Growth, yield and nutrient uptake of guava (*Psidium Guavaja L.*) affected by soil matric potential, fertigation and mulching under drip irrigation

Junaid N Khan[1*], A. K. Jain[1], Rakesh Sharda[1], NavPrem Singh[2], P. P. S. Gill[2], Sumanjeet Kaur[1]

(1. *Department of Soil and Water Engineering, Punjab Agricultural University, Ludhiana-141004, Punjab, India;*
2. *Department of Fruit Science, Punjab Agricultural University, Ludhiana-141004, Punjab, India*)

Abstract: Our objective was to examine the effect of plastic mulching, three soil matric potentials (SMP) treatments {I_1(-20 kPa), I_2(-40 kPa), and I_3(-60 kPa)} and three fertigation levels {F_1(100%), F_2(80%), and F_3(60%) recommended dose of fertilizer} under drip irrigation conditions for nutrient uptake, growth parameters and yield in guava plants. The experiments were set up in factorial randomized block design with eighteen treatment combinations. The experiments were conducted during the year 2012-13. The investigation indicated that the plant canopy spread in (N/S and E/W) directions was greatly affected by different treatments. However, non-significant effects of interaction parameters were found on plant height, crop volume and plant girth. The maximum yield was obtained in MI_2F_2 (68.66 kg per plant and 22.86 t ha^{-1}) followed by NMI_2F_2 (66.50 kg per plant and 22.14 t ha^{-1}) treatments. The maximum percentage of high quality (fruit levels A and B) were 48.2% and 50.1% in -40 kPa irrigation treatment for mulch and no mulch conditions under 100% application of recommended dose of fertilizers. The varying range of leaf nutrients observed for different treatments of irrigation, fertigation and mulch is 1.26-1.74% N, 0.14-0.26% P, 0.44-0.88% K, 36.33-74.23 ppm Zn, 11.33-32.76 ppm Cu, 415.6- 557.3 ppm Fe, 26.80- 39.06 ppm Mn, 0.533-0.762 % Mg and 3.42-5.06% Ca. Based on the results above, it is recommended that controlling SMP between -40 kPa to -45 kPa at 0.2 m depth immediately under the drip emitter and fertilizer dose of 80% recommended dose of fertilizer can be used as an indicator for drip irrigation scheduling in semi-arid region of northwest India.

Keywords: fertilizer application, irrigation strategies, pressure head, tensiometer, leaf uptake

Citation: Khan, J. N., A. K. Jain, R. Sharda, N. Singh, P. P. S. Gill, S. Kaur. 2013. Growth, yield and nutrient uptake of guava (*Psidium Guavaja L.*) affected by soil matric potential, fertigation and mulching under drip irrigation. Agric Eng Int: CIGR Journal, 15(3): 17−28.

1 Introduction

Guava (P*sidium guajava*) is being cultivated on large areas in India (Sharma, 2009) for its high adaptability to varied soil and climatic conditions. Guava fruit is often referred to as apple of tropics probably as it is the only fruit that matches the high nutritive value of more commercially important temperate fruit apple. From horticulture perspective it is one of the most common fruits grown commercially in India and is ranked next to mango, banana and citrus fruits in respect of area and production. The total area under guava in India is 228,500 ha with the production of 2.61 million tons (NHB, 2012). Like any other crops, guava also requires 16 essential elements, and the absence of one or more essential elements affects metabolic process in plant resulting in expression of deficiencies (Singh and Singh, 2007).

India is the second largest consumer of fertilizer in the world after China and the first importer of fertilizers

Received date: 2013-03-21 **Accepted date:** 2013-08-26
* **Corresponding author: Junaid N Khan,** Ph.D Scholar and Associate Professor, SKUAST-Kashmir, Srinagar (J&K), India-191121. Email: junaidk1974@gmail.com.

in the world (FAOSTAT, 2010). In order to assess the fertilizer requirements of guava for cultivars, Allahbad Safeda and Sardar guava, trials have been conducted across the country in India and recommended doses of fertilizers ranges from 360 – 1,000 g of N, 300 – 1,000 g of P and 300 – 1,000 g of K per plant annually. The variation in recommended dose of fertilizer in response to different trials may be associated with soil factor, plant age and the crop growth. The critical examination of these trials and examination of growth curve indicated that 583 g of N/plant, 271 g of P/plant and 400 g of K/plant are optimum for the guava (Singh and Singh, 2007). Different treatments of N, P and K were applied to sardar guava cultivar. Among the different treatments of NPK applied the best results in terms of fruit size, weight and yield were obtained with 500 g of N, 250 g of P_2O_5 and 250 g of K_2O, also, the highest leaf NPK contents were maintained by the plants which received this treatment (Singh, 1997). The response of four year-old guava Paluma variety, under micro irrigation system with 6 m × 5 m spacing to water depth and nitrogen fertilization was done under tropical semi-arid climate in Brazil. Application of 600 g of nitrogen and 300 g of potassium resulted in 7.5 t ha^{-1} yield of crop and average fruit weight of 200 g/fruit. Increasing the fertilizer amount resulted in reduced fruit weight and increase in number of fruits per plant (Jose et al., 2007).

Drip irrigation with fertigation provides an effective and cost-efficient way to supply water and nutrients to crops (Bar-Yosef, 1999). Fertigation enables the application of soluble fertilizers and other chemicals along with irrigation water, uniformly and more efficiently (Narda and Chawla, 2002). Conventional fertilizers such as urea, mono-ammonium phosphate and potassium chloride can be applied using drip irrigation. It was found that the effect of plastic mulch had significant influences on crop yield of guava with all the levels of drip and ring basin methods of irrigations (Singh et al., 2007).

The objectives of the study was to investigate the effects of various levels of soil matric potential, mulch and fertigation treatments on guava leaf nutrient uptake, growth, yield and fruit quality, and to identify the suitable treatment for guava irrigation scheduling and fertigation.

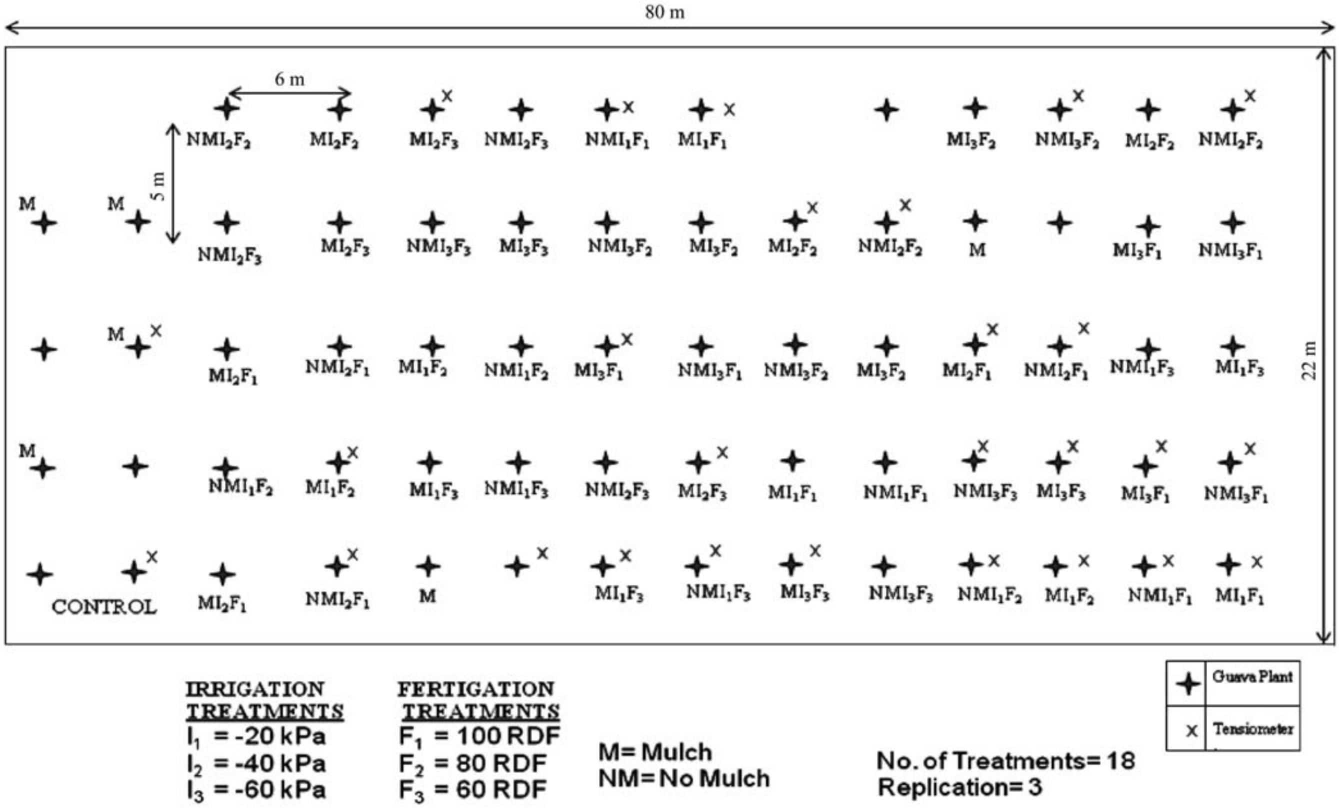
2 Materials and methods

2.1 Experimental site and climate

The experiment was performed at the farmland of the Department of Soil and Water Engineering, at Punjab Agricultural University. The university is located in Ludhiana, Punjab state, Northwest India (30º 56′ N, 75º 52′ E, 247 m above sea level). In Ludhiana, winters are cold and summers are extremely hot, average annual maximum and minimum temperature is about 29.8ºC and 16.5ºC respectively. Annual precipitation mean for the last five years was about 434.1 mm, which is mainly concentrated from June to September. This region has a typical monsoon climate. The soil at the experimental field is sandy loam (clay 9.8%, silt 14.6% and sand 76.7%) having field capacity of 19.21% and bulk density of 1.43 g cm^{-3}.

2.2 Treatment application

Guava plants (cv. Allahbad safeda) were transplanted at a spacing of 6 m × 5 m during March 2009 on a 0.18 ha area. The recommended fertilizer dose of 100% included, 138 g of N, 244 g of P and 360 g of K for four year-old plants. The dose applied to each plant was based on this recommended dose of fertilizer application (Singh and Singh, 2007). Three soil matric potentials of -20 kPa, -40 kPa and -60 kPa were designed for irrigation to the guava plant. Irrigation duration for delivery of water to different treatments was controlled with the help of gate valve provided at the inlet of each plant. Each plant was provided with five drippers of 4 l h^{-1} discharge rate. Three fertigation concentrations were devised based on 100%, 80% and 60% recommended fertilizer application rate to the guava plants. Further, mulching and no mulching as two treatments were also tried on the plants. Black plastic film of 80 micron thickness was used as mulch in the respective plants with 70% of plant canopy area being covered by the mulch. Experiments were laid out in Factorial Randomized block design (RBD) with three replications having 18 treatments. Each replication consisted of one guava plant. Details of the experimental layout are shown in Figure 1. Standard cultural practices for guava crop cultivation were followed as per the recommendations (Singh et al., 2007).



I_1F_1	-20 kPa Soil matric potential irrigation application and 100% application of recommended dose of fertilizer application (NPK).
I_1F_2	-20 kPa Soil matric potential irrigation application and 80% application of recommended dose of fertilizer application.
I_1F_3	-20 kPa Soil matric potential irrigation application and 60% application of recommended dose of fertilizer application.
I_2F_1	-40 kPa Soil matric potential irrigation application and 100% application of recommended dose of fertilizer application.
I_2F_2	-40 kPa Soil matric potential irrigation application and 80% application of recommended dose of fertilizer application.
I_2F_3	-40 kPa Soil matric potential irrigation application and 60% application of recommended dose of fertilizer application.
I_3F_1	-60 kPa Soil matric potential irrigation application and 100% application of recommended dose of fertilizer application.
I_3F_2	-60 kPa Soil matric potential irrigation application and 80% application of recommended dose of fertilizer application.
I_3F_3	-60 kPa Soil matric potential irrigation application and 60% application of recommended dose of fertilizer application.

Figure 1 Schematic diagram of experimental layout and different treatments of irrigation and fertigation

In drip irrigated plants fertilizers were applied after every fourth day with the help of venturi. The dose of fertilizer application was distributed into 42 doses. The application of fertilizer through venturi was started in the month of May, 2012 and continued till October, 2012. Different doses of fertilizer were applied simultaneously through the venturi. A total of 18 plants were fertigated simultaneously for each treatment of fertilizer application. The valves of other plants were closed during fertigation of plants of particular treatment. The fertilizer amount to be applied for 18 plants of the treatments were added up for application of the fertilizer.

Tensiometers were inserted at different depths (20, 30, 40 and 50 cm) and at different radial distances from emitter. However, the tensiometer was found to be working satisfactorily at 20 cm depth and just below the emitter. The soil moisture characteristic curve for sandy loam soil for variation of moisture content at different pressure heads was developed through pressure plate technique. The soil moisture characteristic curve for top layer (0-20 cm) is given in Figure 2. The various irrigation treatments were selected due to variation of soil moisture content from the field capacity level. The three irrigation treatments were selected on the basis of 20%, 35% and 55% decrease in moisture content from the field capacity level of the soil.

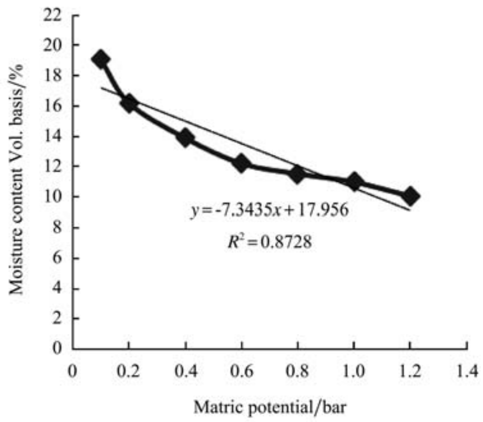


Figure 2 Soil moisture characteristic curve for top layer (0-20 cm) of the soil

2.3 Observations recorded

2.3.1 Plant characters

The plant growth parameters {plant height, plant canopy spread (E-W, N-S), plant volume, stock girth and scion girth} were measured every 25-30 days in both growing seasons of the year 2012. The plant height was measured from ground level to the top of the highest branch of plant ignoring only the off-type shoots. A graduated pole was used to measure the height. The plant canopy spread (N-S, E-W) distance between points to which most of the branches of tree had grown in the north-south and east-west directions were measured and averaged. The off type shoots and solitary branches growing out irregularly from plant canopy were not considered. The graduated pole was used for making measurements. The data on the scion, stock and interstock girth was recorded with the help of measuring tape at height 5 cm above and below the graft unions. The data was expressed as scion, stock and interstock girth. Tree volume was calculated from the values of the tree height and spread (Westwood, 1978).

2.3.2 Fruit characteristics and quality parameters

To assess the effect of treatments on fruiting characters and fruit quality parameters, the various parameters noted were fruit size, fruit weight, yield, TSS, acidity,vitamin C and fruit firmness.

2.3.3 Fruit grading

The guava harvesting was done when the fruit fully ripened. The harvesting was done manually for each of the treatments. The weight was measured with an electronic balance with 0.05 g resolution. Guava fruits were classified into four grades based on guava weight as: A (size > 150 g), B (size 100-150 g), C (size 50-100 g) and D (size < 50 g); total fruit weights of various grades were determined for each plant and the corresponding percentage in each grade was calculated.

2.4 Nutritional status of leaves

The nutritional status of leaves was determined for macro and micro nutrients. The nutritional status of leaves was determined for N, P, K, Ca, Cu, Fe, Mn, Zn and Mg. Samples were collected from middle of each shoot from current season's growth after completion of all the scheduled treatments. Nutrients like Ca, Mg, Cu, Zn, Fe and Mn were determined with Atomic Absorption Spectrophotometer method described by Bradfield and Spencer (1965). N, P and K were determined by standard recommended procedures.

2.5 Statistical analysis

Statistical analysis of guava parameters was done using CPCS1 software and data obtained on various characters were subjected to Factorial RBD analysis interpretation of the data was carried out in accordance with Singh et al (1998). The statistical differences among soil matric potential, fertigation levels and mulch levels and their interaction on plant characteristics, fruit quality and leaf nutrient uptake were tested with Fisher's least significant difference ($P \leq 0.05$) using analysis of variance as mentioned in Singh et al (1998). The ANOVA was performed at $\alpha \leq 0.05$ level of significance to determine if significant differences existed among different treatments.

3 Result and discussion

3.1 Plant growth characteristics

Plant height, plant canopy spread (E-W, N-S) direction, plant volume and stem girth were used as indicators to evaluate crop growth. The effects of soil matric potential, fertigation treatments and mulching were evaluated for guava plants. The maximum plant height was recorded as 3.2 m (I_1F_1 and I_2F_1) for mulched condition and 3.2 m (I_1F_2 and I_3F_3) for non mulched condition, respectively. Ramniwas et al (2012) found that the maximum plant height was in 100% irrigation application by (IW/CPE) ratio and 100% application of recommended doze of fertilizers also, the interaction effect of irrigation and fertigation levels on plant height was non significant. The maximum value of plant canopy spread in (E-W, N-S) directions, canopy volume, stock and scion diameter for mulched conditions were 5.53 m (I_2F_3), 5.0 m (I_2F_2 & I_2F_3), 42.09 m^3 (I_2F_3), 18.4 cm (I_3F_1) and 17.5 cm (I_1F_3). The interaction effect of mulch, irrigation and fertigation was found to be significant in plant canopy spread. However, non significant effect of interaction parameters were found on plant height, crop volume and stem diameter (Table 1). The maximum value of plant canopy spread (E-W,

Table 1 Effect of irrigation and fertigation levels and their interaction ($p \leq 0.05$) on various plant parameters for mulching and no mulching conditions

Treatment	Plant height /m	Plant spread E-W- /m	Plant spread N-S/m	Canopy volume /m^3	Stock diameter /cm	Scion diameter /cm
			MULCHED			
I_1F_1	3.20	5.03^{c*}	4.50^{bcd}	37.98	16.2	16.2
I_1F_2	3.03	5.13^{c}	4.45^{cde}	36.50	16.8	15.6
I_1F_3	3.07	5.10^{c}	4.87^{ab}	39.95	17.7	17.5
I_2F_1	3.20	5.17^{c}	4.82^{abc}	41.74	16.8	16.1
I_2F_2	2.97	5.32^{b}	5.00^{a}	41.34	15.7	15.1
I_2F_3	2.90	5.53^{a}	5.00^{a}	42.09	15.7	15.1
I_3F_1	3.05	4.87^{e}	4.50^{bcd}	35.05	18.4	17.2
I_3F_2	2.97	4.20^{f}	4.87^{ab}	31.81	17.9	17.4
I_3F_3	2.90	3.93^{g}	4.17^{def}	24.87	17.9	17.4
			NON MULCHED			
I_1F_1	2.82	4.90^{jk}	4.57^{hij}	33.09	17.7	17.5
I_1F_2	3.15	4.97^{jk}	4.33^{ijkl}	35.66	17.3	16.2
I_1F_3	3.13	5.02^{j}	4.70^{ghi}	38.70	17.9	16.8
I_2F_1	2.92	5.02^{j}	4.43^{hijk}	34.07	16.6	16.0
I_2F_2	3.05	5.70^{h}	5.03^{g}	45.97	15.9	15.9
I_2F_3	2.97	5.35^{i}	4.80^{gh}	40.32	15.3	15.0
I_3F_1	2.83	4.68^{l}	4.47^{hijk}	30.98	16.5	15.7
I_3F_2	2.87	4.57^{l}	4.37^{ijkl}	29.93	16.0	16.1
I_3F_3	3.18	4.18^{m}	4.80^{gh}	33.53	17.1	15.6
SEm±	0.174	0.049	0.145	0.022	0.0951	0.095
LSD(p≤0.05)	NS**	0.149	0.417	NS	NS	NS
COV (%)	10.02	1.72	5.41	10.92	9.78	10.14
Parameter	Mulch	Irrigation	Fertigation	M x I	I x F	M x F
			LSD($p \leq 0.05$)			
SEm±	0.086	0.124	0.029	0.034	0.102	0.276
Plant height	NS	NS	NS	NS	NS	NS
SEm±	0.023	1.17	0.161	0.166	0.41	0.215
Plant size (E-W)	NS	0.05	0.08	0.05	0.08	0.09
SEm±	0.15	0.42	0.22	0.132	0.247	0.179
Plant size (N-S)	NS	0.17	NS	NS	0.29	NS
SEm±	2.13	12.20	1.77	2.07	3.81	4.86
Canopy volume	NS	2.68	NS	NS	4.65	3.8
SEm±	0.63	1.8	0.58	1.38	0.73	0.08
Stock diameter	NS	1.11	NS	NS	NS	NS
SEm±	0.68	1.51	0.44	1.30	0.75	0.59
Scion diameter	NS	NS	NS	NS	NS	NS

Note: I_1 = -20kPa matric potential, I_2 = -40kPa Matric potential, I_3 = -60kPa Matric potential.

F_1 = 100% RDF, F_2 = 80% RDF and F_3 = 60%RDF (Recommended dose of fertilizer). * Plant parameters values with the same letter in the column are not significant or significant at ($p \leq 0.05$) with different letters.

** NS = Non – Significant, S = Significant; SEm± = Standard Error; COV= Cofficient of Variation.

N-S), canopy volume, stock and scion diameter for non-mulched conditions were 5.7 m (I_2F_2), 5.03 m (I_2F_2), 45.97 m^3 (I_3F_3), 17.9 cm (I_1F_3) and 17.5 cm (I_1F_1). Ramniwas et al. (2012) found that interaction effect of irrigation and fertigation was significant on plant spread. This may be due to the fact that the application of drip irrigation during experimentation effectively increased vegetative growth parameters. Subramanian et al. (1997), Bhardwaj et al. (1995) and Maas and Van (1996) reported that vegitative growth of the plants was found to be influenced favorably by uniform distribution of water in the soil through drip irrigation.

Comparing the means by least significant difference ($LSD_{0.05}$) (Montgomery, 1991), it was observed that there is no significant difference in means of plant height, canopy volume, stock diameter and scion diameter for all the treatments of mulch, irrigation and fertigation. For plant canopy spread in E/W direction for mulched conditions, treatments I_2F_1, I_1F_2, I_1F_3 and I_1F_1 can be grouped together, i.e., any pair in this group does not differ significantly. However, they gave significantly higher plant canopy spread in E/W direction than I_3F_1, I_3F_2 and I_3F_3. Treatments I_2F_2 and I_2F_3 gave significantly higher plant canopy spread than all other treatments. Also, significant difference was observed between the two treatments. Significant difference was also observed between treatments I_2F_2, I_2F_3, I_3F_1, I_3F_2 and I_3F_3. For plant spread in E/W direction for no-mulch conditions, treatments I_1F_1 and I_1F_2 can be grouped together. They gave significantly higher plant canopy spread in E/W direction than I_3F_1, I_3F_2 and I_3F_3. Treatments I_2F_2 and I_2F_3 gave significantly higher plant spread than all other treatments also, there was significant difference between treatments I_2F_2 and I_2F_3. Plant canopy spread were significantly better under alternate day irrigation scheduling and higher levels of fertigation doses (Chandra and Jindal, 2001). The results are in accordance with the findings of Shukla et al. (2000) in aonla, Shirgure et al. (2004) in acid lime, Sulochanamma et al. (2005) and Agarwal and Agrawal (2007) in pomegranate.

For plant spread in N/S direction for mulched conditions, treatments I_2F_2, I_2F_3, I_1F_3, I_3F_2 and I_2F_1 can be grouped together i.e., any pair in this group does not differ significantly. However, they gave significantly higher plant spread in N/S direction than I_3F_3. Treatments I_3F_1, I_1F_2 and I_1F_1 can be grouped together i.e. any pair in this group does not differ significantly. For plant spread in N/S direction for non-mulch conditions, treatments I_2F_2, I_2F_3, I_3F_3 and I_1F_3 can be grouped together i.e., any pair in this group does not differ significantly. However, they gave significantly higher plant spread in N/S direction than I_1F_2. Treatments I_1F_1, I_3F_1, I_2F_1 and I_3F_2 can be grouped together i.e any pair in the group does not differ significantly. Ramniwas et al (2012) reported that 75% (IW/CPE) ratio and maximum dose of fertigation level resulted in maximum plant spread in guava under drip irrigation system.

3.2 Yield and fruit quality

The results of ANOVA on yield showed that soil water potential and mulching had no significant effects on guava yields. However, different levels of fertigation were found to have profound effect on the yield of guava. The results revealed that more irrigation amount did not result in more guava yields for -20 kPa soil matric potential irrigation treatment. The average yields under different treatments in drip irrigation system are given in Figure 3, showing that maximum yield was obtained in MI_2F_2 (68.66 kg per plant and 22.86 t ha^{-1}) followed by NMI_2F_2 (66.50 kg per plant and 22.14 t ha^{-1}). Ramniwas et al (2012) found among various levels of irrigation and fertigation, maximum fruit yield in guava was recorded in I_2 (75% irrigation of IW/CPE) and F_3 (60, 30, 30 g NPK WSF). The results are in conformity with the findings of Biswas et al. (1999) who obtained higher yield from drip irrigated plots at an IW/CPE ratio of 0.8 compared with other treatments in papaya. Patil and Patil (1999) observed that guava fruit yield was the highest when irrigated at an IW/CPE ratio of 0.8. Sharma et al (2011) reported maximum yield in guava for 100% application of recommended dose of fertilizer.

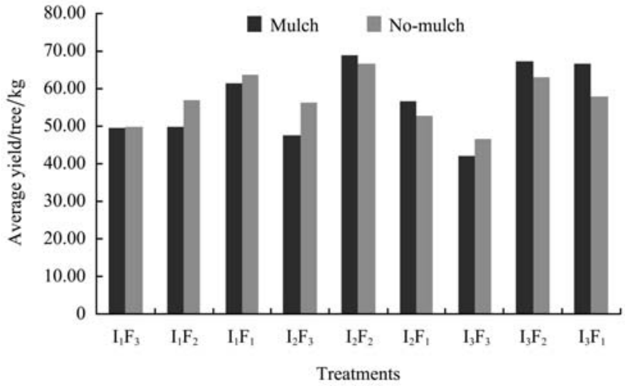


Figure 3 Variation of yield in different treatments of irrigation, fertigation and mulch in drip irrigated guava

The fruit size distribution for 100 and 60% recommended dose of fertilizer application are given in Figure 4 and Figure 5. Maximum fruit size 40-54% were classed into level C, 17-24% for level B, 7-29% for level A, and 5-22% for level D for 100% recommended dose of fertilizer application. Similarly, maximum fruit size 44-61% were classed into level C, 12-21% for level B, 6-26% for level A, and 7-17% for level D for 60% application of recommended dose of fertilizer. The maximum percentages of high quality fruit (fruit levels A and B) were 48.2 and 50.1% in -40 kPa soil matric potential irrigation treatment for mulch and no mulch conditions under 100% application of recommended dose of fertilizers. Similarly, the maximum percentages of high quality fruit (fruit levels A and B) were 41.9 and 29.7% in -40 kPa soil matric potential irrigation treatment for mulch and no mulch conditions under 60% application of recommended dose of fertilizers. The results are in confirmation with Jose et al. (2007) who found that increasing the fertilizer amount resulted in reduced fruit weight and increase in number of fruits per plant.

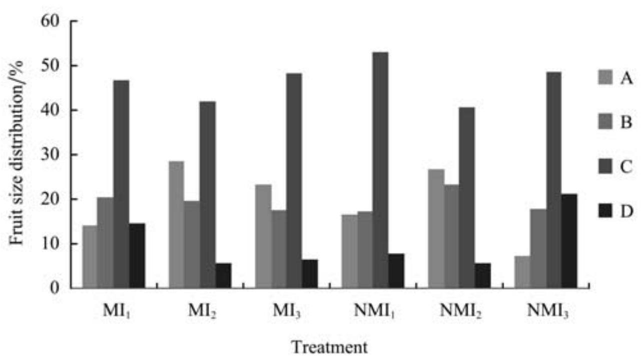


Figure 4 Fruit size distribution for 100% recommended doze of fertilzer for mulch(M) and no mulch(NM) treatment and I_1, I_2, and I_3 irrigation treatments

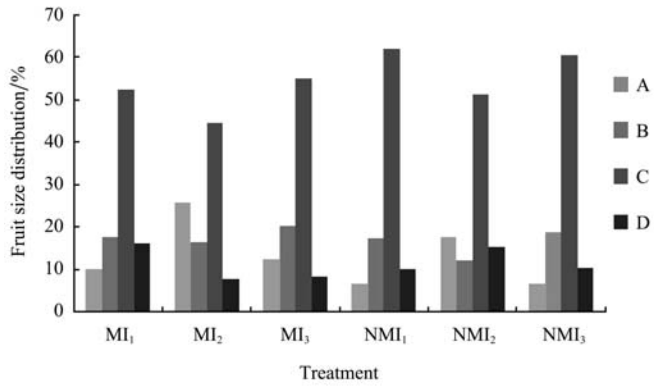


Figure 5 Fruit size distribution for 60% recommended doze of fertilzer for mulch(M) and no mulch(NM) treatment and I_1, I_2, and I_3 irrigation treatments

The maximum value of length, breadth, weight, TSS, acidity, vitamin C and firmness for mulched conditions of guava fruit were 7.3 cm (I_2F_3 and I_3F_1), 6.53 cm (I_2F_3), 161.0 g (I_2F_3), 10.3% (I_2F_2), 0.65% (I_1F_3), 44.8 mg per 100 mL of juice (I_3F_1) and 7.46 kg/cm^2 (I_1F_3). Similarly, the maximum value of length, breadth, weight, TSS, acidity, vitamin C and firmness for non- mulched conditions of guava were 7.13 cm (I_2F_3), 6.2 cm (I_2F_3), 138.06 g (I_2F_3), 9.93% (I_1F_1), 4.53% (I_1F_1), 0.60% (I_3F_2), 46.08 mg per 100 mL of juice (I_2F_3) and 7.46 kg cm^{-2} (I_1F_3). The interaction effect of mulching, irrigation and fertigation was found to be non significant for all the fruit quality parameters. However, the individual effect of mulching, irrigation and fertigation and their interaction on the quality parameters are given in Table 2. Ramniwas et al. (2012) reported that interaction effect of irrigation and fertigation effects on fruit size (length, breadth and diameter) as non significant. However, significant effects of different treatments of fertigation and irrigation on fruit weight and pulp weight were found. The possible explanation for the increase in fruit weight and pulp weight might be due to the increase in vegetative growth. Kumar et al. (2009) recorded the highest bunch weight (weight, length and diameter) with 100% recommended dose of fertilizer in banana. Singh (1997) reported that among the different treatments of N, P and K applied to sardar guava cultivar, the best results in terms of fruit size, weight and yield were obtained with 500 g of N, 250 g of P_2O_5 and 250 g of K_2O, which was the highest dose of fertilizer applied to the plants.

Table 2 Effect of irrigation and fertigation levels and their interaction ($p \leq 0.05$) on various fruit quality parameters for mulching and no mulching conditions

Treatment	Length/cm	Breadth/cm	Weight/g	TSS/%	Acidity/%	Vitamin C (mg per100 ml of juice)	Firmness/kg cm^{-2}
				MULCH			
I_1F_1	7.06	6.3	139.6	8.63	0.49	29.44	6.05
I_1F_2	6.3	5.6	91.6	9.40	0.60	34.56	6.81
I_1F_3	6.3	5.86	104.4	9.47	0.65	35.84	7.46
I_2F_1	7.2	6.2	142.8	9.87	0.50	19.2	4.23
I_2F_2	7.0	6.0	127.3	10.30	0.47	30.72	3.89
I_2F_3	7.3	6.53	161.0	9.13	0.47	22.4	3.61
I_3F_1	7.3	6.46	145.1	9.83	0.60	44.8	4.20
I_3F_2	6.6	6.0	120.4	10.00	0.60	16	3.29
I_3F_3	6.06	5.46	99.0	8.83	0.45	23.04	4.73
				NON MULCH			
I_1F_1	6.53	6.06	117.6	9.93	0.58	38.4	5.76
I_1F_2	6.6	5.86	115.13	9.50	0.56	29.44	6.09
I_1F_3	6.73	5.8	112.13	9.67	0.53	30.08	4.61
I_2F_1	6.6	5.93	109.2	9.27	0.51	28.16	5.12
I_2F_2	6.6	5.86	107.2	9.57	0.58	35.84	4.23
I_2F_3	7.13	6.2	138.06	9.73	0.48	46.08	4.85
I_3F_1	6.46	5.53	99.86	9.77	0.50	44.8	3.89
I_3F_2	6.4	5.73	112.26	9.53	0.60	25.6	4.84
I_3F_3	6.73	5.33	118.73	9.57	0.49	22.4	5.76
SEm±	0.26	0.22	11.10	0.37	0.5	4.74	2.16
LSD($p \leq 0.05$)	NS**	NS	NS	NS	NS	NS	NS
COV (%)	6.85	6.59	16.01	6.79	20.86	24.88	34.45
Parameter	Mulch	Irrigation	Fertigation	M x I	I x F	M x F	
				LSD($p \leq 0.05$)			
SE±	-	0.526	-	-	-	0.589	
Length	NS	0.312	NS	NS	NS	0.441	
SEm±	0.502	0.449	-	-	0.279	-	
Breadth	0.216	0.264	NS	NS	0.458	NS	
SEm±	23.8	23.2	-	-	23.8	18.96	
Weight	10.63	13.02	NS	NS	22.56	18.42	
SEm±	-	10.72	-	-	13.19	-	
Vitamin C	NS	5.56	NS	NS	9.63	NS	
SEm±	-	5.98	-	-	-	-	
Firmness	NS	2.53	NS	NS	NS	NS	

Note: I_1 = -20 kPa matric potential, I_2 = -40 kPa Matric potential, I_3 = -60 kPa Matric potential.

F_1 = 100% RDF, F_2 = 80% RDF and F_3 = 60%RDF(Recommended dose of fertilizer).

** NS = Non – Significant, S = Significant; SEm± = Standard Error; COV= Cofficient of Variation.

3.3 Nutrient status of guava

The effects of soil matric potential, fertigation treatments and mulching were evaluated for nutrient uptake by the leaves. The maximum value of 1.55 % N (I_1F_3), 0.21% P (I_1F_2, I_1F_3 and I_3F_3), 0.88% K (I_1F_1), 26.96 ppm Zn (I_2F_2), 66.93 ppm Cu (I_1F_3), 557.3 ppm Fe (I_1F_1), 39.06 ppm Mn (I_2F_3), 0.762% Mg (I_3F_1) and 4.77% Ca (I_2F_2) were observed for mulched conditions. Similarly, the maximum value of 1.74% N (I_2F_1), 0.26% P (I_3F_3), 0.81% K (I_3F_3), Zn 74.23 ppm Zn (I_2F_3), 32.76 ppm Cu (I_1F_1), 506.6 ppm Fe (I_2F_3), 39.03 ppm Mn (I_2F_2), 0.720% Mg (I_1F_1) and 5.06% Ca (I_2F_3) were observed for non mulched conditions. The interaction effect of mulching, irrigation and fertigation was found to be significant for N, K, Zn, Cu, Mn and Mg. However, the interaction effect of mulching was found to be non significant for P, Fe and Ca (Table 4). The individual effect of mulching, irrigation and fertigation and their interaction on the nutrient status is also, given in Table 4. Kotur et al (1997) reported that leaf nutrient in terms of N, P, K, Ca, Mg, and Cu contents significantly increased under different cultural practices in the order of no mulch > green manure mulch > black polythene mulch. The opposite was true in the case of Fe, Mn and Zn contents, which showed the highest contents under black polythene mulch.

Table 4 Effect of irrigation and fertigation levels and their interaction ($p \le 0.05$) on nutrient status of leaves in guava plant for mulching and no mulching conditions.

Treatment	N/%	P/%	K/%	Zn/ppm	Cu/ppm	Fe/ppm	Mn/ppm	Mg/%	Ca/%
				MULCH					
I_1F_1	1.42^{bc*}	0.15	0.88^{a}	50.20^{b}	22.93^{bc}	557.3	34.53^{bc}	0.552^{cde}	3.42
I_1F_2	1.42^{bc}	0.21	0.86^{a}	64.86^{a}	22.93^{bc}	473.3	26.93^{de}	0.553^{cde}	4.5
I_1F_3	1.55^{a}	0.21	0.59^{cd}	67.20^{a}	16.76^{f}	461.0	26.80^{de}	0.632^{bc}	4.72
I_2F_1	1.35^{bcde}	0.17	0.53^{e}	62.93^{a}	20.80^{bcde}	484.3	28.70^{d}	0.614^{cd}	4.03
I_2F_2	1.32^{def}	0.20	0.62^{c}	44.23^{bc}	26.96^{a}	502.6	36.16^{ab}	0.718^{ab}	4.77
I_2F_3	1.26^{efg}	0.20	0.63^{c}	38.53^{cd}	23.06^{b}	499.3	39.06^{a}	0.719^{ab}	4.55
I_3F_1	1.36^{bcd}	0.15	0.78^{b}	66.93^{a}	21.86^{bcd}	549.6	28.0^{d}	0.762^{a}	4.56
I_3F_2	1.4^{bcd}	0.18	0.44^{f}	62.86^{a}	21.33^{bcd}	451.3	35.26^{ab}	0.533^{def}	4.27
I_3F_3	1.53^{a}	0.21	0.78^{b}	60.0^{a}	20.63^{bcde}	481.3	33.46^{bc}	0.724^{a}	4.67
				NON MULCH					
I_1F_1	1.56^{i}	0.14	0.71^{jk}	36.33^{h}	32.76^{g}	415.6	31.70^{ijk}	0.720^{g}	3.58
I_1F_2	1.29^{n}	0.18	0.57^{n}	43.60^{hi}	21.50^{hij}	484.0	28.93^{jklm}	0.670^{ghi}	4.96
I_1F_3	1.42^{jkl}	0.20	0.69^{kl}	52.20^{fg}	22.76^{hi}	440.6	32.53^{ij}	0.673^{gh}	4.69
I_2F_1	1.74^{h}	0.15	0.73^{ij}	55.56^{f}	21.36^{hij}	454.3	34.03^{ghi}	0.708^{g}	4.23
I_2F_2	1.46^{j}	0.18	0.75^{hi}	69.86^{e}	24.50^{h}	506.0	39.03^{f}	0.607^{hij}	4.29
I_2F_3	1.43^{jk}	0.21	0.64^{m}	74.23^{e}	19.46^{ijk}	501.0	29.03^{ijkl}	0.719^{g}	5.06
I_3F_1	1.4^{jklm}	0.15	0.58^{n}	45.66^{gh}	17.86^{kl}	506.6	37.0^{fgh}	0.678^{gh}	3.97
I_3F_2	1.54^{ij}	0.18	0.78^{gh}	59.73^{f}	11.33^{m}	460.0	37.66^{fg}	0.713^{g}	4.68
I_3F_3	1.16^{o}	0.26	0.81^{g}	58.73^{f}	24.16^{h}	454.0	28.36^{klm}	0.604^{hij}	3.71
SEm±	0.03	0.006	0.03	3.34	1.14	17.36	1.39	0.03	0.26
LSD($p \le 0.05$)	0.094	NS**	0.089	9.6	3.3	NS	4.0	0.087	NS
COV (%)	3.97	5.72	7.75	10.29	9.12	6.23	7.4	7.95	10.55
Parameter	Mulch	Irrigation	Fertigation	M x I	I x F	M x F			
				LSD($p \le 0.05$)					
SEm±	0.01	0.05	0.10	0.2	0.12	0.18			
Nitrogen	S	NS	S	S	S	S			
SEm±	0.01	0.009	0.06	0.01	0.01	0.25			
Phosphorous	S	NS	S	NS	S	NS			
SEm±	0.03	0.08	0.04	0.15	0.11	0.24			
Potassium	NS	S	NS	S	S	S			
SEm±	5.14	8.49	7.26	22.22	7.23	12.99			
Zinc	NS	S	NS	S	S	S			
SEm±	0.37	4.93	2.35	5.37	5.53	4.73			
Copper	NS	S	S	S	S	S			
SEm±	56.0	23.8	27.33	26.52	43.05	49.85			
Iron	S	NS	NS	NS	S	S			
SEm±	2.2	5.21	3.07	1.77	4.49	4.51			
Manganese	NS	S	S	NS	S	S			
SEm±	0.06	0.19	0.06	0.08	0.04	0.06			
Magnesium	S	S	S	S	NS	S			
SEm±	0.07	0.25	0.86	0.37	0.51	0.18			
Calcium	NS	NS	S	NS	S	NS			

Note: I_1 = -20 kPa matric potential, I_2 = -40 kPa Matric potential, I_3 = -60 kPa Matric potential.

F_1 = 100% RDF, F_2 = 80% RDF and F_3 = 60%RDF(Recommended dose of fertilizer) *Nutrients with the same letter in the column are not significant or significant at ($p \le 0.05$) with different letters.

** NS = Non – Significant, S = Significant; SEm± = Standard Error; COV= Cofficient of Variation

Comparing the means by least significant difference ($LSD_{0.05}$) (Montgomery, 1991), for N content under mulched conditions, treatments I_1F_1, I_1F_2, I_3F_2, I_3F_1 and I_2F_1 can be grouped together, i.e., any pair in this group does not differ significantly. Treatments I_1F_3 and I_3F_3 gave significantly higher N content than all other treatments. No significant difference was observed between treatments I_1F_3 and I_3F_3. For N content under non-mulch conditions, treatment I_2F_1 gave significantly higher N content than all other treatments. For K content under mulch conditions, treatment I_1F_1 and I_1F_2 gave significantly higher K content than all other treatments. However, no significant difference was observed between I_1F_1 and I_1F_2. For K content under non-mulch conditions, treatment I_3F_3 and I_3F_2 gave significantly higher K content than all other treatments. However, the two treatments were at par with no significant difference. Singh (1997) reported that among the different treatments of fertilizers applied to sardar guava cultivar, highest leaf N, P, K contents were obtained with 500 g of N, 250 g of P_2O_5 and 250 g of K_2O, which was the maximum level of fertilizer applied to the crops. Similarly, Kaur (2002) found that the higher dose of N, P, K increased the N, P, K contents in the leafs significantly. The guava trees subjected to maximum fertilizer raised the leaf N, P and K contents to the extent of 2.25% N, 0.38% P and 1.54% K. This may be due to increase in soil N, P and K nutrient level and produced the maximum content in the leaves of the plants.

For micro nutrients analysis of Zn, Cu, Mn and Mg, the interaction effect of mulch, irrigation and fertigation was significant. For Zn content under mulch conditions, treatments I_1F_3, I_3F_1, I_1F_2, I_2F_1,I_3F_2 and I_3F_3 can be grouped together i.e., any pair in this group does not differ significantly. However, they gave significantly higher Zn content than I_1F_1, I_2F_2 and I_2F_3 treatments. For Zn content analysis under non-mulch conditions, treatment I_2F_3 and I_2F_2 gave significantly higher value of Zn content than other treatments. However, no significant difference was observed beteen the two treatments. For Cu content under mulch conditions treatment I_2F_2 gave significantly higher Cu content than all other treatments. For Cu content under no-mulch conditions treatment I_1F_1 gave significantly higher Cu content than all other treatments.

For Mn content under mulch conditions treatment I_2F_3, I_2F_2 and I_3F_2 can be grouped together, i.e., the treatments are at par but gave significantly higher Mn content than I_2F_1, I_3F_1, I_1F_2 and I_1F_3. For Mn content under no mulch conditions treatments I_2F_2, I_3F_2 and I_3F_1 can be grouped together, i.e., the treatments do not differ significantly but gave significantly higher Mn content than all other treatments excepting I_2F_1 treatment. For Mg content under mulch conditions I_3F_1, I_3F_3, I_2F_3 and I_2F_2 can be grouped together that the means of these treatments are at par. However, they differ significantly with other treatments expecting I_1F_3 treatment. For Mg content under no mulch conditions the treatments I_1F_1, I_2F_3, I_3F_2 and I_2F_1 gave significantly higher Mg content than I_2F_2 and I_3F_3 treatments. The varying range of leaf nutrients observed for different treatments of irrigation, fertigation and mulch is 1.26-1.74% N, 0.14-0.26% P, 0.44-0.88% K, 36.33-74.23 ppm Zn, 11.33-32.76 ppm Cu, 415.6-557.3 ppm Fe, 26.80-39.06 ppm Mn, 0.533-0.762% Mg and 3.42-5.06% Ca. Kotur et al (1997) reported varying range of nutrients in leaves under different irrigation and fertigation schemes. The ranges of different nutrients observed were 1.4-2.0% N, 0.13-0.60% P, 1.2-1.7% K, 0.60-3.0% Ca, 0.5-0.65% Mg, 25-35 ppm Zn and 50-100 ppm Cu.

4 Conclusion

The present study of effect of matric potential, fertigation, mulch was observed for guava crop under semi-arid conditions of northwest India. The research evaluates the matric potential based irrigation scheduling and optimal fertilizer requirements of guava crop for mulch and no-mulch conditions. The results from the present study conclude that:

1) Controlling SMPs at 0.2 m depth from -20 kPa through -55 kPa and different fertigation doses had minor effect on plant height, plant girth and plant volume. However, significant effect of various treatments were observed on plant canopy spread in N/S and E/W directions. The interaction affect of SMPs, fertigation

treatments and mulches did not have any significant effect on various fruit quality parameters like length, breadth, weight, TSS, acidity, vitamin C and firmness.

2) It was observed that soil water potential and mulching had no significant effects on guava yields. However, different levels of fertigation were found to have profound effect on the yield of guava. Maximum yield was observed for -40 kPa irrigation treatment and 80% recommended dose of fertilizer for both mulch and no mulch condition. The maximum percentages of high quality fruit (fruit levels A and B) were found in treatment MI_2 for all the levels of fertigation.

3) Increasing the irrigation amount did not result in more yield in guava. Both extremes of soil moisture potential i.e -10 kPa and -60 kPa effected the growth characteristics of plants which had significant impact on the yield of the crop

4) The interaction effect of mulching, irrigation and fertigation was found to be significant for N, K, Zn, Cu, Mn and Mg. However, the interaction effect was found to be non significant for P, Fe and Ca. Under no mulch conditions the maximum values of nutrients N, P, Zn and Ca were observed. However maximum value of K, Cu, Fe, Mg and Mn were recorded under mulched conditions.

5) Increasing, the fertigation amount did not result in increased content of micro nutrients like

Cu, Zn Mn and Mg under both mulch and no mulch conditions.

Acknowledgements

The study forms part of the works of project on precision farming and development centre sponsored by National Committee on Plasticulture Applications in Horticulture (NCPAH) Ministry of Agriculture, Department of Agriculture and Cooperation, Govt. of India (GOI), New Delhi.

References

Agarwal, N., and S. Agarwal. 2007. Effect of different levels of drip irrigation on the growth and yield of pomegranate under Chhattisgarh region. *Orissa. Journal of Horticulture,* 35(1): 38-46.

Bar Yosef, B. 1999. Advances in fertigation. *Advances in Agronomy,* 65: 1-75.

Bhardwaj, S. K., I. P. Sharma, A. R. Bhandari, J. C. Sharma, and D. Tripathi. 1995. Soil water distribution and growth of apple plants under drip irrigation. *Journal of Indian Society of Soil Science,* 43(3): 323-327.

Biswas, R. K., S. K. Rana, and S. Mallick. 1999. Performance of drip irrigation in papaya cultivation in new alluvium agro-climatic zone of West Bengal. *Annals of Agricultural Research,* 20(1): 116-117.

Bradfield, E. G., and D. Spencer. 1965. Leaf analysis as a guide to the nutrition of fruit crops and Determination of Mg, Zn, Cu, by Atomic Absorption Spectroscopy. *Journal of Science and Field Agriculture,* 16(1):13-38.

Chandra, A., and P. C. Jindal. 2001. Sustainable fruit production in arid regions for export. *Current Agriculture,* 25(1-2): 13-16.

FAOSTAT. 2010. Online statistical database of Food and Agricultural Organization of United Nations. http:// www. faostat.fao.org/. (Accessed on 14th September, 2011).

José, L. M., D. José, P. Neto, and D. Fernandes. 2007. Response function of the guava to water depth and nitrogen fertilization. *Brazilian Magazine of Fruit Culture,* 29(2): 323-328.

Kaur, T. 2002. Effect of NPK fertilization on tree growth fruit yield and quality of sardar guava. p. 134 M. Sc.Thesis, Punjab Agricultural University, Ludhiana, Punjab, India.

Kotur, S. C., R. Kumar, and H. P. Singh. 1997. Influence of nitrogen, phosphorous and potassium on composition of leaf and its relationship with fruit yield in Allahbad safeda guava (*Psidium guajava L.*) on the alfisol. *Indian Journal of Agricultural Science,* 67(12): 568-570.

Kumar, A., H. K. Singh, N. Kumari, and P. Kumar. 2009. Effect of fertigation on banana biometric characteristics and fertilizer use efficiency. *Journal of Agricultural Engineering, ISAE.,* 46(1): 27-31.

Narda, N. K., and J. K. Chawla. 2002. A simple nitrate sub model for trickle irrigated potatoes. *Irrigation and Drainage,* 51(4): 361-371.

Maas, R., and D. Van. 1996. Adjust water application to expected fruit size. *Fruitlet,* 86(1): 14-15.

Montgometry, D. C. 1991. *Design and analysis of experiments*, Third edition, New York: John Wiley and Sons.

NHB. 2012. Online statistical database of National Horticultural Board, Ministry of Agriculture, Govt. of India. http://www.Indiastat.com /. (Accessed on 12th February, 2013).

Patil, P. V., and V. K. Patil. 1999. Influence of different soil water regimes on root distribution in guava. *Journal of Maharastra Agricultural University,* 24(1): 45-47.

Ramniwas, R. A., D. K. Kaushik, S. P. Sarolia, and V. Sin. 2012. Effect of irrigation and fertigation scheduling on growth and yield of guava (*Psidium guajava* L.) under meadow orcharding *African Journal of Agricultural Research* 7(47): 6350-6356.

Sharma, G., O. C. Sharma, and B. S. Thakur. 2009. *Systematics of fruit crops,* New India Publishing Agency, New Delhi.

Sharma, S., S. K. Patra, and R. Ray. 2011. Effect of drip fertigation on growth and yield of guava. *Environment and Ecology*. 29(1-2): 34-38.

Shirgure, P. S., A. K. Srivastava, and S. Singh. 2004. Growth, yield and quality of acid lime under pan evaporation based drip irrigation scheduling. *Indian Journal of Soil Conservation,* 32(1): 32-35.

Shukla, A. K., R. K. Pathak, R. P. Tiwari, and V. Nath. 2000. Influence of irrigation and mulching on plant growth and leaf nutrient status of aonla (*Emblica officinalis G.*) under sodic soil. *Journal of Applied Horticulture,* 2(1): 37-38.

Singh, V. 1997. Effect of nitrogen, phosphorous and potassium fertilizers on sardar guava. p. 124. M. Sc. Thesis, Punjab Agricultural University, Ludhiana, Punjab, India.

Singh, S., M. L. Bansal, T. P. Singh, and R. Kumar. 1998 *Statistical Methods for Research Workers.* p.310-17, Kalyani publishers, New Delhi.

Singh, H. P., and G. Singh. 2007. Nutrient and water management in guava. *Acta Horticulturae,* 735: 389-398.

Singh, B. K., K. N. Tiwari, S. Chourasia and S. Mandal. 2007. Crop water requirement of guava (*Psidium guajava L.*) Cv. Kg/kaji under drip irrigation and plastic mulch *Acta Horticulturae,* 735: 399-405.

Subramanium, P., S. Krishnaswamy, and M. M. Devasagayam. 1997. Study on the evaluation of drip irrigation in comparison with surface irrigation (basin) in coconut. *South Indian Horticulture,* 45(2): 255-258.

Sulochanamma, B. N., T. Y. Reddy, and G. S. Reddy. 2005 . Effect of basin and drip irrigation on growth, yield and water use efficiency in pomegranate cv. Ganesh*. Acta Horticulturae.* 696: 277-279.

Westwood, M. N. 1978. Temperate Zone Pomology, San Francisco, Freema.