



Physico-chemical Characteristics and Nutrient Status of Guava (*Psidium guajava* L.) Orchards in North-Western India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

One hundred eight soil samples were collected from 12 guava orchards existing at different locations as well as 108 soil samples from non-orchard soils adjoining in the vicinity of selected orchards spread over five blocks of district Rewari namely Bawal, Rewari, Jatusana, Khol and Nahar. The samples were collected from 3 depths (0-15, 15-30, 30-60 cm) and analyzed for physico-chemical properties and available nutrients viz., nitrogen, phosphorus and potassium. The composite leaf sample of guava plants was also collected from each orchard. Rewari district soils (orchard and non-orchard) were sandy loam to loamy sand in nature. The calcium carbonate content in soils showed an increasing trend with depth and it increased significantly with an increase in sand and pH. Soils were alkaline with low organic carbon and nearly one-third of samples were saline. Available nitrogen was low, available phosphorus was low to medium while available potassium was medium to high in soil samples. Despite the high content of available potassium in soils, the plant leaves were found deficient in potassium. Therefore, the use of balanced fertilizers is required for sustainable and enhanced productivity of the guava orchards.

Keywords: *Nutrients; guava; soil samples; leaf samples.*

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1. INTRODUCTION

Guava (*Psidium guajava* L.) is an important fruit of tropical & subtropical areas which can be successfully grown with good profits and can be very handy in "Doubling the farmer's income". It belongs to the family Myrtaceae and is considered a hardy tree that is capable of growing under varied agro-climatic conditions without much care. Portuguese introduced guava in India and subsequently, it became a commercial fruit crop of this country.

India is the largest producer of fruits in the world with 18.8 million tonnes annual production against the world's 46.5 million tonnes and accounts for which is 40.4 % of the total global share [1]. The productivity of Indian orchards is 12.36 metric tonne ha⁻¹ whereas, the world is 16.37 metric tonne ha⁻¹ and hence considerably lower [1].

In India, guava is cultivated throughout the country, but the leading states are Uttar Pradesh, Rajasthan, Madhya Pradesh, Maharashtra, Punjab, Haryana and Bihar. Haryana has a 12090 ha area and 137020 MT production of guava [2]. Major guava growing areas are Sirsa, Fatehabad, Hisar, Jind, Jhajjar, Mahendergarh, Rewari, Sonapat, Karnal, Yamuna Nagar, Ambala and Mewat. The popular cultivars of guava grown by farmers are Hisar Safeda, Hisar Surkha, Allahabad Safeda and L-49.

Guava fruits are an important source of vitamins and minerals in the human diet. Several marvelous industrial products like jam, jelly, sharbat, canned fruit [3] and non - alcoholic beverages can be prepared from guava fruits [4]. Guava can be grown on varied soils ranging from clay to sandy and with acidic (4.5) to alkaline (8.5) pH and hence it occupies a significant place in the horticultural wealth of our nation [5].

In Haryana, there is a prevalent practice of leasing the guava orchards, who don't have ample knowledge of orchards management and as a result, constant mining of soil takes place ultimately leading to soil exhaustion. Besides this, at some places even though the soil may be rich in total nutrients but their availability is limited due to unfavorable soil conditions. Use of leaf analysis to indicate the availability of nutrients in fruit crops has long been accepted. The nutrient status of guava trees in South Africa was surveyed and reports suggest that there were tentative levels of macronutrients in leaves

[6]. However, very scanty information is available on the nutritional status of guava crop in semi-arid regions of Haryana which could be worth making a thoughtful fertilizer schedule for profitable & enhanced production and longer orchard life. Due to paltry information on the available nutrient status of guava orchards in Haryana, it is therefore, needed to assess the soil and leaf nutrient status of soils and study their relationship with other soil attributes. Thus, the study was undertaken to investigate the physio-chemical properties and nutrient status of guava orchards of Rewari district in order to correct their deficiencies.

2. MATERIALS AND METHODS

Twelve guava orchards were selected for survey work from five blocks of Rewari district which lies between 27.95°N to 28.47°N latitude and 76.28°E to 76.85°E longitude in south-west Haryana. Rewari is a part of the Indo Gangetic alluvial plain of Yamuna sub-basin having alluvial and sandy soils with interspersed strike ridges covered by windblown sand. Nearly 80-85% of annual rainfall is received in the monsoon season extending from July to September. Mean annual rainfall in Rewari district is 569.6 mm and the climate is semi-arid which is characterized by hot and dry summer and cold winter. The average minimum and maximum temperature vary from 6 to 41°C during winter (January) and summer (May-June), respectively. The meteorological data was collected from the meteorological observatory of college of agriculture, Bawal (Fig. 1).

To characterize the nutrient status of 12 guava orchards in Rewari district, orchards having at least a 3-acre area were selected. The soil sample from all representative depths (0-15, 15-30, 30-60 cm) was taken from each acre. If the area of the orchard was more than 3 acres, then randomly 3 sites were selected for sampling. The soil sample from all representative depths was taken from a nearby non-orchard area also. A composite sample of leaves was taken from every orchard during August 2019 and their locations were recorded in the form of latitudes and longitudes by using handheld GPS. Samples were collected in thoroughly cleaned plastic bags which were properly and carefully labeled, then brought to the laboratory for chemical analysis.

Mechanical analysis of soil samples was done by the international pipette method [7]. The soil pH (1:2 soil:water suspension) and the electrical

conductivity of the supernatant liquid were estimated as per the method detailed by Richards [8] and organic carbon by Walkley and Black method [9]. The soil samples were analyzed in the laboratory for nitrogen, phosphorus and potassium. Available nitrogen was calculated by the alkaline potassium permanganate method as per the procedure outlined by Asija [10]. Available phosphorus was estimated by standard procedures given by Olsen [11] and available potassium by neutral normal ammonium acetate using the procedure of Hanway and Heidal [12]. In leaves, nutrients (N, P and K) were analyzed taking 0.5 g of dried

plant sample digested with 10 ml of diacid mixture (1 perchloric + 4 nitric acid) on a hot plate till the residual solution became colorless. The final digestate volume was made 50 ml. Analysis of guava leaf samples for nitrogen, phosphorus and potassium was done as per procedure suggested by Lindner [13], Koenig and Johnson [14] and Bhargava and Raghupati [15], respectively. The nutrient index was calculated by using the following method [16].

$$\text{Nutrient Index} = \frac{\text{No. of samples in low} \times 1 + \text{No. of samples in medium} \times 2 + \text{No. of samples in high} \times 3}{\text{Total no. of samples}}$$

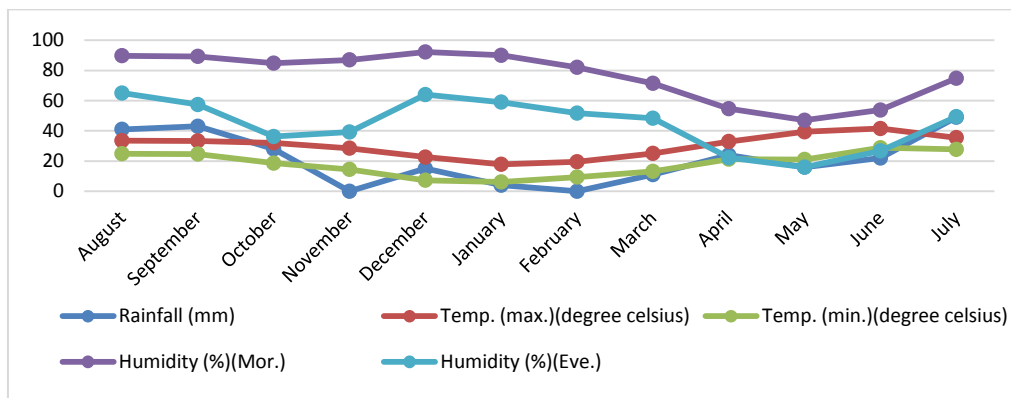


Fig. 1. Metrological data of Rewari district

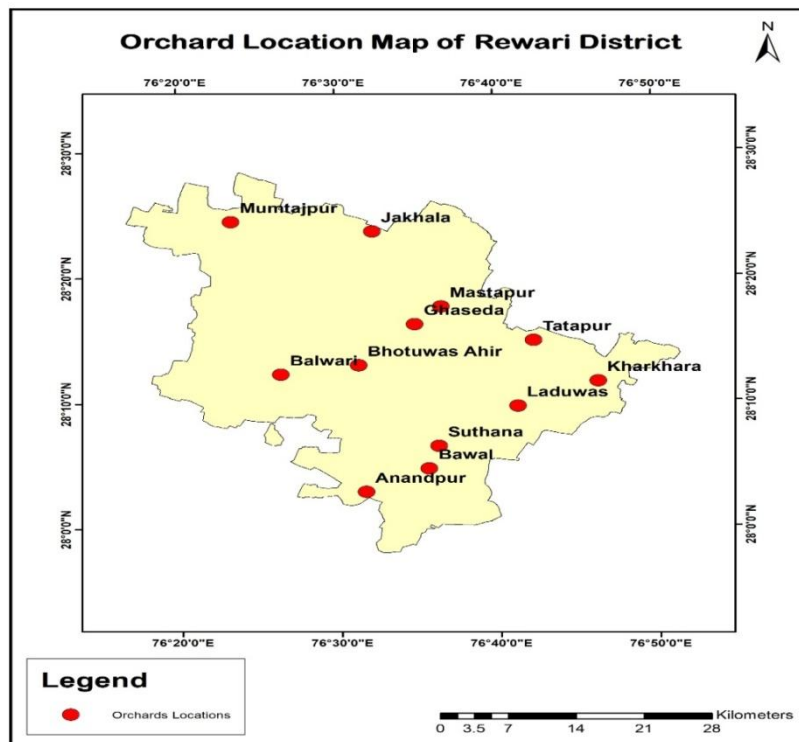


Fig. 2. Location Map of Rewari district

Data analysis: The data was statistically analyzed using EXCEL, OPSTAT statistical software developed by the Department of Statistics, CCSHAU, Hisar [17] at the probability ($p = 0.05$) to drive ANOVA. However, the correlation was computed using SPSS software.

3. RESULTS AND DISCUSSION

Data pertaining to soil texture (Table 1) showed that the sand content in orchard soils varied from 76.3 to 82.9 percent. The minimum and maximum sand content were in S_9 and S_6 soils, respectively. The minimum (8.2%) and maximum (12.4%) silt content were found in soils of orchards S_6 and S_9 , respectively. Clay content in soils varied between 8.7 and 12.0%. Moreover, data indicated that minimum and maximum sand, silt and clay content in non-orchard soil samples varied from 76.1 to 82.5%, 8.6 to 12.5% and 8.6 to 11.8% in S_9 and S_6 soils, S_4 and S_9 soils, S_{11} and S_8 soils, respectively. The texture ranged from sandy loam to loamy sand. Sand had highly significant and inverse relationships with silt ($r = -0.889^{**}$) and clay ($r = -0.911^{**}$) while clay has been found significantly and positively correlated with silt ($r = 0.620^*$) (Table 4). In general, soils of the study area (Rewari) are sandy in nature, which manifests low moisture, poor structural development and low nutrient retention capacity while high infiltration rates and susceptibility to wind erosion [18].

The data (Table 2) indicated that CaCO_3 content of guava orchard soils at 0-15 cm depth varied from traces to 1.30 percent, while in the case of non-orchard soils, it ranged from traces to 1.20 percent. Similarly, the CaCO_3 content in both (orchard and non-orchard) soils at 15-30 cm depth ranged between traces ($S_1, S_4, S_7, S_8, S_{10}$) - 2.80 percent (S_2) and traces ($S_1, S_4, S_7, S_8, S_{10}$) - 3.10 percent (S_2) with a mean value of 0.72 and 0.80 percent, respectively. The CaCO_3 content at 30-60 cm depth in the orchard and non-orchard soils varied from traces - 3.20 percent and traces - 3.50 percent with a mean value of 0.73 and 0.71 percent, correspondingly. CaCO_3 showed an increasing trend with depth. An increase in the CaCO_3 content with depth indicated leaching of calcium from surface soil to sub-surface soils and accumulated in form of calcium carbonate. Comparative high calcium carbonate content of soil might be attributed due to the dominance of the alkaline earth carbonates which are not only high in the soils [19] but also in the water used for irrigation purposes in arid and semi-arid regions [20]. Calcium carbonate had significant

and positive correlation with sand ($r = 0.723^{**}$) and pH ($r = 0.588^*$). On the other hand, it had significant and negative correlation with silt ($r = -0.610^*$), clay ($r = -0.689^*$), organic carbon ($r = -0.578^*$), available nitrogen ($r = -0.682^*$), available phosphorus ($r = -0.673^*$) and available potassium ($r = -0.687^*$) (Table 4). It is obvious from the data (Table 2) that the minimum organic carbon content in orchard soils (0.21 percent) at depth 0-15 cm, was recorded under S_5 , while the maximum (0.49 percent) was under S_7 with a mean value of 0.36 percent. On the other hand, the organic carbon at depth 15-30 cm varied from 0.16 to 0.45 percent. The organic carbon content in soils of the lowest depth (30-60 cm) varied from 0.13 to 0.38 percent. In the case of non-orchard soils, organic carbon values at 0-15, 15-30 and 30-60 cm depth, ranged from 0.21-0.49, 0.17-0.42 and 0.14-0.35 percent, respectively. Organic carbon progressively decreased with increasing depth irrespective of orchard and non-orchard soil. The organic carbon in non-orchard soils was low compared to orchard soils. As per the rating given by Muhr [21], the soils having $< 0.5\%$ OC have been categorized in low organic carbon. All the soil samples of the present study were categorized in the low organic carbon category. The extremely low organic carbon content of these soils could be attributed to the occasional addition of organic matters, lack of natural vegetation and enhanced oxidation of organic matter content due to high temperature [16].

A review of data given in Fig. 3 indicated that the minimum (6.78 and 6.80) and maximum (8.12 and 8.12) pH were reported at 0-15 cm depth in the orchard and non-orchard samples of Mastapur (S_7) and Bhotuwas Ahir (S_{11}), respectively. On the other hand, minimum and maximum pH values of orchard and non-orchard soils at 15-30 cm depth varied statistically from 7.37 to 7.97 and 7.39 to 7.96, respectively. The pH in soils of 30-60 cm depth varied statistically from 7.49 to 8.06 and 7.56 to 8.11 in the orchard and non-orchard soils, respectively. The pH of different depths of sampling under orchards and non-orchard soils showed an irregular trend with increasing depth. The pH of soils increased significantly with increase in sand ($r = 0.913^*$) and CaCO_3 ($r = 0.588^*$) while, it decreased significantly with increase in silt ($r = -0.693^*$), clay ($r = -0.939^{**}$), organic carbon ($r = -0.757^{**}$), available nitrogen ($r = -0.701^*$), available phosphorus ($r = -0.667^*$) and available potassium ($r = -0.671^*$) (Table 4). It is evident from the data (Fig 4) that the electrical conductivity of orchard

soils varied statistically from 2.31 to 4.16 dS m⁻¹ while in non-orchard soils it ranged statistically from 2.28-4.11 dS m⁻¹. Electrical conductivity was found to decrease with increasing soil depth. A critical examination of the data showed that soils samples range from normal to saline in nature. The value of electrical conductivity

indicates that the accumulations of the salts in these soils might be due to the light texture of soils, poor rainfall and application of poor quality water [19, 22]. Moreover, the EC of soils has a non-significant relationship with sand, silt, clay, CaCO₃ and OC content of soils (Table 4).

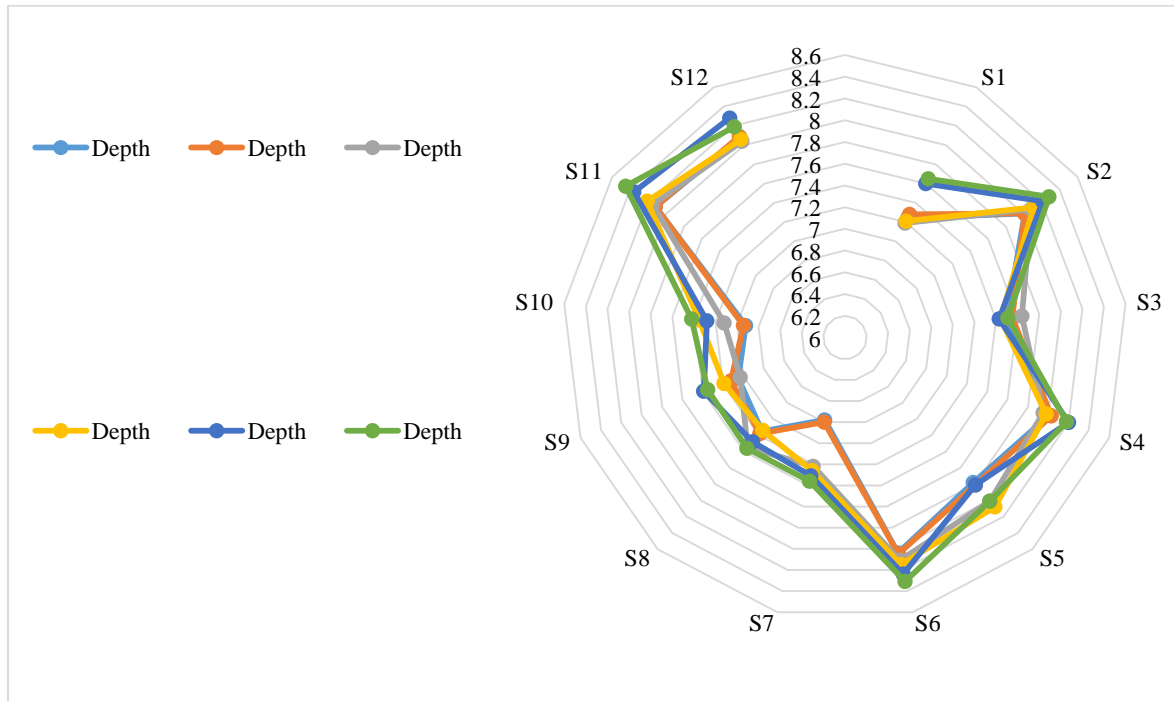


Fig. 3. pH of orchard and non orchard soils of Rewari

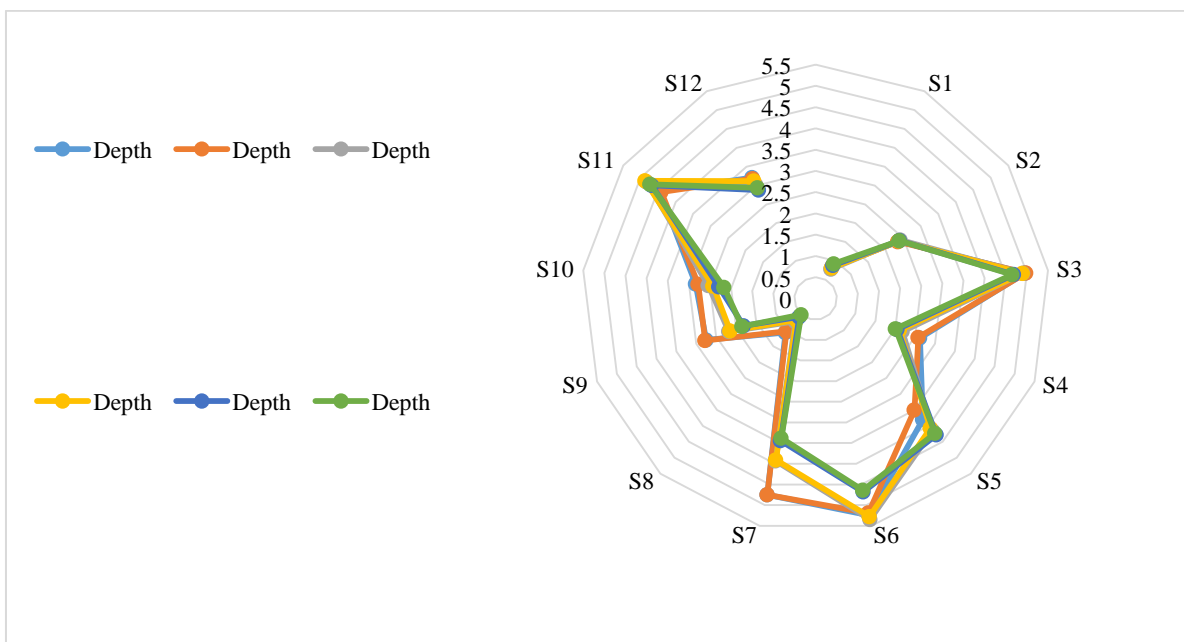


Fig. 4. EC_e of orchard and non orchard soils of Rewari as influenced by depth of sampling

Table 1. Variation in soil texture with depth of sampling in the orchard and non-orchard soils of Rewari

Sample No.	Orchard				Non orchard				Name of village and block
	Sand (%)	Silt (%)	Clay (%)	Textural class	Sand (%)	Silt (%)	Clay (%)	Textural class	
S ₁	78.5	10.1	11.4	Sandy loam	78.6	10.2	11.2	Sandy loam	Anandpur, Bawal
S ₂	81.2	9.9	8.9	Loamy Sand	81.4	9.9	8.7	Loamy sand	Suthana, Bawal
S ₃	78.9	9.8	11.3	Sandy loam	79.1	9.5	11.4	Sandy loam	College of Agriculture, Bawal
S ₄	81.1	8.9	10	Sandy loam	81.3	8.6	10.1	Sandy loam	Kharkhara, Rewari
S ₅	81.5	9.3	9.2	Sandy loam	81.6	9.1	9.3	Sandy loam	Tatapur, Rewari
S ₆	82.9	8.2	8.9	Loamy sand	82.5	8.7	8.8	Loamy sand	Laduwas, Rewari
S ₇	77.2	10.8	12	Sandy loam	77.4	10.9	11.7	Sandy loam	Mastapur, Jatusana
S ₈	76.3	12	11.7	Sandy loam	76.4	11.8	11.8	Sandy loam	Ghaseda, Jatusana
S ₉	76.3	12.4	11.3	Sandy loam	76.1	12.5	11.4	Sandy loam	Jakhala, Nahar
S ₁₀	77.1	11.3	11.6	Sandy loam	77.5	10.8	11.7	Sandy loam	Mumtampur, Nahar
S ₁₁	81.1	10.2	8.7	Loamy sand	81.4	10	8.6	Loamy sand	Bhotuwas Ahir, Khol
S ₁₂	80.8	10.4	8.8	Loamy sand	80.7	10.5	8.8	Loamy sand	Balwari, Khol
Mean	79.40	10.27	10.31		79.5	10.20	10.29		
Range	76.3-82.9	8.2-12.4	8.7-12.0		76.1-82.5	8.6-12.5	8.6-11.8		

Table 2. Variation in CaCO₃ (%) and OC (%) of orchard and non-orchard soils at different locations

Sample No.	Depths (cm)											
	0-15				15-30				30-60			
	CaCO ₃		OC		CaCO ₃		OC		CaCO ₃		OC	
Orchard	Non orchard	Orchard	Non orchard	Orchard	Non orchard	Orchard	Non orchard	Orchard	Non orchard	Orchard	Non orchard	
S ₁	Tr	Tr	0.41	0.39	Tr	Tr	0.35	0.34	Tr	Tr	0.30	0.29
S ₂	1.30	1.20	0.31	0.28	2.80	3.10	0.28	0.26	3.20	3.50	0.25	0.24
S ₃	0.22	0.24	0.42	0.39	0.66	0.70	0.40	0.37	1.18	1.22	0.36	0.32
S ₄	Tr	Tr	0.28	0.25	Tr	Tr	0.24	0.22	Tr	Tr	0.19	0.18
S ₅	0.95	0.78	0.21	0.26	1.76	1.77	0.16	0.23	0.98	0.90	0.13	0.16
S ₆	0.80	0.70	0.22	0.21	1.00	1.10	0.19	0.17	1.80	1.10	0.16	0.14
S ₇	Tr	Tr	0.49	0.49	Tr	Tr	0.45	0.42	Tr	Tr	0.36	0.33
S ₈	Tr	Tr	0.45	0.41	Tr	Tr	0.40	0.38	Tr	Tr	0.38	0.35
S ₉	0.30	0.29	0.44	0.44	0.74	0.74	0.39	0.35	0.38	0.38	0.31	0.29
S ₁₀	Tr	Tr	0.42	0.39	Tr	Tr	0.38	0.36	Tr	Tr	0.36	0.33
S ₁₁	0.84	0.68	0.33	0.31	1.21	1.27	0.28	0.25	0.70	0.83	0.25	0.24
S ₁₂	0.40	0.37	0.39	0.38	0.51	0.95	0.35	0.33	0.53	0.60	0.31	0.29

Sample No.	Depths (cm)											
	0-15				15-30				30-60			
	CaCO ₃		OC		CaCO ₃		OC		CaCO ₃		OC	
	Orchard	Non orchard	Orchard	Non orchard	Orchard	Non orchard	Orchard	Non orchard	Orchard	Non orchard	Orchard	Non orchard
Mean	0.40	0.36	0.36	0.35	0.72	0.80	0.32	0.30	0.73	0.71	0.28	0.26
Range	Tr -1.30	Tr -1.20	0.21-0.49	0.21-0.49	Tr -2.80	Tr -3.10	0.16-0.45	0.17-0.42	Tr -3.20	Tr -3.50	0.13-0.38	0.14-0.35

Table 3. Available primary macronutrients status in the orchard and non-orchard soils of Rewari

Sample No.	Depths (cm)																	
	0-15						15-30						30-60					
	N (kg/ha)		P ₂ O ₅ (kg/ha)		K ₂ O (Kg/ha)		N (kg/ha)		P ₂ O ₅ (kg/ha)		K ₂ O (Kg/ha)		N (kg/ha)		P ₂ O ₅ (kg/ha)		K ₂ O (Kg/ha)	
	Orchard	Non orchard	Orchard	Non orchard	Orchard	Non orchard	Orchard	Non orchard	Orchard	Non orchard	Orchard	Non orchard	Orchard	Non orchard	Orchard	Non orchard	Orchard	Non orchard
S1	144.45	143.51	21.88	20.15	424.01	413.45	140.53	139.44	19.15	18.53	380.78	379.16	116.13	115.51	14.44	14.62	303.82	300.34
S2	115.24	114.73	10.71	10.03	295.11	298.52	113.32	113.17	9.58	9.17	281.09	281.58	101.84	102.87	8.37	8.33	227.01	219.85
S3	130.16	128.22	19.99	20.22	395.42	399.33	125.85	124.83	18.97	18.79	376.67	382.62	111.91	112.51	14.89	14.87	292.52	289.47
S4	152.23	150.78	13.43	13.71	294.41	296.82	150.11	147.93	12.66	13.13	282.06	283.06	126.34	123.68	11.41	11.64	241.68	245.89
S5	106.52	104.96	16.29	16.52	387.33	381.88	105.14	102.18	14.92	14.01	344.54	343.45	101.06	100.33	10.25	10.76	297.91	288.12
S6	119.94	118.17	9.95	9.87	216.78	206.39	116.69	114.62	9.14	9.01	200.65	202.83	103.82	101.46	8.01	7.97	194.52	191.07
S7	153.57	151.63	18.32	16.16	452.03	431.41	148.63	148.13	15.66	13.59	429.11	429.01	136.89	135.24	11.51	11.22	212.02	214.73
S8	148.99	146.24	18.21	17.93	443.25	341.94	146.84	144.97	17.02	16.64	367.72	356.36	123.72	141.73	13.24	13.53	204.73	202.59
S9	163.41	162.35	24.16	16.55	395.66	399.57	159.15	158.22	18.51	15.67	392.54	394.26	144.34	142.14	14.78	13.37	216.67	218.94
S10	152.93	151.91	14.61	13.82	454.16	455.83	146.41	145.35	12.84	11.71	450.05	451.09	133.58	131.85	10.49	10.04	344.03	348.15
S11	109.42	108.25	10.59	10.24	416.33	427.86	104.24	103.57	10.03	9.96	381.72	383.48	101.86	100.02	9.72	9.81	249.19	251.88
S12	144.17	143.48	18.74	17.63	398.68	411.31	142.87	141.66	14.94	14.12	360.93	372.18	118.45	127.27	12.97	12.26	205.74	207.51
Mean	136.75	135.35	16.40	15.23	381.09	372.02	133.31	132.00	14.45	13.69	353.98	354.92	118.32	119.55	11.67	11.53	249.15	248.21
CI (95%)	124.32-	122.95-	13.46-	12.87-	334.17-	325.91-	121.11-	119.73-	12.14-	11.57-	310.01-	311.00-	108.85-	109.23-	10.14-	10.08-	218.22-	217.43-
CV (%)	149.18	147.74	19.34	17.59	428.01	418.13	145.51	144.27	16.75	15.81	397.96	398.84	127.80	129.86	13.19	12.98	280.08	278.98
	14.30	14.41	28.20	24.35	19.37	19.50	14.39	14.62	25.10	24.40	19.55	19.47	12.59	13.57	20.58	19.81	19.53	19.51

Nitrogen is an essential macronutrient for the plant. It influences vegetative growth directly. Data (Table 3) elucidate that the available nitrogen content of surface soil (0-15 cm) of orchard and non-orchard were found to vary statistically between 124.32 to 149.18 kg ha⁻¹ and 122.95 to 147.74 kg ha⁻¹ with a mean value of 136.75 and 135.35 kg ha⁻¹, respectively. Nutrient index of surface soils (0-15 cm) was found 1. The data relating to the available nitrogen content of soil depths (15-30 cm and 30-60 cm) revealed that available nitrogen content of orchard soils ranged statistically from 121.11 to 145.51 kg ha⁻¹ and 108.85 to 127.80 kg ha⁻¹ with an average value of 133.31 and 118.32 Kg ha⁻¹ whereas in case of non-orchard soils at the same depth it varied from 119.73 to 144.27 kg ha⁻¹ and 109.23 to 129.86 kg ha⁻¹ with an average of 132.00 and 119.55 kg ha⁻¹, respectively. All the samples were drawn from the surface and sub-surface soil depth of orchards and non-orchards were found low (100%) in available nitrogen content in the present investigation. The reasons for low available nitrogen in soils under study might be due to less natural vegetation, low amount of organic carbon [23] and sandy texture [24]. Available nitrogen had significant positive correlations with silt ($r = 0.605^*$), clay ($r = 0.677^*$), organic carbon ($r = 0.681^*$) and phosphorus ($r = 0.593^*$) whereas it was found to be significantly and negatively correlated with sand ($r = -0.714^{**}$), calcium carbonate ($r = -0.682^*$) and pH ($r = -0.701^*$) (Table 4). Phosphorus is essential for energy and boosts drought resistance. Available phosphorus content in orchard and non orchard soils (0-15, 15-30 and 30-60 cm) varied statistically from 13.46-19.34, 12.14-16.75, 10.14-13.19 kg ha⁻¹ and 12.87-17.59, 11.57-15.81, 10.08-12.98 kg ha⁻¹, respectively. The available phosphorus was observed to decrease with depth in most of the soils. The reason might be low mobility [25, 26]. Both, orchard and non-orchard soil samples were low to medium in available phosphorus. The correlation coefficient were determined between the available phosphorus and other nutrients for orchards soils and it was concluded that available phosphorus had significant positive correlations with silt ($r = 0.665^*$), clay ($r = 0.652^*$), organic carbon ($r = 0.615^*$) and nitrogen ($r = 0.593^*$) whereas it had significant negative correlation with sand ($r = -0.731^{**}$), calcium carbonate ($r = -0.673^*$) and pH ($r = -0.667^*$). While it had a non-significant relationship with EC and potassium. Potassium provides disease resistance to crops. Data (Table 3) revealed that

the minimum and maximum available potassium content of orchard soils at 0-15, 15-30, 30-60 cm depths was 216.78 and 454.16, 200.65 and 450.05, 194.52 and 344.03 kg ha⁻¹ with a mean of 381.09, 353.98 and 249.15 kg ha⁻¹ while in case of non-orchard soils at the same depths lowest and highest value of available potassium was 206.39 and 455.83, 202.83 and 451.09, 191.07 and 348.15 kg ha⁻¹ with an average of 372.02, 354.92 and 248.21 kg ha⁻¹, respectively. The minimum and maximum value of available potassium at all depths (0-15, 15-30 and 30-60 cm) were recorded in Laduwas (S₆) and Mumtajpur (S₁₀) in orchard soils whereas in non-orchard soils these values lied in Laduwas (S₆) and Jakhala (S₉), respectively. A critical analysis of data revealed that most of the surface (0-15 cm) soil samples were high in available potassium with a nutrient index value of 2.91. This might be due to the presence of potash-bearing minerals (Muscovites, biotite and feldspar), which weather slowly and keep on releasing potash [26]. Available potassium content of orchards soils had significant positive correlations with silt ($r = 0.767^{**}$), clay ($r = 0.718^{**}$) and organic carbon ($r = 0.641^*$) while it had significant and negative correlation with sand ($r = -0.823^{**}$), calcium carbonate ($r = -0.687^{**}$) and pH ($r = -0.671^*$) potassium contents found to have non-significant relationship with nitrogen and phosphorus (Table 4).

It is obvious from the data (Fig. 5) that minimum (0.45 percent) nitrogen content of guava leaf was observed with the orchard S₁₁, whereas, maximum (1.46 percent) was found under orchard S₁₀. The low concentration of nitrogen in guava trees might be due to the low nitrogen status of soils [27], poor organic carbon content, high pH and inadequate application of nitrogen [5]. Besides this, soils of Rewari district are sandy in nature and hence higher leaching losses of nitrogen might be an important reason for reduced uptake. The phosphorus content of guava leaf varied statistically from 0.29 to 0.40 percent with an average of 0.34 percent. The highest value of phosphorus content was obtained in leaves of guava plants of orchard Anandpur (S₁), while its lowest content was recorded for orchard Laduwas (S₆). Medium (33.3%) to low (66.7 %) phosphorus status of orchard soils and its poor uptake & utilization by plants and due to fixation of available phosphorus content by free oxides might be the possible reason. The nutrient index value for phosphorus was 1.33. The potassium content of guava leaf ranged statistically from 0.98 to 1.24

percent with a mean value of 1.11 percent. The leaf samples which were found sufficient in potassium; might have been due to the sufficient availability of potassium in soils of Rewari district and the presence of micaceous minerals [5, 28].

Half of the leaf samples were deficient in potassium. Nitrogen content of guava leaves was found significantly and positively correlated with phosphorus ($r = 0.716^{**}$) and potassium ($r = 0.854^{**}$) (Table 5).

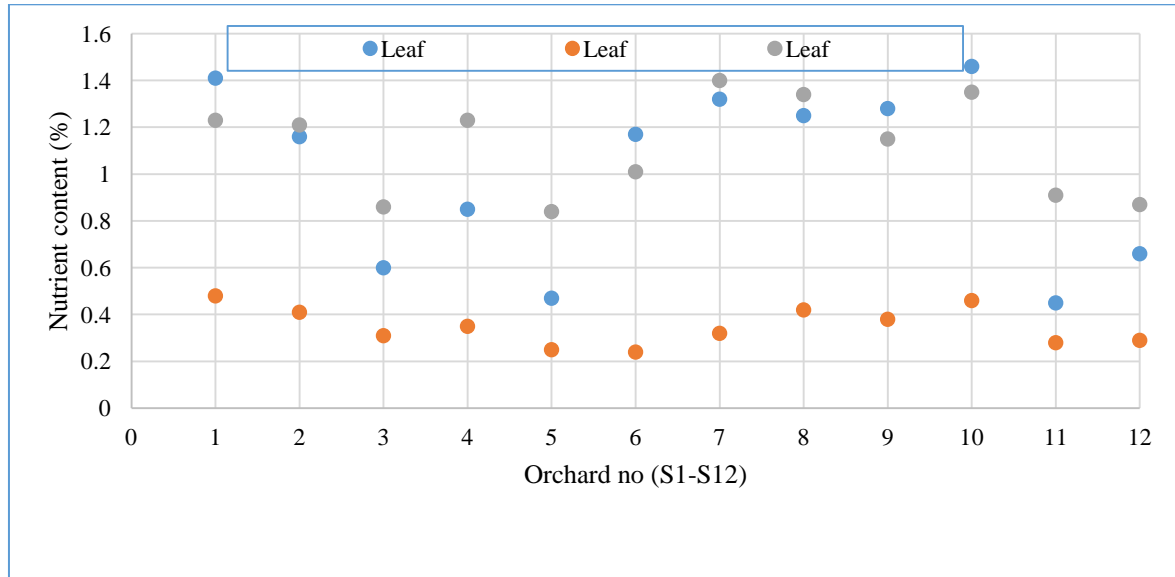


Fig. 5. Guava orchards leaf macronutrient status

Table 4. Correlation matrix between various soil properties

	Sand	Silt	Clay	CaCO ₃	OC	pH	EC	N	P ₂ O ₅	K ₂ O
Sand	1	-0.889 ^{**}	-0.911 ^{**}	0.723 [*]	-0.871 ^{**}	0.913 ^{**}	0.457 ^{NS}	-0.714 ^{**}	-0.731 ^{**}	-0.823 ^{**}
Silt		1	0.620 [*]	-0.610 [*]	0.708 [*]	-0.693 [*]	-0.571 ^{NS}	0.605 [*]	0.665 [*]	0.767 ^{**}
Clay			1	-0.689 [*]	0.852 ^{**}	-0.939 ^{**}	-0.270 ^{NS}	0.677 [*]	0.652 [*]	0.718 ^{**}
CaCO ₃				1	-0.578 [*]	0.588 [*]	0.336 ^{NS}	-0.682 [*]	-0.673 [*]	-0.687 [*]
OC					1	-0.757 ^{**}	-0.340 ^{NS}	0.681 [*]	0.615 [*]	0.641 [*]
pH						1	0.397 ^{NS}	-0.701 [*]	-0.667 [*]	-0.671 [*]
EC							1	-0.530 ^{NS}	-0.400 ^{NS}	-0.223 ^{NS}
N								1	0.593 [*]	0.338 ^{NS}
P ₂ O ₅									1	0.534 ^{NS}
K ₂ O										1

(* 1% significant; ** 5% significant)

Table 5. Correlation matrix between different leaf nutrients

	N	P	K
N	1	0.716 ^{**}	0.854 ^{**}
P		1	0.720 ^{**}
K			1

(* 1% significant; ** 5% significant)

Table 6. Nutritional status of soils under guava cultivation in Rewari district of Haryana

Nutrient	At 0-15 cm depth				At 15-30 cm depth				At 30-60 cm depth			
	Deficient (%)	Adequate (%)	High (%)	Index value (%)	Deficient (%)	Adequate (%)	High (%)	Index value (%)	Deficient (%)	Adequate (%)	High (%)	Index value
N	100	-	-	1	100	-	-	1	100	-	-	1
P ₂ O ₅	25	66.7	8.3	1.83	25	75	-	1.75	41.7	58.3	-	1.58
K ₂ O	-	8.3	91.7	2.91	-	8.3	91.7	2.91	-	66.7	33.3	2.33

4. CONCLUSION

The soil varied from sandy loam to loamy sand. The organic carbon status was low in all samples. The maximum calcium carbonate content in both orchard and non-orchard soil samples was observed in Suthana (S₂). The electrical conductivity of 75% of soil samples was found normal while pH ranged from normal to alkaline. All orchard and non-orchard soil samples were low in nitrogen, however, phosphorus was in deficient to sufficient range. Potassium was sufficient in almost all samples. The soil macronutrients (N, P & K) were negatively correlated with sand while these were positively correlated with silt and clay. Leaf samples of guava were deficient in nitrogen and phosphorus while only 50 percent of samples were low in potassium. Leaf nitrogen, phosphorus and potassium were significantly and positively correlated. The results of the present investigation suggest that balanced fertilizer applications should be recommended for optimizing the productivity of guava orchards.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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