Indian J. Hort. 70(3), September 2013: 333-339

Effect of integrated nutrient management strategies on nutrient status, yield and quality of guava

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ABSTRACT

An experiment was conducted to find out the effect of organic and inorganic sources of fertilizers on yield, quality and nutrient status of winter season guava. The two years pooled data revealed that highest soil nitrogen and phosphorous (269.97 & 19.77 kg/ha), Ca & Mg (7.03 & 2.76 meq/ 100 g soil), leaf nitrogen & phosphorous (1.76 & 0.26%) and leaf Ca & Mg (2.01 & 0.86%) contents, respectively, was obtained with the treatment comprising *Azotobacter* + 25% of N tree^{-1} through FYM + 75% of N tree^{-1} through inorganic fertilizer, whereas, the highest soil potassium (148.23 kg ha^{-1}) and leaf potassium (1.25%) contents was obtained with the application of *Azotobacter* + 50% of N tree^{-1} through FYM + 50% of N tree^{-1} through inorganic fertilizer. The pooled analysis of two year data also indicates that 25% of N tree^{-1} through FYM + 75% of N tree^{-1} through inorganic fertilizer showed highest fruit yield (41.14 kg plant^{-1}) maximum fruit length (8.39 cm), breadth (7.94 cm), weight (244.24 g) and pectin (0.81%), while, *Azotobacter* + 50% of N tree^{-1} through FYM + 50% of N tree^{-1} through inorganic fertilizer showed highest TSS (12.95^{0}Brix), total sugars (8.61%) and minimum physiological loss in weight (14.29%) after ten days under ambient conditions.

Key words: *Psidium guajava*, yield, quality, NPK status, FYM, *Azotobacter.*

INTRODUCTION

Guava (*Psidium guajava* L.) belongs to Myrtaceae family, is an evergreen tree is one of the major fruit crops of India and is extensively grown in wide variety of soil and climatic conditions. It is unfortunate that this major crop has not been seriously attended by researchers for boosting up its production through judicious application of manures and fertilizers. As such there is no standard practice followed by growers. Thus, a more precise method than generalizing on rates is needed as a guide for nitrogen fertilization practice. Since the leaf is the major tissue in plant functions and a sensitive indicator of nutrient status. Therefore, the study was undertaken to standardize the effect of FYM, urea and *Azotobacter* on nutrient status of guava cv. Sardar.

MATERIALS AND METHODS

The present study was conducted at Experimental Orchard of Division of Fruit Science, FOA, Udheywalla, SKUAST-Jammu on 15-year-old guava cv. Sardar during winter season, located in the sub-tropical zone at latitude of 32.43^{0}North and longitude of 74.54^{0}East. The altitude of the place is 300 m from sea level. The winter months experience mild temperature ranging from 6.5^0 to 21.7^{0}C. The farm soil was sandy loam in texture and initial soil status of experimental orchard with regard to mechanical, chemical and biological properties are presented in Table 1. The recommended dose of NPK (572:207:265 g/tree) for guava tree as recommended in package and practices of SKUAST-J was maintained in the experiment, where only nitrogen was manipulated through different levels. Fertilizers were applied after regulating the crop for winter season crop with 1000 ppm NAA at full bloom stage in the second week of May. A total of twelve treatments replicated thrice were executed in randomized block design, *viz.*, T_1 =100% of N tree^{-1} through FYM, T_2 =75% of N tree^{-1} through FYM + 25% of N tree^{-1} through inorganic fertilizer, T_3 = 50% of N tree^{-1} through FYM + 50% of N tree^{-1} through inorganic fertilizer, T_4 = 25% of N tree^{-1} through FYM + 75% of N tree^{-1} through inorganic fertilizer, T_5 = 100% of N/tree through inorganic fertilizer T_6 = *Azotobacter,* T_7 = *Azotobacter* + T_1, T_8 =*Azotobacter* + T_2, T_9 = *Azotobacter* + T_3, T_{10} = *Azotobacter* + T_4, T_{11} = *Azotobacter* + T_5, T_{12} = Absolute control. FYM was applied to the trees around the trunk in the first week of July. *Azotobacter* with a uniform dose of 200 g plant^{-1} was mixed in jaggery solution prepared separately for each tree and were fed to roots. Urea, phosphorus and potassium were worked out after subtracting the quantity of nutrients supplied by organics, and remaining full quantity was applied through urea, single super phosphate and muriate of potash in the mid of July. An observation on organic carbon in soil was determined by Walkley and Black's

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Table 1. Initial status of mechanical and chemical composition of experimental soil.

Particulars	Content
A. Mechanical analysis	
Sand (%)	68.5
Silt (%)	18.5
Clay (%)	13.0
B. Chemical analysis	
pH	7.5
Electrical conductivity (dS m^{-1})	0.11
Organic carbon (%)	0.58
Available nitrogen (kg ha^{-1})	230.15
Available phosphorus (kg ha^{-1})	14.45
Available potassium (kg ha^{-1})	140.5
Available calcium (meq/100 g)	6.04
Available magnesium (meq/100 g)	2.65
C. Microbial population in guava rhizosphere	
Azotobacter counts (x 10^4) per g soil	6.5

method. Available nitrogen was estimated by micro-Kjeldhal method. Available phosphorus content of the soil was extracted with sodium bicarbonate and the blue colour intensity was measured colorimatically at 660 nm wavelength. Available potassium was determined in the neutral normal ammonium acetate extract of soil through flame photometer. Available calcium and magnesium in the soil sample was determined by EDTA method. *Azotobacter* population counts x 10^4 g^{-1} soil by serial dilution agar plating method.

Observations on N, P, K, Ca and Mg leaf status were recorded from twenty fully mature leaves which were collected in the month of July (before fertilizer application) and January (after fruit harvest) from each treatment all around the trees. Nutrient estimation in fruits and leaves for total nitrogen was estimated by micro-Kjeldhal method and results were expressed in per cent nitrogen on the basis of dry weight in leaves. Total phosphorus was determined by vanadomolybdo phosphoric yellow colour method. Potassium content was estimated by flame photometer and results were expressed in percent. The estimation of calcium and magnesium was done through atomic absorption spectrophotometer. Observations on fruit size, fruit weight were based on random five fruit samples. Fruit quality parameters, *viz*., total soluble solids and total sugars (reducing and non reducing sugar) were determined as per standard procedures given by AOAC (1). Pectin was estimated through calcium pectate method.

RESULTS AND DISCUSSION

The effect of various treatments on available organic carbon, N, P, K, Ca and Mg of soil has been enumerated in Table 2. It was observed from the Pooled estimate that various integrated treatment combinations had a significant effect on available soil organic carbon where highest soil organic carbon (0.76%) was observed in soil when cent per cent nitrogen was applied in the form of FYM augmented with

Table 2. Status of available organic carbon, N,P,K, Ca and Mg contents of the soil as influenced by application of FYM, urea and *Azotobacter* in guava.

Treatment	Organic carbon (%)	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)	Calcium (meq/100 g soil)	Magnesium (meq/100 g soil)
T_1	0.73	239.20	16.48	143.40	6.22	2.67
T_2	0.72	241.72	16.99	144.47	6.35	2.68
T_3	0.70	250.67	18.29	145.66	6.46	2.70
T_4	0.68	259.75	18.06	145.54	6.61	2.72
T_5	0.67	249.20	17.71	144.92	6.44	2.69
T_6	0.63	236.48	15.38	142.88	6.06	2.64
T_7	0.76	247.99	17.40	143.97	6.42	2.68
T_8	0.74	258.19	17.81	146.12	6.52	2.71
T_9	0.73	263.30	18.91	148.23	6.80	2.73
T_{10}	0.71	269.97	19.77	147.06	7.03	2.76
T_{11}	0.69	267.96	19.13	146.75	6.82	2.74
T_{12}	0.58	231.14	13.85	136.15	5.95	2.62
CD at 5%	0.02	1.56	1.22	0.68	0.14	0.05

Azotobacter. The increased organic carbon was due to enhanced root growth, which leads to accumulation of organic residues and direct incorporation of organic matter in soil. The statistical difference in average available nitrogen in soil was significant in both the years and in pooled estimates as well. An inquisition of the pooled data in Table 2 revealed that available soil nitrogen reached to a highest level (269.97 kg ha^{-1}) with the treatment comprising 25 per cent nitrogen as FYM + 75 per cent nitrogen as urea augmented with *Azotobacter*. The available nitrogen status in post harvest soil increased successively with increasing nitrogen levels, which was due to integration of organic and inorganic sources, because the FYM favoured mineralization of organic sources of nitrogen in the soil and also due to increased microbial activity which could have stimulated the nitrification process. A build up of nitrogen and organic carbon in soil with different nitrogen sources and levels combined with bio-fertilizers has also been reported by Mishra *et al.* (8).

From the perusal of the pooled data in Table 2 also revealed that highest increase in soil phosphorus (19.77 kg/ha) was recorded in the treatment supplemented with 25 per cent nitrogen as FYM + 75 per cent nitrogen as urea augmented with *Azotobacter*. The increase in available phosphorus with FYM addition was due to release of more phosphorus from organic compounds, increase in microbial population as well as decomposition product of humic substances. The pooled data on available potassium builds up in soil ranged between 148.23 to 136.15 kg/ha. The increased availability was due to be the action of organic acids from the organic matter complex. Some of which in addition to influencing pH, form stable complexes or chelated compounds with cations responsible for phosphate fixation. Application of organic manures significantly reduces the fixation of added as well as native phosphorus making more available to fruits. These results are in agreement with Patidar and Mali (10).

The significant effect of various treatments tried on the soil available calcium has been given in Table 2. Examining the pooled estimates it was observed that the highest build up of soil available calcium (7.03 meq per 100 g soil) and soil magnesium (2.76 meq per 100 g soil) was recorded with the trees receiving 25 per cent nitrogen as FYM + 75 per cent nitrogen as urea augmented with *Azotobacter*. All the treatments tried had resulted in significant build up of soil calcium over control except under the treatment where only trees were inoculated with *Azotobacter* without any application of fertilizer or organic manures. The pooled data on the amount of *Azotobacter* population are presented in Table 3 showing maximum amount of *Azotobacter* population after fruit harvest (29.07 x 10^4 per gram soil) with the trees receiving cent percent nitrogen as FYM augmented with *Azotobacter*, while, minimum amount of population (6.44 x 10^4 per gram soil) was observed in control (T_{12}). It was observed

Table 3. Effect of FYM, urea and *Azotobacter* on *Azotobacter* population, leaf and fruit nitrogen and phosphorus contents of guava.

Treatment	*Azotobacter* count (10^4 g^{-1} soil)		Leaf nitrogen (% DW)		Fruit nitrogen (% DW)	Leaf phosphorus (% DW)		Fruit phosphorus (% DW)
	BFA	AFH	BFA	AFH		BFA	AFH	
T_1	7.64	8.60	1.83	1.65	1.02	0.20	0.20	0.10
T_2	7.31	8.10	1.83	1.66	1.05	0.20	0.21	0.11
T_3	7.03	7.55	1.83	1.68	1.10	0.21	0.22	0.12
T_4	6.73	6.93	1.85	1.72	1.13	0.21	0.24	0.13
T_5	6.48	6.45	1.83	1.68	1.09	0.20	0.22	0.12
T_6	9.57	13.94	1.82	1.61	0.99	0.20	0.19	0.08
T_7	16.48	29.07	1.84	1.67	1.08	0.21	0.22	0.11
T_8	15.82	28.16	1.83	1.68	1.11	0.21	0.24	0.13
T_9	14.34	24.97	1.85	1.72	1.16	0.21	0.25	0.14
T_{10}	12.68	20.52	1.87	1.76	1.22	0.22	0.26	0.15
T_{11}	8.63	11.64	1.86	1.74	1.19	0.22	0.25	0.14
T_{12}	6.47	6.44	1.76	1.57	0.90	0.20	0.16	0.07
CD at 5%	1.88	1.97	0.03	0.03	0.05	NS	0.03	0.03

BFA = Before Fertilizer Application, AFH = After Fruit Harvest, (% DW) = per cent dry weight that organic matter serves as energy source for growth and multiplication of *Azotobacter.* Similar results were also recorded by Panigrahi and Behera (9). On the contrary, Awasthi *et al*. (2) observed increase in spore number with the increased application of N and P through organic sources. It was also observed that increased nitrogen application through inorganic source reduced microbial population. The nitrogen content in leaves recorded after fruit harvest was significantly affected by all the treatments as shown in pooled estimates (Table 3). It was observed that maximum amount of nitrogen content in leaves (1.76%) was recorded from the trees receiving 25 per cent nitrogen as FYM + 75 per cent nitrogen as urea augmented with *Azotobacter*. This increase in uptake of leaf nitrogen was due to integrated application of nutrients through farmyard manures, *Azotobacter* and urea which added supply of nutrients and well developed root system under balanced nutrient application resulting in better adsorption of water and nutrients. The pooled data related to average nitrogen content in fruits of guava showed 1.22 per cent nitrogen content in guava fruit under T_{10}. From the perusal of the pooled data presented in Table 3 also revealed that the leaf phosphorus after harvest reached to highest level of 0.26 per cent recorded from the trees treated with 25 per cent nitrogen as FYM + 75 per cent nitrogen as urea augmented with *Azotobacter.* The pooled data also revealed that fruit phosphorus (0.15%) was observed from the trees treated with 25 per cent nitrogen as FYM + 75 per cent nitrogen as urea augmented with *Azotobacter* (Goswami *et al*., 7). This was due to better build up of soil phosphorus in the root rhizosphere and more tree uptake and such a phenomenon was attributed better regulatory effect in relation to nutrient absorption of fruits. This may be due to better availability of soil phosphorus and more tree uptake. Such a phenomenon was attributed better regulatory effect in relation to nutrient absorption of fruits.

The pooled data of leaf potassium content presented in Table 4 showed significant increase in leaf potassium after fruit harvest, where 50 per cent nitrogen as FYM + 50 per cent nitrogen supplemented as urea augmented with *Azotobacter* recorded maximum leaf potassium (1.25%), which was the highest of all the other treatments. The pooled estimates on the fruit potassium attained a highest level (0.96%) with the trees treated with 50 per cent nitrogen as FYM + 50 per cent nitrogen supplemented as urea augmented with *Azotobacter*. All the other treatments tried had significant effect on fruit potassium as compared to control. Increase in potassium content obtained in the present study is also in conformity with the findings of Bhobia *et al*. (3) in guava. This increase in leaf potassium of guava may be due to combined use of organic and inorganic sources of fertilizers on potassium content and uptake by the fruits that may be ascribed to its role in improving soil physical properties, inturn there

Table 4. Effect of FYM, urea and *Azotobacter* on leaf and fruit potassium, calcium and magnesium contents of guava.

Treatment	Leaf potassium (% DW)		Fruit potassium (% DW)	Leaf calcium (% DW)		Fruit calcium (% DW)	Leaf magnesium (% DW)		Fruit magnesium (% DW)
	BFA	AFH		BFA	AFH		BFA	AFH	
T_1	1.16	1.17	0.87	1.86	1.86	0.18	0.76	0.75	0.63
T_2	1.17	1.18	0.90	1.88	1.88	0.20	0.78	0.76	0.64
T_3	1.18	1.20	0.93	1.90	1.92	0.22	0.83	0.78	0.66
T_4	1.17	1.19	0.92	1.90	1.93	0.23	0.83	0.81	0.67
T_5	1.17	1.19	0.91	1.91	1.90	0.20	0.79	0.79	0.66
T_6	1.18	1.16	0.87	1.87	1.85	0.17	0.77	0.74	0.60
T_7	1.16	1.18	0.89	1.88	1.90	0.19	0.78	0.77	0.64
T_8	1.20	1.21	0.94	1.90	1.92	0.21	0.80	0.80	0.65
T_9	1.21	1.25	0.96	1.93	1.95	0.24	0.81	0.83	0.67
T_{10}	1.19	1.23	0.95	1.96	2.01	0.26	0.82	0.86	0.70
T_{11}	1.19	1.22	0.95	1.93	1.95	0.23	0.80	0.83	0.68
T_{12}	1.15	1.13	0.83	1.79	1.77	0.16	0.77	0.63	0.69
CD at 5%	0.03	0.03	0.03	0.05	0.05	0.03	0.04	0.05	0.03

BFA = Before Fertilizer Application, AFH = After Fruit Harvest, % DW = per cent dry weight is better root resulting more uptake of potassium from native sources.

Pooled data in the Table 4 also enumerates the highest leaf calcium (2.01%) and fruit calcium content (0.26%) after harvest with the trees receiving 25 per cent nitrogen as FYM and rest of nitrogen through urea augmented with *Azotobacter.* This increase in nutrients was due to the production of enzymic complexes by nitrogen-fixers, which have solubilized the unavailable form of nutrient elements and render them available. The statistical analysis of the pooled data presented in Table 4 indicates that leaf magnesium reached to highest level of 0.86 per cent and highest fruit magnesium content (0.70%) from the trees treated with 25 per cent of nitrogen as FYM and 75 per cent of nitrogen as urea augmented with *Azotobacter*. It was also observed that *Azotobacter* influenced the increase in length of main root and the number of secondary roots, which enhanced the uptake of mineral elements. The results are in line with Singh *et al*. (11) where they observed that *Azotobacter* influenced the increase of length of main root and the number of secondary roots, which enhanced uptake of the mineral element uptake.

Nutrients applied without organic manure were less effective in improving the guava productivity even at higher doses and more effective when applied with organic manure. Pooled data of two years in the Table 5 revealed that maximum fruit yield (41.14 kg plant^{-1}), fruit length (8.39 cm), diameter (7.94 cm), weight (244.24 g) and volume (248 cc) of guava was obtained with the application of 25 per cent nitrogen in the form of FYM + 75 per cent nitrogen through urea augmented with *Azotobacter*. These findings are in line with Dey *et al*. (4) who reported an increase in the physical characteristics of guava with the application of biofertilizer and organic manure alone. Beneficial effect of integrated sources on yield of guava could be attributed to the fact that FYM after proper decomposition and mineralization supplied available nutrients directly to the trees, which had solublizing effect on fixed forms of nutrient in soil and had improved physico-chemical and microbial environment leading to better expression of response to applied chemical fertilizers these are important constituents of nucleotides, protein, chlorophyll and enzymes, taking part in various metabolic processes and having direct impact on vegetative and reproductive phases of fruits. The increase in average fruit weight due to the integration of organic sources of nutrients occurred due to accelerated mobility of photosynthates from source to sink as influenced by the growth hormones, released or synthesized due to organic sources of nutrients. The increase in fruit volume was attributed to the corresponding increase in length and diameter. Similar results were also observed by Yadav *et al*. (12).

With regards to chemical composition of fruits, pooled data in the Table 6 showed that highest total soluble solids (12.95°Brix) and total sugar (8.61%), reducing and non-reducing sugars (4.83 and 3.58%) were recorded maximum with application of 50 per cent nitrogen through FYM and rest through urea augmented with *Azotobacter*. It was observed that nitrogen stimulates the functioning of enzymes in the physiological processes, which have improved the total soluble solids content of the fruits. The highest total

Table 5. Effect of FYM, urea and *Azotobacter* on yield, fruit size, weight, volume and specific gravity of guava.

Treatment	Yield (kg pt^{-1})	Length (cm)	Diameter (cm)	Fruit wt. (g)	Fruit vol. (cc)	Pulp wt. (g)	Sp. Gr.
T_1	24.74	7.73	7.44	153.65	152.13	120.98	1.01
T_2	26.30	7.80	7.47	156.66	155.12	124.09	1.01
T_3	34.16	7.97	7.60	176.60	176.61	144.25	1.00
T_4	36.61	8.16	7.72	188.40	188.41	156.41	1.00
T_5	32.97	7.87	7.52	170.91	169.23	138.86	1.01
T_6	22.30	7.56	7.20	137.96	136.60	105.25	1.01
T_7	29.55	7.80	7.49	169.05	167.38	136.59	1.01
T_8	35.05	7.98	7.64	187.06	187.04	154.61	1.00
T_9	38.70	8.27	7.80	197.40	197.41	165.43	1.00
T_{10}	41.14	8.39	7.94	244.24	248.00	214.12	0.99
T_{11}	38.95	8.32	7.86	239.00	240.23	207.05	1.00
T_{12}	18.86	7.34	7.15	128.17	125.66	95.32	1.02
CD at 5%	6.27	0.13	0.12	1.33	2.68	1.87	0.01

Table 6. Effect of FYM, urea and *Azotobacter* on TSS, acidity, sugars, ascorbic acid and pectin contents of guava.

Treatment	TSS (°Brix)	Titratable acidity (%)	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Ascorbic acid (mg/100 g of pulp)	Pectin (%)
T_1	11.89	0.45	7.59	4.46	2.98	209.21	0.61
T_2	12.43	0.47	7.75	4.50	3.08	208.20	0.62
T_3	12.62	0.49	8.08	4.66	3.25	205.34	0.67
T_4	12.49	0.49	7.90	4.61	3.13	203.31	0.71
T_5	12.35	0.53	7.76	4.53	3.07	194.78	0.66
T_6	11.73	0.51	7.42	4.32	2.77	191.04	0.57
T_7	12.12	0.48	7.65	4.52	2.97	212.34	0.62
T_8	12.67	0.48	8.20	4.73	3.30	212.05	0.69
T_9	12.95	0.51	8.61	4.83	3.58	207.15	0.74
T_{10}	12.86	0.51	8.55	4.81	3.56	206.12	0.81
T_{11}	12.70	0.54	8.24	4.75	3.31	198.87	0.78
T_{12}	11.58	0.51	7.10	4.23	2.73	184.94	0.50
CD at 5%	0.03	N.S	0.10	0.02	0.07	1.43	0.04

sugars was attributed to the involvement of nitrogen in various energy sources like amino acids and amino sugars. Similar findings are in line with Dutta *et al.* (5). An inquisition of the pooled data in Table 6 also depicted that highest ascorbic acid (212.34 mg per 100 g of pulp) was observed with cent per cent nitrogen through FYM augmented with *Azotobacter*, which was due to catalytic activity of several enzymes, which participates in the biosynthesis of ascorbic acid. Pectin content in the pooled data was observed maximum with the increased nitrogen rates and was observed highest (0.81%) from the trees receiving 25 per cent nitrogen through FYM and rest through urea augmented with *Azotobacter*.

With respect to per cent physiological loss in weight of guava under ambient conditions, the pooled data of two years indicates that shelf-life of guava was found to be ten days after fruit harvest where minimum PLW after two, four, six, eight and after ten days (1.53, 3.55, 5.63, 9.30 and 14.29%),

Table 7. Effect of FYM, urea and *Azotobacter* on per cent physiological loss in weight of guava under ambient conditions.

Treatment	After 2 days	After 4 days	After 6 days	After 8 days	After 10 days
T_1	1.91	7.15	13.35	18.55	23.60
T_2	1.83	4.35	8.92	15.13	20.71
T_3	1.69	4.11	8.33	14.40	19.45
T_4	1.71	4.15	8.61	14.63	19.72
T_5	1.80	4.23	8.75	14.95	19.83
T_6	2.07	7.45	13.70	18.88	24.05
T_7	1.87	6.92	13.44	18.35	20.72
T_8	1.67	3.96	6.10	10.02	15.58
T_9	1.53	3.55	5.63	9.30	14.29
T_{10}	1.56	3.67	5.83	9.73	14.70
T_{11}	1.61	3.87	5.87	10.12	15.43
T_{12}	2.17	7.46	14.14	19.47	24.79
CD at 5%	0.21	1.42	2.08	2.81	4.88

respectively was recorded when the trees were treated with 50 per cent nitrogen 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 reduced respiration and transpiration which inturn resulted in low cumulative physiological loss in weight and increased shelf life. Similar results are in agreement with Gautam *et al.* (6). These studies thus concluded that organic source of nitrogen along with biofertilizer when applied in integrated manner can be replaced with chemical fertilizers for increasing the yield, quality and nutrient status of guava.

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Received : April, 2011; Revised : November, 2012;
Accepted : February, 2013