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Studies on influence of mulching and fertigation in guava var. Lucknow 49 under high density planting system

Nandhini M, S Parthiban, J Rajangam, K Venkatesan and MP Kavitha

Nandhini M
Department of Fruit Science, Horticultural College and Research Institute, Periyakulam, Tamil Nadu, India

S Parthiban
Department of Spices and Plantation Crops, Horticultural College and Research Institute, Periyakulam, Tamil Nadu, India

J Rajangam
Department of Fruit Science, Horticultural College and Research Institute, Periyakulam, Tamil Nadu, India

K Venkatesan
Department of Floriculture and Landscape Architecture, Horticultural College and Research Institute, Periyakulam, Tamil Nadu, India

MP Kavitha
Department of Natural Resource Management, Horticultural College and Research Institute, Periyakulam, Tamil Nadu, India

Corresponding Author:
S Parthiban
Department of Spices and Plantation Crops, Horticultural College and Research Institute, Periyakulam, Tamil Nadu, India

Abstract
The field experiment was carried out to evaluate the effect of mulching and fertigation on growth, yield and quality of guava var. L-49 under high density planting system during 2020-21 at Horticultural College and Research Institute, Periyakulam. Four levels of fertigation dose (50%, 75%, 100% through fertigation, 100% RDF soil application) in combination with four levels of mulching (black polythene mulch, weed mat, paddy straw and no mulch) was evaluated laid out in split plot design and replicated twice. The result indicated that fertigation and mulching significantly influenced the growth, yield and quality parameters of guava. Among the treatment combination, 100% RDF through fertigation with paddy straw mulch reported maximum growth parameters like plant height, stem girth, canopy spread. Maximum values of yield parameters *viz*. number of fruits per plant, fruit weight, fruit length, yield per plant and quality parameters like TSS, ascorbic acid and total sugar were observed in 75% RDF through fertigation with paddy straw mulch on comparison with other treatments. Hence, 75% RDF through fertigation with paddy straw considered as environment friendly practise which saves fertilizer requirement for guava cultivation under high density planting system.

Keywords: Guava, lucknow-49, mulching, fertigation, high density planting

1. Introduction
Guava (*Psidium guajava* L.) is an evergreen tropical fruit crop that is widely cultivated in tropical regions around the world. It is a species of the Myrtaceae family. Guava is also known as the "poor man's apple" due to its low production costs and high nutritional value. Guava is said to have originated in Tropical America, in a region that extends from southern Mexico through Central America. The guava is now grown all over the world in tropical and subtropical regions. India, Brazil, Mexico, and South Africa are the top guava producers. In India, it is cultivated in an area of 0.28 million hectares, with an annual yield of 4.30 million tonnes (National Horticultural Board, 2019-20). Uttar Pradesh, Maharashtra, Madhya Pradesh, Bihar, West Bengal, Punjab, Tamil Nadu, Gujarat, and Karnataka are the major states in India that produce guava. The area in Tamil Nadu is about 9690 hectares, with a production of 6.86 lakh tonnes (NHB, 2018) [12]. When compared to Madhya Pradesh (19.57 t ha^{-1}), the productivity of guava in Tamil Nadu (16 t ha^{-1}) is slightly lower (Horticultural Statistics at a Glance, 2018) [9]. The guava is almost cultivated in all the districts of Tamil Nadu and mostly cultivated in Dindigul, Madurai, Vellore, Virudhunagar and Cuddalore districts.
Guava has been identified as an excellent fruit for ensuring nutritional security. It is an excellent source of tannins, phenols, triterpenes, flavonoids, essential oils, saponins, carotenoids, lectins, vitamins, fibre, and fatty acids. The fruits contain a good amount of thiamine, niacin, and riboflavin, as well as a fair amount of vitamin A (about 250 IU/100g). It is also one of the most abundant sources of ascorbic acid, with 75 to 260 mg/100gm.
Present days, many guava producers have embraced the idea of "high density planting" for guava production, which results in a greater number of plants per hectare, varying from 1111 to 3333 plants, depending on the plant spacing, which varies between 3 × 3 m and 2 × 1.5 m. Producers require nutrient management systems for meadow guava orchards (Chavan *et al.,* 2020) [5]. As a tropical fruit crop, guava production is constrained by scarce water resources. Guava is cultivated as a rainfed crop in a significant proportion of Tamil Nadu state, and it is watered at 7–15-day intervals based on soil moisture and water availability. Moisture imbalances, particularly during the fruit growth period, usually result in reduced quality of fruits.

Drip irrigation has tremendous potential due to its increased water efficiency and ability to prevent water stress all through the growing season by delivering sufficient moisture during crucial crop development stages. Supply of nutrients via fertigation is the most effective approach for focusing root activity and providing an easy way of maintaining appropriate fertility levels in the soil and water supply as needed by the plants (Shirgure *et al.*, 2001) [21]. Fertigation is a technique that uses drip or spray irrigation to provide fertilizers to crops together with irrigation water on a continuous basis in a coordinated way, allowing for consistent nutrient absorption by plants while saving money on both irrigation and fertilizer inputs (Patel and Rajput, 2011) [15]. While drip irrigation, including fertigation, has been used successfully in other fruit crops such as banana (Pandey *et al.*, 2001) [13] and papaya (Jeyakumar *et al.*, 2010) [10], its impact on guava has not been thoroughly explored.

Mulching enhances microbial activity in soil through improving soil agro-physical characteristics. Mulching also reduces the usage of Nitrogenous fertilizers, enhances soil physical properties, inhibits weed development, and may contribute for increased productivity. Polyethylene mulches are extensively utilized in vegetable and other horticultural crops, and they have substantially reduced weed-related crop losses. Sharma *et al.* (2011) [20] achieved a greater guava yield via fertigation rather than basin irrigation, which also reduces infiltration and evaporation losses. In this regard, there is a need to use precise nutrient application methods in conjunction with mulching tactics under the HDP system in Tamil Nadu in order to increase production and quality of guava. With this background in mind, the present study was undertaken to determine the impact of mulching and fertigation on growth, yield and quality of guava var. L-49 under HDP system.

2. Materials and Methods

The experimental trial was carried out during 2020-21 in at Department of Fruit Science, Horticultural College and Research Institute, Periyakulam. The geographical coordinates of 10.13º N latitude and 77.59º E longitude, and at the altitude of 289 MSL. The present investigation was laid out in Split plot design with 16 treatment combinations and two replications. Fertigation (Factor 1) denoted as F *viz.*, 50% RDF, 75% RDF, 100% RDF and 100% RDF (soil application) and mulching (Factor 2) denoted as M *viz.*, Black polythene mulch, Weed mat, Paddy straw and No mulch. Fertilizers were given in split doses at different growth stages as per the technical programme after fruit harvest of previous season till fruit growth from March to August 2021. The fertilizers were supplied through drip irrigation system and regulated using drip tappers installed at every laterals.

Table 1: Treatment combinations

Treatment combination	Details
F1M1	50% RDF + Black Polythene mulch
F1M2	50% RDF + Weed mat
F1M3	50% RDF + Paddy straw
F1M4	50% RDF + No mulch
F2M1	75% RDF + Black Polythene mulch
F2M2	75% RDF + Weed mat
F2M3	75% RDF + Paddy straw
F2M4	75% RDF + No mulch
F3M1	100% RDF + Black Polythene mulch
F3M2	100% RDF + Weed mat
F3M3	100% RDF + Paddy straw
F3M4	100% RDF + No mulch
F4M1	100% RDF (soil application) + Black Polythene mulch
F4M2	100% RDF (soil application) + Weed mat
F4M3	100% RDF (soil application) + Paddy straw
F4M4	100% RDF (soil application) + No mulch

Table 2: Fertigation Scheduling in Guava

Stage of application	N (%)	P_2O_5 (%)	K_2O (%)
After fruit harvest	40	60	20
During fruit set	40	40	20
Fruit growth	20	-	60
Total	100	100	100

2.1 Observations recorded

Various growth parameters *viz.,* plant height, basal girth, canopy spread and number of primary branches were calculated from samples of five trees per each replication. The yield parameters *viz***.,** fruit length, fruit weight, fruit girth, number of fruits per plant and fruit yield per plant were recorded from selected and tagged trees at random and average was calculated. For quality parameters, fruits were selected randomly from each replication. The Total Soluble Solids of the fruit pulp was measured using digital hand held refractrometer. Titrable acidity was measured according to the method described by Ranganna, 2001 [18]. Ascorbic acid estimation was carried out as per AOAC method. (A.O.A.C, 2001). The firmness of the fruits was measured with hand held penetrometer [Model: FT 011 (0-11 lbs)] by the force required for puncturing the fruits. The total sugar was determined by Anthrone method (Bala *et al*., 2013) [3]. The data were subjected to statistical analysis (Panse and Sukhatme, 1967) [14] by using the AGRES software developed by TNAU.

3. Result and Discussion

3.1 Growth parameters

The data on growth parameters namely plant height, stem girth, canopy spread in North- South and East- west directions as influenced by mulching and fertigation and their interactions are presented in Table 3.

Among different fertigation levels, the maximum increase in plant height (0.56 m) was observed in F3 (100% RDF through fertigation) followed by F2 @ 75% RDF (0.51 m). When comparing different mulching materials paddy straw mulch recorded the maximum increase in plant height (0.50 m) which was followed by black polythene mulch (0.47). Among the treatment combinations F3M3 i.e., fertigation with 100% RDF and paddy straw mulch (0.63 m) recorded maximum increase in plant height.

The increase in stem girth maximum value of 0.91 cm with fertigation @ 100% RDF and it was followed by 0.86 cm with fertigation @ 75% RDF. Similarly, paddy straw mulch (0.83 cm) recorded the maximum increase in stem girth when averaged over different mulches. Further interaction effect of fertigation and mulching showed maximum value of 1.09 cm observed in treatment combination F3M3 (100% RDF with paddy straw) and lowest value (0.39 cm) was observed in F4M4 (100% RDF soil application without mulch).

Also, the data recorded on influence of different fertigation levels on increase in canopy spread indicated that maximum value in F3 with 100% RDF through fertigation in (0.68 m and 0. 0.68 m respectively) N-S and E-W direction. Whereas, minimum value (0.48 m and 0.42m respectively) was recorded in F4 with 100% RDF through soil application in N-S and E-W direction. Among different mulching materials M3 paddy straw mulch recorded maximum value (0.65 m and 0.62 m respectively) of canopy spread in N-S and E-W direction. Among the treatment combination F3M3 100% RDF with paddy straw reported the maximum (0.77 m and 0.75 m respectively) in N-S and E-W directions. This is due to the higher dose of fertilizer application with organic mulch (paddy straw) resulted in significant increase in nutrient uptake by the plants and also better environment in the root zone for better vegetative growth than other treatment (Bhagyashree *et al*. 2020) [4]. These findings were in accordance with Das *et al*. (2010) [6] in guava, Sadarunnisa *et al*. (2010) [19] in papaya, Khan *et al*. (2013) [11].

3.2 Yield parameters

The yield parameters such as number of fruits per plant, fruit weight, fruit length, fruit diameter, yield per plant, yield per hectare were significantly influenced by the fertigation and mulching treatments. The data indicated that number of fruits per plant (29.62), fruit weight (177.69 g), fruit length (8.49 cm), fruit diameter (7.76 cm), yield per tree (5.19 kg/ tree), yield per hectare (11.54 t/ha) were highest at fertigation with 75% RDF which was followed by fertigation with 100% RDF.

The mulching material recorded higher number of fruits per plant (31.12), fruit weight (177.51 g), fruit length (8.51 cm), fruit diameter (7.74 cm), yield per tree (5.42 kg/ tree), yield per hectare (12.05 t/ha) in paddy straw when averaged over other mulches.

The interaction effect of fertigation and mulching showed significantly maximum values of yield characters of guava at 75% RDF through fertigation with paddy straw mulch (F2M3) with number of fruits per plant (40.4), fruit weight (189.51 g), fruit length (9.13 cm), fruit diameter (8.51 cm), yield per tree (7.46 kg/ tree), yield per hectare (16.58 t/ha) which was followed by F3M3 (100% RDF through fertigation with paddy straw). Irrespective of 100% RDF through fertigation, 75% RDF through fertigation and paddy straw mulch resulted in optimum nutrient availability and translocation of food material that accelerated the fruit growth and improved fruit yield characters (Ramnivas *et al*. (2013) [17]. The results were in accordance with the findings of, Singh *et al*. (2006) [22] in pomegranate, Samant *et al*. (2017) [8] in mango, Thakur *et al*. (2012) [2] in peach, Ramnivas *et al*. (2013) [17] in guava.

3.3 Quality parameters

The parameters such as TSS, Titrable acidity, Ascorbic acid, Total sugar, and firmness were used as indicator to evaluate the quality of fruit as influenced by mulching and fertigation in this study. The observations recorded during the experimental period indicated that 75% RDF through fertigation had maximum TSS (11.85º B), ascorbic acid (187.72 mg/100g pulp), total sugar (9.41%), firmness (14.90 lbs.), with lowest acidity (0.44%) which was followed by F3 fertigation with 100% RDF.

Comparing the influence of mulching materials used, paddy straw mulch (M3) reported significantly higher TSS (11.79º B), Ascorbic acid (183.79 mg/100g pulp), Total sugar (9.52%), firmness (15.02 lbs), with lowest acidity (0.43%) when averaged over other treatments.

Among the treatment combinations of mulching and fertigation the treatment F2M3 75% RDF through fertigation with paddy straw showed the significantly higher TSS (12.75º B), Ascorbic acid (228.07 mg/100g pulp), total sugar (10.24%), firmness (16.35 lbs), with lowest acidity (0.39%) whereas the lowest values were recorded in combination of F4M4 100% RDF through soil application without mulch. The better performance in the treatment combination may be due effective absorption of macro nutrients, high endogenous C: N ratio caused by optimum level of fertigation (Bhagyashree *et al*. 2020) [4] and good environment in root zone maintaining soil moisture under mulched condition (Sahu and Sahu, 2020) [16]. The result obtained were in conformance with findings of Das *et al*. (2010) [6], Das *et al*. (2016) [7], Sahu and Sahu (2020) [16] in guava.

Table 3: Influence of mulching and fertigation on growth parameters of guava var. Lucknow 49

Increase in Plant Height (m)					
Treatment	M1	M2	M3	M4	Mean
F1	0.39	0.35	0.42	0.33	0.37
F2	0.52	0.5	0.56	0.46	0.51
F3	0.59	0.52	0.63	0.49	0.56
F4	0.39	0.36	0.40	0.31	0.36
Mean	0.47	0.43	0.50	0.39	
	F	M	F ×M	M×F	
SEd	0.003	0.005	0.010	0.011	
CD at 0.05	0.009	0.012	0.023	0.024	
Increase in Stem Girth (cm)					
	M1	M2	M3	M4	Mean
F1	0.69	0.64	0.72	0.61	0.66
F2	0.91	0.84	0.95	0.76	0.86
F3	0.93	0.84	1.09	0.81	0.91

F4	0.59	0.43	0.56	0.39	0.49
Mean	0.77	0.68	0.83	0.64	
	F	M	F ×M	M×F	
SEd	0.01	0.01	0.01	0.01	
CD at 0.05	0.02	0.01	0.03	0.03	
Canopy Spread N-S (m)					
Treatment	M1	M2	M3	M4	Mean
F1	0.50	0.43	0.54	0.39	0.46
F2	0.69	0.64	0.73	0.59	0.65
F3	0.71	0.66	0.77	0.61	0.68
F4	0.51	0.43	0.58	0.40	0.48
Mean	0.60	0.54	0.65	0.49	
	F	M	F ×M	M×F	
SEd	0.00	0.00	0.01	0.01	
CD at 0.05	0.00	0.01	0.02	0.02	
Canopy spread E-W (m)					
Treatment	M1	M2	M3	M4	Mean
F1	0.52	0.49	0.57	0.42	0.49
F2	0.67	0.62	0.71	0.59	0.63
F3	0.70	0.65	0.75	0.63	0.68
F4	0.43	0.4	0.48	0.37	0.42
Mean	0.57	0.53	0.62	0.50	
	F	M	F ×M	M×F	
SEd	0.00	0.00	0.01	0.01	
CD at 0.05	0.01	0.01	0.02	0.02	

Table 4: Influence of Influence of mulching and fertigation on yield parameters of guava var. Lucknow 49

Number of fruits per plant					
Treatment	M1	M2	M3	M4	Mean
F1	24.60	20.50	29.30	16.90	22.82
F2	32.20	23.30	40.40	22.60	29.62
F3	30.60	28.80	34.60	21.90	28.97
F4	19.30	16.10	20.20	13.40	17.24
Mean	26.67	22.17	31.12	18.69	
	F	M	F ×M	M×F	
SEd	0.18	0.28	0.53	0.57	
CD at 0.05	0.45	0.59	1.12	1.19	
Fruit Weight (g)					
Treatment	M1	M2	M3	M4	Mean
F1	166.32	165.36	169.31	161.43	165.60
F2	181.66	170.17	189.51	169.42	177.69
F3	170.51	167.84	181.29	170.73	172.59
F4	167.12	163.43	169.96	159.58	165.02
Mean	171.40	166.70	177.51	165.28	
	F	M	F ×M	M×F	
SEd	2.52	1.67	3.84	3.34	
CD at 0.05	6.18	3.45	8.56	6.90	
Fruit length (cm)					
Treatment	M1	M2	M3	M4	Mean
F1	6.89	6.53	8.04	6.14	6.90
F2	8.81	8.13	9.13	7.91	8.49
F3	8.27	7.74	8.78	8.41	8.30
F4	7.85	6.27	8.12	5.91	7.03
Mean	7.95	7.16	8.51	7.09	
	F	M	F ×M	M×F	
SEd	0.12	0.07	0.18	0.15	
CD at 0.05	0.29	0.15	0.40	0.31	
Fruit diameter (cm)					
Treatment	M1	M2	M3	M4	Mean
F1	6.14	5.76	7.23	5.39	6.13
F2	8.02	7.38	8.51	7.16	7.76
F3	7.52	6.90	7.94	7.73	7.52
F4	7.02	5.62	7.47	4.93	6.26
Mean	7.17	6.41	7.78	6.30	
	F	M	F ×M	M×F	
SEd	0.07	0.06	0.14	0.13	
CD at 0.05	0.19	0.14	0.30	0.28	

Yield per plant (kg/plant)					
Treatment	M1	M2	M3	M4	Mean
F1	4.12	3.18	4.83	2.49	3.65
F2	5.76	4.01	7.46	3.55	5.19
F3	5.12	4.38	6.07	3.43	4.74
F4	3.29	2.38	3.34	2.09	2.77
Mean	4.57	3.48	5.42	2.88	
	F	M	F ×M	M×F	
SEd	0.02	0.03	0.06	0.06	
CD at 0.05	0.06	0.07	0.14	0.14	
Yield per hectare (t/ha)					
Y ha	M1	M2	M3	M4	Mean
F1	9.15	7.07	10.73	5.53	8.12
F2	12.80	8.91	16.58	7.89	11.54
F3	11.38	9.73	13.49	7.62	10.55
F4	7.31	5.29	7.42	4.64	6.16
Mean	10.15	7.74	12.05	6.42	
	F	M	F ×M	M×F	
SEd	0.10	0.09	0.19	0.19	
CD at 0.05	0.24	0.20	0.42	0.40	

Table 5: Influence of mulching and fertigation on quality parameters of guava var. Lucknow 49

Total Soluble Solids (° B)					
Treatment	M1	M2	M3	M4	Mean
F1	11.37	11.18	11.42	10.13	11.02
F2	12.13	11.32	12.75	11.23	11.85
F3	11.88	11.67	12.18	11.21	11.73
F4	10.76	10.02	10.83	9.80	10.35
Mean	11.53	11.04	11.79	10.59	
	F	M	F ×M	M×F	
SEd	0.11	0.09	0.19	0.18	
CD at 0.05	0.28	0.19	0.43	0.38	
Titrable acidity (%)					
Treatment	M1	M2	M3	M4	Mean
F1	0.47	0.53	0.43	0.56	0.49
F2	0.41	0.49	0.39	0.50	0.44
F3	0.43	0.46	0.41	0.53	0.46
F4	0.52	0.57	0.51	0.61	0.55
Mean	0.46	0.51	0.43	0.55	
	F	M	F ×M	M×F	
SEd	0.004	0.006	0.011	0.012	
CD at 0.05	0.010	0.012	0.024	0.025	
Ascorbic acid (mg/ 100g)					
Treatment	M1	M2	M3	M4	Mean
F1	228.07	148.07	164.91	124.21	166.31
F2	166.32	207.02	228.07	149.47	187.72
F3	161.40	175.44	210.90	139.65	171.84
F4	136.84	118.87	131.32	105.98	123.25
Mean	173.15	162.35	183.79	129.82	
	F	M	F ×M	M×F	
SEd	1.39	1.68	3.23	3.36	
CD at 0.05	3.41	3.47	6.90	6.95	
Total sugar (%)					
Treatment	M1	M2	M3	M4	Mean
F1	9.16	8.71	9.32	8.28	8.86
F2	9.54	9.01	10.24	8.86	9.41
F3	9.42	9.21	9.87	8.76	9.31
F4	8.65	8.16	8.69	7.76	8.31
Mean	9.19	8.77	9.52	8.41	
	F	M	F ×M	M×F	
SEd	0.11	0.09	0.19	0.19	
CD at 0.05	0.27	0.19	0.43	0.39	
Firmness (lbs)					
Treatment	M1	M2	M3	M4	Mean
F1	14.36	13.15	14.86	12.49	13.71
F2	15.23	14.21	16.35	13.83	14.90
F3	15.12	14.72	15.94	13.64	14.85

F4	12.62	12.41	12.94	10.14	12.02
Mean	14.33	13.62	15.02	12.52	
	F	M	F ×M	M×F	
SEd	0.17	0.11	0.26	0.23	
CD at 0.05	0.42	0.24	0.59	0.49	

4. Conclusion

In the present study, the treatment with 100% RDF through fertigation and paddy straw mulching reported maximum vegetative growth parameters *viz.* plant height, stem girth and canopy spread which was followed by 75% RDF through fertigation with paddy straw mulch. The yield parameters *viz.* number of fruits, fruit weight and quality parameters *viz.* TSS, ascorbic acid and total sugar were significantly higher in 75% RDF through fertigation with paddy straw which is found to save 25% of fertilizer requirement. Paddy straw mulch found to be economically feasible and environment friendly method for controlling weed and improving the fruit quality. Thus, from the above study it is concluded that fertigation with 75% RDF with paddy straw mulch is ideal for guava productivity and quality under high density planting system.

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