (Statistical Analysis Software) were used for statistical analysis.

RESULTS AND DISCUSSION

Perusal of the data indicated (Table 1) that tree volume was not significantly affected by drip irrigation coupled with mulching that might be due to regular concurrent pruning. Fruit number, fruit weight and yield were recorded for consecutive years from 2009-2012 and pooled data of three years are presented (Table 2). The fruit yield was calculated on the basis of canopy volume of tree. The average maximum temperatures (33.8 ± 2.8°C) and minimum (24.2 ± 1.2°C) in rainy season and maximum 26.5 ± 2.3°C and minimum (10.2 ± 1.9°C) in winter season were recorded during the study period. The total annual rainfall received was 1026.6 mm and ranged between 8.7-27.3 mm during rainy season and 4.8-17.5 mm during winter season. The minimum and maximum relative humidity ranged between 52.83 ± 3.0 to 88.9 ± 3.6% during the experimental period. The mean daily pan evaporation ranged from 2.0 to 4.9 mm per day during winter months and 4.03 to 7.10 mm per day during summer months in successive years. The number of fruits per tree at harvest and yield in guava

Table 1. Effect of drip irrigation and polyethylene mulch on growth of guava cv. Allahabad Safeda under meadow orcharding.

Treatment	Detail	Tree volume (m^3)			
		2009-10	2010-11	2011-12	Mean
T1	40% PE + PM	0.113	0.196	0.317	0.209
T2	60% PE + PM	0.099	0.178	0.284	0.187
T3	80% PE + PM	0.107	0.164	0.257	0.176
T4	100% PE + PM	0.154	0.214	0.325	0.231
T5	40% PE + WPM	0.134	0.197	0.323	0.218
T6	60% PE + WPM	0.121	0.227	0.288	0.212
T7	80% PE + WPM	0.159	0.215	0.308	0.227
T8	100% PE + WPM	0.141	0.221	0.367	0.243
T9	100% PE basin irrigation + PM	0.184	0.256	0.332	0.257
T10 (control)	100% PE basin irrigation + WPM	0.173	0.232	0.304	0.236
CD (p = 0.05)		0.010	0.017	0.022	-

PE = Pan evaporation, PM = polyethylene mulching, WPM = Without polyethylene mulching

Table 2. Effect of drip irrigation and polyethylene mulch on fruit number, fruit weight and yield of guava cv. Allahabad Safeda under meadow orcharding.

Treatment	Detail	No. of fruits per tree	Fruit wt. (g)*	Fruit yield (kg m^{-3})
T1	40% PE + PM	25.07	100.67	12.14
T2	60% PE + PM	26.4	103.37	14.67
T3	80% PE + PM	27.3	107.2	16.92
T4	100% PE + PM	25.8	101.33	11.35
T5	40% PE + WPM	24.3	99.43	11.23
T6	60% PE + WPM	25.43	100.9	12.35
T7	80% PE + WPM	26.27	105.53	12.10
T8	100% PE + WPM	24.97	99.13	10.38
T9	100% PE basin irrigation + PM	23.7	96.17	8.86
T10 (control)	100% PE basin irrigation + WPM	21.47	90.77	8.21
CD (p = 0.05)		2.91	3.01	2.35

PE = Pan evaporation, PM = polyethylene mulching, WPM = Without polyethylene mulching; *Mean of 10 fruits

were also influenced by drip irrigation. Drip irrigation 80% PE level and black polyethylene mulching (T3) showed significantly high yield (16.92 kg m^{-3}), number of fruits per tree (27.3 $tree^{-1}$), and fruit weight (107.2 g) compared to minimum yield (8.21 kg m^{-3}), number of fruits per tree (21.47 $tree^{-1}$) and fruit weight (90.77 g) in control trees (Table 2). Improvement in fruit quality in terms of higher TSS (12.1°Brix), total sugars (6.61%), ascorbic acid (169.2 mg 100 g^{-1}) and reduced acidity (0.27%) in T3 was recorded as compared to less TSS (10.1°Brix), total sugars (6.12%), ascorbic acid (159.6 mg 100 g^{-1}) and high acidity (0.34%) in control trees (100% PE + basin irrigation) (Table 3). Water saving to the tune of 47.52% through mulching along with drip irrigation was observed against mulched with basin irrigated trees (18.33%) *vis-à-vis* unmulched basin irrigation (taken as 0 value) (Fig. 2). The results are in conformity with the findings of Shirgure *et al.* (14), Srinivas (19) and Dixit *et al.* (6) under different climatic conditions.

The soil moisture increased 20-35% with increasing the drip irrigation regimes in the 0-40 cm, *i.e.* the effective root zone in the guava plants (Fig. 1a, b & c). But the persistency of soil moisture was varied in different treatments and drip irrigation along with mulching exhibited less fluctuation (Fig. 1c) as compared to drip irrigation without mulch (Fig. 1b) followed by basin irrigation and no mulching (Fig. 1a).

Table 3. Effect of drip irrigation and polyethylene mulching on fruit quality of guava cv. Allahabad Safeda under meadow orcharding.

Treatment	Detail	TSS (°Brix)	Ascorbic acid (mg/100 g FW)	Total sugars (%)	Acidity (%)
T1	40% PE + PM	11.2	163.1	6.32	0.29
T2	60% PE + PM	11.4	167.5	6.41	0.28
T3	80% PE + PM	12.1	169.2	6.61	0.27
T4	100% PE + PM	11.3	162.7	6.38	0.28
T5	40% PE + WPM	10.8	161.2	6.22	0.33
T6	60% PE + WPM	10.9	165.3	6.32	0.32
T7	80% PE + WPM	11.0	167.3	6.40	0.30
T8	100% PE + WPM	11.1	160.2	6.21	0.29
T9	100% PE basin irrigation + PM	11.2	161.0	6.23	0.30
T10 (Control)	100% PE basin irrigation + WPM	10.1	159.6	6.12	0.34
CD (p=0.05)		1.01	0.045	5.43	0.053

PE = Pan evaporation, PM = polyethylene mulching, WPM = Without polyethylene mulching

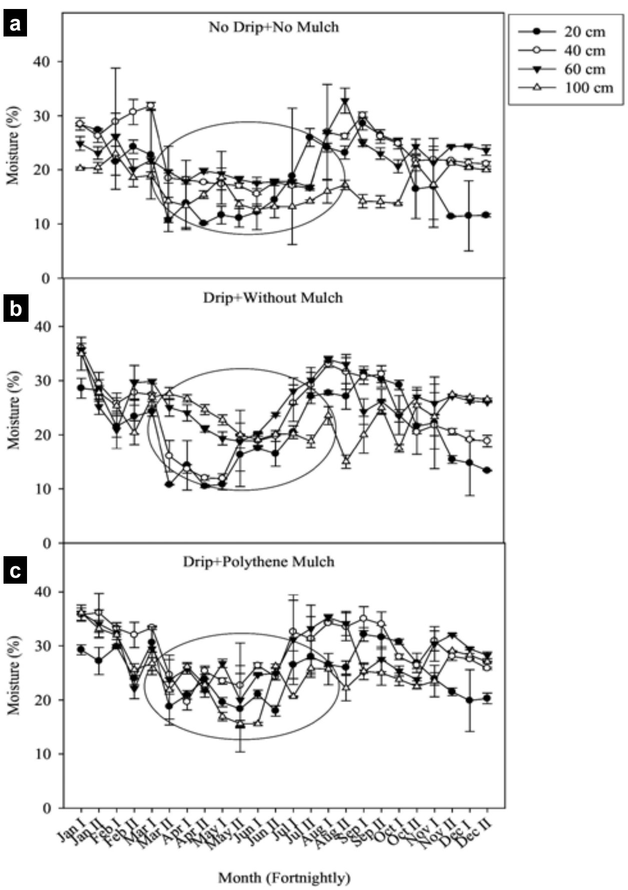

Fig. 1. Soil moisture in different depths under different treatments. (a) no drip + no mulch, (b) drip without mulch, and (c) drip with mulch in meadow orcharding of guava cv. Allahabad Safeda

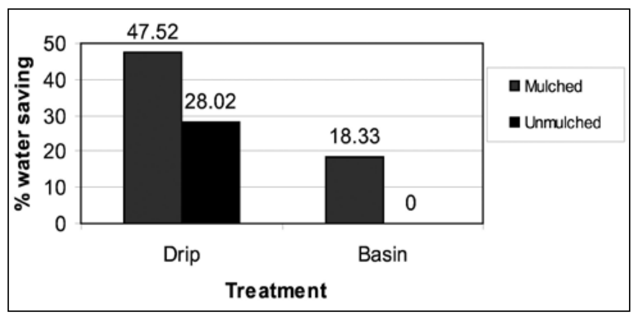

Fig. 2. Water saving (%) in mulched and unmulched guava plants calculated on the basis of unmulched basin irrigation (as 0 value).

Drip irrigation with mulching provides a consistent moisture regime in the soil due to which root remains active through out the season resulting in optimum availability of nutrient and its proper absorption, which favours the fruit growth and development in guava. Increase in number of fruits per tree in mango due to reduced drip irrigation regime was also observed by Pavel and Villiers (11). Coelho and Borges (4) emphasized the importance of drip irrigation in fruit crops for better yield and quantity.

Adequate moisture was required during vegetative growth for optimum flowering and fruit development. The maximum available soil moisture content was recorded with drip irrigation at 100% PE + polyethylene mulching, which was at par with 80% PE + PM during successive months resulting in to water saving of 20% without hampering the yield and quality of guava. The nutrient content, *viz.*, organic carbon, available phosphorus, available potassium,

Table 4. Soil characteristics of meadow orcharding of guava under mulch and unmulched conditions at different soil depths.

Treatment	Depth (cm)	pH	Organic carbon (%)	Avail. P (ppm)	Avail. K (ppm)	Exchg. Ca (ppm)	Cl^- (mg 100 g^{-1})
Mulching	0-25	6.94 ± 0.11	0.350 ± 0.04	6.0 ± 0.74	87.3 ± 5.9	128.2 ± 5.6	8.7 ± 1.16
	25-50	6.97 ± 0.17	0.311 ± 0.03	6.0 ± 0.71	81.6 ± 4.7	117.6 ± 2.9	8.7 ± 1.35
	50-100	6.99 ± 0.16	0.264 ± 0.03	4.6 ± 0.64	82.5 ± 4.6	117.1 ± 3.2	6.6 ± 0.99
Unmulched	0-25	6.97 ± 0.13	0.331 ± 0.02	5.6 ± 0.75	76.1 ± 2.7	119.3 ± 3.7	8.4 ± 1.17
	25-50	6.77 ± 0.11	0.272 ± 0.05	5.3 ± 0.78	71.0 ± 3.6	113.7 ± 1.3	6.9 ± 0.57
	50-100	6.74 ± 0.12	0.253 ± 0.02	4.2 ± 0.71	75.3 ± 3.3	112.2 ± 2.1	6.1 ± 1.12

exchangeable calcium and chloride also varied in different soil depths having maximum content under mulching in 0-25 cm depth of soil. Similarly, black polyethylene mulch can also be attributed to the fact that the temperature and the moisture content under mulching was conducive during different seasons creating a congenial environment for higher microbial population resulting in higher yield with better quality (Garg *et al*., 7). In case of drip irrigation, water is made available in the root zone thereby reducing the water stress near roots. Similar results were also reported by Panigrahi *et al.* (10), Dixit *et al.* (6), Ramniwas *et al.* (12) and Shirgure *et al.* (14) in different fruit crops. It may be concluded from the present study that guava should be irrigated at 80% PE coupled with polythene mulching in 2 m × 1 m density for increasing yield and quality.

ACKNOWLEDGEMENTS

The authors are grateful to the Director, Central Institute for Subtropical Horticulture, Lucknow for providing necessary facilities and to the National Committee on Plasticulture Applications in Agriculture and Horticulture, MoA, New Delhi for financial support and Dr Kailash Kumar for laboratory analysis.

REFERENCES

1. Alcoverro, T., Zimmerman, R.C., Kohrs, D.G. and Alberte, R.S. 1999. Resource allocation and sucrose mobilization in light-limited eelgrass *Zostera marina*. *Mar. Ecol. Prog. Ser.* **187**: 121-31.
2. AOAC. 2000. *Official Methods of Analysis of Association of the Analytical Chemists Inc*. Virginia, USA.
3. Cetin, B., Yazgan, S. and Tipi, T. 2004. Economics of drip irrigation of olives in Turkey. *Agric. Water Manag.* **66**: 145-51.
4. Coelho, E.F. and Borges, A.L. 2004. Irrigation and fertigation in mango. *Acta Hort*. **646**: 121-23.
5. Dinesh, K., Pandey, V. and Nath, V. 2008. Effects of drip irrigation regimes on growth, yield and quality of mango hybrid Arka Anmol. *Indian J. Hort.* **65**: 409-12.
6. Dixit, A., Sharma, D., Agarwal, N. and Dubey, P. 2003. Effect of drip irrigation and mulch on mango yield and its fruit quality characters. *Plant Arch.* **3**: 199-202.
7. Garg, N., Singh, G., Yadav, P., Goyal, N. and Soni, M.K. 2007. Effect of mulching on microbial population in guava orchard soils. *Indian J. Agri. Sci.* **77**: 241-43.
8. INCID. 1994. *Drip Irrigation in India*, Indian Committee on Irrigation and Drainage, New Delhi.
9. Jackson, M.L. 1973. *Soil Chemical Analysis*, Prentice Hall of India Pvt. Ltd, New Delhi.
10. Panigrahi, H.K., Agrawal, N., Agrawal, R., Dubey, S. and Tiwari, S.P. 2010. Effects of drip irrigation and polythene mulch on the fruit yield and quality parameter of mango (*Mangifera indica* L.). *J. Hort. Sci.* **5**: 140-43.
11. Pavel, E.W. and de Villiers, A.J. 2004. Response of mango trees to reduced irrigation regimes. *Acta Hort*. **646**: 63-68.
12. Ramniwas, Kaushik, R.A., Sarolia, D.K., Pareek, S. and Singh, V. 2012. Effect of irrigation and fertigation scheduling on growth and yield of guava (*Psidium guajava* L.) under meadow orcharding. *African J. Agri. Res*. **7**: 6350-56.
13. Ranganna, 1979. *Manual Analysis of Fruit and Vegetable Products*, Tata McGraw-Hill Co. Ltd., New Delhi, pp. 2-95.

14. Shirgure, P.S., Srivastava, A.K. and Singh, Shyam. 2004. Growth, Yield and quality of acid lime under pan evaporation based drip irrigation scheduling. *Indian J. Soil Cons*. **32**: 32-35.

15. Singh, B.K., Tiwari, K.N., Chourasia, S.K. and Mandal, S. 2007. Crop water requirement of guava (*Psidium guajava* L.) cv. KG/ KAJI under drip irrigation and plastic mulch. *Acta Hort*. **735**: 399-405.

16. Singh, G. 2010. Development of meadow orchard in guava for higher production. *Prog. Hort*. **42**: 129-33.

17. Singh, P., Singh, A.K. and Sahu, K. 2006. Irrigation and fertigation of pomegranate cv. Ganesh in Chhattisgarh. *Indian J. Hort.* **63**: 148-51

18. Singh, V.K., Singh, G. and Bhriguvanshi, S.R. 2009. Effect of polyethylene mulch on soil nutrient level and root, leaf and fruiting characterstic of mango (*Mangifera indica*). *Indian J. Agri. Sci.* **79**: 411-17.

19. Srinivas, K. 2005. Drip irrigation studies in mango for growth and yield. *Ann. Rep. I.I.H.R. Bengaluru*, pp. 20-21.

20. Sulochanamma, B.N., Reddy, T.Y. and Reddy, G.S. 2005. Effect of basin and drip irrigation on growth, yield and water use efficiency in pomegranate cv. Ganesh. *Acta Hort*. **696**: 277-79.

21. Vorosmarty, C.J., Green, P., Salisbury. J. and Lammers, R.B. 2000. *Global Water Resources: Vulnerability from Climate Change and Population Growth Science*, **289** (5477), pp. 284-88.

22. Westwood, M.N., Reimer, F.C. and Quackenbush, V.L. 1963. Long term yield as related to ultimate tree size of three pear varieties grown on rootstock of five *Pyrus* spp. *Proc. Amer. Soc. Hort. Sci*. **82**: 103-08.

23. Yemm, E. and Willis, A.J. 1954. The estimation of carbohydrate in plant extracts by anthrone. *Biochem J.* **57**: 508-14.

Received : November, 2015; Revised : September, 2015; Accepted : October, 2015