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Studies on Plant Density and Integrated Nutrient Management for Growth, Yield, Quality and Shelf Life of Guava cv. Lalit in Rainy Season

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ABSTRACT

The Field investigations were carried out know the effect of organic, inorganic and bio-fertilizers on growth and yield of guava (Psidium guajava L.) cv. Lalit" was carried out at Regional Horticulture Research Station, College of Horticulture, Bengaluru. The vegetative growth and yield was significantly influenced at different spacing levels (2 x 2, 3 x 3, 6 x 3 and 6 x 6 m). In rainy season the maximum plant height (2.81 m), plant spread (N-S direction) (2.85 m), plant spread (E-W direction) (2.69 m) and canopy volume (11.76 m^3), number of fruits (171.74), fruit yield per tree (12.63 kg), TSS (15.14°B), minimum titratable acidity (0.44 %), ascorbic acid (169.24 mg 100^{-1} g pulp) was observed in 6 x 6 m spacing. Whereas, the fruit yield (16.74 t ha^{-1}) was maximum in 2 x 2 m spacing, the minimum physiological loss of weight (8.51 %), mean shelf life of life (6.83 days) were observed in 2 x 2 m spacing whereas, the integrated nutrient management significantly influenced vegetative growth characteristics after 8 month of growth stage the maximum plant height (2.81 m), plant spread (N-S & E-W) 2.74 & 2.67 m respectively, and canopy volume (11.71 m^3), number of fruits (236.06), fruit yield per tree (15.71 kg), fruit yield (15.08 t ha^{-1}), TSS (15.77°B), titratable acidity (0.34 %), ascorbic acid (184.52 mg 100^{-1} g pulp), physiological loss of weight (6.85 %), mean shelf life of life (7.17 days) was observed in (T_{10}) Azotobacter @ 20 g + PSB @ 20 g + vermicompost @ 10 kg + 50 % recommended NPK.

***Key words:** organic, inorganic and bio-fertilizers, guava, vegetative growth, yield, quality attributes.*

INTRODUCTION

Guava (*Psidium guajava* L.) is a popular fruit crop in India. It can be grown in tropical and subtropical climate fruits are highly nutritious, which were rich in vitamin 'C'[1]. The integrated approach of organic, inorganic and bio-fertilizers were used to know the effect on vegetative growth and its impact on yield parameters and quality parameters of cv. Lalit in rainy season.

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Plant density and nutritional management plays an important role in obtaining higher yield and quality fruits. The use of organic manures, bio-fertilizer and chemical fertilizer play a crucial role in getting higher net returns. However, systematic studies on integrated nutrient management in high density planting and its nutrient management are very meager in guava crop. Hence, current investigation was undertaken to study the effect of different plant densities on fruit yield and integrated nutrient management (INM). Continuous application of huge amount of chemical fertilizers hampers the fruit quality, soil health, life span of crop and causes environmental pollution. The integrated nutrient management paves a way to overcome these problems. The nutrients required by the plant can be supplied from different sources, through bio-fertilizers, organic manures and inorganic fertilizers; the integrated nutrient management (INM) is the best approach for sustainable crop production.

MATERIALS AND METHODS

The present research was carried out at the Regional Horticultural Research Experimental Centre (RHREC), UHS, Campus, Bengaluru during the year 2012-13, research was conducted on three year old guava trees. Experiment was conducted on four different plant densities included, (2 x 2 m, 3 x 3 m, 6 x 3 m and 6 x 6 m). The treatment aggregates of T_1: FYM (10 kg) + recommended NPK (50:25:75 g plant^{-1}), T_2: Vermicompost (10 kg) + recommended NPK, T_3: FYM (5 kg) + vermicompost (5 kg) + recommended NPK, T_4: FYM (10 kg) + vermicompost (10 kg) + 50% recommended NPK, T_5: *Azotobacter* (20 g) + FYM (10 kg) + 50% recommended NPK, T_6: *Azotobacter* (20 g) + vermicompost (10 kg) + 50% recommended NPK, T_7: PSB (20 g) + FYM (10 kg) + 50% recommended NPK, T_8: PSB (20 g) + vermicompost (10 kg) + 50% recommended NPK, T_9: *Azotobacter* (20 g) + PSB (20 g) + FYM (10 kg) + 50% recommended NPK, T_{10}: *Azotobacter* (20 g) + PSB (20 g) + vermicompost (10 kg) + 50% recommended NPK. The bio-fertilizers were procured from Department of Microbiology, UAS, Bengaluru. The experiment was statistically carried out by split plot design with ten treatments replicated thrice with two trees per replication.

The observations recorded for vegetative growth, plant height (m) and plant spread (N-S & E-W), Canopy volume[2] was calculated by using formula,

$$V = \frac{4}{6}\pi h r^2$$

where, π – 2.14, h- Height of tree (m),

$$r = \frac{\text{Sum of E} - \text{W and N} - \text{S directions (m)}}{4}$$

number of fruits, fruit yield per tree, fruit yield per hectare

Chemical analysis: The guava fruits were analysed for Total Soluble Solids (TSS), titratable acidity, ascorbic acid.

Using “Digital-hand refractometer (0-53°Brix)” the total soluble solids of the guava fruits were recorded and expressed in degree Brix (ºB).

Titratable acidity was determined by titration method[3]. Ready to serve juice was homogenized in a blender and 10 ml of extract guava juice was mixed with distilled water and volume was made up to 50 ml. A known volume of the filtrate (10 ml) was titrated against 0.01N NaOH using phenolphthalein as indicator. Acidity was calculated as percentage of citric acid equivalents using citric acid standard curve.

$$\text{Acidity (\%)} = \frac{\text{Titre Value X Std. Value(mg)X Total Vol. of Extract X CorrectionFactor X 100}}{Assay\ Volume\ X\ Weight\ of\ Sample(g)X1000}$$

Vitamin C content was determined by 2, 6-Dichlorophenol indophenol (DCPIP) method[4]. Ten grams of extract guava juice was mixed thoroughly with 4% oxalic acid solution, squeezed through a muslin cloth and volume was made up to 50 ml. Vitamin C content present in the solution was estimated by titrating a known quantity of the extract against DCPIP. Vitamin C content was calculated as mg of ascorbic acid equivalents per 100 g fresh weight using a standard curve of L-Ascorbic acid.

$$Vitamin\ C\ (mg\ 100g^{-1}) = \frac{\text{Titre Value X Std. Value X Total Volume of Extract X 100}}{\text{Assay } Volume\ X\ Weight\ of\ Sample(g) X1000}$$

Shelf life studies: The guava fruits were studied for physiological loss in weight and mean shelf life during storage.

Physiological loss in weight of fruits was done by taking fruit weight during storage at regular intervals with the help of an electronic balance. It was calculated by using the following formula and data were expressed in percentage.

$$PLW(\%) = \frac{Initial\ Weight - Weight\ after\ known\ Storage\ Period}{Initial\ Weight} X100$$

Harvested fruits of each treatment were stored at room temperature at 27 + or - 5 °C to study the storage life of the fruits. The data were statistically analyzed by adopting standard procedures and interpreted using analysis of variance.

RESULTS AND DISCUSSION

During rainy season crop (2013), plant spacing S_4 (6 x 6 m) resulted in highest plant height of 2.36 m and 2.81 m at initial and eighth month growth stages respectively. Also, the least plant height of 1.71 m and 2.04 m was observed in spacing 2 x 2 m (S1) at the same growth stages. Whereas, the INM treatments revealed significant differences among the treatments with T_{10}: [*Azotobacter* (20 g) + PSB (20 g) + vermicompost (10 kg) + 50% recommended NPK] resulting in highest plant height of 2.36 m and 2.97 m at initial and eighth month growth stages respectively followed by INM treatment T_9: [*Azotobacter* (20 g) + PSB (20 g) + FYM (10 kg) + 50% recommended NPK] with plants exhibiting plant heights 2.25 m and 2.68 m at the same growth stages. The plant spacing S_4 (6 x 6 m) resulted in highest plant spread (N-S) of 2.40 m and 2.85 m at initial and eighth month growth stages respectively. Also, the least spread (N-S) of 1.56 m and 1.86 m was observed in spacing 2 x 2 m (S_1) at the same growth stages. Whereas, the INM treatments revealed significant differences among the treatments with T_{10}: [*Azotobacter* (20 g) + PSB (20 g) + vermicompost (10 kg) + 50% recommended NPK] resulting in highest plant spread (N-S) of 2.30 m and 2.74 m at initial and eighth month growth stages respectively followed by INM treatment T_9: [*Azotobacter* (20 g) + PSB (20 g) + FYM (10 kg) + 50% recommended NPK] with plants exhibiting plant spread (N-S) of 2.23 m and 2.65 m at the same growth stages (Table 1).

The highest plant spread (E-W) S_4 (6 x 6 m) of 2.26 m and 2.69 m at initial and eighth month growth stages respectively. Also, the least plant spread (E-W) of 1.56 m and 1.86 m was observed in spacing 2 x 2 m (S_1) at the same growth stages. Whereas, the INM treatments revealed significant differences among the treatments with T_{10}: [*Azotobacter* (20 g) + PSB (20 g) + vermicompost (10 kg) + 50% recommended NPK] resulting in highest plant spread (E-W) of 2.24 m and 2.67 m at initial and eighth month growth stages respectively followed by INM treatment T_9: [*Azotobacter* (20 g) + PSB (20 g) + FYM (10 kg) + 50% recommended NPK] with plants exhibiting plant spread (E-W) of 2.17 m and 2.59 m at the same growth stages. The plant spacing S_4 (6 x 6 m) resulted in highest canopy volume of 6.96 m^3 and 11.76 m^3 at initial and eighth month growth stages respectively, the least canopy volume of 2.28 m^3 and 3.85 m^3 was observed in spacing 2 x 2 m (S_1) at the same growth stages. Whereas, the INM treatments revealed significant differences among the treatments with T_{10}: [*Azotobacter* (20 g) + PSB (20 g) + vermicompost (10 kg) + 50% recommended NPK] resulting in highest canopy volume of 6.93 m^3 and 11.71 m^3 at initial and eighth month growth stages respectively followed by INM treatment T_9: [*Azotobacter* (20 g) + PSB (20 g) + FYM (10 kg) + 50% recommended NPK] with plants exhibiting canopy volume of 6.19 m^3 and 10.45 m^3 at the same growth stages (Table 2).

The maximum number of fruits (171.74) was in rainy season under wider spaced (6 x 6 m) plots, application of organic, inorganic and bio-fertilizers, the number of fruits was maximum (236.06) in the treatment T_{10} (*Azotobacter* @ 20 g + PSB @ 20 g + vermicompost @ 10 kg + 50 % recommended NPK) and the maximum fruit yield per tree and the higher fruit yield per tree was recorded under (6 x 6 m) spacing with the yield about (12.63 kg tree^{-1}). The adaptation of integrated nutrient management gives the maximum fruit yield (15.71 kg tree^{-1}) in the treatment (T_{10}) *Azotobacter* @ 20 g + PSB @ 20 g + vermicompost @ 10 kg + 50 % recommended NPK (Table 4). The fruit yield per hectare was recorded maximum in 2 x 2 m (16.74 t ha^{-1}). The integrated nutrient management had significantly influenced on different source of organic and inorganic sources of nutrients. The application of *Azotobacter* @ 20 g + PSB @ 20 g + vermicompost @ 10 kg + 50 % recommended NPK (T_{10}) results maximum fruit yield (15.08 t ha^{-1}), followed by the combination of *Azotobacter* @ 20 g + PSB @ 20 g + FYM @ 10 kg + 50 % recommended NPK (T_9) (12.55 t ha^{-1}) (Table 3).

The total soluble solids showed significant impact by spacing and integrated nutrient management, it vary at different densities 2 x 2 m, 3 x 3 m, 6 x 3 m and 6 x 6 m (14.77, 14.93, 14.97, 15.14 ^{0}Brix respectively). The application of *Azotobacter* @ 20 g + PSB @ 20 g + vermicompost @ 10 kg + 50 % recommended NPK (T_{10}) results higher total soluble solids (15.77 ^{0}Brix), followed by the combination of *Azotobacter* @ 20 g + PSB @ 20 g + FYM @ 10 kg + 50 % recommended NPK (T_9) (15.44 ^{0}Brix). The titratable acidity of guava fruits showed significant prominence in spacing and integrated nutrient management at 6 x 3 m and 6 x 6 m recorded minimum acidity of 0.44 % respectively. Application of *Azotobacter* @ 20 g + PSB @ 20 g + vermicompost @ 10 kg + 50 % recommended NPK (T_{10}) were significantly influenced by organic and inorganic sources of nutrients, results in least titratable acidity (0.34 %) and the highest titratable acidity (0.62 %) was observed in (T_1). The ascorbic acid content of guava was influenced by integrated nutrient management and different spacing. At the different spacing 2 x 2 m, 3 x 3 m, 6 x 3 m & 6 x 6 m (162.75, 167.63, 167.67 & 169.24 mg 100^{-1} g pulp respectively) was observed. The application of *Azotobacter* @ 20 g + PSB @ 20 g + vermicompost @ 10 kg + 50 % recommended NPK (T_{10}) results higher amount of ascorbic acid content (184.52 mg 100^{-1} g pulp), the lowest ascorbic acid content (152.80 mg 100^{-1} g pulp) observed in (T_1) FYM @ 10 kg + recommended NPK 50:25:75 g per plant (Table 4).

The physiological weight loss of fruits was minimum (8.51 %) in 2 x 2 m spacing and the minimum physiological weight loss was (6.85 %) observed in T_{10} (*Azotobacter* @ 20 g + PSB @ 20 g + vermicompost @ 10 kg + 50 % recommended NPK). The maximum (6.83) shelf life of fruits were observed in 2 x 2 m and the maximum shelf life of fruits (7.17) observed in T_{10} (*Azotobacter* @ 20 g + PSB @ 20 g + vermicompost @ 10 kg + 50 % recommended NPK) (Table 5).

The results of present study reveals the variations in plant height is may be due to the regular pruning was undertaken as a common practice for all high density treatment except the wider spaced plot. Thus, more or less similar dwarf plant height was observed in the entire high density plot. On the other side, the highest plant was observed in wider spacing plot. S_4 (6 x 6 m) plant growth was not restricted by adopting pruning. These results were confirmed by earlier reports of guava high density studies reported that a spacing of 6 x 6 m resulted the maximum tree height as compared to 6 x 4 and 6 x 5 m spacing[5]. The high density was coupled with the regular pruning however, some studies without pruning were conducted by many researches[6], and the application of organic manures would have helped in the plant metabolism through the supply of such important micronutrients in the early growth phase[7]. The better efficiency of organic manures in combination with inorganic fertilizers might be due to the fact that organic manures would have provided the micronutrients such as zinc, iron, copper, manganese, etc., in an optimum level. The maximum plant spread was noticed in 6 x 6 m spacing. Improvement of crop growth was influenced by *Azotobacter*, the microbial inoculants, which bring about fixation of atmospheric nitrogen through free-living N_2 fixers in rhizosphere. The vegetative growth of guava was improved by the application of different fertilizers, organic manure and bio-fertilizers[8]. The increasing of canopy volume might be due to the better nutritional environment, application of organic matter improve the soil health by improving physicochemical and biological activities of soil[9]. The favorable effect of vermicompost on vegetative growth might be due to the fact that in addition to improving the various aspects of soil systems (physico-chemical and biological), it also alters various enzymatic activities in plants such as peroxidase, catalase etc, which promotes cell elongation, root and shoot growth and carbohydrate metabolism[10]. The integrated use of organic manures and bio-fertilizers along with chemical fertilizers improves physico-chemical properties of soil besides improving the efficiency of applied chemical fertilizers which helps in the betterment of yield and its other components. The bio-fertilizers encouraged better growth and accumulate optimum dry matter with induction of growth hormones, which stimulated cell division, cell elongation, activate the photosynthesis process[11], The similar findings were reported in guava[12,13,14&15]. Application of 50 percent pruning in May produced the highest yield (25.8 kg $tree^{-1}$) than unpruned (7.6 kg $tree^{-1}$) in winter crop of guava cv. 'Sardar'[16]. The results of long-term fertilizer experiments suggested that neither organic manures alone nor exclusive application of chemical fertilizers could achieve the yield sustainability at a high order under modern farming where the nutrient turnover in the soil plant system is quite high[17]. A significant increase in yield and yield parameters in guava with integrated nutrient application may be due to vigorous vegetative growth and increased chlorophyll content, which together accelerated the photosynthetic rate and thereby increased the supply of carbohydrates to plants. The beneficial role of supplemented organic manures and bio-fertilizers in improving soil physical, chemical and biological role is well known, which in turn helps in better nutrient absorption by plants and resulting higher yield[18].

The chain reactions in these components and beneficial effect of worms which is brought about by mucoses deposit of epidermal cells an coelomic fluids of earthworms, rich in plant growth substances and through rapid mineralization and transformation of plant nutrients in soil and also through the exertion of plant promoting substances, vitamins and amino acid content produced by the microorganism of bio-fertilizers might have possibly been a reason of the improvement in quality of the fruit[19]. The significant increase in TSS ($^{\circ}$B) and ascorbic acid content was observed with the application of organic manures, leading to availability of nutrients in rhizosphere for a longer period. So, the application of organic manures along with chemical fertilizers improves the soil fertility status i.e. during the decomposition of organic manures organic acids were released which will solubilizing some of the insoluble nutrient compounds and make it available to the plant, it also improves soil aeration, water holding capacity of soil improves aggregate formation, suppresses the some of the pests and diseases[20&21]. The similar findings were agreed that the fruit quality in guava was governed by the application of nutrients by integrated approach will significantly increase in TSS may be attributed to increased absorption of nutrients by the plants as a result of improved physico-chemical and biological activities in the soil and the combined role of these inputs upon the better portioning of metabolites from source to the sink[22]. The physiological loss in weight of guava under ambient conditions, recorded for the two year which declares that the shelf life was increased up to the ten days after harvest which was recorded when the trees were treated with 50 per cent nitrogen through supplemented through FYM and rest of nitrogen through urea augmented with *Azotobacter*. This may be due to altered physiology and biochemistry of the fruit as influenced by both organic and inorganic fertilizers that reduces respiration and transpiration in fruits which resulted in low cumulative physiological loss in weight and increased shelf life[11]. The shelf life of guava fruits were increased to 12.50 days by the application of 75:75:100 g NPK + *Azotobacter* @ 5 ml tree^{-1} + PSB @ 5 ml per tree[23]. The shelf-life of mango fruits was influenced significantly due to integrated nutrient management treatments T_7 (500 : 250 : 250 g NPK + 50 kg FYM + *Azotobacter* 250 g) resulted in the maximum period of storage or shelf-life (15.43 days) at room temperature. On the other hand, the control treatment having full dose of NPK only (T_1) reduced the storage or shelf-life of mango fruits, *i.e.* only up to 9.94 days[24]. The increase in shelf life of fruits by increasing shelf life (12.00 days) by the application of 150:187.5:187.5 g NPK + 5 kg vermicompost + rhizosphere bacteria culture per plant will minimizing post harvest losses will go a long way in increasing fruit production indirectly in papaya cv. Surya[25].

Table 1: Effect of high density guava and integrated nutrient management on plant height (m) and plant spread (N-S direction) (m)

Treatments	Plant height (m)										Plant spread (N-S)									
	Initial days				Mean	After 8 months				Mean	Initial days				Mean	After 8 months				Mean
	S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
T_1	1.49	1.56	2.14	2.22	**1.85**	1.78	1.85	2.55	2.65	**2.21**	1.26	1.86	1.96	2.10	**1.79**	1.50	2.21	2.33	2.50	**2.14**
T_2	1.57	1.99	2.15	2.28	**2.00**	1.87	2.37	2.56	2.72	**2.38**	1.50	1.89	2.24	2.17	**1.95**	1.79	2.25	2.67	2.58	**2.32**
T_3	1.64	2.04	2.22	2.29	**2.05**	1.95	2.43	2.65	2.73	**2.44**	1.51	1.91	2.25	2.28	**1.99**	1.80	2.28	2.68	2.72	**2.37**
T_4	1.70	2.08	2.25	2.32	**2.09**	2.02	2.48	2.68	2.76	**2.49**	1.55	2.06	2.28	2.35	**2.06**	1.85	2.45	2.71	2.80	**2.45**
T_5	1.73	2.22	2.29	2.32	**2.14**	2.06	2.64	2.72	2.76	**2.55**	1.57	2.12	2.29	2.39	**2.09**	1.87	2.53	2.73	2.85	**2.49**
T_6	1.72	2.22	2.31	2.34	**2.15**	2.04	2.64	2.75	2.78	**2.56**	1.58	2.17	2.35	2.45	**2.13**	1.88	2.58	2.79	2.91	**2.54**
T_7	1.75	2.25	2.30	2.37	**2.17**	2.08	2.68	2.74	2.82	**2.58**	1.61	2.18	2.36	2.47	**2.16**	1.92	2.59	2.81	2.95	**2.57**
T_8	1.82	2.25	2.35	2.46	**2.22**	2.16	2.68	2.80	2.93	**2.64**	1.65	2.19	2.38	2.49	**2.18**	1.96	2.61	2.83	2.97	**2.59**
T_9	1.82	2.26	2.44	2.49	**2.25**	2.16	2.69	2.91	2.97	**2.68**	1.68	2.20	2.47	2.55	**2.23**	2.00	2.62	2.95	3.03	**2.65**
T_{10}	1.88	2.59	2.46	2.50	**2.36**	2.24	3.09	2.93	2.97	**2.81**	1.69	2.29	2.50	2.70	**2.30**	2.02	2.73	2.98	3.22	**2.74**
Mean	**1.71**	**2.15**	**2.29**	**2.36**		**2.04**	**2.55**	**2.73**	**2.81**		**1.56**	**2.09**	**2.31**	**2.40**		**1.86**	**2.48**	**2.75**	**2.85**	
		S.E.m±		**CD @ 5%**			**S.E.m±**		**CD @ 5%**			**S.E.m±**		**CD @ 5%**			**S.E.m±**		**CD @ 5%**	
S		0.02		0.08			0.03		0.09			0.03		0.10			0.03		0.12	
T		0.01		0.02			0.01		0.02			0.01		0.02			0.01		0.02	
S x T		0.03		0.07			0.03		0.08			0.03		0.09			0.04		0.10	

T_1: FYM (10 kg) + recommended NPK (50:25:75 g plant^{-1})

T_2: Vermicompost (10 kg) + recommended NPK

T_3: FYM (5 kg) + vermicompost (5 kg) + recommended NPK

T_4: FYM (10 kg) + vermicompost (10 kg) + 50% recommended NPK

T_5: *Azotobacter* (20 g) + FYM (10 kg) + 50% recommended NPK

T_6: *Azotobacter* (20 g) + vermicompost (10 kg) + 50% recommended NPK

T_7: PSB (20 g) + FYM (10 kg) + 50% recommended NPK

T_8: PSB (20 g) + vermicompost (10 kg) + 50% recommended NPK

T_9: *Azotobacter* (20 g) + PSB (20 g) + FYM (10 kg) + 50% recommended NPK

T_{10}: *Azotobacter* (20 g) + PSB (20 g) + vermicompost (10 kg) + 50% recommended NPK

S_1- 2 x 2 m **S_2- 3 x 3 m** **S_3- 6 x 3 m** **S_4- 6 x 6 m**

Table 2: Effect of high density guava and integrated nutrient management on plant spread (E-W direction) (m) and canopy volume (m^3)

Treatments	Plant spread (E-W)										Canopy volume (m^3)									
	Initial days				Mean	After 8 months				Mean	Initial days				Mean	After 8 months				Mean
	S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
T_1	1.35	1.87	2.51	2.05	**1.94**	1.61	2.22	2.99	2.44	**2.31**	1.38	2.91	5.78	5.16	**3.81**	2.33	4.92	9.77	8.71	**6.43**
T_2	1.37	1.92	2.21	2.08	**1.89**	1.64	2.28	2.63	2.47	**2.26**	1.75	3.89	5.76	5.56	**4.24**	2.96	6.57	9.73	9.39	**7.16**
T_3	1.54	1.95	2.39	2.18	**2.01**	1.84	2.32	2.84	2.60	**2.40**	2.07	4.11	6.47	6.17	**4.70**	3.50	6.94	10.92	10.42	**7.95**
T_4	1.56	2.02	2.26	2.21	**2.01**	1.86	2.41	2.69	2.63	**2.40**	2.23	4.69	6.27	6.51	**4.92**	3.76	7.91	10.58	11.00	**8.31**
T_5	1.57	2.09	2.08	2.26	**2.00**	1.87	2.49	2.47	2.69	**2.38**	2.30	5.33	5.90	6.78	**5.08**	3.89	8.99	9.97	11.46	**8.58**
T_6	1.59	2.12	2.05	2.29	**2.01**	1.90	2.52	2.44	2.73	**2.40**	2.33	5.52	6.02	7.08	**5.24**	3.93	9.33	10.17	11.96	**8.85**
T_7	1.60	2.19	2.18	2.30	**2.07**	1.90	2.61	2.60	2.74	**2.46**	2.43	5.81	6.41	7.29	**5.49**	4.11	9.81	10.83	12.31	**9.27**
T_8	1.67	2.30	2.30	2.33	**2.15**	1.99	2.74	2.74	2.78	**2.56**	2.70	6.11	6.95	7.74	**5.87**	4.56	10.33	11.73	13.07	**9.92**
T_9	1.67	2.35	2.29	2.39	**2.17**	1.99	2.80	2.73	2.84	**2.59**	2.75	6.33	7.48	8.19	**6.19**	4.65	10.68	12.64	13.83	**10.45**
T_{10}	1.67	2.47	2.33	2.51	**2.24**	1.99	2.94	2.78	2.99	**2.67**	2.88	7.92	7.77	9.16	**6.93**	4.86	13.38	13.12	15.47	**11.71**
Mean	**1.56**	**2.13**	**2.26**	**2.26**		**1.86**	**2.53**	**2.69**	**2.69**		**2.28**	**5.26**	**6.48**	**6.96**		**3.85**	**8.89**	**10.95**	**11.76**	
	S.E.m ±			**CD @ 5%**		**S.E.m ±**			**CD @ 5%**		**S.E.m ±**			**CD @ 5%**		**S.E.m ±**			**CD @ 5%**	
S	0.025			0.09		0.03			0.10		0.43			1.48		0.72			2.50	
T	0.006			0.02		0.01			0.02		0.10			0.29		0.18			0.50	
S x T	0.028			0.08		0.03			0.09		0.47			1.33		0.80			2.25	

T_1: FYM (10 kg) + recommended NPK (50:25:75 g $plant^{-1}$)

T_2: Vermicompost (10 kg) + recommended NPK

T_3: FYM (5 kg) + vermicompost (5 kg) + recommended NPK

T_4: FYM (10 kg) + vermicompost (10 kg) + 50% recommended NPK

T_5: *Azotobacter* (20 g) + FYM (10 kg) + 50% recommended NPK

T_6: *Azotobacter* (20 g) + vermicompost (10 kg) + 50% recommended NPK

T_7: PSB (20 g) + FYM (10 kg) + 50% recommended NPK

T_8: PSB (20 g) + vermicompost (10 kg) + 50% recommended NPK

T_9: *Azotobacter* (20 g) + PSB (20 g) + FYM (10 kg) + 50% recommended NPK

T_{10}: *Azotobacter* (20 g) + PSB (20 g) + vermicompost (10 kg) + 50% recommended NPK

S_1- 2 x 2 m **S_2- 3 x 3 m** **S_3- 6 x 3 m** **S_4- 6 x 6 m**

Table 3: Effect of high density guava and integrated nutrient management on number of fruits, fruit yield (kg tree^{-1}) and fruit yield (t ha^{-1})

Treatments	Number of fruits					Fruit yield per tree (kg)					Fruit yield per hectare (t ha^{-1})				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
T_1	73.48	60.32	86.33	82.25	**75.59**	2.73	3.16	4.67	4.77	**3.83**	6.82	3.51	2.65	1.32	**3.58**
T_2	82.25	80.06	104.18	108.57	**93.77**	4.05	4.09	5.55	6.2	**4.97**	10.11	4.55	3.09	1.72	**4.87**
T_3	95.41	104.18	122.83	104.18	**106.65**	4.03	5.04	6.64	8.37	**6.02**	10.08	5.6	3.72	2.32	**5.43**
T_4	104.18	108.57	137.08	130.5	**120.09**	5.26	5.68	7.96	9.29	**7.05**	13.14	6.32	4.42	2.57	**6.61**
T_5	114.05	152.44	154.63	176.56	**149.42**	6.42	7.18	8.74	13.13	**8.87**	16.06	7.98	4.94	3.64	**8.16**
T_6	137.08	159.02	156.82	191.92	**161.21**	6.55	8.07	10.97	14.14	**9.93**	16.38	8.96	6.13	3.92	**8.85**
T_7	165.6	167.79	154.63	205.08	**173.27**	6.59	8.66	14	15.35	**11.15**	16.48	9.62	7.79	4.25	**9.54**
T_8	198.5	176.56	205.08	213.85	**198.5**	8.45	9.09	15.03	16.43	**12.25**	21.11	10.1	8.36	4.55	**11.03**
T_9	176.56	191.92	233.59	244.56	**211.66**	10.21	9.54	16.23	18.32	**13.58**	25.53	10.6	9.01	5.08	**12.55**
T_{10}	216.04	213.85	254.43	259.91	**236.06**	12.68	11.59	18.28	20.27	**15.71**	31.7	12.88	10.15	5.61	**15.08**
Mean	**136.32**	**141.47**	**160.96**	**171.74**		**6.7**	**7.21**	**10.81**	**12.63**		**16.74**	**8.01**	**6.03**	**3.5**	
	S.E.m ±		**CD @ 5 %**			**S.E.m±**		**CD @ 5 %**			**SEm±**		**CD @ 5 %**		
S	0.95		3.3			0.21		0.73			0.43		1.49		
T	1.53		4.3			0.15		0.43			0.16		0.46		
S x T	3.05		8.59			0.36		1.01			0.53		1.49		

T_1: FYM (10 kg) + recommended NPK (50:25:75 g plant^{-1})
T_2: Vermicompost (10 kg) + recommended NPK
T_3: FYM (5 kg) + vermicompost (5 kg) + recommended NPK
T_4: FYM (10 kg) + vermicompost (10 kg) + 50% recommended NPK
T_5: *Azotobacter* (20 g) + FYM (10 kg) + 50% recommended NPK
T_6: *Azotobacter* (20 g) + vermicompost (10 kg) + 50% recommended NPK
T_7: PSB (20 g) + FYM (10 kg) + 50% recommended NPK
T_8: PSB (20 g) + vermicompost (10 kg) + 50% recommended NPK
T_9: *Azotobacter* (20 g) + PSB (20 g) + FYM (10 kg) + 50% recommended NPK
T_{10}: *Azotobacter* (20 g) + PSB (20 g) + vermicompost (10 kg) + 50% recommended NPK

S_1- 2 x 2 m **S_2- 3 x 3 m** **S_3- 6 x 3 m** **S_4- 6 x 6 m**

Table 4: Effect of high density guava and integrated nutrient management on total soluble solids (%), titratable acidity (%) and ascorbic acid (mg 100^{-1} g pulp)

Treatments	Total soluble solids (°Brix)					Titratable acidity (%)					Ascorbic acid (mg 100^{-1} g pulp)				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
T_1	13.88	14.05	14.05	14.29	**14.07**	0.64	0.61	0.63	0.57	**0.62**	149.06	153.53	153.56	155.07	**152.8**
T_2	14.09	13.75	14.29	14.49	**14.15**	0.56	0.56	0.53	0.54	**0.55**	151.64	156.19	156.22	157	**155.26**
T_3	14.19	14.76	14.49	14.84	**14.57**	0.53	0.53	0.53	0.51	**0.52**	153.74	158.36	158.39	159.94	**157.61**
T_4	14.39	14.69	14.69	14.9	**14.67**	0.48	0.48	0.49	0.46	**0.48**	160.4	165.21	165.24	166.86	**164.43**
T_5	14.69	15.23	14.9	15.1	**14.98**	0.43	0.43	0.42	0.43	**0.43**	161.15	165.98	166.02	167.64	**165.2**
T_6	14.9	15.27	15.1	15.3	**15.14**	0.4	0.39	0.39	0.41	**0.4**	163.18	168.07	168.1	169.75	**167.27**
T_7	15.1	16.01	15.4	15.4	**15.48**	0.39	0.39	0.37	0.37	**0.38**	166.09	171.08	171.11	172.79	**170.27**
T_8	15.3	14.79	15.5	15.5	**15.28**	0.37	0.38	0.35	0.37	**0.37**	168.8	173.87	173.9	175.61	**173.05**
T_9	15.5	14.93	15.61	15.71	**15.44**	0.35	0.36	0.35	0.37	**0.36**	173.46	178.66	178.7	180.45	**177.82**
T_{10}	15.71	15.77	15.71	15.91	**15.77**	0.34	0.35	0.32	0.32	**0.34**	180	185.4	185.44	187.26	**184.52**
Mean	**14.77**	**14.93**	**14.97**	**15.14**		**0.45**	**0.45**	**0.44**	**0.44**		**162.75**	**167.63**	**167.67**	**169.24**	

	Total soluble solids S.E.m ±	Total soluble solids CD @ 5 %	Titratable acidity S.E.m ±	Titratable acidity CD @ 5 %	Ascorbic acid S.E.m±	Ascorbic acid CD @ 5 %
S	0.001	0.005	0.0001	0.0005	0.03	0.12
T	0.003	0.007	0.0011	0.003	0.06	0.17
S x T	0.005	0.015	0.0021	0.0058	0.12	0.33

T_1: FYM (10 kg) + recommended NPK (50:25:75 g $plant^{-1}$)
T_2: Vermicompost (10 kg) + recommended NPK
T_3: FYM (5 kg) + vermicompost (5 kg) + recommended NPK
T_4: FYM (10 kg) + vermicompost (10 kg) + 50% recommended NPK
T_5: *Azotobacter* (20 g) + FYM (10 kg) + 50% recommended NPK
T_6: *Azotobacter* (20 g) + vermicompost (10 kg) + 50% recommended NPK
T_7: PSB (20 g) + FYM (10 kg) + 50% recommended NPK
T_8: PSB (20 g) + vermicompost (10 kg) + 50% recommended NPK
T_9: *Azotobacter* (20 g) + PSB (20 g) + FYM (10 kg) + 50% recommended NPK
T_{10}: *Azotobacter* (20 g) + PSB (20 g) + vermicompost (10 kg) + 50% recommended NPK

S_1- 2 x 2 m **S_2- 3 x 3 m** **S_3- 6 x 3 m** **S_4- 6 x 6 m**

Table 5: Effect of high density guava and integrated nutrient management of guava fruits shelf life studies in rainy season

Treat ments	Physiological loss of weight (%)				Mean	Mean shelf life of fruit (days)				Mean
	S_1	S_2	S_3	S_4		S_1	S_2	S_3	S_4	
T_1	9.54	10.68	9.62	10.8	**10.16**	6.53	6.49	6.51	6.53	**6.52**
T_2	9.28	10.64	9.44	10.7	**10.02**	6.57	6.51	6.55	6.55	**6.55**
T_3	8.99	10.63	9.44	10.58	**9.91**	6.58	6.53	6.57	6.59	**6.57**
T_4	8.7	9.18	9.25	10.01	**9.29**	6.65	6.55	6.61	6.59	**6.6**
T_5	8.52	9.04	8.97	9.26	**8.95**	6.75	6.67	6.65	6.61	**6.67**
T_6	8.33	8.59	8.92	9.05	**8.72**	6.85	6.8	6.83	6.81	**6.82**
T_7	8.04	7.85	8.75	8.94	**8.4**	6.95	6.85	6.87	6.85	**6.88**
T_8	7.93	7.56	8.38	8.8	**8.17**	7.03	6.87	6.91	6.93	**6.94**
T_9	7.87	6.97	8.22	7.64	**7.67**	7.15	7.03	7.01	7.03	**7.06**
T_{10}	7.84	5.73	6.5	7.32	**6.85**	7.25	7.15	7.13	7.15	**7.17**
Mean	**8.51**	**8.69**	**8.75**	**9.31**		**6.83**	**6.75**	**6.76**	**6.76**	
	S.E.m ±		**CD @ 5 %**			**S.E.m ±**		**CD @ 5 %**		
S	0.07		0.24			0.003		0.01		
T	0.12		0.34			0.009		0.025		
S x T	0.24		0.67			0.017		0.048		

T_1: FYM (10 kg) + recommended NPK (50:25:75 g plant^{-1})
T_2: Vermicompost (10 kg) + recommended NPK
T_3: FYM (5 kg) + vermicompost (5 kg) + recommended NPK
T_4: FYM (10 kg) + vermicompost (10 kg) + 50% recommended NPK
T_5: *Azotobacter* (20 g) + FYM (10 kg) + 50% recommended NPK
T_6: *Azotobacter* (20 g) + vermicompost (10 kg) + 50% recommended NPK
T_7: PSB (20 g) + FYM (10 kg) + 50% recommended NPK
T_8: PSB (20 g) + vermicompost (10 kg) + 50% recommended NPK
T_9: *Azotobacter* (20 g) + PSB (20 g) + FYM (10 kg) + 50% recommended NPK
T_{10}: *Azotobacter* (20 g) + PSB (20 g) + vermicompost (10 kg) + 50% recommended NPK

S_1- 2 x 2 m **S_2- 3 x 3 m** **S_3- 6 x 3 m** **S_4- 6 x 6 m**

CONCLUSION

The effect of bio-fertilizer along with inorganic fertilizer on quality of guava cv. Lalit was studied. Experimental findings revealed that different treatments of bio-fertilizers and inorganic fertilizer significantly increased the plant height, plant spread, canopy volume, number of fruits, fruit yield per tree, fruit yield per hectare, total soluble solids, ascorbic acid content. Physiological loss weight and mean shelf life was minimum in fruits, whereas, the minimum acidic content was declined in fruits was observed in the combination of *Azotobacter* (20 g) + PSB (20 g) + vermicompost (10 kg) + 50 % recommended NPK while control recorded minimum. Inoculation of *Azotobacter* and PSB along with inorganic fertilizers also proved effective.

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