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RESPONSE OF GUAVA TREES (*PSIDIUM GUAJAVA*) TO SOIL APPLICATIONS OF MINERAL AND ORGANIC FERTILISERS AND BIOFERTILISERS UNDER CONDITIONS OF LOW FERTILE SOIL

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ABSTRACT

The goal of this study was to assess the influence of different organic fertilisers – vermicompost, mulching, *Azotobacter*, phosphate solubilising microbes (PSM) and *Trichoderma harzianum* added each year to mineral fertilisers containing NPK and to farmyard manure (FYM) on leaf nutrient status, tree growth, fruit yield and quality of guava grown in low fertile soil. The results revealed that vermicompost, bio-fertilisers and organic mulching resulted in yield and fruit quality boosters, as compared to application of NPK and FYM as the only organic fertiliser. Significant differences in plant height, canopy spread and stem girth of guava plants were obtained in combination, where *Azotobacter*, *T. harzianum*, PSM and organic mulching were applied. The leaf nutrient contents (N, P, K, Ca, Mg, Fe, Cu, Mn and Zn) were within sufficient ranges. Fruit yields and quality were highest in combination, where vermicompost, *Azotobacter, T. harzianum*, PSM and organic mulching was applied. Fruit quality parameters *viz*. soluble solid concentration, titratable acidity, total sugars and ascorbic acid showed positive correlation with the available macro- and micronutrients in the soil.

Key words: Guava, mineral and organic fertilisers; bio-fertiliser; plant nutrition; growth and yield; fruit quality

INTRODUCTION

The soil quality determines the sustainability and productivity of any agro-ecosystem (Dwivedi & Dwivedi 2007). Integration of organic substrates with mineral fertilisers can have significant effect on the physical, microbiological and chemical properties of soil, which are indirectly responsible for supporting plant growth (Adak et al. 2012). In particular, the microbiological properties of the soil can affect organic matter decomposition, enzymatic activities, changes in biomass carbon, microbial population, respiration rate and the ratio of biomass carbon to total organic carbon (Adak et al. 2013).

Vermicompost, which is a stabilised organic material produced by interactions between earthworms and microorganisms, in a non-thermophilic processes, has been reported to enhance seed germination and growth and plant yields in a greenhouse (Atiyeh et al. 2000) and to improve growth and plant yield under field conditions (Arancon et al. 2004). Such increased productivity of crops in response to vermicompost amendments has been attributed to greater availability of mineral nutrients as well as their richer microbial populations than in commercial plant growth substrates and farmyard manure (FYM). The presence of plant growth-influencing substances in vermicomposts, such as plant growth hormones and humic acids has also been suggested as a possible factor contributing to increased microbiological processes, plant growth and yields (Pramanik et al. 2010).

Soil microorganisms are the important component in the natural soil sub ecosystem, because they

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contribute not only to nutrient availability, but also bind soil particles into stable aggregates, which improves soil structure and reduce its erosion. Microbial inoculants, like *Azotobacter*, phosphate solubilising microbes (PSM) and *Trichoderma* may contribute to improve crop productivity through enhanced biological nitrogen (N) fixation, increased availability and absorption rates of nutrients, stimulation of plant growth through hormonal action, antibiosis or decomposition of organic residues (Adak et al. 2007, 2009). The production of organic acids such as citric, fumaric, malic and succinic acids in the vicinity of insoluble nutrient forms can bring about solubilisation in soil.

In India, Uttar Pradesh is one of the important states where guava (*Psidium guajava*) trees are planted on large scale, often in degraded lands with low fertile soils (Adak et al. 2012). Depleted nutrients and absence of efficient nutrient management systems are main factors limiting both guava tree growth and fruit yield. Shortage of quantitative information on the response of guava to organic and inorganic fertilisers under semi-arid agro ecosystems of subtropical India has inspired to examine the influences of organic and inorganic fertilisers and bio-fertilisers on plant nutrition, tree growth, yield and fruit quality of guava grown in an alluvial soil poor in major nutrients.

MATERIALS AND METHODS

Experimental site, trial design and the treatments

A field experiment was established out on a sandy loam soil during 2007-2011 in the experimental farm of Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow (26.54 °N latitude, 80.45 °E longitude and 127 m above sea level), Uttar Pradesh, India. During 2007-2011 from August to January, the mean monthly maximum temperatures ranged from 16.9 to 34.1 °C and minimum temperature varied between 4.5 and 26.2 °C. The relative humidity from August to January was high, ranging from 79 to 95%. Total rainfall in this period was 321, 664, 766 and 387 mm during 2007-08, 2008-09, 2009-10 and 2010-11, respectively. The pan evaporation varied from 0.9 to 5.1 mm per day with an average of 3.1 mm. During experiment, there was no limitation of sunlight because bright sunshine in given months did not exceed 8 h.

The experiment was conducted in a randomised block design with four replications on newly planted ‘Shweta’ guava trees, grown at a spacing of 5 × 5 m. For all plants same amount of inorganic fertilisers was applied: 120 g N, 60 g P, and 50 g K/tree/year. N was applied as urea and diammonium phosphate (DAP), P as DAP and K as muriatic potash (MOP) given in the basin before flowering. Half dose of N, K and full dose of P was applied in the month of July and remaining N and K was applied during 3rd week of September. Irrigation was applied through drip during 2nd week of April, May, June and last week of December in the tree basin based on 60% open pan evaporation of this region. The soil was sandy loam in texture and contained: sand – 65.3, silt – 27.3 and clay – 7.4% with pH 7.22, EC0.109 $d \cdot Sm^{-1}$, organic carbon 2.7%, available N – 45.5, P – 2.1, K – 67.5 $mg \cdot kg^{-1}$, extractable Fe – 4.63, Mn – 6.22, Zn – 0.24 and Cu – 0.4 $mg \cdot kg^{-1}$ measured with diethylene triamine penta acetic acid (DTPA).

The experimental treatments consisted of: farmyard manure (FYM), vermicompost, mulching and microbial inoculants/bio-fertilisers – *Azotobacter*, phosphate solubilising microbes (PSM) and *Trichoderma harzianum*. Paddy straw and guava leaf litter (1 : 1) was used as mulching at a rate of 5 kg per plant (10-cm thick). Bio-fertilisers were applied at the rate of 100 g per plant. The nutrient contents on dry weight basis of vermicompost were 1.57% N, 1.15% P, 1.75% K and 3320, 397, 112, 48 $mg \cdot kg^{-1}$ of Fe, Mn, Zn, Cu, respectively while in FYM were 0.8% N, 0.3% P, 0.92% K and 3135, 222, 75, 34 $mg \cdot kg^{-1}$ of Fe, Mn, Zn, Cu, respectively.

The following treatments were studied:

T_1 – 10 kg FYM,

T_2 – 10 kg FYM + *Azotobacter* + PSM + *T. harzianum*+ organic mulching,

T_3 – 10 kg vermicompost + *Azotobacter* + PSM + *T. harzianum*+ organic mulching,

T_4 – 5 kg FYM + 5 kg vermicompost + *Azotobacter* + PSM + *T. Harzianum* + organic mulching,

T_5 – *Azotobacter* + PSM + *T. harzianum* + organic mulching.

Measurements and observations

Tree growth parameters like plant height, stem girth at the height of 25 cm above the ground, canopy spread in north–south and east–west directions were measured every year in the month of December. Fruit yields and quality parameters were recorded after the beginning of commercial fruiting in seasons 2009-2011. Ten fruits were randomly picked from each treatment. Physical fruit parameters like weight, diameter and length were recorded immediately after harvest. Fruit quality parameters, namely soluble solids concentration (SSC), titratable acidity (TA), total sugars and ascorbic acid were determined in accordance with methods given by Ranganna (2001).

Plant and soil analysis

Third pairs of leaves from the apex, being a nutritional index for guava (Bhargava & Chadha 1993), were taken from each plot. The leaf samples were decontaminated by washing first with tap water, then in 0.2% detergent solution and 0.1 N HCl solution followed by washing in single and double distilled water (Bhargava &Raghupathi 2005). Excess of water on the surface was removed by pressing between the folds of blotting paper. The leaves were dried in an oven at 48 °C for 72 h, and then they were ground in a grinder. Nitrogen was determined by micro-Kjeldahl method and P by vanadomolybdate colorimetric method, potassium and the micronutrients, such as iron (Fe), manganese (Mn), copper (Cu) and zinc (Zn) were determined by means of atomic absorption spectrophotometer – AAS (Chemito AA203D model), and calcium (Ca) and magnesium (Mg) by Inductively Coupled Plasma Emission (ICPE) spectrophotometer (Model IRIS-Intrepid II XSP).

Soil samples were collected each year from the tree basin at depth of 0-30 cm from all treatments before application of fertilisers. Soil organic carbon was estimated by chromic acid digestion method (Walkley & Black 1934). Available N was estimated by auto-N analyser using potassium permanganate ($KMnO_4$) index data according to the procedure given by Subbiah & Asija (1956), available P was estimated by the Olsen method (Olsen et al. 1954) using spectrophotometer and available K was determined by extraction with 1 N ammonium acetate at pH 7.0, by AAS. Soil pH and electrical conductivity were measured in a 1 : 2.5 soil : water, while textural analysis was performed by hydrometer method. Available Zn, Cu, Mn and Fe contents of soil were extracted by DTPA (Lindsay & Norvell 1978). Concentrations of the above micronutrients in the extract were determined by AAS.

Statistical analysis

The data over 3 years experiment were analysed using repeated measurements model of ANOVA. The mean comparisons were done by means of the Duncan multiple range procedure at $p = 0.05$. The relationships of leaf nutrient status and soil properties with yield and quality parameters were worked out by means of Pearson's correlation coefficient 'r'. The SAS software v. 9.3 has been used for all calculations.

RESULTS AND DISCUSSION

Growth, yield and fruit quality of guava

Tree growth parameters, namely plant height, stem girth, canopy spread are given in Table 1. The data indicated that maximum plant height and canopy spread were recorded in T_5, i.e. in response to application of NPK coupled with mulching and microbial inoculants (with the exception for 2009-2010). Also, canopy spread in both directions, i.e. north–south and east–west was significantly higher in T_5 than in all other treatments. Tree stem girth recorded in T_5 was significantly bigger than that of T_1.

Only balanced growth of a fruit tree ensures an early onset of cropping, high yield and superior quality of fruits. Therefore, neither intensive vigour nor excessive dwarfness of trees is desirable. In this study, the treatments consisting different organic supplements to basic mineral fertilisers stimulated plant vigour. Improvement of tree growth in T_2 to T_5 may be attributed to the fact that the applied materials improved status of organic matter and nutrient availability in the soil. Of course, growth and development of plant is a function of soil–plant interaction and weather conditions. Particularly, rainfall and air temperature frequently determines response of plants to added inputs. Research report on the subtropical fruit crops like mango has showed good performance of mulched trees as compared with non-mulched ones (Singh et al. 2009). Reddy et al. (2009) observed that under semi-arid tropical conditions canopy spread of mango trees significantly varied over a period of five years of experimentation in drip irrigated regimes along with all nutrition treatments over control.

Table 1. Effect of organic and inorganic fertilisers and bio-fertilisers on growth parameters of 'Shweta' guava trees

Trait	Treatments	2008-09	2009-10	2010-11	Mean
Plant height (cm)	T_1	113 ± 5.5^{b}	193 ± 5.9^{b}	336 ± 6.1^{d}	214 ± 3.2^{c}
	T_2	142 ± 5.6^{ab}	233 ± 7.1^{ab}	344 ± 6.7^{c}	240 ± 1.0^{abc}
	T_3	129 ± 4.2^{b}	238 ± 3.0^{a}	341 ± 6.7^{c}	236 ± 6.3^{bc}
	T_4	154 ± 4.7^{ab}	243 ± 4.5^{a}	363 ± 4.1^{b}	253 ± 4.8^{ab}
	T_5	184 ± 5.7^{a}	225 ± 2.9^{ab}	398 ± 7.7^{a}	269 ± 3.4^{a}
Stem girth (cm)	T_1	2.4 ± 0.09^{b}	15.3 ± 1.8^{a}	25.8 ± 5.2^{b}	14.5 ± 1.7^{b}
	T_2	2.4 ± 0.08^{b}	17.0 ± 1.2^{a}	29.8 ± 1.7^{a}	16.4 ± 3.7^{ab}
	T_3	3.3 ± 0.01^{ab}	17.8 ± 1.6^{a}	26.3 ± 3.0^{ab}	15.8 ± 1.6^{ab}
	T_4	3.2 ± 0.08^{ab}	19.0 ± 1.8^{a}	29.0 ± 4.2^{ab}	17.1 ± 3.0^{ab}
	T_5	3.7 ± 0.06^{a}	19.0 ± 1.1^{a}	32.8 ± 2.6^{a}	18.5 ± 4.6^{a}
Canopy spread north–south direction (cm)	T_1	94 ± 5.3^{b}	250 ± 6.8^{c}	375 ± 5.1^{b}	240 ± 4.8^{d}
	T_2	104 ± 5.5^{b}	305 ± 10.0^{c}	383 ± 9.5^{b}	264 ± 3.7^{c}
	T_3	130 ± 6.8^{ab}	298 ± 5.2^{c}	420 ± 2.6^{ab}	283 ± 5.5^{bc}
	T_4	139 ± 3.3^{ab}	318 ± 7.8^{b}	421 ± 4.7^{ab}	293 ± 4.8^{b}
	T_5	178 ± 3.4^{a}	343 ± 5.2^{a}	459 ± 3.1^{a}	327 ± 4.9^{a}
Canopy spread east–west direction (cm)	T_1	97 ± 5.2^{b}	230 ± 7.4^{b}	364 ± 5.8^{b}	230 ± 3.7^{d}
	T_2	106 ± 3.5^{b}	278 ± 6.3^{ab}	375 ± 8.9^{ab}	253 ± 6.0^{c}
	T_3	133 ± 5.4^{ab}	293 ± 4.1^{ab}	389 ± 7.8^{ab}	272 ± 9.0^{b}
	T_4	138 ± 3.3^{ab}	303 ± 4.9^{ab}	410 ± 2.6^{ab}	283 ± 7.3^{b}
	T_5	173 ± 4.3^{a}	335 ± 6.1^{a}	458 ± 5.8^{a}	322 ± 2.9^{a}

Means ± SD within column and for each trait with the same letter are not significantly different by Duncan's Multiple Range Test at $p \leq 0.05$.

Data on fruit yield and quality parameters, viz. fruit weight, diameter and length, total soluble solids, acidity, total sugars and vitamin C content are given in Table 2. The fruit yield recorded in T_3 was statistically at the same level as in T_2, T_4 and T_5, but it was significantly higher than in T_1. Replacement of FYM (T_1) with vermicompost coupled with organic mulching and microbial inoculants (T_3) resulted in significant increase in fruit yield. The quality parameters of fruits were also affected by organic and inorganic fertilisers. Mean fruit weight, length and fruit diameter increased on plots fertilised with vermicompost, microbial inoculants and mulching. The highest and lowest mean growth and quality parameters were recorded in the treatments T_3 and T_1, respectively. The mean fruit diameter and length was 7.8-6.6 cm and 7.7-6.1 cm, respectively. Significant differences in biochemical quality parameters were also stated (Table 2). The values of SSC in T3 and T1 were 12.5 and 10.8°Brix, titratable acidity 0.31 and 0.17%, total sugars 9.1 and 8.2% and ascorbic acid 265 and 185 mg·100 g^{-1} of pulp, respectively.

Yield of perennial fruit crops like guava is highly dependent on cultivar, cultivation technology, biotic and abiotic stresses during growing season. The highest fruit yield in this study was obtained in response to application of vermicompost + microbial inoculants and organic mulching + NPK fertiliser. It was significantly higher as compared to trees supplied with NPK + FYM as well as the plots without vermicompost. This indicates the positive role of vermicompost for guava fruiting. The improvement in physical attributes of fruit quality in trees supplied with vermicompost might be due to synergistic effect of organic and mineral fertilisers on the physicochemical conditions of soil. Such improved soil conditions were also observed in mandarin orchards established on clay loam soil in semi-arid climate, where mulching around trees was applied (Panigrahi et al. 2008). Adak et al. (2012) also observed improved soil water content and temperature changes in the root zone area of high density guava cultivation under subtropical climatic condition. Moreover, Milosevic & Milosevic (2009) also observed that applications of inorganic fertilisers along with organic manures enhanced the nutrient use efficiency ensuring better vegetative growth of trees, higher yields and quality of apple fruits.

Table 2. Effect of organic and inorganic fertilisers and bio-fertilisers on fruit yield and quality of 'Shweta' guava

Trait	Treatment	2009-10	2010-11	Mean
	T1	16.6 ± 2.47^{b}	35.9 ± 3.10^{d}	26.2 ± 2.86^{b}
	T2	25.6± 2.43^{ab}	40.0 ± 2.05^{c}	32.8 ± 3.17^{ab}
Yield (kg·ha^{-1})	T3	33.1 ± 2.10^{a}	57.8 ± 2.53^{a}	45.4 ± 4.42^{a}
	T4	30.5 ± 3.43^{a}	44.7 ± 2.10^{b}	37.6 ± 2.63^{ab}
	T5	22.5 ± 2.73^{ab}	40.3 ± 2.41^{c}	31.4± 3.05^{ab}
	T1	148 ± 4.6^{c}	191 ± 5.4^{d}	170 ± 4.8^{c}
	T2	181 ± 3.8^{bc}	221 ± 5.9^{c}	201 ± 4.1^{bc}
Fruit weight (g)	T3	235 ± 7.3^{a}	263 ± 6.2^{a}	249 ± 4.3^{a}
	T4	201 ± 7.2^{ab}	236 ± 2.1^{b}	219 ± 2.7^{ab}
	T5	181 ± 2.8^{bc}	208 ± 4.8^{d}	195 ± 3.6^{bc}
	T1	6.2 ± 0.6^{b}	7.0 ± 0.3^{b}	6.6 ± 0.3^{b}
	T2	6.9 ± 0.1^{ab}	7.4 ± 0.8^{b}	7.2 ± 0.7^{ab}
Fruit diameter (cm)	T3	7.6 ± 0.6^{a}	8.0 ± 0.6^{a}	7.8 ± 0.6^{a}
	T4	7.1 ± 0.1^{a}	7.5 ± 0.6^{b}	7.3 ± 0.5^{ab}
	T5	6.9 ± 0.1^{ab}	7.4 ± 0.6^{b}	7.2 ± 0.5^{ab}
	T1	6.2 ± 0.7^{b}	5.9 ± 0.6^{ab}	6.1 ± 0.6^{c}
	T2	6.9 ± 0.1^{b}	6.4 ± 0.3^{ab}	6.7 ± 0.4^{bc}
Fruit length(cm)	T3	8.2 ± 0.7^{a}	7.2 ± 0.3^{a}	7.7 ± 0.7^{a}
	T4	7.1 ± 0.2^{b}	7.0 ± 1.0^{ab}	7.1 ± 0.6^{ab}
	T5	6.9 ± 0.3^{b}	6.1 ± 0.6^{ab}	6.5 ± 0.6^{bc}
	T1	10.8 ± 0.6^{b}	10.9 ± 0.5^{b}	10.8 ± 0.5^{c}
	T2	11.5 ± 0.4^{ab}	11.6 ± 0.4^{ab}	11.5 ± 0.8^{bc}
SSC (°Brix)	T3	12.7 ± 0.5^{a}	12.3 ± 0.5^{a}	12.5 ± 0.8^{a}
	T4	11.8 ± 0.4^{ab}	11.8 ± 0.9^{ab}	11.8 ± 0.6^{b}
	T5	11.6 ± 0.3^{ab}	11.1 ± 0.5^{ab}	11.3 ± 0.4^{bc}
	T1	0.17 ± 0.02^{c}	0.17 ± 0.02^{d}	0.17 ± 0.01^{d}
	T2	0.25 ± 0.01^{b}	0.26 ± 0.02^{b}	0.25 ± 0.01^{b}
Titratable acid-ity (%)	T3	0.31 ± 0.02^{a}	0.32 ± 0.01^{a}	0.31 ± 0.01^{a}
	T4	0.26 ± 0.03^{b}	0.26 ± 0.02^{b}	0.26 ± 0.02^{b}
	T5	0.22 ± 0.03^{b}	0.23 ± 0.02^{c}	0.23 ± 0.02^{c}
	T1	8.1 ± 0.13^{d}	8.3 ± 0.30^{c}	8.2 ± 0.22^{c}
	T2	8.5 ± 0.10^{c}	8.6 ± 0.26^{bc}	8.5 ± 0.18^{b}
Total sugar (%)	T3	9.3 ± 0.10^{a}	9.1 ± 0.30^{ab}	9.2 ± 0.23^{a}
	T4	8.9 ± 0.18^{b}	9.3 ± 0.13^{a}	9.1 ± 0.25^{a}
	T5	8.7 ± 0.08^{b}	8.6± 0.47^{bc}	8.7 ± 0.32^{b}
	T1	188 ± 5.4^{d}	182 ± 2.0^{c}	185 ± 6.2^{c}
	T2	208 ± 3.8^{c}	237 ± 5.7^{b}	223 ± 5.2^{b}
Ascorbic acid (mg·100 g^{-1} of pulp)	T3	247 ± 4.8^{a}	283 ± 6.7^{a}	265 ± 3.3^{a}
	T4	226 ± 3.8^{b}	267± 6.8^{ab}	247 ± 4.8^{ab}
	T5	210 ± 3.4^{c}	236 ± 1.8^{b}	223± 4.7^{b}

Means ± SD within column and for each trait with the same letter are not significantly different by Duncan's Multiple Range Test at $p \leq 0.05$

Table 3. Effect of organic and inorganic fertilisers and bio-fertilisers on organic carbon and soil nutrient status in 'Shweta' guava orchard

Trait	Treatment	2008-09	2009-10	2010-11	Mean
Organic carbon (%)	T_1	0.33 ± 0.002^{c}	0.33 ± 0.002^{b}	0.34 ± 0.000^{c}	0.33 ± 0.000^{c}
	T_2	0.41 ± 0.002^{ab}	0.35 ± 0.000^{ab}	0.39 ± 0.000^{b}	0.38 ± 0.000^{b}
	T_3	0.47 ± 0.002^{a}	0.43 ± 0.003^{a}	0.52 ± 0.000^{a}	0.48 ± 0.001^{a}
	T_4	0.43 ± 0.001^{ab}	0.40 ± 0.001^{ab}	0.36 ± 0.000^{c}	0.39 ± 0.000^{b}
	T_5	0.39 ± 0.001^{bc}	0.35 ± 0.000^{ab}	0.38 ± 0.000^{b}	0.37 ± 0.000^{b}
Available N ($mg \cdot kg^{-1}$)	T_1	44.0 ± 5.5^{a}	58.0 ± 6.2^{b}	60.0 ± 2.2^{b}	54.0 ± 5.3^{b}
	T_2	56.8 ± 8.2^{a}	64.3 ± 8.6^{a}	62.3 ± 2.7^{ab}	61.1 ± 5.0^{a}
	T_3	57.5 ± 15.3^{a}	66.0 ± 2.0^{a}	73.8 ± 2.9^{a}	65.8 ± 2.0^{a}
	T_4	58.3 ± 5.7^{a}	62.0 ± 2.7^{a}	66.8 ± 5.1^{ab}	62.3 ± 6.0^{a}
	T_5	53.5 ± 9.8^{a}	60.5 ± 2.8^{a}	69.3 ± 3.1^{ab}	61.1 ± 2.8^{a}
Available P ($mg \cdot kg^{-1}$)	T_1	30.7 ± 2.7^{a}	18.9 ± 3.9^{b}	21.0 ± 5.2^{b}	24.1 ± 0.1^{c}
	T_2	35.3 ± 5.2^{a}	22.4 ± 5.4^{ab}	24.0 ± 2.0^{ab}	27.2 ± 0.2^{bc}
	T_3	45.7 ± 7.0^{a}	30.2 ± 3.0^{a}	27.4 ± 4.1^{a}	34.4 ± 0.3^{a}
	T_4	40.7 ± 8.2^{a}	24.8 ± 3.1^{ab}	25.2 ± 3.5^{ab}	30.2 ± 0.3^{b}
	T_5	34.4 ± 5.6^{a}	22.6 ± 2.4^{ab}	22.7 ± 2.2^{ab}	26.0 ± 0.2^{c}
Available K ($mg \cdot kg^{-1}$)	T_1	97 ± 11.0^{b}	172 ± 7.8^{a}	268 ± 31.0^{c}	179 ± 4.4^{c}
	T_2	106 ± 9.1^{a}	181 ± 4.2^{a}	406 ± 16.0^{b}	231 ± 8.1^{b}
	T_3	108 ± 20.8^{a}	191 ± 7.7^{a}	512 ± 13.0^{a}	270 ± 5.9^{a}
	T_4	110 ± 21.7^{a}	185 ± 9.4^{a}	334 ± 23.0^{c}	210 ± 4.3^{b}
	T_5	94 ± 23.2^{b}	176 ± 6.9^{a}	292 ± 23.0^{c}	187 ± 3.3^{c}
DTPA extractable Fe ($mg \cdot kg^{-1}$)	T_1	2.14 ± 0.02^{a}	4.81 ± 0.81^{a}	5.02 ± 0.83^{a}	3.99 ± 0.85^{a}
	T_2	2.97 ± 0.18^{a}	4.58 ± 0.56^{a}	4.84 ± 0.16^{a}	4.13 ± 0.34^{a}
	T_3	2.21 ± 0.13^{a}	4.13 ± 0.26^{a}	5.19 ± 0.56^{a}	3.84 ± 0.76^{a}
	T_4	2.59 ± 0.32^{a}	4.44 ± 0.45^{a}	5.10 ± 0.82^{a}	4.04 ± 0.56^{a}
	T_5	3.39 ± 0.01^{a}	4.37 ± 0.43^{a}	4.98 ± 0.03^{a}	4.24 ± 0.21^{a}
DTPA extractable Mn ($mg \cdot kg^{-1}$)	T_1	2.68 ± 0.24^{a}	5.01 ± 0.14^{a}	11.30 ± 4.2^{b}	6.33 ± 0.63^{b}
	T_2	2.29 ± 0.11^{a}	5.06 ± 0.31^{a}	12.34 ± 2.4^{b}	6.56 ± 0.98^{b}
	T_3	2.01 ± 0.01^{a}	5.66 ± 0.08^{a}	16.37 ± 1.1^{a}	8.01 ± 0.18^{a}
	T_4	2.18 ± 0.01^{a}	6.49 ± 0.19^{a}	12.41 ± 1.9^{b}	7.03 ± 0.79^{b}
	T_5	1.95 ± 0.00^{a}	5.73 ± 0.18^{a}	12.53 ± 1.3^{b}	6.73 ± 0.58^{b}
DTPA extractable Zn ($mg \cdot kg^{-1}$)	T_1	0.57 ± 0.005^{a}	0.33 ± 0.003^{b}	0.47 ± 0.001^{b}	0.51 ± 0.009^{c}
	T_2	0.59 ± 0.011^{a}	0.73 ± 0.110^{ab}	0.73 ± 0.004^{b}	0.68 ± 0.002^{c}
	T_3	0.67 ± 0.018^{a}	1.31 ± 0.110^{a}	0.68 ± 0.020^{a}	0.88 ± 0.040^{a}
	T_4	0.52 ± 0.009^{a}	1.17 ± 0.019^{ab}	0.65 ± 0.003^{a}	0.78 ± 0.090^{b}
	T_5	0.54 ± 0.005^{a}	0.56 ± 0.03^{ab}	0.65 ± 0.008^{a}	0.52 ± 0.001^{c}
DTPA extractable Cu ($mg \cdot kg^{-1}$)	T_1	0.14 ± 0.002^{a}	$0.10 \pm 0.001c$	0.39 ± 0.003^{c}	0.21 ± 0.007^{c}
	T_2	0.30 ± 0.014^{a}	0.27 ± 0.007^{bc}	0.45 ± 0.014^{c}	0.34 ± 0.003^{bc}
	T_3	0.41 ± 0.048^{a}	1.03 ± 0.016^{a}	0.87 ± 0.150^{a}	0.77 ± 0.030^{a}
	T_4	0.38 ± 0.030^{a}	0.70 ± 0.062^{ab}	0.58 ± 0.016^{b}	0.55 ± 0.080^{ab}
	T_5	0.28 ± 0.020^{a}	0.38 ± 0.024^{bc}	0.46 ± 0.016^{c}	0.37 ± 0.020^{bc}

Means ± SD within column and for each trait with the same letter are not significantly different by Duncan's Multiple Range Test at $p \le 0.05$

Table 4. Pearson's correlation coefficient among leaf nutrient status, yield and quality parameters of fruits of 'Shweta' guava, $n = 60$ (5 treatments × 4 replications × 3 years)

Soil parameters	Yield	SSC	Ascorbic acid	Titratable acidity	Total sugar	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu
Yield	-	0.923*	0.959**	0.974**	0.912*	0.848*	0.932*	0.949*	0.962**	0.981**	0.878**	0.852*	0.982**	0.914*
Soluble solid conc.		-	0.987**	0.959**	0.973**	0.955*	0.947*	0.979**	0.964**	0.979**	0.960**	0.930*	0.872**	0.990**
Ascorbic acid			-	0.958*	0.984**	0.955*	0.931*	0.991**	0.966**	0.995**	0.971**	0.954*	0.926*	0.981**
Titratable Acidity				-	0.911*	0.857*	0.974**	0.948*	0.979**	0.980**	0.875**	0.831*	0.932*	0.942*
Total sugar					-	0.991**	0.916*	0.993**	0.954*	0.966**	0.965**	0.961**	0.858	0.989**
N						-	0.836**	−0.023	0.724*	0.622*	0.408	0.230	0.793**	0.487
P							-	−0.387	0.819**	0.535*	0.545*	0.218	0.711**	0.180
K								-	−0.316	0.911**	−0.530*	−0.124	−0.023	0.612*
Ca									-	0.023	−0.180	−0.435	0.901**	−0.031
Mg										-	0.920**	0.825**	0.256	0.962**
Fe											-	0.865**	0.015	0.215
Mn												-	−0.240	0.449
Zn													-	0.110
Cu														-

**Significant at 0.01 level, *Significant at 0.05 level

Table 5. Pearson's correlation coefficient among yield, fruit quality and soil parameters in guava orchard, $n = 60$ (5 treatments × 4 replications × 3 years)

Parameters	SSC	Ascorbic acid	Titratable acidity	Total sugar	Avail. N	Avail. P	Avail. K	Fe	Mn	Zn	Cu
Yield	0.923*	0.959**	0.974**	0.912*	0.959**	0.913*	0.921*	0.962**	0.984**	0.942*	0.844
SSC	-	0.989**	0.959**	0.973**	0.935*	0.981**	0.953*	0.979**	0.943*	0.925*	0.956*
Ascorbic acid		-	0.958*	0.984**	0.947*	0.975**	0.937*	0.990**	0.951*	0.946*	0.950*
Titratable acidity			-	0.914*	0.962**	0.940*	0.967**	0.967**	0.998**	0.938*	0.868*
Total sugar				-	0.941*	0.937*	0.870*	0.950*	0.897*	0.874*	0.931*
Avail. N					-	0.874	0.870**	0.919*	0.958*	0.847*	0.808*
Avail. P						-	0.974**	0.989**	0.929*	0.970**	0.983**
Avail. K							-	0.971**	0.961**	0.971**	0.922*
Fe								-	0.963**	0.980**	0.952*
Mn									-	0.942*	0.851*
Zn										-	0.932*
Cu											-

**Significant at 0.01 level (two-tailed), *Significant at 0.05 level (two-tailed)

The content of minerals and correlations

The levels of N, P, Ca and Mg in leaves among the studied treatments varied significantly, while P showed no significant variation (data not shown). Status of most of the nutrients (except for Fe and organic matter) in soil as a result of the treatment T_3 was higher as compared to plots, on which trees were supplied with FYM + NPK (T_1) (Table 3).

Fruit yield was positively correlated with major leaf nutrients, secondary nutrients and micronutrients. Analysis revealed also significant relationship among the soil and plant parameters. The quality parameters (SSC, titratable acidity, total sugars and ascorbic acid) showed significant positive correlation coefficient (*r*) with major leaf nutrients (N, P, K) ranging from 0.85* to 0.99*, secondary nutrients (Ca and Mg) from 0.95** to 0.99** and micronutrients (Fe, Mn, Zn and Cu) from 0.83* to 0.99** (Tables 4, 5). Furthermore, it was observed that the studied soil parameters were also significantly correlated with quality attributes of fruits and yield. Soluble solid concentration, titratable acidity, total sugar and ascorbic acid content of fruits were correlated with available N, P, K and micronutrients in soil. Thus, the positive effect of soil and leaf parameters on yield and quality in guava was obtained. The leaf nutrient concentrations are strongly influenced by the composition of added organic and inorganic inputs and help in optimizing fertiliser scheduling (Saenz et al. 1997; Pestana et al. 2005; Raina et al. 2011; Rodrigues et al. 2011).

CONCLUSION

Results of the study demonstrated that vermicompost should be given priority over FYM along with organic mulching available at farm level for fertiliser scheduling in guava orchards of Uttar Pradesh, India on soil with low clay content. Yield and quality parameters of fruits were positively correlated to the soil and leaf factors indicating that proper nutrient management systems has to be developed, in order to sustain the orchard productivity and fruit quality of guava. Soil restoration strategy with integration of organic sources under conditions of coarse-textured soils of low fertility and with high economic fruit crop of guava should find a place in decision support system.

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