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Nutritional status of soils and leaves of guava (*Psidium guajava*) orchards of Agra district, Uttar Pradesh

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ABSTRACT

A study was conducted on soil and plant nutritional status of guava orchards in order to identify the nutrients that are deficient / low by surveying 100 guava orchards, collection of leaf and soil samples in guava growing Agra district. In general, soils were alkaline in reaction and low in organic carbon. The range (mean) values of available N, P, K and S were 175.0 to 235.0 (196.5 kg ha^{-1}), 8.5 to 24.0 (27.5 kg^{-1}), 180.0 275.0 (218.5 kg ha^{-1}) and 9.0 to 26.0 (15.5 kg ha^{1}), respectively in orchard soils. As regards to DTPA extractable Fe, Mn and Cu, the status of these micronutrient cations was adequate in these soils. The soils of guava orchards were deficient in DTPA-Zn to the extent of 45 per cent. Most of the nutrients showed positive relationship with organic carbon content. These elements were negatively related with soil pH and calcium carbonate. The yield limiting nutrients differed from orchards to orchards though some of the nutrients were more prominent. The leaf samples were deficient in nitrogen, sulphur and zinc. On the other hand, P, K, Fe, Cu contents in majority of leaves were in optimum range in guava orchards. The ranges of nitrogen, phosphorus, potassium and sulphur content in guava leaves were from 1.55, to 2.18, to 0.16 to 0.32, 1.20 to 2.10 and 0.18 to 0.35 per cent, respectively. The corresponding ranges of micronutrient cations, i.e. Fe, Mn, Cu and Zn in guava leaves were from 145 to 242, 28.0 to 60.0, 4.5 to 10.6 and 17.5 to 35 mg kg^{-1}.

Keywords: Major nutrients, micronutrients soils, leaves, guava orchards

INTRODUCTION

Guava (*Psidium guajava*), the apple of the tropics, is one of the most common fruits in India. It claims to be the fourth most important fruit in area and productivity after mango, banana and citrus. It is considered to be one of hardy fruits capable of growing under adverse conditions of soils and climate. Growers prefer guava cultivation due to the fact that it can be grown in variety of soils with pH range from 6.5 to 8.5 or more. The orchards are generally grown on marginal lands as an alternate where normal crops are not taken up the resource poor farmers of the region do not apply manures and fertilizers and are dependent on native soil fertility. This is more so in case of guava orchards. The yield and quality is, therefore, expectedly poor and not competitive. A number of factors viz. low fertility status presence of hard pans, poor cultural practices have been reported to be responsible for such low yields. It is, therefore, essential that guava trees are supplied with suitable and adequate nutrients for ensuring the sustained productivity. The deficiency of both major and micronutrients are reported as the crop is scarcely fertilized in Agra region. Incipient deficiency or hidden hunger is causing considerable damage to guava crop resulting in economic loss. The use of leaf analysis to indicate nutrient availability in fruit crops has long been accepted (Kotur *et al.* 1997, Parihar *et al.* 2013). Leaf is the principal site of plant metabolism and the changes in nutrients supply are reflected in the composition of leaf. Both soil and plant analyses techniques are complementary to each other. Much work on soil and foliar diagnosis of guava crop has not been reported. Hence, the present investigation was taken up.

MATERIALS AND METHODS

Soil samples were collected from more than 10 year old orchards in Agra district of Uttar Pradesh up to the depth of 0-30 cm at 100 locations. Each sample was made from five random samples of an orchard and pooled together to form one representative sample. Each soil sample was air dried, ground in a wooden pestle with mortar and passed through a 2mm sieve for determining various soil properties. The pH and electrical conductivity (EC) of the soils was determined in 1 : 2.5 soil-water suspension with glass electrode pH meter

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and sol bridge, respectively. Organic carbon was estimated employing Walkley and Black wet oxidation method (Jackson, 1973), calcium carbonate by rapid titration method, available N by alkaline potassium permanganate method (Subbiah and Asija, 1956) available P by Olsen's method (Olsen *et al.* 1954), available K in NH_4OAc extract using flame photometer (Hanway and Heidel 1952) and available S by turbiditimic method (Chesnin and Yien 1951). The DTPA-extractable Fe, Mn, Cu and Zn were determined as the procedure outlined by Lindsay and Norvell (1978) using atomic absorption spectrophotometer. Leaf samples were collected from each orchard during the survey (August – September) as outlined by Bhargava (2002). The leaf samples were decontaminated by washing in sequence with tap water to remove the dirt or soil, then in 0.2% detergent solution followed by washing in distilled water. These samples were digested in a di acid mixture of HNO_3 : $HClO_4$ (5:1). Phosphorus, K and S were determined by adopting standard procedures Jacson (1973). Nitrogen in leaf samples was determined by modified Kjeldahl method, Micronutrient cations were determined in acid extract using atomic absorption spectro-photometer. Simple correlation coefficients were computed relating nutrient content with physiochemical properties of the soils.

RESULTS AND DISCUSSION

Properties of Orchard soils

A perusal of the data (Table 1) indicated that the pH of guava orchards soils varied from 7.4 to 8.8 showing alkaline nature of the soils. The relatively higher pH of the soils may be due to the high amount of alkaline earth metals. The EC of the soil water suspension (1 : 2.5) ranged between 0.15 and 0.85 dSm^{-1}. The higher content of soluble salts appeared due to irrigation with saline water and insufficient leaching during rainy season. The range of variation in organic carbon content was from 3.5 to 6.0 g kg^{-1} with an average value of 4.5 g kg^{-1}. This variation in the organic carbon content of the soils may be attributed to variation in the texture of the soils and differences in the management practices (Sharma *et al.*, 2018). Calcium carbonate content in these soils varied from 5.0 to 25.0 gkg^{-1} with an average value of 13.5 g kg^{-1}. Similar results were reported by Mustafa *et al.* (2016) in soils of Kheragarh tehsil of Agra district.

Table 1: Physico-chemical properties and status of nutrients in soils of guava orchards

Nutrient	Range	Mean
Physico-chemical properties		
pH	7.4 – 8.8	–
EC (dSm^{-1})	0.15 – 0.85	0.27
Organic carbon (g kg^{-1})	3.5 – 6.0	4.5
Calcium carbonate (g kg^{-1})	5.0 – 25.0	13.5
Available nutrients		
Nitrogen (kg ha^{-1})	175.0 – 235.0	196.5
Phosphorus (kg ha^{-1})	8.5 – 24.0	17.5
Potassium (kg ha^{-1})	180.0 – 275.0	218.5
Sulphur (kg ha^{-1})	9.0 – 26.0	15.5
Iron (mg kg^{-1})	6.0 – 15.0	9.5
Manganese (mg kg^{-1})	3.8 – 9.0	5.2
Copper (mg kg^{-1})	0.28 – 0.75	0.48
Zinc (mg kg^{-1})	0.47 – 1.40	0.69

Nutrient status of orchard soils

Amount of available nitrogen in soils of guava orchards ranged between 175 and 235 kg ha^{-1} with a mean value of 196.5 kg ha^{-1}. Most of the soils understudy fall in the category of low available nitrogen status. This variation in available nitrogen status appears to be due to marked variation in the characteristics of the soils (Mustafa *et al.* 2016). Available N had significant positive correlation with soil organic carbon. Positive correlation of low degree was noticed between available N and EC and $CaCO_3$. The amount of available phosphorus ranged between 8.5 and 24.0 kg ha^{-1} in the soil samples collected from guava orchards of Agra district (Table 1) Indicating that certain orchards were deficient in P availability. Mustafa *et al.* (2016) reported similar results in soils of Kheragarh tehsil of Agra district. Available P had significant positive correlation with organic carbon and negative one with pH and $CaCO_3$. Available potassium content in these soils ranged from 180 to 275 kg ha^{-1} with a mean value of 218.5 kg ha^{-1}. Similar results were reported by Sharma *et al.* (2018) in orchard soils of Jammu. Most of the soil samples fall in the category of medium K status. Available potassium had positive significant correlation with organic carbon. Positive correlations of low degree were observed between available K and pH, EC and calcium carbonate. Available sulphur content in these soils ranged from 9.0 to 26.0 kg ha^{-1} with a mean value of 15.5 kg ha^{-1}. About 55% soil samples showed lower amount of available sulphur. There was a significant relationship between available sulphur and organic carbon. It had also significant positive correlation with EC. Available iron content in these soils ranged between 6.0 and 15.0 mg kg^{-1}. These results are comparable with the findings of Parihar *et al.* (2013) where available Fe in soils of guava orchards was reported between 3.16 and 7.80 mg kg^{-1}. Majority of soil samples may be rated as high in available iron (Mustafa *et al.* 2016). Available iron was significantly and positively correlated (Table 2) with organic carbon ($r = 0.425^{o}$). This indicates that soils rich in organic carbon are likely to have high DTPA Fe contents. It had negative relationship with calcium carbonate. The amount of Mn in soil extracted by DTPA ranged from 3.8 to 9.0 mg kg^{-1}. Most of the orchards had adequate concentration of Mn in their soils. Savita *et al.* (2013) also reported similar results. A significant and positive correlation was observed between DTPA-Mn and organic carbon. Available Mn had negative correction of lower degree with pH and calcium carbonate. It is evident from the correlation values that the main factors responsible for variation in DTPA-extractable Mn were pH, calcium carbonate and organic carbon. DTPA-Cu in these soils ranged from 0.28 to 0.75 mg kg^{-1} with a mean value of 0.48 mg kg^{-1}. The orchards had sufficient status of available copper in their soils (Parihar *et al.* 2013). All the soils have sufficient amount of available copper. The availability of copper was significantly and positively correlated with organic carbon as organic matter acts as chelating agent. Available Cu was negatively correlated with $CaCO_3$ and pH (Table 2).

Table 2: Correlation coefficients between soil properties and available Nutrients

Nutrient	pH	EC	Organic carbon	Calcium carbonate
Nitrogen	0.095	0.188	0.643**	0.110
Phosphorus	-0.033	0.051	-0.505**	-0.119
Potassium	0.055	0.144	-0.415**	-0.210
Sulphur	0.111	0.287*	0.440**	0.140
Micronutrients				
Iron	-0.233	0.156	0.425**	-0.127
Manganese	-0.045	0.191	0.301*	-0.182
Copper	-0.014	0.078	0.265*	-0.288*
Zinc	-0.164	0.184	0.303**	-0.564**

**significant at 5% level, ** significant at 1% level*

The available Zn content in these soils ranged between 0.47 and 1.40 mg kg^{-1} with a mean value of 0.69 mg kg^{-1}. Considering critical value of 0.6 mg kg^{-1}, the deficiency of Zn was rated up to 45 per cent. Wide spread deficiency of zinc has also been reported by Parihar *et al.* (2013) in soils of guava orchards of Madhya Pradesh. The Zn deficiency in these soils might be attributed to continuous mining of native zinc, imbalanced fertilization and no external addition of Zn through organic and inorganic sources. Available Zn was positively and significantly related with organic carbon and negatively with pH (Table 2). These results are in accordance with those of Singh and Chauhan (2020). Thus, DTPA-extractable Zn was in deficient level in these soils. Therefore, Zn requirement has to be supplied through external sources.

Nutrient status of guava leaves

The nitrogen content in the guava leaves varied from 1.55 to 2.18 per cent with a mean value of 1.92 per cent. The nitrogen content in majority of guava orchards was in deficient range when the values were compared with the values reported by Kotur *et al.* (1997).Tomar *et al.* (2020) also reported similar results. Phosphorus content in leaves of guava varied from 0.16 to 0.32% with a mean value of 0.23 per cent. The P content in majority of leaves was in optimum range according to Kumar *et al.* (1990). The overall range for K content in guava leaves was from 1.20 to 2.10% with a mean value of 1.62 per cent. The K content in leaves of majority of orchards was in optimum range. Similar results were reported in guava orchards by Tomar *et al.* (2020). The leaves of guava orchards of Agra district had the widest range of variation in sulphur content 0.18 to 0.35 %). Majority of the leaf samples were deficient in sulphur (less than 0.20%). Similar results were reported by Tomar *et al.* (2020). A study of the data (Table 3) showed that the iron content in the guava leaves varied from 145 to 242 mg kg^{-1} with a mean value of 198 mg kg^{-1}. Almost all the orchards had optimum Fe content in leaves when value was compared with the critical limit (50-120 ppm). These results are in conformity with the finding of Parihar *et al.* (2013). Manganese content in guava leaves ranged between 28 and 60 mg kg^{-1} with a mean value of 44 mg kg^{-1}. Most of the leaf samples collected from different orchards was in the optimum range as per standards of Kotur *et al.* (1997). The leaf copper content varied from 4.5 to 10.6 mg kg^{-1} with a mean value of 6.5 mg kg^{-1}. Kumar *et al.* (1990) reported 4.0 to 14.0 ppm copper in leaves of guava orchards. The leaf Zn content varied from 17.5 to 35.0 mg kg^{-1} with a mean value of 26.4 mg kg^{-1}. Majority of leaf samples (54%) were deficient in zinc content (Tomar *et al.*, 2020). The leaf nutrient concentration among the orchards studied indicated that wider variations existed among the content of nutrients of orchards of Agra district. There existed a large variation among orchards in terms of soil fertility status, quantity of fertilizer applied and other cultural operations, which resulted in the wider variation in leaf nutrient contents of different orchards (Bhargava, 2002).

Table 3: Nutrient contents in guava leaves of different orchards

Nutrient	Range	Mean
Nitrogen (%)	1.55 – 2.18	1.92
Phosphorus (%)	0.16 – 0.32	0.23
Potassium (%)	1.20 – 2.10	1.62
Sulphur (%)	0.18 – 0.35	0.27
Iron (mg kg^{-1})	145 – 242	198.0
Manganese (mg kg^{-1})	28.0 – 60.0	44.0
Copper (mg kg^{-1})	4.5 – 10.6	6.5
Zinc (mg kg^{-1})	17.5 – 35.0	26.4

It may be concluded from the results that judicious application of N, P, S and Zn is necessary for sustaining fruit production in guava orchards of Agra district. The amount of Fe, Mn and Cu were adequate in orchard soils. The leaves of these orchards have low content of N, S and Zn but are adequate in other elements. The study suggested the need for close monitoring of deficient nutrients in soil and leaf samples of guava orchards to enhance guava production in Agra region of Uttar Pradesh. The results indicated that soil and leaf analyses together identified nutrient imbalances in leaf and soil samples of guava orchards.

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