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Evaluation of soil fertility status and nutrition of orchards

R.A. Khattak and Z. Hussain
Department of Soil and Environmental Sciences, NWFP Agricultural University, Peshawar

Abstract

The present study, an integral component of the Natural Resource Conservation Project (NRCP) under the Environmental Rehabilitation in NWFP and Punjab (ERNP) programme, was initiated to evaluate the fertility status of the soils and orchard (apple, peach, pear, citrus and plum) nutrition of Galliyat area of Abbottabad district, representing three units (Birote, Boi and Thai). A total of 74 soil samples (0-30 cm depth) from 48 sites in Birote unit and 13 sites each from Thai and Boi units and plant samples from 50 sites in Birote and Thai units were collected. The physico-chemical properties of soils showed that texture of soils of all the units were loam and silt loam with dominant silt fraction suggesting removal of clay content from the upper soils due to soil erosion leaving the higher contents of sand and silt. The soils were neutral to slightly alkaline, pH ranging from 6.8 to 7.9 and non-saline. The soils were moderately calcareous, with medium to high organic matter (>1%). The results indicated that more than 50% soil samples were deficient in N concentrations and 35.4, 46.2 and 53.8% samples of Birote, Boi and Thai units contained medium P concentrations (<10 mg kg^{-1}). Low concentrations of N and P might be associated with losses through leaching or runoff, as the texture of the soils was mostly loam or silt loam. Potassium concentrations were found sufficient in all the soils which might be attributed to the presence of K bearing minerals. Nearly all the soils were sufficient in Cu, Fe and Mn concentrations with 4.2 and 23.1% of soils of Birote and Boi units having deficient Zn levels (<1.0 mg kg^{-1}). Plant analysis suggested that nearly 50% of fruit orchards contained low N and P, while K concentrations were high in all samples. Cu and Fe concentrations were high in 70 and 90% samples, respectively, while 70% contained moderate Mn concentrations and 80% samples were deficient in Zn.

Keywords: macronutrients, micronutrients, fertility, orchards, galliyat

Introduction

Natural Resource Conservation Project (NRCP), Galliyat, is a joint venture of European Commission (EC) and Pakistan Forest Department working for the Environmental Rehabilitation in NWFP and Punjab (ERNP). This study, the soil fertility evaluation and orchard nutrition of Galliyat area, is a component of NRCP. The main objective of the project is to prevent mismanagement and to conserve natural resources such as forests, agricultural land, livestock and water. The approach is based on the proper utilization and management of these resources for the development of the rural population through community participation.

The fertility of soil is affected by various physical, chemical and biological properties of soil. The soil physical properties mainly soil texture and chemical properties such as pH, lime, electrical conductivity (EC) and organic matter content and concentrations of macro- micronutrients mainly determine the soil fertility and its productivity

Soil texture is basic to many other soil properties and serves as an indicator of water holding capacity, cation exchange capacity, aeration and organic matter content. Turrion *et al*. (2000) reported that stable P increased with decreasing particle size both in pasture and forest-mountain soils of Khyrgyzia than the soils under natural vegetation of the cultivated soils. Soil texture also controls the retention and losses of nutrients in soil-plant environment. The nutrient level of the soils, under humid forest vegetation of Cameroon, was generally higher where organic matter was more abundant (Moukam and Ngakanou, 1997). Organic matter associated with fine texture could be considered more humified (Caravaca *et al*., 1999) and helps in the formation of soil aggregates, which maintain soil porosity (Stevenson, 1986).

The pH has significant influence on solubility and bioavailabilty of nutrients. NO_3 and NH_4 -N are available in a relatively wider range of pH (6.0-8.5). In calcareous soils with high pH the availability of P to plants is decreased. The solubility of P is optimum over a narrow pH range (6.5-7.5). The micronutrients, Fe, Cu, Zn and Mn are more soluble in the pH range 5.0 to 6.0, and their availability in soils varies considerably with the seasonal changes in temperature, moisture and microbial activity (Hodgson, 1963). The pH of soil environment is considered to be a good indicator of soil fertility in apple orchard in Ukraine (Kozak, 1995).

Nitrogen may be removed from soil by crop and grazing, as elemental N and ammonia. In undisturbed natural forests and grasslands with no massive N removals in crop production and grazing, the N in precipitation serves to restore the small quantities that are lost from these soils. Losses of P occur through leaching and erosion. Leaching represents a major mechanism of P loss from forestland. The available K varies with the soil texture depending upon the parent material and its degree of weathering. Generally, clayey soils have more available K than loamy and sandy soils (Saleem and Bertilsson, 1978).

*E-mial: ra_khattak@yahoo.com

Copper, Fe, Mn and Zn are required by plants in minute quantities. Cu is slightly less abundant in soils than Zn (Lindsay, 1979). Elements reduce the uptake of one or more micronutrients by plants such as reduction in Fe and Mn uptake by plants as a result of P fertilization or Fe deficiencies caused by excess Ca and Mn. (Olsen and Sommers, 1982).

The NRCP has established fruit orchards in different ecological zones of the project area. In addition to the environmental conditions, evaluation of soil fertility is necessary for the successful orchard growth and development in this far-flung and difficult Galliyat region.

The objective of this study was to evaluate the physico-chemical properties (texture, pH, EC, lime and organic matter) of soils and macro (N, P and K) and micronutrients (Zn, Cu, Fe and Mn) in soils and orchards of Galliyat area and to formulate recommendation for the management of the soil fertility for crop production on sustainable basis.

Materials and Methods

Location and description of the project area

Abbottabad is the capital of Hazara, lying on an altitude of 1295.04 m above mean sea level, with total population (urban and rural areas) of 880,666 (District census report of Abbottabad, 1998). Basically it is a military cantonment and used to be a hill station known for its clean environment.

The project area of Galliyat constitutes Birote, Thai and Boi units. Birote and Thai units are located on Murree Abbottabad road and lie within 65 and 30 km distance from Abbottabad city, respectively. The main settlements of Birote-unit are Birote, Malkot, Kooza gali, Doonga gali, Ayubia, Nathiagali, Kalabagh, Malaachh and their respective villages. Apple is major fruit orchard with wheat and maize crops in the region but peach, pear, plum and citrus is also grown Farmers add urea, FYM and DAP to fertilize their soils in some areas.

Boi-unit includes Mujaffa, Dalola, Paal, Deedal Mera and other villages. Boi is situated towards the north of Abbottabad on the bank of river Kunhar. Citrus is the major fruit orchard and farmers add urea and FYM to their soils. Across the Kunhar River, the hills of Azad Kashmir can be viewed.Thai-unit includes Bagnotar, Thai, Namlimera, Kalapani, Mera Rehmat Khan, Chamiali and surrounding villages. Apple is major fruit orchard and urea and FYM are added to soil.

Climate is highly preferable for apple, pear, peach, plum, walnut and other orchards in Birote and Thai units, while Boi with a little warm climate having mean summer temperature of 23 ^{0}C favours citrus fruits. The area was surveyed for few days by the team to obtain informations about the appropriate number of samples, access to the area and overall conditions of the three project areas. Soil and plant samples were taken from certain villages and following methodology was used to evaluate the fertility status of Galliyat soils and the nutritional status through tissue analysis of the major fruit trees.

Sampling and processing of soils and plants

Compoosite soil samples (8-10 samples per site from 0-30 cm depth) were collected from 74 (48 from Birote and 13 each from Thai and Boi units) sites. Samples were properly packed in labeled bags and brought to the laboratory of the department of Soil and Environmental Sciences, NWFP Agricultural University, Peshawar. After air drying, the sample were gently crushed, sieved (2 mm) and properly stored for analysis.

Fifty plant samples (10-15 young, fully expanded leaves per plant) of apple, plum, pear, peach and citrus were collected from the selected sites of Birote and Thai units. The plants were 1-2 year old growing on the boundaries of the small size terraced agricultural land. Leaves were washed with distilled water, oven-dried at 70 ^{0}C for 48 h, ground in Wiley-Mill and stored for the analysis.

Analysis of soils and plants

Samples of soils and plants were analyzed using the following methodology.

Soils were analyzed for their physico-chemical properties such as soil texture (Koehler *et al*., 1984), soil $pH_{(1:5)}$ (Mclean, 1982) using 105 Ion Analyzer pH meter, Soil $EC_{(1:5)}$ (Richards, 1954), lime and soil organic matter (Nelson and Sommers, 1982).

AB-DTPA extracts of soils (Soltanpour and Schwab, 1977) and plant digest (using HNO_3 and $HClO_4$ mixture for digestion) were prepared and analyzed for Cu, Fe, Mn and Zn using Atomic Absorption Spectrophotometer "Perkin Elmer" model No.2380 while K using' Perkin Elmer' Flame Photometer model No.2380 and P by Spectrophotometer "Spectronic Lmbda (λ) 35" using required standard solutions. Total nitrogen in soils and plants were determined using Kjeldahl distillation procedure as described by Bremner and Mulvaney (1982).

Results and Discussion

The results of 74 soil samples (48 from Birote unit and 13 each from Boi and Thai units) and 50 plant samples are presented and discussed in this section and data provided in Table 1 to 10.

Physico-chemical soil properties

Soil texture, pH, EC, Lime ($CaCO_3$) and organic matter content

Texture of 63% of the soils of Birote unit was loamy dominated with the high (41.4±8.87%) silt content compared

to 37.5±9.30 and 20.8±62.5% sand and clay, respectively (Table 1). It was observed that the soils situated on the upper side of slope contained more sand and silt contents with predominantly sand stone.

Table 1. Particle (Sand, Silt and Clay) size analysis and textural classes of Galliyat soils.

Sr. No.	Locations	%Sand	%Silt	%Clay	Textural class
1	Birote	37.5±9.3	41.4±8.9	20.8±5.4	Loam
2	Boi	48.8±16.1	41.4±12.1	9.75±5.4	Loam
3	Thai	32.7±10.2	49.3±11.3	17.6±6.5	Loam

Most of the Boi soils had textural class of either sandy loam or loam with average values of 48.8±16.4, 41.4±12.1 and 9.75±5.44% sand, silt and clay particles (Table 1). Soils of Thai unit were silt loam with dominant silt fraction, having sand, silt and clay contents of 32.7±10.2, 49.3±11.3 and 17.6±6.51% (Table 1).

The textural analysis of Galliyat soils revealed that clay content might have been removed from the upper soils due to soil erosion leaving the higher contents of sand and silt, or these soils had higher sand and silt in the parent material soils were derived from.

On the whole, the particle size analysis suggested that the soils being loamy in nature are best suited for all kinds of agricultural crops and fruit trees. However, being well drained in nature, the chances of nutrient leaching are always more if the level of organic matter is not maintained. Thus, it is very important to add organic and chemical fertilizer to maintain adequate fertility status of these soils.

The pH values of the soils of Birote, Boi and Thai units ranged from 6.8-7.9, 6.9-7.8 and 7.0-7.7 with mean values of 7.6±0.21, 7.3±0.26 and 7.46±0.23, respectively (Table 2, 3 and 4). The pH values of soil suspension (1:5) of all representative soils were mostly neutral and slightly alkaline in reaction. The small variation in soil pH values could be attributed to the variability in calcium carbonate equivalent, soil organic matter and in leaching of bases.

The EC recorded for Birote, Boi and Thai soils ranged from 0.05-2.10, 0.30-1.60 and 0.15-1.15 with mean values of 0.95±0.040, 0.75±0.30 and 0.80±0.35 dS m^{-1}, respectively (Table 2, 3 and 4). The results suggested that these soils were low (<2-4 dS m^{-1} at 25 ^{0}C) in electrolyte concentration due to leaching induced by heavy rainfall. Such low EC value is a matter of concern with respect to maintain required levels of bases on sustainable basis indicating the susceptibility of soils to nutrient leaching in the absence of adequate levels of soil organic matter.

Lime ($CaCO_3$) content of Birote, Boi and Thai soils ranged from 2.0-19.8, 1.82-9.51 and 4.25-11.4 mean values of 10.5±4.20, 4.75±1.92 and 6.11±2.24%, respectively, while organic matter content ranged from 1.32-9.50, 1.0-4.36 and 1.98-5.94 with mean values of 4.18±1.83, 2.94±1.25 and 3.75±1.103%, respectively (Table 2, 3 and 4). The data suggested that these desirable SOM levels (>1.0%) as compared to common agricultural soils, will promote soil aggregation and prevent losses of nutrient (Stevenson, 1986). The decresase in SOM at some locations might be associated with factors like high temperature (more organic matter decomposition) and low density of natural vegetation.

Total N and AB-DTPA extractable P, K, Cu, Fe, Mn and Zn in Galliyat soils

Birote unit

The data of percent total N has been changed into mg soil N kg^{-1} on the w/w basis for the sake of convenience. The total N, P, K, Cu, Fe, Mn and Zn concentrations in the Birote soils of Galliyat area fell within the range of 660-4750, 1.12-44.4, 192-1270, 2.37-8.34, 2.19-17.75, 0.76-226.5 and 0.56-8.85 with mean values of 2094.8±916.9, 11.8±9.15, 514.5±246.7, 4.44±1.19, 8.69±3.58, 28.6±46.5 and 3.35± 2.15 mg kg^{-1}, respectively (Table 5).

Data obtained from this study clearly indicated low and medium concentrations of total N in all the birote soils, while only 42% soils contained sufficient P concentrations (Table 5) when compared with reported values (Hesse, 1971; Havelin and Soltanpour, 1981; Soltanpour, 1985). Amponsah *et al*. (2000) observed the levels of total N ranging from 14400 to 27900 mg kg^{-1} in five peat soil samples. It is commonly believed that in high SOM, most of the P is in organic fraction that is less sensitive to AB-DTPA. Given these SOM values and pH values, it is possible that organic P fraction of the soils was not fully extracted by AB-DTPA solution.

The high K concentrations found in all soils (Table 5) might be due to high organic matter and moderately calcareous nature of these soils (Table 2). Most of the Pakistani soils contained adequate levels of more than 150 mg K kg^{-1} (Sadiq, 1986). For winter cereals, optimum levels of 110 to 299 mg kg^{-1} were found for medium loam Grey forest soils of Russian Nonchernzemic zone (Velichko and Proshkin, 1999).

Micronutrients showed large variation in concentrations in the study sites with high concentrations of Cu and Mn (Table 5). Hodgson *et al*. (1966) reported that the concentrations of Cu in soil solutions obtained by various techniques from different soils varied from 3 to 135 mg kg^{-1}. The concentrations of Cu, Fe, Mn and Zn in soils of Dir district were found to be 1.88, 17.25, 8.58 and 1.9 mg kg^{-1} (Adil, 1987), while the Cu, Mn and Zn concentrations in the soils of Madison country, Missouri (USA) ranged from 1 to 450, 17 to 1227 and 14 to 142 mg kg^{-1}, respectively (Davies and Wixon, 1985). In this study, 8 and 17% soil samples of Birote unit contained medium concentrations of Fe and Zn with 4% samples low in Zn (Table 5) when compared with reported values (Hesse, 1971; Havelin and Soltanpour, 1981; Soltanpour, 1985).

Table 2. Soil textural class, pH, EC, lime and organic matter content of Birote unit, Galliyat.

Sr. No.	Place of sampling	Textural class	pH (1:5)	EC (1:5) dS m^{-1}	$CaCO_3$	SOM
					----------%-------	
1.	Khan Khurd	Loam	7.6	2.05	6.6	2.77
2.	Sungle Kot	Loam	7.6	1.15	5.0	4.62
3.	Paripond Nagri Bala	Loam	7.6	0.65	18.95	4.62
4.	Bara Reen Nagri Bala	Loam	7.6	0.95	19.75	3.96
5.	Sanati Nagri Bala	Loam	7.8	1.10	10.90	1.65
6.	Kalsora Nagri Bala	Loam	7.7	1.05	10.60	1.32
7.	Tareri Tatyal	Silt loam	7.0	0.5	13.3	4.62
8.	Tatyal Proper	Loam	7.7	0.9	8.95	1.65
9.	Khu Tatyal	Loam	7.4	0.85	13.85	5.35
10.	Lotharan Tatyal	Loam	6.8	0.5	12.55	4.95
11.	Nammal	Loam	7.7	1.60	11.40	3.56
12.	Ali Abad 2	Silt loam	7.5	0.05	2.0	1.98
13.	Ali Abad 1	Loam	7.3	0.35	4.85	4.62
14.	Pagar Khan Kalan	Silt loam	7.5	1.0	13.85	5.94
15.	Retli Khan Kalan	Silt loam	7.1	1.95	8.05	7.66
16.	Kotli Khan Kalan	Loam	7.6	1.05	14.60	6.20
17.	Bagla Darwaza Khanispur (DK)	Silt loam	7.8	1.25	8.50	5.74
18.	Sungle Day (DK)	Sandy loam	7.6	1.25	11.2	5.74
19.	Hashmi Tand (DK)	Clay loam	7.7	1.35	14.55	9.50
20.	Chappar Khetar (DK)	Loam	7.5	2.10	13.9	7.66
21.	Loharan Khetar (DK)	Loam	7.6	1.55	19.0	3.63
22.	Gora Bagla (DK)	Sandy loam	7.6	1.25	12.25	5.28
23.	Darwaza Khas	Sandy loam	7.7	0.80	9.8	4.62
24.	Seri Darwaza Khas	Loam	7.7	0.65	5.3	4.62
25.	Dhara Darwaza Khas	Sandy loam	7.6	0.80	4.55	3.96
26.	Seri Salia 1	Loam	7.6	1.70	11.45	5.68
27.	Seri Salia 2	Silt loam	7.6	1.20	7.25	4.42
28.	Kala Bun	Loam	7.8	1.20	12.15	1.98
29.	Ram Kot 1 (A)	Sandy loam	7.6	0.70	5.3	2.64
30.	Ram Kot 1 (B)	Loam	7.7	1.05	6.8	2.11
31.	Ram Kot 2	Sandy loam	7.8	1.55	14.13	1.32
32.	Khanis Pur	Loam	7.5	0.90	10.0	7.52
33.	Banni Jandala	Loam	7.7	0.80	10.98	3.30
34.	Lower Jundala	Loam	7.5	0.65	8.9	3.96
35.	Kalapani Near Mochi Dhara	Loam	7.7	0.75	13.3	3.30
36.	Upper Jandala	Loam	7.8	0.75	11.9	3.17
37.	Doli Jandala	Loam	7.7	0.75	19.55	5.41
38.	Dunga Gali	Loam	7.5	0.75	7.4	3.10
39.	Kala Bun Upper Malaachh	Clay loam	7.7	0.75	11.40	3.56
40.	Kala Bun Lower Malaachh	Loam	7.6	0.65	5.00	1.32
41.	Kanisan Malaachh	Loam	7.6	1.20	7.35	4.36
42.	Serpata Malaachh	Silt loam	7.6	0.75	6.75	2.77
43.	Khui Barian Malaachh	Sandy loam	7.7	0.75	5.85	3.96
44.	Jaswara Malaachh	Sandy clay loam	7.8	1.05	8.75	2.31
45.	Sukakus	Loam	7.8	0.80	13.15	4.29
46.	Badhiar	Sandy clay loam	7.8	0.80	11.73	4.29
47.	Sara	Loam	7.9	0.65	7.05	2.97
48.	Pasala	Loam	7.5	0.90	14.65	6.60
Average $\pm$ SD			7.6±0.21	0.95±0.040	10.5±4.20	4.18±1.83

Table 3. Soil textural class, pH, EC, lime and organic matter content of Boi unit, Galliyat.

Sr. No.	Place of sampling	Textural class	pH (1:5)	EC dS m^{-1}	$CaCO_3$ %	SOM %
1	Barbeen	Silt loam	7.3	0.90	3.49	1.00
2	Hotar Upper Bandi	Sandy loam	7.3	0.85	4.93	2.97
3	Darbiali Lower Bundi	Loam	7.4	1.60	5.65	1.65
4	Rankot 1	Loam	7.1	0.55	5.60	2.64
5	Dana Rankot	Silt loam	7.1	0.30	3.85	1.98
6	Paal	Sandy loam	7.6	0.50	2.85	1.45
7	Tori	Loam	7.6	1.15	6.70	1.85
8	Dalola	Sandy loam	7.5	0.50	1.82	1.98
9	Deedal Mera	Loamy sand	7.8	1.00	4.70	1.98
10	Darra	Loam	7.6	0.75	9.51	3.83
11	Mujaffa	Loam	7.4	0.80	4.80	4.22
12	Bai Dalola	Silt loam	7.2	0.65	4.30	4.36
13	Badal Kundi	Sandy loam	6.9	0.50	3.50	4.29
	Average $\pm$ SD		7.3±0.26	0.75±0.30	4.75±1.92	2.94±1.25

Table 4. Soil textural class, pH, EC, lime and organic matter content of Thai unit, Galliyat.

Sr. No.	Place of sampling	Textural class	PH (1:5)	EC dS m^{-1}	$CaCO_3$ %	SOM %
1	Kund	Silt loam	7.6	1.10	5.45	2.64
2	Mera Rehmat Khan	Loam	7.4	0.90	4.75	3.96
3	Kania Basala Kalapani	Silt loam	7.5	1.00	4.35	1.98
4	Rasulia Lower	Silt loam	7.7	1.10	6.2	3.53
5	Karati Bagh	Loam	7.7	0.80	6.0	5.94
6	Juma Bagla Bagh	Loam	7.0	0.15	4.25	3.56
7	Seri Bagh	Silt loam	7.4	0.25	4.45	3.17
8	Namli Mera Upper	Silt loam	7.1	0.65	4.75	4.82
9	Namli Mera Lower	Loam	7.3	0.75	9.58	3.43
10	Mohallah Nakar Chhatri 2	Loam	7.7	1.15	11.4	4.29
11	Mohallah Parat Chhatri 1	Silt loam	7.7	0.75	8.25	4.36
12	Rasulia Upper	Silt loam	7.4	1.15	5.05	4.75
13	Khorian Kalapani	Silt loam	7.5	0.60	5.0	2.31
	Average $\pm$ SD		7.46±0.23	0.80±0.35	6.11±2.24	3.75±1.103

Boi Unit

Boi soils contained concentrations of total N, P, K, Cu, Fe, Mn and Zn within the range of 500-2180, 2.24-14.5, 166.8-598.4, 3.29-11.5, 4.59-17.87, 4.86- 63.4 and 0.65-7.28 with meam values of 1323.2±596.6, 8.69±3.85, 322.2±136.5, 5.93±2.77, 9.72±4.11, 16.6±16.0 and 2.76±1.85 mg kg^{-1}, respectively (Table 6).

Soils under natural forest in Ashanti region, Ghana showed an increase from 2000 to 3000 mg N kg^{-1} with increase in altitude in association with moisture gradient, while, exchangeable K concentration ranged from 0.4 to 0.3 cmol kg^{-1} (Amponash and Meyer, 2000). The P and K concentrations of Colorado soils used in green house ranged from 0.6 to 29.0 and 36 to 1250 mg kg^{-1}, respectively (Havlin and Soltanpour, 1981). Similarly, 77 and 16% of the soil samples of the study sites had low and 23 and 46% had medium N and P concentrations, respectively, while K was high in all soils (Table 6). Factors such as different parent material, low SOM and high sand and silt contents might be responsible for relatively lower N and P concentrations as compared to Birote soils (Table 5).

The concentrations of Cu, Fe, Mn and Zn in the surface soil samples of Swat, Dir and Malakand Agency, NWFP ranged from 2.01 to 14.81, 22.5 to 39.9, 45.8 to 48.1 and 0.39 to 5.69 mg kg^{-1}, respectively (Mahmood *et al*., 1986). The orchard soils near Chungju Lake, Korea contained average Cu and Zn concentrations of 5.6 and 13.7 mg kg^{-1}, respectively (Yim, 1998). All the soils of Boi unit contained adequate levels of Cu, Fe and Mn with 23 and 77% soils with low to medium concentrations of Zn (Table 6) which might be associated with suitability of soil pH favouring the solubility of these nutrients (Table 3).

Table 5. Concentrations of total N and AB-DTPA extractable P, K, Cu, Fe, Mn and Zn in soils of Birote unit, Gallyiat.

Sr. No.	Sampling locations	Total N	AB-DTPA-extractable P	K	Cu	Fe	Mn	Zn
			----------mg kg^{-1}----------					
1.	Khan Khurd	1390	13.87	442.4	4.51	5.11	9.52	1.71
2.	Sungle Kot	2310	2.97	476.4	6.84	5.42	13.24	1.14
3.	Paripond Nagri Bala	2310	6.28	330.0	5.55	5.52	9.61	2.15
4.	Bara Reen Nagri Bala	1980	14.21	334.8	3.96	2.19	30.70	2.55
5.	Sanati Nagri Bala	830	10.44	276.0	6.21	7.39	6.85	2.38
6.	Kalsora Nagri Bala	660	11.56	264.0	7.02	6.65	0.76	1.67
7.	Tareri Tatyal	2310	10.17	862.8	3.16	11.82	17.58	3.86
8.	Tatyal Proper	830	10.77	573.6	5.64	5.99	5.64	1.23
9.	Khu Tatyal	2780	22.87	985.2	3.63	8.10	51.71	6.88
10.	Lotharan Tatyal	2580	13.22	693.6	3.69	17.75	71.91	2.54
11.	Nammal	1780	3.63	662.4	5.26	8.71	9.22	0.56
12.	Ali Abad 2	990	5.55	405.6	4.98	8.82	5.35	1.42
13.	Ali Abad 1	2310	12.22	630.0	2.53	11.05	18.36	1.98
14.	Pagar Khan Kalan	2970	15.99	962.4	3.18	7.86	54.57	7.01
15.	Retli Khan Kalan	3830	13.28	688.8	5.73	16.94	9.06	5.15
16.	Kotli Khan Kalan	3100	24.12	608.4	4.73	10.04	18.79	5.48
17.	Baglar (DK)	2870	15.46	681.6	4.64	7.40	19.82	5.40
18.	Sungle Day (DK)	2870	7.13	721.2	4.08	6.87	56.71	6.51
19.	Hashmi Tand (DK)	4750	44.41	1270.8	4.07	12.63	7.83	8.20
20.	Chappar Khetar (DK)	3830	10.70	1137.6	3.14	11.42	7.58	5.10
21.	Loharan Khetar (DK)	1820	13.28	480	3.61	7.80	8.41	4.76
22.	Gora Bagla (DK)	2640	29.34	544.8	4.05	7.53	15.79	8.85
23.	Darwaza Khas	2310	22.54	543.6	2.37	6.10	6.59	2.22
24.	Seri Darwaza Khas	2310	1.12	369.6	4.95	7.66	16.71	1.15
25.	Dhara Darwaza Khas	1980	10.90	345.6	2.81	5.57	18.95	3.24
26.	Seri Salia 1	2840	28.15	900	3.34	2.27	206.04	5.69
27.	Seri Salia 2	2210	8.32	498.0	5.62	2.29	90.37	2.89
28.	Kala Bun	990	2.31	378	3.07	3.59	126.28	2.85
29.	Ram Kot 1 (A)	1320	9.71	434.4	4.86	6.48	10.6	2.76
30.	Ram Kot 1 (B)	1060	13.48	489.6	5.51	3.53	8.28	1.31
31.	Ram Kot 2	660	16.72	612.0	4.28	6.24	12.24	4.82
32.	Khanis Pur	3760	28.95	621.6	4.37	15.55	51.41	4.70
33.	Banni Jandala	1650	8.85	273.6	3.95	13.57	7.51	2.83
34.	Lower Jundala	1980	3.70	192.0	3.53	10.92	4.79	1.18
35.	Kalapani	1650	7.97	434.4	3.66	13.46	16.81	4.36
36.	Upper Jandala	1590	2.11	236.4	3.17	12.01	15.89	0.85
37.	Doli Jandala	2710	24.1	277.2	4.21	9.04	19.40	3.42
38.	Dunga Gali	1550	5.22	231.6	3.77	12.14	17.57	1.23
39.	Kala Bun UMalaachh	1780	3.04	352.8	5.10	9.19	12.77	2.91
40.	Kala Bun L Malaachh	660	1.78	303.6	4.60	10.25	4.12	2.12
41.	Kanisan Malaachh	2180	5.61	436.8	4.68	11.66	12.70	3.86
42.	Serpata Malaachh	1390	2.51	312.0	4.37	10.80	10.40	2.10
43.	Khui Barian Malaachh	1980	9.45	669.6	5.25	8.83	9.70	3.10
44.	Jaswara Malaachh	1160	4.82	248.4	4.21	8.02	4.61	1.69
45.	Sukakus	2150	6.61	337.2	3.72	11.03	3.57	1.69
46.	Badhiar	2150	3.10	397.2	4.94	7.85	6.84	1.79
47.	Sara	1490	1.38	225.6	4.33	10.10	3.27	1.23
48.	Pasala	3300	23.20	543.6	8.34	6.10	226.5	8.20
		2094.8±916.9	11.8±9.15	514.5±246.7	4.44±1.19	8.69±3.58	28.6±46.5	3.35±2.15
		Status of % soil samples of Birote unit (n=48)						
Low		50 (24)	23 (11)	0	0	0	0	4 (2)
Medium		50 (24)	35 (17)	0	0	8 (4)	0	17 (8)
High		0	43 (20)	100 (48)	100 (48)	92 (44)	100 (48)	79 (38)

Table 6. Concentrations of total N and AB-DTPA extractable P, K, Cu, Fe, Mn and Zn in soils of Boi unit, Gallyiat.

Sr. No.	Sampling Locations	Total N	AB-DTPA-extractable					
			P	K	Cu	Fe	Mn	Zn
			---mg kg^{-1}---					
1	Barbeen	500	5.61	289.2	3.41	7.83	6.06	0.86
2	Hotar U Bandi	1490	11.89	573.6	9.15	9.64	12.93	3.27
3	Darbiali L Bundi	830	9.05	598.4	11.52	6.82	14.81	3.55
4	Rankot 1	1320	2.44	298.8	5.73	12.39	7.81	1.86
5	Dana Rankot	990	2.24	238.8	3.29	8.87	5.61	1.11
6	Paal	730	12.09	243.6	5.80	8.95	16.99	0.79
7	Tori	930	12.16	325.2	10.29	17.87	33.66	3.77
8	Dalola	990	11.63	240.0	4.40	11.55	9.83	3.57
9	Deedal Mera	990	10.24	237.6	7.18	7.69	17.77	0.65
10	Darra	1992	14.47	234.0	4.72	4.69	4.86	4.13
11	Mujaffa	2110	6.47	468.0	3.76	17.11	13.87	3.23
12	Bai Dalola	2180	6.74	166.8	4.19	8.41	7.89	1.89
13	Badal Kundi	2150	7.93	274.8	3.63	4.59	63.44	7.28
	Average ± SD	1323.2±596.6	8.69±3.85	322.2±136.5	5.93±2.77	9.72±4.11	16.6±16.0	2.76±1.85
	Status of % soil samples of Boi unit (n=13)							
Low		77 (10)	16 (2)	0	0	0	0	23 (3)
Medium		23 (3)	46 (6)	0	0	0	0	8 (1)
High		0	38 (5)	100 (13)	100 (13)	100 (13)	100 (13)	69 (9)

Table 7. Concentrations of total N and AB-DTPA extractable P, K, Cu, Fe, Mn and Zn in soils of Thai unit, Galliyat.

Sr. No.	Sampling locations	Total N	AB-DTPA-extractable					
			P	K	Cu	Fe	Mn	Zn
			---mg kg^{-1}---					
1	Kund	1320	7.13	411.6	6.49	2.38	112.91	3.25
2	Mera Rehmat Khan	1980	14.47	342.0	3.95	5.64	10.90	1.65
3	Kania Basala Kalapani	990	7.66	240.0	4.13	9.00	6.70	1.11
4	Rasulia Lower	1770	5.02	505.2	17.32	11.98	68.03	1.88
5	Karati Bagh	2970	12.88	361.2	3.85	2.17	18.38	3.73
6	Juma Bagla Bagh	1780	4.42	192.0	5.63	10.48	3.73	2.43
7	Seri Bagh	1590	2.77	218.4	4.94	4.45	8.63	1.27
8	Namli Mera Upper	2410	10.11	1206.0	5.23	19.53	4.81	6.72
9	Namli Mera Lower	1720	15.86	376.8	6.22	16.63	7.71	3.41
10	Mohallah Nakar Chhatri 2	2150	2.11	278.4	8.98	13.33	31.52	1.31
11	Mohallah Parat Chhatri 1	2180	7.27	406.8	6.13	5.52	12.24	2.42
12	Rasulia Upper	2380	8.85	430.8	5.07	11.27	17.97	2.17
13	Khorian Kalapani	1160	2.31	300	5.65	10.82	10.22	1.16
	Average ± SD	1876.9±551.3	7.76±4.56	405.3±257.2	6.43±3.54	9.48±5.32	24.1±31.7	2.50±1.54
	Status of % soil samples of Thai unit (n=13)							
Low		62 (8)	23 (3)	0	0	15 (2)	0	0
Medium		38 (5)	54 (7)	0	0	8 (1)	0	31 (4)
High		0	23 (3)	100(13)	100(13)	77 (10)	100(13)	69 (9)

Table 8. Index values for total N and AB-DTPA- P, K, Cu, Fe, Mn and Zn in soils reported by various sources.

Elements	Low	Medium	High
	----------mg kg^{-1}----------		
	Hesse (1971)		
Total N	1000-2000	2000-5000	Above 5000
	Havelin and Soltanpour (1981)		
P	<3	4-7	>11
K	<60	61-120	>120
Cu	<0.5	-	>0.5
Fe	<0.2	2.0-4.0	>4.0
Mn	<1.8	-	>1.8
Zn	<1.0	1.0-1.5	>1.5
	Soltanpour (1985)		
Cu	<0.3	0.3-0.5	>0.5
Fe	<3.0	3.0-5.0	>5.0
Mn	<0.6	0.6-1.0	>1.0
Zn	<0.9	0.9-1.5	>1.5

Thai Unit

The total N, P, K, Cu, Fe, Mn and Zn concentrations in the Thai soils of Galliyat area were found to be within the range of 900-2970, 2.11-15.9, 192-1206, 3.85-17.3, 2.17-19.5, 3.73-112.9 and 1.11-6.72 with meam values of 1876.9±551.3, 7.76±4.56, 405.3±257.2, 6.43±3.54, 9.48±5.32, 24.1±31.7 and 2.50±1.54 mg kg^{-1}, respectively (Table 7).

Soils of Muzaffarabad, Azad Kashmir contained 20,000 and 10 mg kg^{-1} of total N and P, respectively (Mcvean and Robertson, 1976). Critical levels of 11 and 144 mg kg^{-1} for P and K were found in the soils of Albama, Georgia (Rodriguez *et al*., 1999). Major upland soils of northern part of China contained 66 to 974 mg kg^{-1} of exchangeable and water soluble K (Han and Egashira, 1999). The soils of Erzincan plain, Turkey, contained K, Mn and Zn levels of 61 to 731, 3.9 to 15.0 and 1.2 to 3.6 mg kg^{-1}, respectively, (Guleryuz *et al*., 1999).

All these studies suggested that 62 and 38%, and 23 and 54% soils samples (Table 7) contained low and moderate levels of total N and P (Hesse, 1971; Havelin and Soltanpour, 1981; Soltanpour, 1985) which might be associated with losses due to leaching or runoff, as the texture of the soils was mostly sandy or silt loam (Table 1). Adequate K concentrations in study sites may be attributed to K bearing minerals.

McBride (1978 b) reported that the high values of Cu might be due to relatively high organic matter. Moderate to low content of Fe was found in Ebryo (Spain) soils (Abaidia *et al*., 1981). Generally, the Mn level of soils varies from 20 to 3000 mg kg^{-1} (Mitchell, 1964). Similarly, Cu and Mn concentrations in all the soils of Thai unit were found adequate while 15% samples were low in Fe and 8 and 31% of those contained moderate values of Fe and Zn (Table 7) when compared with values reported by Hesse (1971), Havelin and Soltanpour (1981) and Soltanpour (1985).

Plant analysis

Total N, P and K concentrations in orchard leaves of Galliyat

The concentrations of total N, P and K in leaves of orchards (apple, citrus, peach, pear and plum) of Galliyat (Birote and Thai unit) ranged from 12.0-28.7, 0.01-1.66 and 20.2-42.5 with mean values of 20.2±3.18, 0.91±0.43 and 31.2±4.77 g kg^{-1}, respectively (Table 9).

In the high yield apple orchards in Henan province, China, leaf N, P and K concentrations were 22.2, 1.98 and 13.2 g kg^{-1} with 21.5 mg Zn kg^{-1} (Xia *et al*., 1998). According to Svagzdys (1999) reported total N, P and K concentrations of 2000, 2.3 and 15.3 g kg^{-1} with 127.4 mg Mn kg^{-1} in the leaves of apple orchards in Lithuania, Russia. The optimum leaf N for apple orchard should be 20.0 to 23.8 g kg^{-1} (Fallahi *et al*., 2001) (Table 10). According to Embleton *et al*. (1987) the P concentrations of citrus orchard containing less than 0.9 g kg^{-1}, was considered deficient, while more than 23 g K kg^{-1} was considered excessive. The values below 3.6, 36 and 16 mg kg^{-1} for Cu, Fe, Mn and Zn in citrus leaves are considered deficient while more than 22, 250, 1000 and 300 mg kg^{-1}, respectively are considered high (Embleton *et al*., 1987).

Therefore, the study suggested that nearly 50% of the fruit orchards in the area contained low N and P concentrations which may affect their productivity adversely. Studies revealed that P was present in organic form in high organic matter content and therefore, it was less available to plant. The K concentrations, on the other hand, were found sufficient in all samples (Table 9).

It was also observed that orchard leaves could accumulate very high concentrations of K, more than 30 g kg^{-1}. The average K concentration in the apple orchard leaves in British Columbia, Canada was found to be 8.2 g kg^{-1}, suggesting K deficiency (Neilsen *et al*., 1998). The plum orchards at some locations of the study area were mostly desiccated which might be associated with the excessive concentration of K (42.5 g kg^{-1}) in the leaves (Mengel and Kirkby, 1987).

Micronutients (Cu, Fe, Mn, Zn) Concentrations in Orchard Leaves of Galliyat

The concentrations of Cu, Fe, Mn and Zn ranged from 1.8-109, 147-1521, 10.1-866 and 7.5-31.5 with mean values of 32.8±23.9, 351.9±48.1, 330.7±237.2 and 16.8±5.1 mg kg^{-1}, respectively (Table 9).

Plant tissues normally contain 3-40 and 10-100 mg kg^{-1} of Cu and Zn, respectively, depending upon plant species and soil factors while Zn concentration in leaf sample of apple cv. Ohrim in Yuri district of Japan were deficient (12-22 mg kg^{-1}) but next year it contained sufficient concentration of 35 mg kg^{-1} (Sato *et al*., 1994).

Table 9. Concentrations of total N, P, K, Cu, Fe, Mn and Zn in orchard leaves of Birote and Thai units, Galliyat.

Sr. No.	Sampling Locations	N	P	K	Cu	Fe	Mn	Zn
		---------- g kg^{-1}----------			----------mg kg^{-1}----------			
1	Sungle Kot	18.9	0.66	29.9	16.0	269	62.8	19.2
2	Paripond Nagri Bala	18.9	0.71	33.1	109.7	320	63.0	21.0
3	Bara Reen Nagri Bala	23.5	1.53	38.35	30.0	285	110.7	12.8
4	Sanati Nagri Bala	19.6	0.49	28.65	28.2	560	42.5	14.9
5	Kalsora Nagri Bala	17.9	0.80	34.40	52.2	281	45.7	12.8
6	Tareri Tatyal	25.2	0.01	33.95	10.1	511	103.6	11.6
7	Tatyal Proper	19.6	1.07	31.05	50.6	206	96.0	11.9
8	Khu Tatyal	20.2	0.28	23.65	26.5	1108	241.2	18.4
9	Lotharan Tatyal	28.7	1.39	34.70	6.3	636	50.9	14.3
10	Nammal	19.3	0.86	33.40	32.8	413	725	17.7
11	Ali Abad 2	23.5	1.56	34.20	20.4	342	206.8	7.5
12	Ali Abad 1	17.9	1.27	30.15	67.0	209	727.5	15.6
13	Pagar Khan Kalan	23.1	1.17	31.45	36.6	217	10.1	10.9
14	Retli Khan Kalan	21.4	1.06	30.40	26.8	197	218.9	14.8
15	Bagla (DK)	24.9	0.87	31.00	21.3	391	313.1	18.1
16	Sungle Day(DK)	21.4	0.99	35.10	21.1	305	549.0	22.1
17	Hashmi Tand (DK)	20.2	0.54	28.15	52.5	270	338.7	31.5
18	Chappar Khetar (DK)	25.6	1.61	39.40	56.0	182	486.1	14.3
19	Loharan Khetar (DK)	22.4	0.22	38.20	91.9	266	23.2	21.8
20	Gora Bagla (DK)	21.0	1.32	34.50	25.1	175	111.7	16.1
21	Darwaza Khas	21.6	0.73	31.00	26.5	222	625.7	13.4
22	Seri Darwaza Khas	17.9	0.59	32.90	30.9	486	192.6	15.1
23	Dhara Darwaza Khas	14.7	0.08	30.85	31.1	1521	392.4	26.8
24	Seri Salia 1	20.7	0.65	25.40	19.8	239	308.3	30.4
25	Seri Salia 2	23.1	0.96	34.75	77.4	232	370.6	20.4
26	Kala Bun	17.2	0.54	20.40	19.6	284	571.1	20.2
27	Ram Kot 1 A	19.6	0.99	33.00	4.2	235	383.4	13.2
28	Ram Kot 1 B	21.7	0.35	30.65	25.4	305	312.0	11.6
29	Ram Kot 2	12.0	0.29	26.90	25.2	556	259.0	19.2
30	Khanis Pur	12.0	1.09	30.85	21.2	875	294.2	17.3
31	Banni Jandala	15.4	1.33	32.10	46.1	308	521.5	25.1
32	Lower Jandala	18.9	1.34	31.35	5.0	614	772.7	18.2
33	Kalapani	16.8	0.79	33.00	8.5	365	588.7	19.4
34	Upper Jandala	18.7	0.87	33.0	2.8	229	53.7	19.0
35	Doli Jandala	16.1	1.74	25.20	3.1	431	169.8	11.1
36	Dunga Gali	22.1	1.27	33.65	48.3	168	190.5	12.2
37	Kala Bun U Malaachh	21.0	0.64	26.70	36.9	304	690.8	17.1
38	Kala Bun L Malaachh	19.6	0.87	29.65	40.9	326	613.6	9.6
39	Kanisan Malaachh	20.2	1.66	35.75	63.5	203	284.2	16.7
40	Serpata Malaachh	23.1	0.79	35.60	16.6	224	114.7	15.1
41	Khui Barian Malaachh	21.7	0.87	42.50	66.8	315	647.8	17.7
42	Jaswara Malaachh	21.4	0.85	18.10	1.8	198	286.4	16.7
43	Sukakus	21.0	1.03	20.20	53.0	147	706.6	12.4
44	Badhiar	20.7	1.02	34.80	69.8	216	866.0	14.9
45	Sara	15.8	0.97	32.20	9.2	309	218.8	19.0
46	Pasala	22.4	1.14	35.90	11.0	322	253.1	16.7
47	Karati Bagh	20.3	1.17	29.15	19.7	202	33.7	19.9
48	Juma Bagla Bagh	19.6	0.34	27.75	24.5	198	430.2	10.9
49	Seri Bagh	20.7	0.2	27.60	27.1	161	537.5	22.9
50	Namli Mera Upper	18.7	1.36	27.60	21.6	257	319.4	9.1
	Average ± SD	20.16 ± 18	0.91± 0.43	31.2 ± 4.77	32.8 ± 23.9	351.9 ± 48.09	330.7± 237.2	16.8±5.06
		Status of % soil samples of Thai unit (n=13)						
Low		42 (21)	60 (30)	0	8 (4)	0	2 (1)	80 (40)
Medium		48 (24)	40 (20)	2 (1)	22 (11)	10 (5)	70 (35)	20 (10)
High		8 (4)	0	98 (49)	70 (35)	90 (45)	28 (14)	0

When the values of Cu, Fe, Mn and Zn observed in apple orchard leaves grown in Galliyat were compared with standard values (Jones, 1972 and Kabata-Pendias, 1986), it was observed that Zn concentrations were low in 80% orchards, Cu and Fe was high in 70-90% while 70% contained moderate levels of Mn (Table 10). The excessive accumulation of K may also be a confounding factor to inhibit the Zn absorption by plant (Mengel and Kirkby, 1987).

Table 10. Index Values for Total N, Cu, Fe, Mn and Zn in Plants Reported by Various Sources.

Elements	Deficient	Sufficient	Toxic
	(Fallahi *et al*., 2001)		
Optimum N (g kg^{-1})	<20	20-23.8	>24
	(Jones *et al*., 1972)		
	----------mg kg^{-1}----------		
Cu	<4	5-20	>20
Fe	<50	50-250	Unknown
Mn	<20	20-500	>500
Zn	<20	25-150	>400
	(Kabata-Pendias, 1986)		
Cu	2-5	5-30	20-100
Fe	-	-	-
Mn	15-25	20-300	300-500
Zn	10-20	27-150	100-400

Conclusions and Recommendations

It was concluded from findings of this study that Birote, Thai and Boi soils were loamy in nature, with sand and silt being the dominant fraction. The pH of the three units was found within the normal range and electrical conductivity of the soils found low indicating the lower amount of soluble salts in these soils. Soils were found slightly calcareous in nature.

The low nutrient concentrations might be due to losses through leaching, as these soils were found sandy in nature or due to low soil organic matter because of rapid decomposition at some locations.

To get potential and quality produce, proper fertilization to orchards reported deficient in various nutrients is recommended.

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