Characterization and nutrients indexing of apple orchard soils of Bangil area of Dist. Baramulla

ZAHOOR AHMAD

(2001-A-637-M)

DIVISION OF SOIL SCIENCE

FACULTY OF POSTGRADUATE STUDIES
Sher-e-Kashmir
University of Agricultural Sciences & Technology of Kashmir   Shalimar
Srinagar

2003

INTRODUCTION

Apple (*Malus domestica* Borkh) is grown all over the world in temperate regions at an altitude ranging from 1350-2600 metres above mean sea level with an annual rainfall from evenly spread rains up to 125-175 cm. It is a native of South East Asia and Europe and belongs to family Rosaceae. In India Jammu and Kashmir and Himachal Pradesh are the main apple growing states besides some hilly areas of Kumon region of Uttranchal. Apple grown in Kashmir is famous for its taste, flavour and colour. The state of Jammu and Kashmir has an area of 217545 ha under fruit crops with 86651 ha under apple and has an annual production 929022 metric tonnes of apple (Anonymous, 2000). Among various land uses cultivation of apple is quite profitable and represents the fruit industry of Kashmir sharing 90.99 per cent of total fruit production. The apple production is 8.52 metric tonnes although higher in the country but is far below than 40.7 metric tonnes per hectare-in USA (Nagi *et al*. 1998). This low production of fruit in India is primarily owing to the soil fertility status, root stock scion vigour besides following improper orchard management practices. The economic ends have given an impetus to commercial apple production in the state resulting in an increase in area under various fruits which increased from 82486 hectares in 1974-75-217545 hectares in 1999-2000 (Anonymous, 2000).

Red delicious, Maharaji and American are the principal commercial cultivars of apple in the valley and account for 75 per cent of apple cultivation. Plant growth, yield and fruit quality besides the nutritional status of tree are directly influenced by many factors related to environmental conditions and orchard management. Production of fancy fruits is related to the nutrient availability in the soil and their absorption by roots. Soils having a high nutrient status give a head start to plants and also reduces the expense of fertilizing the tree. Soil characteristics to a great extent influence the tree health and quality fruit production in addition to requirements of different nutrients. Because of the physiological peculiarities of perennial plants, soil analysis does not provide enough information about the nutritional status of the tree and fertilizer to be applied in the orchards (Basso *et al.*, 1988). Thus soil and plant analysis are complimentary to each other because at times one will supply the information that the other may not therefore, it is advisable to consider analysis of both the components in assessing the nutritional status of fruit crops especially those fruit crops where the plants have deep and ramified root system. Nutritional imbalance in the soil causes nutritional disorders and consequently affects both the quality and quantity of fruit, in addition the plants become more susceptible to diseases and pests. It is therefore, inevitable to have a knowledge of nutrient distribution vertically down the profile and to evaluate the contribution of subsurface soil to plant nutrition and potential capacity of soil to supply nutrients to the plants.

Apple tree, like other plants need different nutrients in varying quantities to achieve proper growth and fruiting. As reported by (Kanwar, 1988) a yield of 7200 kg of apple removes 13.5, 4.6 and 15.9 kg of Nitrogen, Phosphorus, and Potassium, respectively in addition to 4.5, 1.4 and 2.8 kg of the same by leaves and wood. This therefore, emphasizes that the studies be undertaken to establish and standardize optimum requirement of nutrient element for satisfactory yield. The properties and management of soil may be most effectively studied and classified accordingly. It provides information pertinent to nutritional status of soil and its suitability for different crops. Despite the importance of the area under study for producing quality apple, no systematic study has been undertaken with respect to characterization and nutritional indexing of apple orchard soil. Keeping in view the above facts the present investigation entitled “characterization and Nutrient Indexing of Apple Orchard Soils of Bangil area of district Baramulla” was undertaken with the following objectives.

1. To determine the nutritional status of apple orchard soils
2. To study the relationship of available nutrients with physico-chemical properties and
3. To study the leaf nutrient status of apple orchards
4. To study the relationship between available and leaf nutrient content
5. To characterize and classify the soil as per soil taxonomy

CHAPTER-II

REVIEW OF LITERATURE

The literature pertinent to the present investigation is briefly reviewed in this chapter under the following heads:

2.1 Depth wise distribution of available nutrients

2.2 Physio-chemical properties of soil

2.3 Relationship between available nutrients with physio-chemical properties

2.4 Leaf nutrient status of apple orchards

2.5 Relationship between available and leaf nutrient content.

2.6 Soil characterization and classification

2.1 Depth wise distribution of available nutrients

2.1.1 Nitrogen

Handoo (1983) found that the available Nitrogen content in surface soils of Kashmir valley was medium to high and ranged from 120-304 ppm. Verma *et al*. (1985) have reported that soils of Una and Hamirpur district of Himachal Pradesh are low in available Nitrogen and those of Kangra, Mandi, Bilaspur, Simla and Sirmour are medium.

Kaista *et al*. (1990) observed that the available Nitrogen content in the north western Himalayan soils varied from 111-503 ppm in surface layers and 115-605 ppm in subsurface layers indicating regular decrease with depth.

Makaya and Bishnoi (1990) reported that podzolic silt loam soils of Palampur (H.P) contained 596.0 kg of available nitrogen per hectare. Mandal *et al*. (1990) also reported highest nitrogen status in surface soils and it regularly decreased with depth in middle hill and upper hill forest soils of eastern Himalayas.

Singh and Bhandari (1992) reported that the soils of apple orchards of Kinnuar district of Himachal were low to medium in available Nitrogen. Sharma and Bhandari (1992) observed that the available Nitrogen ranged from 92.0- 231.0 and 87.0-222.0 ppm with mean value of 158.10 and 137.90 ppm in surface and sub surface soils of apple orchards of Himachal Pradesh, respectively.

Mushki (1994) reported that the available Nitrogen content in apple orchard soils of Kashmir ranged from 56.0 – 140.0 and 22.50 –117.60 ppm in surface and subsurface layers respectively.

According to Gunjoo (1994) the available Nitrogen content in mid hill soils of Jammu region was low to medium ranging from 131.0-445.00 kg per hectare with a mean value of 230.00 kg per hectare. Wani (1994) observed that available Nitrogen content in surface and subsurface layers of saffron growing soils of Kashmir varied from 124.54-336.63 and 149.45-373.63 kg per hectare with mean value of 238.62 and 246.61 kg per hectare respectively. Mir (1994) reported that the available Nitrogen content in Almond orchards of Kashmir varied from 64.82-226.42 ppm with a mean value of 137.90 ppm in surface soils, where as in sub-surface soils it varied from 42.44-169.35 ppm with a mean value of 83.50 ppm. Peer (1994) observed that soils of Kashmir contained medium to high content of available Nitrogen ranging from 278.0 – 511.5 kg per hectare.

Khan *et al.* (1997) reported that available Nitrogen in surface soils ranged from 97- 202 mg per kg where as it ranged from 30-168 mg kg^{-1} in sub-surface soils in some bench mark soils of Bangladesh.

Walia *et al.* (1998) reported available Nitrogen ranged from 95.0-159.0 mg kg^{-1} soil in surface and 51.0-159.0 mg Nitrogen kg^{-1} soil in sub-surface horizons of some land forms of Budelkhand region of Utter Pradesh. Awasthi *et al.* (1998) reported that available Nitrogen status of apple orchards in Shimla district of Himachal Pradesh ranged from 113.3-173.6 per cent. Available Nitrogen was negatively correlated with pH and Calcium Chloride (Minhas and Bora, 1982; Agarwal and Tripathi, 1977).

2.1.2 Phosphorus

Gupta (1974) observed that the available Phosphorus in soils of Jammu and Kashmir varied from 9.15-30.0 ppm. Singh and Raman (1982) have reported that the concentration of available Phosphorus ranged between 28-32 ppm in the soils of north western Himalayas. The total and available Phosphorus did not depict any conspicuous pattern with soil depth.

Handoo (1983) reported that the surface horizons of the soils of J&K showed medium to high available Phosphorus status and the content varied from 7.5-12.5 ppm in Kashmir valley with a decreasing trend with the depth. The available Phosphorus in peach orchard soils of Punjab varied from 2.0-48.0 and 2.0-56.0 mg kg^{-1} soil in surface and sub-surface layers, respectively (Arora, *et al.* 1989). Chibba and Sekhon (1985) did not find any conspicuous relationship of available Phosphorus with depth. Singh and Ahuja (1990) while studying the distribution of Phosphorus reported low to medium Phosphorus status with maximum accumulation of available Phosphorus in surface layer of Ghagger River

Basin. Mandal *et al.* (1990) observed a uniform distribution of available Phosphorus in some pedons of Eastern Himalayas. Available Phosphorus ranged from 5-15 mg kg^{-1} soil (Khan *et al*. 1997). Chaudhry and Dass (1990) reported that available Phosphorus ranged from 3-10 ppm in surface soils and 1-21 ppm in sub-surface soils in Ravines of Yumana. Thakur and Bhandari (1986) have reported that organic carbon and calcium carbonate content significantly effect Phosphorus content of soils. Jaggi *et al* (1990) found that available Phosphorus in the surface soils of Himachal Pradesh was in the range of 1.3-19.9 ppm.

Makaya and Bishnoi (1990) reported that available Phosphorus in podzolic silt loam soils of Palampur (H.P) was 10.9 kg ha^{-1}. Ganai *et al*. (1991) reported that available Phosphorus in the soils of cherry orchards of Kashmir valley (J&K) ranged from 6.60-14.50 ppm. Kanthalya and Bhat (1991) have observed non-significant correlation of available Phosphorus with organic carbon which they attributed to dominance of inorganic Phosphorus.

Singh and Bhandari (1992) reported that apple orchard soils of Kinnuar districts (H.P) were high in available Phosphorus ranging from 14-52 ppm. Sharma and Bhandari (1992) reported that available Phosphorus in surface and subsurface soils of apple orchards of Himachal Pradesh ranged from 10.5-40.5 and 6.5-34.33 ppm with mean value of 25.5 and 17.9 ppm, respectively.

According to Mir (1994) the available Phosphorus varied from 5.11- 13.33 and 2.59-15.16 ppm in surface and subsurface layers of almond orchard soils of Kashmir, respectively. The available Phosphorus in apple orchard soils of Kashmir varied from 10.0-26.00 and 09.0-26.0 ppm in surface and subsurface layers, respectively (Mushki 1994). According to Gunjhoo (1994) the available Phosphorus in mid hill soils of Jammu region varied from 7.30 –22.50 kg ha^{-1}.

Wani (1994) observed a range of 8.00-14.00 and 6.00-14.00 ppm of available Phosphorus with mean values of 10.00 and 9.50 ppm in surface and subsurface layers of saffron growing soils of Kashmir, respectively. According to Awasthi *et al*. (1998) the available phosphorus content of apple orchards in Shimla district of Himachal Pradesh ranged from 25.7-45.6 per cent.

2.1.3 Potassium

Handoo (1983) reported that available Potassium in soils of Kashmir varied from 64.0-136.0 ppm in the surface horizons. Verma *et al*. (1985) have observed that in most of the soils of Himachal Pradesh available Potassium is medium to high. The available Potassium in peach orchard soils of Punjab decreased with depth and ranged from 57-249 mg kg^{-1} soil in surface layers and 37-249 mg kg^{-1} in subsurface layers, respectively (Arora *et al*. 1989).

Makaya and Bishnoi (1990) found that available Potassium in podzolic silt loam soils of Palampur (H.P) was 223.9 kg ha^{-1}. Mandal *et al*. (1990) reported a range of 47.2-289.3 ppm in some forest soils of eastern Himalayas.

Ganai, *et al*. (1991) observed that available Potassium in cherry orchard soils of Kashmir ranged from 84.0-130.0 ppm. According to Singh and Bhandari (1992) the apple orchard soils of Kinnuar district of Himachal Pradesh were high in available Potassium and ranged from 120.0-170.0 ppm. Sharma and Bhandari (1992) observed that available Potassium in apple orchard soils of Himachal Pradesh ranged from 182.0-540.0 ppm with a mean value of 340.0 ppm in surface layers and 135.0-415.0 ppm with a mean value of 263.7 ppm in sub-surface layers.

Peer (1994) reported that soils of Kashmir valley exhibited a medium range of available Potassium and it was in the range of 59.00-105.0 ppm. According to Mir (1994) the available Potassium in almond orchard soils of Kashmir varied from 108.44-207.75 and 67.32-151.84 ppm in surface and sub-surface layers, respectively with maximum amount in surface horizons.

Wani (1994) observed that available Potassium status was high in saffron growing soils of kashmir and ranged from 219.52-313.60 ppm with a mean value of 277.5 ppm in surface layers and 206.80-300.16 ppm with a mean value of 261.80 ppm in sub-surface layers. According to Gunjoo (1994) the available Potassium in mid hill soils of Jammu region varied from 65.0-334.0 kg ha^{-1} with a mean value of 189.0 kg ha^{-1}. According to Mushki (1994) the available potassium in apple orchard soils of Kashmir ranged from 0.319-0.578 per cent. The available Potassium content in the apple orchard soils of Himachal Pradesh ranged from 115-220 mg kg^{-1} with mean value of 164.3 in surface soils and 95- 185 with a mean value of 133.6 mg kg^{-1} in sub-surface soils (Sharma and Bhandari, 1995).

Dar (1996) reported that available Potassium content in almond orchard soils of district Srinagar of Kashmir ranged from 80.0-205.0 ppm. Das *et al*. (1997) reported that available Potassium varied from 110-220 mg kg^{-1} in watershed areas of Phulbani district of Orissa. Khan *et al*. (1997) reported that the available potassium in bench mark soils of Bangladesh ranged from 51-477 mg kg^{-1} soil. Awasthi *et al*. (1998) reported that Potassium content in apple orchard soils of Himachal Pradesh ranged from 143.0-191.5 with a mean value of 161.9 ppm.

2.1.4 Calcium

Bansal *et al*. (1969) reported that Calcium content ranged from 13.5-20.0 and 11.0-34.25 m.e per 100 gm soil in surface and sub-surface layers of Andhartal soil series of Madhya Pradesh, respectively indicating an accumulation of Calcium in Bhorigon. Handoo (1983) observed that exchangeable Calcium varied from

13.5-18.75 m.e per 100 gm soil in the soils of Kashmir and was the most dominant cation in soils. The exchangable Calcium in the podzolic silt loam soils of Palampur (H.P) was 4.0 Cmol kg^{-1} soil as observed by Makaya and Bishnoi (1990). Kaistha *et al.* (1990) found that exchangable Calcium in the soils of north western Himalayan soils varied from 3.2-22.6 Cmol kg^{-1} soil. Verma *et al*. (1990) reported that exchangeable calcium in the high altitude soils of Kashmir ranged from 0.75-20.40 Cmol kg^{-1} soil with Calcium as dominant cation. Exchangeable Calcium varied from 5.2 – 17.5 Cmol kg^{-1} in mid Shiwalik hills of Himachal Pradesh (Singh *et al*., 1990). Sannigrahi *et al*. (1990) observed 6.2-27.0 Cmol kg^{-1} soil Calcium in different horizons of some hill soils of Nilgiri. While studying some Alfisols in Orissa, Sahu and Patnaik (1990) found Calcium as dominant cation in exchange complex and also observed higher amount in sub-surface than in surface soils.

Singh *et al*. (1991) while studying the forest soils of Mizoram found Calcium as a dominant exchangeable cation followed by Magnesium and also no regular distribution of these cations was observed with respect to altitude.

Gupta and Tripathi (1992) observed that exchangeable Calcium in the soils of north west and central Himalayan region of Himachal Pradesh ranged from 18-6.3 Cmol kg^{-1} soil. Singh and Bhandari (1992) reported that apple orchard soils of Kinnuar district of Himachal Pradesh were high in available Calcium and ranged between 840-230 ppm. Sharma and Bhandari (1992) reported that available Calcium in apple orchard soils of Himachal Pradesh was in the range of 256-1216 ppm with a mean value of 620 ppm in surface layers and 152-1076 ppm with a mean value of 485.2 ppm in subsurface layers. Peer (1994) observed that exchangeable Calcium was a dominant cation varying from 12.96-15.10 C mol kg^{-}

^{1} soil in soils of Kashmir. According to Mushki (1994) the exchangeable Calcium in apple orchard soils of Kashmir varied from 6.20-16.80 and 5.60-18.00 Cmol kg^{-1} soil in surface and subsurface layers, respectively.

Wani (1994) found hat exchangeable Calcium in some saffron growing soils of Kashmir ranged from 12.5-17.1 and 13.7-18.0 Cmol kg^{-1} with mean values of 14.8 and 15.9 Cmol kg^{-1} soil in surface and subsurface layers, respectively. Sharma and Bhandari (1995) reported a range of 660-1640 mg kg^{-1} soil available Calcium in apple orchard soils of Himachal Pradesh. Dar (1996) reported that available Calcium content in cherry orchard soils of district Srinagar ranged from 1880.0-2280.0 ppm. Awasthi *et al*. (1998) while assessing the nutrient status of apple orchards of Himachal Pradesh reported that available Calcium content in soils ranged from 12.94-16.03 ppm with a mean value of 1389 ppm. Awasthi *et al*. (1999) reported that Calcium content in peach orchard soils of Sirmour district of Himachal Pradesh ranged from 1.28-1.65 ppm with a mean value of 1.40 ppm and the status was medium to high.

2.1.5 Magnesium

According to Handoo (1983) exchangeable Magnesium in the soils of Kashmir valley varied from 2.40-4.40 m.e per 100 g soil with no definite trend in its distribution along the profile

The exchangeable Magnessium content in the podzolic silt loam soils of Palampur (H.P) was 2.0 Cmol kg^{-1} soil (Makaya and Bishnoi, 1990). Kaistha *et al*. (1990) found that exchangeable Magnesium ranged from 0.1-9.5 Cmol kg^{-1} soil in the soils of north western Himalayan region Verma *et al*. (1990) reported that the exchangeable Magnesium in high altitude soils of Kashmir was found in the range of 0.25-6.75 Cmol kg^{-1} soil by Verma *et al*. (199). Sahu and Patnaik (1990) found poor content of Magnesium in some Alfisols of Orissa ranging between 0.1-1.8 Cmol kg^{-1} soil. Singh and Bhandari (1990) reported that the apple orchard soils of kinnour district of Himachal Pradesh were high in available Magnesium and it ranged between 440-1520 ppm. Gupta and Tripathi (1992) observed that exchangeable Mg in soils north west and central Himalayan region of Himachal Pradesh varied from 1.9-14.5 Cmol kg^{-1} soil. Sharma and Bhandari (1992) reported that available Magnesium varied from 110-338.0 ppm with a mean value of 225.6 ppm in surface soils of apple orchards of Himachal Pradesh, where as it varied from 72.0-276.0 ppm with a mean value of 163.3 ppm in sub-surface soils.

Singh *et al*. (1991) found exchangeable Magnesium decreasing along the depth at different altitudes in the soils of Mizoram. Bhoumik and Totey (1990) reported a range of 2.6-12.0 Cmol kg^{-1} in some teak forests of Madhya Pradesh with less recycling of Magnesium to "A" horizon than Calcium. Updhayay and Awasthi (1993) while studying the leaf nutrient ranges of apple trees in Himachal Pradesh revealed that magnesium content in the soil ranged from 4.19-13.57 ppm with a mean value of 12.55 ppm. Wani (1994) reported that the exchangeable Magnesium in saffron growing soils of Kashmir ranged from 1.5-2.8 and 1.2-3.0 Cmol kg^{-1} soil with mean value of 2.2 and 2.3 Cmol kg^{-1} soil in surface and sub-surface layers, respectively.

According to Peer (1994) the exchangeable Magnesium in Kashmir soils ranged from 2.45-3.45 Cmol (P^+) kg^{-1} soil. Gunjoo (1994) found that the exchangeable Magnesium in mid hill soils of Jammu region was 2.74 Cmol (P^+) soil. Sharma and Bhandari (1995) while analyzing the mineral nutrient status of apple orchards of Himachal Pradesh revealed that the Magnesium content of orchard soils ranged between 20-600 ppm with a mean value of 421.4 ppm and reported that Magnesium showed an inconsistent pattern in soil layers. Sannigrahi *et al*. (1996) observed a range of 2.5-10.9 Cmol kg^{-1} exchangeable Magnesium in some dominant soil series of Nilgire.

Das *et al*. (1997) reported that exchangeable Magnesium varied from 0.2-1.7 Cmol kg^{-1} in some Alfisols of Meghalya. Awasthi *et al*. (1998) while analyzing the nutrient status of apple orchards of Himachal Pradesh revealed that the Magnesium content in orchard soil ranged between 405-528 ppm with a mean value of 440 ppm in soils. similarly Awasthi *et al*. (1999) while working on mineral nutrient status of peach orchards in Sirmour district of Himachal Pradesh observed that Magnesium content in soil ranged between 395.0-567.0 ppm with a mean value of 443.0 ppm in soils.

2.1.6 Sulphur

Westwood (1988) reported that best availability of Sulphur in the soil was in the pH range of 6.0-10.0 and main source of Sulphur in the soil may come from SO_4 in irrigation water, residues of pesticides sprays, organic matter and Sulphur containing fertilizers. According to Arora *et al*. (1989) the available Sulphur in peach orchard soils of Punjab ranged from 5.7-32.9 and 5.7-28.3 mg kg^{-1} soil in surface and sub-surface layers respectively. Balanagoudar and Satyanarayana (1990) have observed that water soluble and sulphate sulphur were low in surface horizons and increased with depth in some soils of north Karnataka. They have further indicated that the water soluble sulphur varied from 1.4-230.6 ppm with an average of 28.7 ppm while as sulphate Sulphur varied from 2.8-250.0 ppm with an average of 29.3 ppm. Tripathi and Singh (1992) observed that sulphate sulphur in the soils of Himachal Pradesh ranged from 5.5-21.2 ppm and showed a decreasing trend with the depth. Singh and Bhandari (1992) reported that apple orchard soils of kinnour district of Himachal Pradesh were high in available Sulphur and ranged from 6.0 – 45.0 ppm.

Sharma and Bhandari (1992) observed that sulphate Sulphur ranged from 7.2-29.4 ppm with a mean value of 14.3 ppm in surface layers and from 6.2-30.7 ppm with a mean value of 14.9 ppm in sub surface layers of apple orchards of Himachal Pradesh and it showed an inconsistent distribution pattern with soil depth. Sreemannarayan and Raju (1994) observed that available Sulphur in Vertisols and Alfisols were 13.04 and 8.20 mg kg^{-1} soil, respectively. Gunjoo (1994) reported that the sulphate Sulphur in the mid hill soils of Jammu region raged from 2.80-7.10 ppm with a mean value of 4.67 ppm. Bhogal *et al*. (1996) reported that available Sulphur ranged from 1.4 - 20.8 mg kg^{-1} in surface soils in Calciorthents of north Bihar. Trivedi *et al*. (1998) reported that different forms of Sulphur in general decreased with depth and showed significant positive relationship with organic carbon content. Venkatesh and Satyanarayan (1999) reported that available Sulphur ranged from 3.1 - 55 ppm with an average of 11.1 ppm in Vertisols of north Karnataka. The sulphate Sulphur ranged from 7.3 - 136.0 mg kg^{-1} with mean value of 45.9 mg kg^{-1} in Inceptisols of Delhi (Gowri - Sankar and Shukla, 1999). As reported by Dar (1996) the available Sulphur was in the range of 8.62 – 11.25 ppm with an inconsistent distribution pattern, in cherry orchard soils of Srinagar district of Kashmir.

2.1.7 Zinc

Bansal *et al*. (1969) reported that Zinc content in Adhartal soil series in Madhya Pradesh varied from 0.2-0.8 ppm in surface layers and 0.21-1.3 ppm in sub-surface layers, respectively. According to Cox and Kamprath (1972) the critical range for DTPA-extractable Zinc in soil was 0.5-1.0 ppm. The available

Zinc content in the hill soils of Utter Pradesh was found in the range of 0.29-6.80 ppm by Rawat and Mathpal (1981). Ganai *et al*. (1982) found that available Zinc in apple orchards of Anantnag (J&K) ranged from 1.20-1.90 ppm in surface soils and 0.4-1.80 ppm in sub-surface soils. Bhandari and Randhawa (1985) exhibited that available Zinc varied from 0.2-3.5 ppm with a mean value of 1.6 ppm in surface soils, while as it varied from traces in to 1.7 ppm with a mean value of 0.4 ppm in subsurface soils of apple orchards of Himachal Pradesh. Sakel *et al*. (1986) observed that available Zinc in sub himalayan hill and forest region soils of Bihar ranged from 0.15-7.80 ppm with a mean value of 1.05 ppm Jalali *et al*. (1989) reported that DTPA-extractable Zinc in high altitude soils ranged from 0.35-0.65 ppm and was higher than that of karewas and valley basin soils of Kashmir. They further reported that available Zinc decreased with soil depth. Arora *et al*. (1989) observed that available Zinc varied from 0.29-2.01 and 0.11-1.94 mg kg^{-1} soil in surface and sub-surface soils of peach orchards of Punjab, respectively. According to Kanthaliya and Saxena (1992) the available Zinc in semi arid soils of Rajasthan varied from 0.36-1.41 ppm with a mean value of 0.65 ppm. Sharma and Bhandari (1992) found that available Zinc in apple orchard soils of Himachal Pradesh varied from 0.75-4.60 and 0.47-3.50 with mean values of 2.6 and 1.48 ppm in surface and sub-surface layers, respectively. Upadhayay and Awasthi (1993) reported that Zinc content in Himachal Pradesh soils ranged from 2.76-4.19 ppm with a mean value of 3.58 ppm. According to Mushki (1994) DTPA-extractable Zinc in apple orchard soils of Kashmir varied from 0.47-0.66 ppm. Tripathi *et al*. (1994) reported that available Zinc varied from 0.1-2.8 mg kg^{-1} soil with a mean value of 0.5 mg kg^{-1} soil and indicated that it decreased with depth. Dar (1996) observed that DTPA-extractable Zinc in cherry orchard soils of district

Srinagar varied from 0.33-1.82 ppm. Khan *et al*. (1997) while analyzing the production potential of some bench mark soils of Bangladesh revealed that Zinc content in different soil series varied from 0.16-1.16 mg kg^{-1}.

Mamgain *et al*. (1998) reported that the available Zinc content in apple orchard soils of Himachal Pradesh ranged between 2.73-3.66 ppm with a mean value of 2.99 ppm.

2.1.8 Copper

Bansal *et al*. (1969) observed that the Copper content in surface and subsurface soils of Adhartal series of Madhya Pradesh varied from 0.4-0.8 and 0.1-2.4 ppm, respectively. According to Rawat and Mathpal (1981) the available Copper in the hill soils of Utter Pradesh ranged from 0.23-5.4 ppm with an average value of 2.68 ppm. Sakal *et al*. (1985) reported that available Copper in calcareous soils was in the range of 0.2-10.7 ppm. Bhandari and Randhawa (1985) observed that available Copper in apple orchards of Himachal Pradesh varied from 0.8-7.6 and 0.1-5.3 ppm with mean value of 2.3 and 1.4 ppm in surface and sub-surface soils, respectively. According to Kanwar and Tripathi (1986) the soils of north western Himalayan region showed a range of 0.4-4.0 ppm of DTPA-extractable Copper. Sakal *et al*. (1986) observed that DTPA-extractable Copper varied from 0.21-5.88 ppm with a mean value of 1.31 ppm in sub Himalayan hill and forest region soils of Bihar. According to Jalai *et al*. (1989) the available Copper in soils of Kashmir ranged from 0.07-0.33 ppm. Arora *et al*. (1989) found that available Copper in peach orchards of Punjab was in the range of 0.07-2.24 and 0.03-2.24 mg kg^{-1} soil in surface and sub-surface soils, respectively. The available Copper in apple orchards of Himachal Pradesh ranged from 1.4-9.7 and 1.1-4.2 ppm with mean value of 4.4 and 2.6 ppm in surface and sub-surface soils, respectively (Sharma and Bhandari, 1992). Kanthaliya and Saxena (1992) reported that available Copper in semi arid soils of Rajasthan varied from 0.25-1.44 ppm with a mean value of 0.69 ppm. In saffron growing soils of Kashmir DTPA-extractable Copper ranged from 0.15-0.50 and 0.10-0.32 ppm with mean value of 0.35 and 0.18 ppm in surface and sub-surface layers, respectively. Tripathi *et al.* (1994) revealed that the content of DTPA-extractable Copper decreased with depth and was in the range of 0.4-4.8 mg kg^{-1} soil with an average value of 1.7 mg kg^{-1} soil. Mushki (1994) observed that DTPA-extractable Copper in apple orchard soils of Kashmir valley varied from 1.52-1.80 ppm. According to Sharma and Bhandari (1995) the Copper content of Himachal Pradesh soils were found in the range of 1.1-6.5 mg kg^{-1} and 0.8-5.2 mg kg^{-1} of soil with mean value of 3.6 and 2.9 mg kg^{-1} of soil in surface and sub-surface layers, respectively. Upadhayay and Awasthi (1993) while working on leaf nutrient ranges of plus apple trees in Himachal Pradesh found that Copper content in soils ranged from 2.32-4.44 ppm with a mean value of 3.30 ppm.

Dar (1996) revealed that the DTPA-extractable Copper content in the cherry orchard soils of district Srinagar ranged from 0.88 to 2.89 ppm. Khan *et al.* (1997) observed that the Copper content in bench mark soils of Bangladesh varied from 1.3-1.0 mg kg^{-1} of soil. Mamgain *et al.* (1998) while working on the relationship between fruit yield and nutrient reported that Copper content in Himachal Pradesh soil was in the range of 2.86-4.13 ppm with a mean value of 3.38 ppm.

2.1.9 Manganese

Rawat and Mathpal (1981) found that available Manganese in hill soils of Utterpradesh ranged from 3.6-26.0 ppm with a mean value of 13.0 ppm.

According to Sakal *et al*. (1985) the calcareous soils of Bihar contained 0.9-141.9 ppm of available Manganese. The available Manganese in apple orchards of Himachal Pradesh varied from 7.3 –188.8 and 1.4-81.3 ppm with mean value of 58.5 and 18.7 ppm in surface and subsurface soils, respectively (Bhandari and Randhawa, 1985). According to Sakal *et al*. (1986) the available Manganese was found in the range of 1.75-82.50 ppm with a mean value of 17.85 ppm in soils of sub-Himalayan hill and forest region of Bihar. Gajindragadkar and Rathore (1988) reported that DTPA-extractable Manganese in soils of Gwalior (M.P) was in the range of 1.6-23.6 ppm with a mean value of 6.9 ppm. Jalali *et al*. (1989) reported that available Manganese in soils of Kashmir decreased with depth.

Arora *et al*. (1989) observed that available Manganese ranged from 4.7-18.9 and 0.50-33.3 mg kg^{-1} in surface and sub-surface soils in peach orchards of Punjab, respectively. The available Manganese in apple orchards of Himahcal Pradesh ranged from 8.0 – 68.00 and 6.0-28.0 ppm in surface and subsurface soils, respectively (Sharma and Bhandari, 1992). Kanthaliya and Saxena (1992) observed that available Manganese insemi arid soils of Rajasthan varied from 4.4-23.6 ppm with a mean value of 11.61 ppm. Upadhayay and Awasthi (1993) while working on leaf nutrient ranges of apple trees in Himachal Pradesh observed that the DTPA-extractable Manganese content of apple orchard soils of Himachal Pradesh ranged between 30.1-42.8 ppm with a mean value of 36.4 ppm. The DTPA-extractable Manganese in apple orchard soils of Kashmir varied from 19.30-28.9 ppm (Mushki, 1994). Tripathi *et al* (1994) reported that avaialble Manganese with an average value of 29.0 mg kg^{-1} soil did not show any specific distribution trend with depth. Wani (1994) observed that DTPA-extractable Manganese in saffron growing soils of Kashmir varied from 2.0-78.0 and 0.95-

36.7 ppm with mean value of 17.88 and 9.81 ppm in surface and subsurface layers, respectively.

Basso and Williams (1988) while working on nutritional status of apple orchards of Brazil observed that most of the soils were having normal range of Manganese content.

Dar (1996) reported that the DTPA-extractable Manganese in cherry orchard soils of Srinagar district varied from 10.7-61.0 ppm. Khan *et al* (1997) observed that Manganese content in bench mark soils of Bangladesh ranged from 7.0-79.0 mg kg^{-1} of soil. Mamgain *et al.* (1998) observed that the DTPA-extractable Manganese ranged between 13.5-26.9 ppm with a mean of 22.1 ppm in soils of Himachal Pradesh.

2.1.10 Iron

According to Rawat and Mathpal (1981) the available Iron in hill soils of Utter Pradesh ranged from 0.4-8.40 ppm with a mean value of 3.20 ppm. A range of 9.0-84.0 and 2.2-62.5 ppm with mean value of 42.0 and 21.3 ppm in surface and sub-surface soils of apple orchards in Himachal Pradesh was observed by Bhandari and Randhawa (1985). Sakal *et al*. (1985) observed a range of 1.4-19.0 ppm of available Iron in calcareous soils of Bihar. Arora *et al*. (1989) reported that available Fe varied from 4.5 –17.0 and 4.3-17.2 mg kg^{-1} soil in surface and sub-surface soils of peach orchards in Punjab, respectively. Rana *et al*. (1984) observed that only 2.2 per cent orchard soils in Himachal Pradesh were showing sufficient index for DTPA-extractable Iron. Jalali *et al.* (1989) observed that available Fe generally decreased with depth and was higher in high altitudes and valley basin soils than in karewa soils and the range was 24-124, 6-116 and 3-21 ppm, respectively. Kulkarni and Vasuki (1991) reported that DTPA-extractable

Iron ranged from 2.8-6.0 ppm in surface soils of Karnataka. The DTPA-extractable Iron content in calcareous soils of Bihar ranged from 3.1-36.4 ppm with a mean value of 8.3 ppm (Prasad and Sakal, 1991). Kanthaliya and Saxena (1992) reported that available Iron insemi arid soils of Rajasthan varied from 2.4-11.0 ppm. Sharma and Bhandari (1992) reported that available Iron varied from 22.6-18.0 and 12.8-84.5 ppm in surface and subsurface soils of apple orchards of Himahcal Pradesh, respectively. Tripathi *et al*. (1994) found that the content of DTPA-extractable Iron decreased with the soil depth and ranged from 6.2-41.2 mg kg^{-1} soil in Himachal Pradesh soils.Wani (1994) found that available Iron in surface soils of saffron growing areas of Kashmir was in the range of 8.0-72.0 ppm with a mean value of 23.0 ppm, where as in subsurface soils it varied from 6.0-37.0 ppm with a mean value of 16.0 ppm.Dar (1996) while working on nutrient status of cherry orchard soils of district Srinagar found that the DTPA-extractable Iron in these orchards ranged from 9.9-57.4 ppm.Mamgain *et al*. (1998) while working on relationship between the fruit yield and nutrients found that the DTPA-extractable Iron in Himachal Pradesh soils ranged from 16.8-34.9 ppm with a mean value of 22.3 ppm.

2.2 Physio-chemical properties of soils

2.2.1 Mechanical composition of soils

Mechanical composition is important for assessing the nutrient supplying power of the soil as well as its potential to supply water and air to the plants (Dar, 1996). The texture determines the magnitude of surface on which the reaction can occur (Foth and Turk, 1973). Mahapatra *et al*. (2000) observed that the sub humid soils of Kashmir region vary greatly in texture from loamy skeltal (mostly on steep slopes) to silty clay loam and clay loam (in plains and karewas). Nayak *et al.* (1999) reported that there is increase in the clay content in the lower horizons of the profiles. Ray *et al.* (1997) observed that in soil profiles of east Godhawari and Karim-Nagar districts of Andra Pradesh the clay content was erratic in its down ward destribution. Sarkar *et al.* (1997) reported that the clay content of higher altitudes of eastern Ghat area of Orissa ranged from 34.3- 65.2 per cent and from 12.1-43.1 per cent in lower altitude soils. Elahi *et al.* (1996) reported that in soils of Madhupur in Bangladesh the clay content varied from 25.9-61.5 per cent. Bhaskar and Subbaiah (1995) reported that the soils of Nillore district are light in texture and clay content increase in sub surface horizons in all the soils except in Allimadugu soils which has uniform loamy texture throughout the depth. Handoo (1983) reported that the dominant soil texture Kashmir soils ranged from clay loam to silty clay loam.

The texture of almond orchard soils of Kashmir ranged from clay loam to silty clay loam and the clay content was in the range of 25.0-32.0 and 24.5-39.5 per cent with mean value of 28.33 and 32.67 per cent in surface and subsurface layers respectively with an erratic distribution with depth (Mir, 1994). Mushki (1994) reported that texture of apple orchard soils of Kashmir valley ranged from silt loam to clay loam, while peer (1994) observed texture of soils of Kashmir as loam to clay loam. Dar (1996) reported that the texture of cherry orchard soils of Srinagar district ranged between loamy and silty clay loam. The texture of apple orchard soils in Himachal Pradesh was reported in the range of sandy loam to clay loam (Sharma and Bhandari; 1992). In apple orchard soils of Anantnag district of Kashmir the clay content was observed in the range of 30-39 percent (Ganai *et al.* 1982).

2.2.2 Soil reaction (pH)

The pH of the soil being an important physio-chemcial characteristic, influences the suitability of a soil for crop production, availability of nutrients, microbial activity and soil physical properties like structure and permeability etc. Minhas and Singh (1980) reported that soil pH varied from 5.5-8.5 in Kinnuar district, 6.3-7.3 in Lahulspiti of Himachal Pradesh and around 8.5 in Ladakh district of Jammu and Kashmir. The soil pH varied from 6.3-7.5 in some Bench mark soils of Kashmir. Jalali *et al*. (1989). A pH range of 7.2-8.5 in Kinnuar district was observed by Singh and Bhandari (1989), while as in soils of Madhya Pradesh a pH range of 6.0 -8.0 was reported by Dhar *et al*. (1989). Verma *et al*. (1990) observed that pH in the surface soils of Kashmir valley was 5.6- 6.0 with a slight increase in sub-horizons in Duksam and Yus locations. Wallia and Roa (1996) reported tendency of pH to increase with depth.

2.2.3 Calcium carbonate

Calcium carbonate in the soil affects the soil reaction thereby affecting the availability of plant nutrients. Gupta *et al*. (1980) reported 6.0-8.0 per cent calcium carbonate in the soils of Jammu and Kashmir. Hadwani *et al*. (1989) reported that Calcium carbonate content varied from 2.0-74.0 and 5.0-34.5 percent in some soils of Junagrah and Rajkot respectively. They also observed regular decrease with depth in some soil profiles, while in other profiles such trend was not observed. Prakash and Singh (1985) reported that in alluvial soils of western Uttar Pradesh Calcium Carbonate ranged from 7.9-9.3 and 8.0-9.2 per cent in surface and subsurface soils respectively, while in northern Himalayan soils Calcium carbonate ranged from 0.08-5.18 per cent. Sharma *et al*. (1997) reported that the Calcium Carbonate content varied from 2.0 -151.0 g kg^{-1} in some Entisols of

Gwalior district of Madhya Pradesh. Singh *et al*. (2000) reported that upland soils have no free calcium carbonate while it ranged from 2.8-8.2 per cent in low land soils of Soan basin (Bihar).

2.2.4 Electrical conductivity

Soils generally differ in their salt content which affects their ability to grow crops. excess salts interfere with water and nutrient up take. Arora *et al*. (1989) reported that Electrical conductivity of the surface layer ranged from 0.2-0.4 dSm^{-1} and that of the sub-surface layers also ranged from 0.2-0.4 dSm^{-1} in peach orchard soils of Punjab. Dar (1996) while working on cherry orchards of Kashmir reported that Electrical conductivity of the surface soils ranged from 0.11-0.48 dSm^{-1} with a mean value of 0.24 dSm^{-1} and in sub-surface soils it varied from 0.08-0.36 dSm^{-1} with a mean value of 0.17 dSm^{-1} having an erratic trend with increase in soil depth. Maji and Bandyopadhyay (1996) reported Electrical conductivity value of 0.30-0.45 dSm^{-1} in some profiles of coastal soils of Balasore, Orissa. Tripathi *et al*. (1997) reported that Electrical conductivity ranged from 0.11-0.53 dSm^{-1} in some grapevine orchards of Haryana State. Anantwar *et al*. (2000) reported that Electrical conductivity ranged from 0.25- 0.43 and 0.20-0.45 in soils of basaltic plateau of Wardha district Maharashtra.

Mir (1994) reported that the Electrical conductivity of surface soils varied from 0.14-0.35 with a mean value of 0.21 dSm^{-1} where as in subsurface soils it varied from 0.1 – 0.36 with a mean value of 0.18 dSm^{-1} in almond orchards of Kashmir. According to Wani (1994) the Electrical conductivity in surface and subsurface layers of saffron growing soils of Kashmir was in the ranged of 0.09 – 0.32 and 0.09-0.32 dSm^{-1} with a mean value of 0.16 and 0.16 dSm^{-1} respectively. Mushki (1994) observed that the Electrical conductivity ranged from 0.15 –0.39 and 0.10 – 0.43 in surface and subsurface layers of apple orchard soils of Kashmir, respectively. Ganai *et al*. (1982) reported that the Electrical conductivity of apple orchard soils of Anantnag district of Kashmir valley was in the range of 0.10-0.15 m mhos per cm in surface layers and 0.10-0.14 m mhos per cm in subsurface layers.

2.2.5 Organic carbon

According to Paul and Clark (1989) the stability of soil aggregates, release of essential nutrients for plant growth, maintenance of soil microbial dynamics and biochemcial changes in the soil are attributed to the organic matter content of the soil. Brady (2002) also observed that it serves as an index of soil productivity and accounts for one third of CEC of soil. The variation in soil organic carbon content is due to variable organic mater composition and its variable rates of decomposition which inturn is influenced by climate, vegetation, nature and management of soil, kind of organic residues added and drainage conditions (Foth and Turk, 1973). Gupta *et al*. (1980) reported that percentage of organic carbon varied from 0.28-4.18 per cent under different climatic conditions of Jammu and Kashmir state. The organic carbon content was estimated to vary from 1.80 -2.50 per cent in some soils of Kinnuar district of Himachal Pradesh (Singh and Bhandari, 1989). Vadivelu and Bandyopadhyay (1997) reported that organic carbon content ranged between 6.0-20.1 g kg^{-1} in soils of Minicoy Island, Lakshadweep. Ganai *et al*. (1999) reported that organic carbon varied from 0.6 - 1.6 per cent in surface soils of almond orchard of Kashmir valley.

Mushki (1994) reproted that organic carbon content in apple orchard soils of Kashmir ranged from 0.90-3.18 and 0.15-2.16 per cent in surface and subsurface layers, respectively. According to Wani (1994), the organic carbon content in surface and subsurface layers of saffron growing soils of Kashmir ranged from 0.18-0.87 and 0.15-0.54 per cent with mean value of 0.59 and 0.36

per cent, respectively. Ganai *et al*. (1991) observed that organic carbon content in cherry orchard soils of Kashmir ranged from 0.68-1.12 per cent. Kaista *et al.* (1990) reported that the percentage of organic carbon in north western Himalayan soils was in the range of 0.14-3.47 per cent. Arora *et al.* (1989) observed that the organic carbon content in surface layer of peach orchard soils of Punjab was in the range of 0.90 – 0.60 per cent, while as in subsurface layers it was in the range of 0.10 – 0.90 per cent. Bhandari and Randhawa (1985) observed that the organic carbon content of surface and subsurface soils of apple orchards of Simla hills (H.P) was in the range of 0.6-5.0 and 0.2-3.6 per cent respectively. Handoo (1983) reported that the organic carbon content varied fom 0.45-4.83 per cent in Kashmir valley soils with high content in surface horizons. According to Ganai *et al*. (1982) the organic carbon content of the apple orchard soils of Anantnag district of Kashmir was in the range of 0.93-0.98 percent in surface layers and 0.48-0.86 per cent in subsurface layers with regular decrease with soil depth. Rawat and Mathpal (1981) reported that the organic carbon content in hill soils of Uttar Pradesh was found in the range of 0.25-2.12 per cent.

2.2.6 Cation exchange capacity

The cation exchange studies are helpful in soil classification and to know the nutrient status of the soil. The value of CEC vary according to type and amount of the soil colloid present, pH and organic matter content of the soil (Tan, 1982). The CEC of Kashmir soils vary from 20.0 to 33.0 meq/100 g soil Gupta *et al*. (1980) and Handoo (1983). Slightly lower value of 7.1-9.2 meq/100 g soil in some pedons of Kashmir were noticed by Verma *et al*. (1990). They contributed it to formation of chelated compounds of calcium ions with organic acids, thereby reducing the amount of exchangeable ions in the soil. The CEC of 10.9-35.8 C moles kg^{-1} was reported by Singh *et al*. (1991) and Gupta and Tripathi (1992) in mid altitude soils of Kangra and solan districts of Himachal Pradesh, respectively. Higher value of CEC in surface layers were observed which decreased with depth (More *et al*., 1988) and Sahu *et al.* (1990) but Verma *et al*. (1990) reported no relation of CEC with depth and observed an increase in CEC with increase in altitude.

2.3 Relationship of available nutrients with physio-chemical properties

It has been reported by many workers that organic carbon bears a significant influence on various soil properties. Rahul and Paliwal (1978) reported a negatively significant relationship between Sulphur and Organic carbon. Gupta *et al*. (1987) recorded highly negatively significant correlation between organic carbon and available Nitrogen, Phosphorus and Potassium in soils of Rajouri district of Jammu region.

Singh (1987) and Kumar (1987) observed a negatively significant and positive correlation of organic carbon with phosphorus and potassium, respectively.

Khan *et al*. (1997) obtained a positively non-significant correlation between organic carbon and micronutrients . Jassal *et al*. (2000) did not found any significant correlation of organic carbon with Calcium and Magnesium.

Raina (1988) observed negatively and significant correlation between pH and available Potassium, whereas correlation between pH and available Phosphorus was of lower order.

A large number of workers have found a positively significant relationship between micronutrient cations viz. Zinc, Copper, Maganese and Iron with pH (Jalali *et al.*, 1989; Gupta and Srivastava, 1990).

Khan *et al.* (1997) observed a positively significant relationship between soil pH and available micronutrient cations. Available phosphorus was found significantly and negatively correlated with soil pH (Yaresheemi *et al.* 1998). Jalali *et al*. (1989) reported that available Zinc, Copper, Maganese and Iron exhibited a negative relationship with Calcium carbonate content of soil. Mir (1994) reported a negatively significant correlation between Calcium carbonate and available Nitrogen, Phosphorus and Potassium. Khan *et al*. (1997) observed a positively non-significant relationship between Calcium carbonate and available micronutrient cations. Available Calcium and Magnesium exhibited a positively significant correlation with calcium carbonate (Jassal *et al*. 2000).

Sharma *et al.* (2000) reported a positively significant relationship between soil calcium carbonate and available Sulphur.

Jalali *et al*. (1989) observed that clay content had negative relationship with available Zinc, Copper, Manganese and Iron in valley basin soils, while positive relationship was observed in Karewa and high altitude soils.

Singh and Ahuja (1990) observed a positive relationship between clay content of soil and available Nitrogen, Phosphorus and Potassium contents.

Misra *et al.* (1990) found that available Sulphur had positively significant correlation with clay content in mixed red yellow soils and negative relationship with clay content in brown forest soils.

Sharma *et al*. (2000) showed a positively non-significant correlation between clay content and available Sulphur in soil.

2.4 Leaf nutrient status of apple orchards

2.4.1 Nitrogen

Bhandari and Sharma (1981) reported that the apple orchards of Shimla hills are adequately supplied with Nitrogen. The Nitrogen content of mid terminal shoot leaves of Red delicious, starking Delicious and Golden Delicious cultivars was reported to vary from 1.6 - 2.76, 18.82 - 2.76 and 1.78 - 2.80 with mean value of 2.41, 2.41 and 2.34 per cent, respectively.Basso and Wilms (1988) while establishing the nutrient status of apple orchard in Southern Brazil found leaf Nitrogen content "above normal" or "excess" attributing it to annual application of this nutrient and natural release by soil. Basso *et al*. (1990) reported that the leaf Nitrogen content varied from 2.10 - 3.19 per cent in apple leaves. Verma and Singh (1990) while studying the seasonal changes in nutrient composition of Golden Delicious apple leaves reported that Nitrogen content was 2.30 per cent in August at Mashobra, Shimla (H.P).Goh and Malakouthi (1992) while working DRIS norms and indices for apple orchards in Canterbury, New Zealand found 2.22 per cent as mean value of leaf Nitrogen with higher concentration in leaf Nitrogen due to biological Nitrogen fixation by Rhizobia legumes present in the vegetation of grass alleys of orchards.Verma and Singh (1993) while studying the nutrient status of Red Delicious cultivar at Bajaura, Kulu (H.P) reported that leaf with petiole showed intermediate Nitrogen content of 2.5 percent.Singh and Bhandari (1992) reported leaf Nitrogen content in apple orchards of Himachal Pradesh ranged from 1.44 - 2.64, 1.44 - 2.40, 1.44- 2.72 with mean value of 2.01, 2.00, 1.79 in Royal Delicious, Red Delicious and Golden Delicious. Nitrogen status of apple leaves ranged from 2.46 - 2.65 with mean value of 2.56

(Upadhayay and Awasthi, 1993). Sharma and Bhandari (1995) revealed a range at Nitrogen content 1.92 - 2.62, 1.73 - 2.52 and 1.68 - 2.58 with corresponding mean value of 2.29, 2.25 and 2.18 in Red Delicious, Royal Delicious and Golden Delicious apple orchards of Himachal Pradesh.

Awasthi *et al*. (1998) reported that Nitrogen status of apple leaves ranged from 111.3 - 173.6 with mean value of 134.1 ppm. Mamgain *et al*. (1998) reported that Nitrogen status in apple leaves ranged from 2.10 - 2.40 percent with mean value of 2.26 percent in Rajgarh area of Himachal Pradesh. Jovanovic *et al*. (1998) noticed that the leaf Nitrogen content in apple orchards of Yugoslavia varied between 2.28-2.53 per cent. Sinha *et al*. (1998) reported that the optimum standard value for leaf Nitrogen is 2.70 percent. Dris and Niskanin (1998) reported that leaf Nitrogen content in the apple orchard of Finland ranged from 14.6 – 23.1 kg^{-1}. Veleais *et al*. (1998) observed that the sufficiency range of leaf Nitrogen related to yield was 2.00-3.00 per cent.

2.4.2 Phosphorus

The Phosphorus content of mid terminal shoot leave of Red Delicious, starking Delicious and Golden Delicious apple cultivars was reported to vary from 0.12 - 0.45, 0.14 - 0.49 and 0.12 - 0.50 per cent with mean value of 0.21, 0.20 and 0.18 per cent, respectively in some orchards of Shimla district of Himachal Pradesh. (Sharma and Bhandari, 1995). Sharma *et al*. (1982) observed in apple orchards of Kulu district that the leaf Phosphorus content in three cultivars viz. Red Delicious, Royal Delicious and Golden Delicious except of few orchards ranged from 0.09 - 0.26 per cent. Rana *et al*. (1984) reported that leaf Phosphorus content in apple orchards of Himachal Pradesh ranged from 0.07 - 0.38 per cent. Haynes (1990) while examining the nutrient status of apple orchards in canterbury, New Zealand found that leaf Phosphorus content varied from 0.17 - 0.23 per cent and 0.15 - 0.24 per cent in Cox's orange and Braeburn cultivars,respectively. Rawat and Ranvir (1991) while studying the nutrient status of leaf samples of different sizes in Nanital, U.P; reported that a sample of minimum thirty leaves will be appropriate and observed the Phosphorus content ranged from 0.20 per cent in Red Delicious apple trees. Goh and malakouti (1992) while studying the DRIS norms and indices of apple orchards in New Zealand observed leaf Phosphorus in the sufficiency range (0.19%) indicating adequate level for apple trees. The Phosphorus content of mid terminal shoot leaves of current seasons growth was observed to vary from 0.13 – 0.26 per cent in apple orchards of Mandi district of Himachal Pradesh (Sharma and Bhandari; 1992). Bhandari and Sharma (1995) reported that Phosphorus content of mid terminal leaves of Red Delicious, Royal Delicious and Golden Delicious apple ranged from 0.2-0.4, 0.16-0.30 and 0.19-0.4 per cent, respectively in soils of Sirmour district of Himahcal Pradesh. Verma and Kulbir Singh (1990) while studying the seasonal changes in nutrient composition of Golden Delicious apple leaves reported that Phosphorus content in apple leaves was 0.19 per cent. Dris and Niskanen (1998) observed a mean value of 0.22 per cent of leaf Phosphorus content in apple orchard of A land Islands. Awasthi *et al*. (1998) while studying mineral nutrient status of apple orchards in Shimla district of Himachal Pradesh reported that the Phosphorus content of leaves ranged from 0.30-0.58 per cent with mean value of 0.47 percent. Awasthi *et al* (1999) reported the Phosphorus content in peach orchards of Sirmour district of Himachal Pradesh ranged from 0.42 - 0.70 per cent with mean value of 0.55 per cent.

2.4.3 Potassium

Morgan and Henneaty (1979) while studying the Golden Delicious apple orchards of Ireland observed leaf Potassium content varied from 1.4 - 1.9 per cent. Haynes (1990) assessed the leaf Potassium content varied from 0.09 - 1.90 and 0.60 - 1.80 per cent with mean of 1.30 and 1.20 per cent in Cox's orange and Braeburn apple cultivars, respectively. Verma and Kulbir Singh (1990) while studying the seasonal changes in nutrient composition of Golden Delicious apple leaves, reported that the Potassium content was 1.22 per cent at Mashobrra, Shimla (U.P). Failla *et al*. (1990) reported a range of Potassium content from 1.61-1.89 per cent in medium vigorous shoot leaves of current seasons growth in Italy. Rawat and Ranvir (1991) while studying the nutrient status of leaf samples of different sizes in nanital, U.P. reported Potassium content of 1.43 per cent in Red Delicious apple trees.Singh and Bhandari (1992) while studying the leaf nutrient status of apple leaves of Kinnuar district reported that Potassium content ranged from 0.59 - 1.87, 0.67 - 1.85 and 0.70 - 1.80 in Royal Delcious, Red Delicious and Golden Delicious, respectively.Sharma and Bhandari (1992) reported that Potassium content in three cultivars viz. Red, Royal and Golden Delicious in Mandi district of Himachal Pradesh ranged from 1.08 - 1.90, 0.95 - 1.85 and 0.98 - 1.80 per cent with mean value of 1.48, 1.38 and 1.34 per cent, respectively. Upadhayay and Awasthi (1993) reported that in apple leaves Potassium content ranged from 1.36-1.74 per cent with mean value of 1.62 per cent. Muskhi (1994) reported that Potassium content of Ambri, Maharaji and Red Delicious apple cultivars ranged from 1.30 - 2.40, 0.96 -1.80 and 1.30 - 2.50 percent, respectively with mean value of 1.59, 1.43 and 1.55 per cent in Kashmir valley. Mamgain *et al*. (1998) reported that Potassium content in apple leaves ranged from 1.20 - 1.65 per cent with mean value of 1.47 per cent in Rajgarh area of Himachal Pradesh.

Awasthi *et al*. (1998) while studying the mineral nutrient status of apple orchards in Shimla district of Himachal Pradesh reported that the potassium content in apple leaves varied from 1.20 -1.9 with a mean value of 1.6 per cent.

2.4.4 Calcium

Sharma *et al*. (1982) while studying the nutrient status of apple orchards in Kulu valley of Himachal Pradesh found Calcium content of leaves varied from 0.90 -1.62 per cent in all the cultivars viz. Royal Delicious, Red Delicious and Golden Delicious. Basso and Wilms (1988) while assessing the nutritional status of apple orchards in southern Brazil reported the percentage of samples with insufficient levels of calcium was more than 75 per cent. Haynes (1990) found calcium status of Cox's orange and Breaburn apple cultivars in centerbury ranged from 0.73 -1.5 and 0.92-2.1 per cent with a mean value of 1.1 and 1.3 per cent, respectively.

Singh and Bhandari (1992) while studying the nutriational status of apple orchards of kinnaur district of Himachal Pradesh found Calcium content of leaves ranged from 1.10 -2.02 per cent , 1.11 - 2.06 and 1.16-2.10 with mean value of 1.04, 1.43 and 1.47 in Royal Delicious, Red Delicious and Golden Delicious cultivars, respectively. Upadhayay and Awasthi (1993) have reported that leaf Calcium content in starking Delicious cultivars varied from 1.27-1.42 per cent with a mean value of 1.35 per cent. Atkinson *et al*. (1995) while studying the concentration of Calcium in spur and extension leaves of Cox's orange pippin reported a range of 1.87-1.98 and 0.82-1.00 per cent, respectively Awasthi *et al*. (1998) reported the leaf Calcium content in apple orchards of Himachal Pradesh ranged from 1.50 - 2.20 with mean value of 1.9 per cent. The Calcium content of

1.37 per cent in Royal delicious apple orchards of Rajgarh area of Himachal Pradesh was reported by Mamgain *et al*. (1998).

2.4.5 Magnesium

Sharma *et al*. (1982) reported that the Magnesium content varied from 0.57-0.75 per cent in the leaves of Red Delicious, Royal Delicious and Golden Delicious cultivars in apple orchards of Kulu valley of Himachal Pradesh. Haynes (1990) reported in cox's orange and Braebrum cultivars of apple trees in canterbury, New Zealand leaf Magnesium varied from 0.21 -0.43 and 0.21 -0.48 per cent with mean value of 0.32 and 0.37 per cent, respectively. Rawat and Ranvir (1991) while studying the nutrient status of leaf samples observed that the Magnesium content ranged from 0.60-0.65 per cent in Red Delicious apple cultivars. Upadhayay and Awasthi (1993) reported an optimum range of Magnesium 0.41-0.62 per cent in plus starking Delicious apple tree. Mervin and Warren (1994) while studying the “Empire” and “Jonagold” cultivars on MM-111 root stock reported that Magnesium content of these cultivars ranged from 0.32-0.38 per cent. Atkinson *et al*. (1995) reported that Magnesium content in Cox's orange ranged from 0.16-0.22 per cent. Sharma and Bhandari (1995) revealed that Magnesium content ranged from 0.27-0.45, 0.27-0.41 and 0.30- 0.45 with mean value of 0.35, 0.33 and 0.36 per cent in Red Delicious, Royal Delicious and Golden Delicious cultivars of apple orchards of Himachal Pradesh, respectively. Mamgain *et al*. (1998) while studying the nutrient status of apple orchards of Rajgarh area of Himachal Predesh reported a Magnesium content of 0.317 per cent in Royal Delicious apple cultivars. Awasthi *et al*. (1998) reported that the Magnesium content in the leaves of apple orchards of Shimla district of Himachal Predash ranged from 0.34 – 0.44 per cent with a mean value of 0.39 per cent.

2.4.6 Sulphur

Shear and Foust (1980) reported that normal range of Sulphur in the leaves of cherry was in the range of 0.13-0.84.

Badyal and Kar (1984) reported the Sulphur content in the laves of plum cultivar Santa Rosa was in the range of 0.19-0.35 per cent. Singh (1987) reported that leaf Sulphur content of apple orchards of kinnaur district in Red , Royal and Golden Delicious cultivars varied from 8-45, 6-43 and 11-78 ppm, respectively.

Sulphur content of mid terminal shoot leaves of Red, Starking and Golden Delicious cultivars varied from 0.04 - 0.20, 0.04 -0.21 and 0.02 -0.20 per cent with mean value of 0.13, 0.14 and 0.10 per cent, respectively (Bhandari and Sharma 1981). Singh and Bhandari (1992) reported that in apple orchards of Kinuar district of Himachal Pradesh the leaf Sulphur content ranged from 0.20 -0.68, 0.19 - 0.69 and 0.18 to 0.78 in Royal Delicious, Red Delicious and Golden Delicious cultivars of apple, respectively. Awasthi (1993) reported that the value of leaf Sulphur in apple orchards of Himahcal Pradesh varied between 0.11 - 0.69 per cent. Sharma and Bhandari (1995) while assessing the nutritional status of apple orchards of Sirmour district of Himachal Pradesh reported that the leaf Sulphur ranged from 0.13 - 0.26, 0.12 - 0.22 and 0.12 - 0.23 with mean values of 0.26, 0.17 and 0.18 per cent in Red Delicious, Royal Delicious and Golden Delicious cultivars, respectively. Kumar and Singh (1995) found that foliar concentration of Sulphur in apple orchards of Kumaon hills was optimum.

2.4.7 Zinc

Haynes (1990) observed a range of 14 - 117 and 53 - 90 ppm of Zinc with mean values of 63 and 58 ppm for Cox’s orange and Braebum apple cultivars in Canterbury, New Zealand. Upadhayay and Awasthi (1993) reported that Zinc content of starking Delicious apple leaves varied from 28.6 -45.6 ppm. Awasthi (1993) reported that the values of leaf Sulphur in apple orchards of Himachal Pradesh varied from 28.5 - 45.1 ppm in mid terminal shoot leaves of plus starking Delicious apple cultivars. Sharma and Bhandari (1995) while studying the nutritional status of Red, Royal and Golden Delicious apple cultivars reported that the Zinc content in apple leaves of these cultivars ranged from 12-40, 20 -30 and 16 -44 ppm with mean values of 31.4, 26.0 and 27.5 ppm, respectively. Mamgain *et al*. (1998) while studying the nutritional status of apple orchards of Himachal Pradesh reported that Zinc content in apple leaves ranged from 20.1- 25.4 ppm.

2.4.8 Copper

Upadhayay and Awasthi (1993) assessed and reported that the leaf Copper content in starking Delicious varied from 17.5 - 23.8 ppm with a mean value of 20.5 ppm. Mervin and warren (1994) reported that the Copper content in apple leaves varied from 4.3 – 5.4 ppm. Mushki (1994) observed the leaf Copper content in Ambri, Maharaji and Red Delicious cultivars ranged between 7.0 -17.0, 7.0 - 12.0 and 4.0 -11.0 ppm with a mean value of 11.2, 8.2 and 6.7 ppm, respectively. Singh and Bhandari (1992) while working with the nutrient status of apple orchards reported that the foliar content of Copper in Royal, Red and Golden Delicious cultivars ranged from 3.9-13.6, 3.9-13.9 and 3.1-10.7 ppm with the corresponding mean values of 8.4, 8.2 and 7.1 ppm. Sharma and Bhandari (1995) reported that the Copper content in apple leaves of Red, Royal and Golden Delicious ranged from 10-22, 10-24 and 12 -21 ppm with mean values of 14.7, 17.5 and 15.9 ppm, respectively. Mamgain *et al*. (1998) while studying the relationship between fruit yield and nutrients reported that the Copper content of leaves ranged from 7.90 -10.50 ppm with mean value of 9.86 ppm.

2.4.9 Manganese

Mervan and Warren (1994) while working with apple orchards at Ithaca, New York found that Manganese content in apple leaves varied from 137-179 ppm. Atkinson *et al*. (1995) found that in Cox's orange the spur leaf Manganese content varied from 44 - 229 per cent. Sharma and Bhandari (1995) reported that Manganese content of Red, Royal and Golden Delicious ranged from 42 -88, 36 - 96 and 40-82 ppm, respectively. Kumar and Singh (1995) while studying the nutrient content of apple orchards of Kumaon hills in Utter Pradesh noticed that most of the orchards were optimum in foliar concentration of Manganese. Mamgain *et al*. (1998) while studying the relationship between fruit yield and nutrients found that Manganese content of apple leaves varied from 45.3 to 56.0 ppm with a mean value of 51.0 ppm. Guleryuz *et al*. (1998) indicated that manganese content in the leaves of starking Delicious were inadequate while working with the apple orchards of Erzinean plain.

2.4.10 Iron

Sharma *et al*. (1982) while surveying the nutrient status of apple orchard in Kulu district of Himachal Pradesh reported that Iron content in apple leaves varied from 114.17-202.50 ppm, 143.95-267.50 ppm in Red and Golden Delicious, respectively. Upadhayay and Awasthi (1993) while working on nutritional status of apple orchards in Himachal Pradesh revealed that Iron content of apple leaves varied from 353-484 ppm in starking Delicious with mean value of 416 ppm. Sharma and Bhandari (1995) reported that Iron content of apple leaves of Himachal Pradesh apple orchards ranged from 280 to 560ppm, 170-460 ppm and 240 - 480 ppm with the mean values of 377.1, 334.8 and 344.8 ppm in Red, Royal and Golden Delicious cultivars, respectively. Mamgain *et al*. (1998) reported that in apple orchards of Himachal Pradesh leaf Iron content ranged from 192-253 ppm with a mean value of 218 ppm.

2.5 Relationship between available and leaf nutrient contents

2.5.1 Nitrogen

Morgan and Hennerty (1979) reported poor relationship between leaf Nitrogen and soil Nitrogen in Golden Delicious apple orchards of Ireland. In a long term studies in the forest stepple zone of Ukrainian trees growing on cherno-podzolic sandy soils was directly correlated with available Nitrogen in soil. But no such correlation was noted in trees growing on fertile chernozem soils (Rybin *et al*., 1979). Stoilov and Vitanov (1979) observed that application of increasing rates of Nitrogen alone increased Nitrogen content of leaves of plum. Meland (1982) reported that for van cultivation of sweet cheery correlations were found between soils and fruit content of Nitrogen and Potassium. Nitrogen content of the leaves of schattenmorelle cultivars of sour cherry increased with increasing Nitrogen supply (Matzner and Maurer, 1982). Magnani *et al*. (1984) have reported that Nitrogen content in leaves of peach trees was directly correlated with application of fertilizer rates. A positively significant correlation between soil and leaf Nitrogen was observed in apple orchards of Kinuar district of Himachal Pradesh by Singh (1987).

Misgar (1992) revealed a positively significant correlation between soil and leaf Nitrogen in Ambri apple orchards of Pulwama district of Jammu and Kashmir.

Singh and Bhandari (1992) observed that in case of Royal Delicious nitrogen from surface layers was significantly and positively correlated with its respective content in leaves. Mushki (1994) observed that Nitrogen content in the leaves of Ambri, Maharaji and Red Delicious cultivars did not bear any significant correlation for any of the soil depths.

Narboo (1994) observed positive relationship between soil and leaf Nitrogen in apricot orchards of Kargil district of Jammu and Kashmir.

Mir (1994) studied that a positively significant relationship existed between soil and leaf Nitrogen in almond orchards of Kashmir valley.

In a long term studies in Himahcal Pradesh for nutrient status in apple orchards, it was found that leaf Nitrogen and soil Nitrogen were directly correlated with each other (r=0.67) Awasthi *et al*. (1998).

Awasthi *et al*. (1999) observed a positively significant correlation of available Nitrogen with leaf Nitrogen in apple orchards of Sirmour district of Himachal Pradesh.

Wani, G.N. (2001) while studying the distribution of secondary nutrient elements in apple orchard soils of North Kashmir revealed that there was a positively significant correlation between leaf Nitrogen content of Red Delicious, Maharaji and American appirouge cultivars and available Nitrogen.

Bhat (2001) observed that the Nitrogen content in the leaves of three cultivars of apple viz. Golden Delicious, Starcrimson and cooper-4, showed a positively significant correlation with available Nitrogen content.

2.5.2 Phosphorus

Singh (1987) revealed a positively significant correlation between soil and leaf Phosphorus for Royal Delicious and Golden Delicious cultivars while Red Delicious cultivar did not reveal any such relationship in apple orchards of Kinnuar district of Himachal Pradesh. Walker and Mason (1960) have observed a positively significant correlation between soil and leaf Phosphorus. Misgar (1992) observed non-significant relationship between soil and leaf Phosphorus content in Ambri apple orchards of Pulwama district of Jammu and Kashmir. Singh and Bhandari (1992) reported that the available soil Phosphorus from both surface and sub-surface soils was significantly and positively correlated with the phosphorus content in the leaves of Golden Delicious apple cultivar. A correlation coefficient value of (r=0.666) was observed between soil and leaf Phosphorus content in apricot by Narboo (1994). Mir (1994) observed a positively significant relationship between soil and leaf Phosphorus in almond orchards of Kashmir valley. Leaf Phosphorus of Ambri and Red Delicious cultivars of apple in Kashmir valley exhibited a positively significant correlation coefficient (r=0.81 and r=0.92) respectively for 0-20 cm soil depth, whereas Maharaji cultivar did not reveal any such significant relationship between leaf P and available soil Phosphorus (Mkushki, 1994). Awasthi *et al*. (1998) revealed a positively significant relationship of available soil Phosphorus with leaf Phosphorus in apple orchards of Shimla district of Hamachal Pradesh. Wani (2001) while studying the distribution of secondary nutrients in apple orchards soils of north Kashmir revealed that the Phosphorus content in the leaves of three cultivars of apple viz. Red Delicious, Maharaji and American appirouge showed non-significant correlation for both surface and surface available Phosphorus content. Bhat (2001) while studying the nutritional status of high density plantation of apple orchard soils of North Kashmir observed that the leaf Phosphorus content of Golden Delicious, Starcrimson and cooper-4, cultivars of apple showed positively significant relationship with surface phosphorus content, while as Phosphorus content of

Golden Delicious leaves exhibited a positive significant correlation with sub-surface soil Phosphorus.

2.5.3 Potassium

According to Stoilov and Marinov (1979) application of high rates of Potassium increased the Potassium content in the leaves of apricot.

David *et al*. (1959) while analyzing the nutritional status of apple orchards of North Carolina State observed statistically significant correlation between leaf potassium content and available soil Potassium content.

A significant correlation between exchangeable Potassium and leaf Potassium in peach orchards was observed by Kenworthy and Gilligon (1948).

Titus and Boynta (1953) have observed a significant correlation between soil and leaf Potassium in all horizons.

Walker and Mason (1960) have also reported a statistically significant correlation coefficient between soil and leaf Potassium content in apple.

Morgan and Henneaty (1979) observed a significant relationship between leaf Potassium and available Potassium in Golden Delicious orchards of Ireland.

Singh (1987) observed a positively significant correlation between soil and leaf Potassium in Royal Delicious cultivar while significant relationship did not exist between soil and leaf Potassium in Red Delicious and Golden Delicious cultivars of apple in Kinnuar district of Himachal Pradesh.

A positively significant relationship between soil and leaf Potassium was observed in Ambri apple orchards of Pulwama district of Jammu and Kashmir (Misgar, 1992). Singh and Bhandari (1992) revealed that in case of Royal Delicious leaf potassium exhibited a positively significant relationship with available soil potassium content.

The Potassium content in leaves of Ambri cultivar has shown positively significant correlation (r=0.81 and r=0.67) with available Potassium in 0-20 cm and 20-40 cm soil depths respectively, while a significant relationship could not be ascertained between available soil Potassium and leaf Potassium in case of Maharaji and Red Delicious cultivars of apple in Kashmir valley (Mushki, 1994).

Mir (1994) observed positively significant relationship between leaf Potassium and available Potassium in surface soils of almond orchards of Kashmir valley, while positively non-significant relationship was observed between leaf Potassium and available Potassium in subsurface layers.

Awasthi *et al.* (1998) observed positively significant correlation between available soil Potassium and leaf Potassium. Bhat (2001) revealed that the Potassium content in the leaves of Star crimson and cooper-4 cultivars of apple showed a positively significant relationship with the Potassium content in surface soils, while as Potassium content of Golden Delicious leaves exhibited a positively significant correlation with subsurface soil Potassium. Wani (2001) while studying the distribution of secondary nutrients in the apple orchards of north Kashmir revealed that the leaf Potassium content in Red Delicious and Maharaji exhibited a positively significant correlation with soil available Potassium for 0-20 cm soil depth. However, leaf Potassium content in Maharaji and American appirouge also showed a positively significant correlation with respective available Potassium content for 80-100 cm soil depth, respectively.

2.5.4 Calcium

A positive correlation was observed between leaf Nitrogen and leaf Calcium as leaf Calcium increased with increasing rates of N in plum (Stoilov and Vitanov, 1979).

Neilson and Edwards (1982) observed a poor relationship between soil Calcium and leaf Calcium content in apple cultivar of Red Delicious and Mcintosh in Okangan apple orchards. Morgan and Hennerty (1979) have observed that available Calcium was poorly correlated with leaf Calcium in Red Delicious apple cultivars.

A positively significant relationship between soil and leaf Calcium has been observed for Royal Delicious, Red Delicious and Golden Delicious cultivars of apple orchards in Kinnuar district of Himachal Pradesh (Singh, 1987).

Haynes (1990) while working with apple orchards in canterbury New Zealand observed no significant correlation between soil and leaf Calcium.

Singh and Bhandari (1992) observed a positively significant correlation between available and leaf Calcium.

Sharma and Bhandari (1992) reported a positively significant relationship between soil and leaf Calcium in apple orchards of Himachal Pradesh.

Misgar (1992) observed a positively significant correlation between soil and leaf Calcium in Ambri apple orchards of Pulwama district of Jammu and Kashmir.

Narboo (1994) observed a positively significant correlation coefficient (r=0.958) between leaf calcium and available Calcium in apricot orchards of Kargil district of Jammu and Kashmir.

Mir (1994) found positively significant relationship between soil Calcium and leaf Calcium in almond orchards of Kashmir valley. The Calcium content in the leaves of Ambri cultivar exhibited a positively significant correlation coefficient of (r = 0.92), (r= 0.81) and (r=0.72) at 0-20, 20-40 and 40-60 cm soil depths, respectively, however no such relationship was observed in Maharaji and Red Delicious cultivars of apple in Kashmir Valley (Mushki, 1994).

Awasthi *et al*. (1998) while working on mineral nutrient status of apple orchards in Shimla district of Himachal Pradesh revealed a positively significantly positive relationship between available Calcium and leaf Calcium content.

Awasthi *et al*. (1999) reported a positively significant correlation of available Calcium with leaf Calciumin peach orchards. Wani (2001) while assessing the distribution of secondary nutrient in apple orchards of north Kashmir, concluded that the Calcium content in leaves of Red Delicious, Maharaji and American appirouge showed a positively significant correlation with available Calcium content up to the depth of 60 cm.

Bhat (2001) while studying the nutrient status of high density plantation of apple orchard soils of north Kashmir observed that the Calcium content in the leaves of Golden Delicious, Starcrimsor and cooper-4 bore a positively significant correlation with that of available Calcium content.

2.5.5 Magnesium

Neilson and Edwards (1982) observed a direct relationship between leaf and soil Magnesium content in the apple cultivars of Red Delicious and Mcintosh in Okangan apple orchards.

According to Singh (1987) a positively significant relationship between leaf and soil Magnesium was observed for Royal Delicious cultivar of apple in Kinuar district of Himahcal Pradesh, while Red Delicious and Golden Delicious cultivars did not show any such relationship for Magnesium.

Haynes (1990) have observed a positively significant relationship between leaf Magnesium and available soil Magnesium in Cox’s orange cultivar while in Braeburn it was not significant.

Sharma and Bhandari (1992) revealed a positively non-significant relationship between leaf Magnesium and available Magnesium in apple orchards of Himachal Pradesh.

Misgar (1992) observed a positive and positively significant correlation between soil and leaf Magnesium content in Ambri apple orchards of Pulwama district of Jammu and Kashmir.

A positively significant correlation coefficient (r=0.69) was observed in Ambri cultivar of apple for 0-20 cm soil depth in Kashmir valley, while Maharaji and Red Delicious cultivar did not exhibit any such positively significant relationship for soil Magnesium and leaf Magnesium contents (Mushki, 1994).

A positively significant correlation coefficient (r=0.66 and 0.53) between leaf Magnesium in thin shelled and medium shelled cultivars of almond and available Magnesium in surface soils was observed by Mir (1994).

Narboo (1994) studied negatively non-significant relationship between soil and leaf Magnesium in apricot orchards of Kargil district (J&K). Awasthi *et al.* (1998) found a positively significant relationship between foliar content of Magnesium and available soil Magnesium in apple orchard soils inshimla district of Himahcal Pradesh.. Awasthi *et al.* (1999) reported a significant positive relationship of soil Mg with leaf Mg in apple orchard soils of sirmour district of Himachal Pradesh.

Wani (2001) observed positively significant correlation between leaf Magnesium of Red Delicious, Maharaji and American appirouge cultivars of apple and available soil Magnesium content for surface soil (0-20 cm).

Bhat (2001) observed that the Magnesium content in leaves of Golden Delicious, starerimson and cooper-4 bore a positively significant relationship with the available Magnesium content up to 0-30 cm depth.

2.5.6 Sulphur

Singh (1987) observed a positively significant relationship between soil and leaf Sulphur for Royal Delicious cultivar of apple in Kinnuar district of Himachal Pradesh, while Red Delicious and Golden Delicious cultivars did not reveal such significant relationship.

Ludders (1990) found that high Potassium sulphate supply increased sulphate content of leaves of schattenmorelle sweet cherry on prunus Mahalib root stock.

Sharma and Bhandari (1992) revealed a positively significant relationship between leaf Sulphur and available Sulphur in surface soils of apple orchards of Himachal Pradesh, while non-significant correlation was shown between leaf and sub-surface soil Sulphur.

A positively significant relationship was found between available Sulphur and leaf Sulphur in Royal Delicious apple cultivar (Singh and Bhandari, 1992).

Dar (1996) observed a positively significant correlation between available Sulphur and leaf Sulphur content in cherry orchards of Kashmir.

Wani (2001) observed that Sulphur content in Red Delicious, Maharaji and American appirouge bore a positively significant correlation with available Sulphur content up to a soil depth of 60 cm.

Bhat (2001) revealed that Sulphur content in the leaves of Golden Delicious, Starcrimson and cooper-4 bore a positively significant correlation with the available Sulphur content of surface soils.

2.5.7 Zinc

Morgan and Hennerty (1979) reported a non-significant relation between foliar Zinc and Phosphorus levels indicating absence of Zinc-Phosphorus relationship in Golden Delicious apple orchards of Ireland.

A positively significant relationship between DTPA-extractable Zinc in soil and leaf Zinc was observed in apple orchards of Anantnag district (J&K) by Ganai *et al.* (1982). Sharma and Bhandari (1992) reported that Zinc showed no consistent relationship between its soil and leaf analysis values. Misgar (1992) reported no significant relationship between Zinc content of leaves and soils in Ambri apple orchards of Pulwama district of Jammu and Kashmir.

Mir (1994) revealed a positively significant correlation between soil Zinc and leaf Zinc in almond orchards of Kashmir valley.

Mushki (1994) reported that Ambri, Maharaji and Red Delicious cultivars of apple did not show any significant relationship of available Zinc with leaf content.

Bhat (2001) observed that the Zinc content in leaves of Golden Delious Star crimson and cooper-4 cultivars of apple did not bear any significant relationship with available Zinc content.

2.5.8 Copper

Singh (1987) observed a positively significant relationship between soil and leaf Copper for Royal Delicious cultivar but non-significant relationship for Red

Delicious and Golden Delicious cultivars of apple in Kinnuar district of Himahcal Pradesh.

According to Sharma and Bhandari (1992) a positively significant correlation was observed between available Copper in soil and Copper content in leaves of apple in Himachal Pradesh.

Misgar (1992) studied a non significant relationship between leaf and soil Copper at various depths in Ambri apple orchards of Pulwama district (J&K).

Mir (1994) showed a positively significant relationship between available Copper in soil and leaf Copper in almond orchards of Kashmir valley.

A positively significant correlation coefficients of (r=0.87 and r= 0.69) were observed between soil and leaf Copper content for a soil depth of 0-20 cm in Ambri and Red Delicious cultivars, respectively while Ambri cultivar showed a negatively significant relationship (r=0.68) for 80-100 cm soil depth and Maharaji did not have any such significant relationship for Copper content in apple orchards of Kashmir valley (Mushki, 1994).

Bhat (2001) observed that Copper content in leaves of Golden Delicious, Starcrimson and cooper-4 bore a positively significant relationship with available content in surface soils.

2.5.9 Manganese

Singh (1987) recorded non-significant relationship between soil and leaf Manganese in apple orchards of Kinnuar district of Himachal Pradesh.

Li *et al* (1988) reported a positively significant correlation between soil available Manganese and leaf Manganese in apple orchards of China.

Neilson *et al.* (1990) observed a positively significant relationship between Manganese content in leaf and available Manganese.

Haynese (1990) did not reveal any such relationship between leaf Manganese content and available Manganese content in Cox's orange and Brachurn cultivars of apple.

Misgar (1992) observed non-significant relationship between available Manganese and leaf Manganese in Ambri apple orchards of Pulwama district (J&K).

Sharma and Bhandari (1992) found positively significant correlation coefficient (r=0.55) between leaf Manganese and available Manganese in surface soil of apple orchards in Himachal Pradesh while no such significant relationship was observed between leaf Manganese and available Manganese in subsurface soils.

Mir (1994) revealed positively significant correlation coefficient (r=0.52 and r= 0.54) between leaf and soil Manganese at 10-20cm and 20-40 cm depths, respectively for thin shelled cultivars, while no such significant relationship was observed between leaf Manganese and available Manganese for medium shelled cultivars of almond at 0-20 cm soil depth. The available Manganese content in soil and leaf did not exhibit any significant relationship in Ambri, Maharaji and Red Delicious cultivars under study (Mushki, 1994).

Bhat (2001) observed a positively significant relationship between surface available Manganese content and leaf Manganese content of three apple cultivars viz, Golden Delicious, Starcrimson and cooper-4.

2.5.10 Iron

Singh (1987) reported a non-significant relationship between soil and leaf Iron in apple orchards of Kinnuar district of Himahcal Pradesh.

Li *et al.* (1988) reported a positively significant correlation between available soil and leaf Iron content.

Sharma and Bhandari (1992) observed positively significant correlation between leaf Iron content and available Iron in soil of apple orchards of Himachal Pradesh.

Misgar (1992) observed a non-significant relationship between leaf and soil Iron in Ambri apple orchards of Pulwama district of Jammu and Kashmir.

Mir (1994) reported a positively significant relationship between leaf Iron content and available Iron content at 0-20 cm and 20-40 cm depths for thin shelled and medium shelled cultivars of almonds in Kashmir valley, while no such significant relationship was observed at lower depths.

Iron content in the soil and in the leaf did not reveal any significant relationship in Maharaji, and Red Delicious cultivars, while as Ambri cultivar showed a positively significant relationship (r=0.67) between soil and leaf Iron contents for soil depth of 0-20 cm (Mushki, 1994).

Bhat (2001) observed positively significant relationship between available Iron content of surface soils and Iron content in leaves of three cultivars of apple such as Golden Delicious, star crimson and cooper-4.

2.6 Soil characterization and classification

The information required for qualifying parameters for characterization and classification is briefly reviewed as under:

2.6.1 Morphological characteristics

Shinde *et al*. (1984) studied the soils of saffron growing areas of Jammu and Kashmir and reported that the colour of the soils under saffron cultivation as light yellowish brown (10 YR 6/4 D) where as those which were not under saffron as darker yellowish brown (10 YR 5/4 D), with clay loam to silty clay loam texture. The structure is moderately developed angular to sub angular blocky. According to Pal and Deshpande (1987) the two pedons namely Gogji Pather and Wathora of Kashmir valley were dark brown, yellowish brown and dark grayish brown, the texture of the soils was generally silty loam to silty clay loam with moderately developed granular, angular to sub-angular blocky structure. Gupta *et al*. (1988) while reporting about some alluvial soils of Jammu district, revealed that the colour of some soil profiles varied from yellowish brown (10 YR 5/4) to pale brown (7.5 YR 4/3) in the surface and from pale brown (10 YR 6/3) to dark brown (7.5 YR 4/2). The texture of soils ranged from clay loam, loam to silty clay loam and sandy clay loam with fine granular structure.

Sharma and Qaher (1989) reported that the colour of upper horizons of outer Himalayan sols was darkish yellowish brown to very dark grey. The texture of upper horizons varied from loam to silty clay loam and were weakly to moderately developed with granular to sub-angular blocky soil structure. Verma *et al*. (1990) studied the soils under forests of Kashmir valley and observed that the surface soils (26-46 cm) have dark brown to very dark grey colour 10 YR hue chroma 1-3 and 3. The soil structure is weak to moderate granular in the surface and moderate to strong sub-angular blocky in the sub-surface horizons. The texture of the soil is silty loam and soil consistence is loose, soft and friable in dry and moist conditions. Kaishta and Gupta (1994) studied some soils of the North-western Himalayan region and revealed that the soils of four pedons were yellowish brown to dark yellowish brown. The texture of the profiles was silty loam to sandy clay loam. The structure was weak to moderate, granular in the surface and moderate to sub-angular blocky in the sub-surface horizons.

According to Sharma *et al*. (1994), the colour of the surface and sub-surface soils of soan river valley of Himachal Pradesh, varied from brown to dark yellowish brown. The texture of the soils varied from sand to sandy loam. The presence of Calcium carbonate was evidenced by strong to violent effervescence. The consistency in surface soils is friable, non-sticky and non-plastic which is an indication of poor water retention of these soils.

While studying the characterization and classification of Entisols in different soils moisture regimes of Punjab, Sidhu *et al*. (1994), reported that all the Entisols exhibit A-C profiles indicating weak pedogenic development. The soils have colour 10 YR hues but 7.5 YR hues are also obtained in the sub-surface horizons of some soils, value and chroma vary from 3-7 and 2-6 respectively. The texture varied from sand to clay. They have weakly developed sub-angular blocky structure. The consistence varied from firm to friable.

Mishra and Ghosh (1995) while studying the characterization of soils derived from mica-rich parent material in two topo sequences, revealed that the colour of the first topo sequence changed to dark side down the slope while the reverse trend was reverse in the second topo sequence. The soil texture varied from loam and silty loam in the first sequence, while clay loam sand in the second topo sequence. These soils were gravelly and exhibited blocky structure with varying grades.

Sidhu *et al*. (1999) while characterizing and classifying some dominant soils of Jammu region for land use planning reported that soils of Great Himalayas were brown to yellowish brown (10 YR 4/4 to 4/6) in colour, very shallow to moderately deep and loamy in texture.

Sharma *et al.* (2001) reported that soil colour in Katiwar region soils of Gujrat varied from red to grey with hues of 5 YR, 7.5 YR, 10 YR values of 3 - 4 and chromas of 2- 4.

Sahu *et al*. (2001) while reporting about characterization and classification of some vertisols of western zone in Orissa inferred that the colour of the soils was 10 YR, value ranged from 2-5 and chroma 1-2. The structure ranged from medium, moderate, sub-angular blocky to coarse strong sub-angular blocky through depth.

Nayak *et al*. (2001) reported that the colour of three out of five pedons of central Research Station Bhubaneswar ranged from light yellowish brown to yellowish red on the surface to red in sub-surface horizon. Soil structure varied from sub-angular blocky on the surface to angular blocky in the surface horizon. The colour of other two pedons varied from pinkish gray to gray and light gray to light brownish gray from surface and sub-surface soils.

2.6.2 Soil classification

Shinde *et al*. (1984) studied the soils of saffron growing areas of Jammu and Kashmir and classified them as Vertic Hapludalfs and Typic Eutrochrepts, where as the adjoining non-saffron growing soils as Typic Hapludalfs and Fluventic Eutrochrepts. Sehgal *et al*. (1985) have characterized mountain soil on slopes formed on chloritic schist and valley soils from gneisses under Typic Hapludolls and Mollic Hapludalfs respectively in central Himalayas.

Gupta *et al.* (1986) classified the soils of Jammu and Kashmir as Ustorthents, Eutrochrepts /Haplumbrepts and Haplumbrept/ Undorthents. Biswas

(1985) classified some typical soils from Dadra and Nagar Haveli under Vertisols, Alfisols, and Entisols.

Sambyal and Sharma (1986) conducted a study on some lower Himalayan eroded forest soils and reported that soils belonging to the order Alfisols were stable, the Mollisols and Inceptisols moderately erodible and the Enentisols most susceptible to erosion.

Gangopadhyay *et al.* (1986) identified three pedons with in an altitudinal range of 1970 m and 2425 m in Sikkim Forest Division. These were classified as Typical Hapludulf, Mollic Ochraqualfs and Humic Hapludalf based on soil profile morphology and analytical data. Pal and Deshpande (1987) studied the two bench mark soils of Kashmir valley and classified them as Mollic Hapludalf (Gogji pather) and Mollic Haplaquepts (Wathora). Nair and Chamuah (1988) conducted a study on some pine forest soils of Meghalaya and classified them as Tropeptic Haplorthox, Haplohumox, Lithic Undorthent, Typic Udipsamment and Tropeptic Halorthox. The soils belong to the orders Entisols and Oxisols. The soils udner different forest vegetation sequences in the foot hill region of Darjeeling district were classified as Typic Haplumbrept, udic Haplustoll, Typic Hapludoll, Typic Humitropept, Fluventic Umbric Dystrochrept and Humic Hapludalt, these soils belongto the order inceptisols, Mollisols and Ultisols as revealed by Gangopadhayay *et al*. (1989). The soils under forests of Kashmir valley were classified as Typic Hapludoll, Lithic Hapludoll and Typic Argiudolls as reported by Verma *et al*. (1990). Walia and Chammah (1990) classified the four pedons in foot hill soils of Arunachal Pradesh as Inceptisols and Ultisols. These soils were deep, moderately fine textured, rich in organic carbon, acidic in reaction and exhibited the development of cambic and argillic horizons. Boumik and Totey

(1990) studied the soils of Teak forests in Madhya Pradesh and classified these as Mollisols. Sahu *et al*. (1986) have classified soils along the sea coast of the Bay of Bangal in Orissa in to Vertic and Typic Haplaquepts. Sannigrahi *et al*. (1990) have classified dominant hill soils of Nilgri in to Lithic Drystric and Typic Eutrochrepts on the basis of morphological and physio-chemical properties. Singh *et al.* (1991) while conducting a detailed survey of mid altitude soils of outer Himalayas observed that these soils were developed on similar group of rocks overlain by infrakarol and karol series of the carboniferous lower Mesozoic period under monsoon climate as conditioned by undulating topography and peculiar natural drainage system. These soils have been classified in the orders of Alfisols, Inceptisols and Entisols. Kastha and Gupta (1994) classified representative two pedons from cultivated and two from uncultivated areas as Inceptisols and Entisols. The soils were classified as Typic Undorthents, Typic Entrochrepts (uncultivated) and Typic Undifluvents (cultivated). Sahu *et al*. (1990) while studying pedons formed on the highly weather material and iron ore series in northern plateau of Orissa classified Shamakhunta and the Saukti pedons with argellic horizons under Alfisol and Joshipur pedon as Oxisol. Jalali *et al.* (1989) have classified the soils developed on various physiographic zones of Kashmir valley viz. high altitude, karewa and valley basin as Agriudolls, Hapludalfs and Ochraqualf respectively.

Strain Evains (1994) studied four sites that had been mined for sand and gravel near the town of Green land and classified them as Typic Udipsamments, Typic Udorthents, Typic, Udifluvents and Aquic Udifluvents.

Sharma *et al.* (1997) while studying the Inceptisols of North-west India, reported that the soils were classified as Dystric Eutrochrepts and Typic

Eutrochrepts. The soils developed weak horizon in interdunal areas and are classified as Ustrochrepts. The soils developed on foot slopes are non calcareous and those on top slopes are calcareous.

Sindhi *et al*. (1999) while studying the characteristics and classification of some dominant soils of Jammu region for land use planning placed these soils in Entisols and Inceptisols soil orders.

Sharma *et al*. (2001) while reporting about characteristics and classification of soils of Kathiawar region of Gujrat as influenced by topography, revealed that the soils of Devpur series, Gondal series, Meghpur series, Shivrajgadh series, Semla series, Bhola series, Haripur series and Vavniya series have been classified as Lithic Ustorthents, Lithic Haplustepts, Typic Haplustepts, Vertic Haplustepts, Calcivsterts, Calcic Haplustepts, Typic Haplustepts and Udic Haplustepts at sub-group level, respectively.

Sahu *et al*. (2001) further classified some vertisols of western zone in Orissa as Chromic Haplusterts on the basis of morphological, physical and chemical characteristics.

Nayak *et al*. (2000) while studying the characterization and classification of soils of central Research Station Bhubaneshwar reported that three pedons out of five were grouped under order Alfisols because of presence of argillic horizon and percentage base saturation of more than 35 percent, while as the other two pedons were placed under order Inceptisols and Entisols.

CHAPTER-III

MATERIALS AND METHODS

3.1 General description of the area

The state of Jammu and Kashmir comprising of extreme western sector of the Himalayas occupies almost a central position in Asia. It is northern most state of India located between 30^{o} 17′ and 37^{o} 16′ latitude 73^{o} 26′ and 80 30′ longitude and 81^{o} each Greenwich. The state of Jammu and Kashmir contributes 48% of total temperate fruit production of the country.

The valley of Kashmir is enclosed by great Himalayas in north and lesser Himalayas in South. The climate of Kashmir valley being temperate, is quite suitable for the cultivation of temperate fruits especially apple and nuts. District Baramulla is the fruit bowl of the valley.

The Bangil area in Baramulla district is spread over fifty square kilometres starting from Pattan and ends at Putkah. The area is comprised of karewas and foot hills. Karewas locally known as “Wudrs” are lacustrine pleistocene and post pleistocene deposits and occupy most of the study area. The whole area is located within an altitude of 1650-1800 metres above the mean sea level (Mushki, 1994).

Table 1 Soil and Plant samples collection sites

Orchard No.	Location
1.	Kalantra
2.	Kreeri
3.	Tappar
4.	Kralweth
5.	Batapora

6.	Lalpore
7.	Tilgam
8.	Mamoosa
9.	Kanloo
10.	Moghama
11.	Nihalpora
12.	Sheerpora
13.	Khore
14.	Shrakwara

3.2 Collection of soil samples

Soil profiles were exposed from the apple orchards which are of uniform age and maintained by the similar management practices (Table 1). On spot morphological observations were recorded as per USDA soil Survey Manual. Soil samples were collected at an interval of 20 cm upto a depth of 80 cm.

3.3 Leaf samples

Leaf samples from pest and disease free trees of Red delicious cultivar were selected from the same orchards from where the soil samples were collected. The leaf samples were collected as per the procedure outlined by Kenworthy (1964).

3.4 Preparation of samples

3.4.1 Soil samples

The soil samples were air dried in shade, crushed with wooden pestle and mortar and sieved through 2 mm sieve. The sieved samples were labelled and stored in polythene bags for subsequent chemical analysis.

3.4.2 Leaf samples

The fresh leaf samples were first washed in running tap water to decontaminate from dust and other foreign material followed by dipping in dilute hydrochloric acid (0.1 N Hcl). Further washing was repeated with single and double distilled water. The samples were then air dried on filter papers and oven dried at 60±5^{o}C for 24 hours. The samples were then homogenized in a stainless steel blender to pass through 2 mm mesh and stored in air tight polythene bags for chemical analysis.

3.5 Soil analysis

The soil samples were analyzed for various physico-chemical properties like organic carbon, pH, Electrical Conductivity, Calcium Carbonate, mechanical separates (sand, silt and clay), CEC. Available Nitrogen, Phosphorus, Potassium, Sulphur, Calcium, Magnesium and DTPA extractable Zinc, Copper, Manganese and Iron were also determined in these soil samples. The procedures adopted for the analysis are as follows:

3.5.1 pH

The pH of soil samples was determined in 1:2.5 soil water suspension using a glass electrode pH meter as described by Jackson (1973).

3.5.2 Electrical conductivity

The electrical conductivity of soil water extract was determined with the help of solubridge Jackson (1973).

3.5.3 Calcium carbonate

Determination of Calcium Carbonate was done by adopting rapid titration method as described by Piper (1966).

3.5.4 Organic carbon

Organic carbon was determined by Walkley and Black (1934) method.

3.5.5 Mechanical analysis

The mechanical composition of soil was determined by International Pipette method as described by Piper (1966).

3.5.6 Cation exchange capacity (CEC)

Scholenbergers method of leaching the soil with neutral normal ammonium acetate and determination of ammonical nitrogen (Jackson, 1973) was followed to determine CEC of soil.

3.5.7 Available Nitrogen

Nitrogen in soils was determined by alkaline permanganate method as described by Subbiah and Asija (1956).

3.5.8 Available Phosphorus

Phosphorus in soil was estimated by 0.5 M Sodium bicarbonate (pH 8.5) method as outlined by Olsen *et al.* (1954).

3.5.9 Available Potassium

Potassium was extracted with neutral normal ammonium acetate (Merwin and Peech, 1950) and Potassium in extract was determined by Flame Photometer.

3.5.10 Available Calcium and Magnesium

These were estimated by versenate titration method, Black (1965).

3.5.11 Available Sulphur

Available Sulphur in soils was determined turbidimetrically (Chesnin and Yien, 1951).

3.5.12 DTPA-extractable micronutrient cations

The method of Lindsay and Norvel (1978) was used for the estimation of micronutrient cations. Ten g soil was shaken for 2 hours with 20 ml of extracting solution consisting of 0.005 M DTPA (Diethylene triamine penta acetic acid), 0.01 M $Cacl_2$ and 0.1M TEA (Triethanol amine) buffered at 7.3 with Hcl and filtered, the filterate was stored for analysis.

The Zinc, Copper, Manganese and Iron in the filterate were determined on an atomic absorption spectrophotometer after standardizing the instrument with proper standards.

Table 2: Critical limits of available nutrients

Nutrient Element	Soil fertility class			Reference
	Low	**Medium**	**High**	
OC %	0.5	0.5-1.0	1.0>	Walkley and Black (1934)
N (ppm)	125	125-250	250>	Subiah and Asija (1956)
P (ppm)	4	4-11	11>	Olsen *et al.* (1954)
K (ppm)	44	44-125	125>	Hanway and Heidal (1952)
S (ppm)	10.0	-	-	Kanwar and Mohan (1964)
Zn (ppm)	0.6	0.6-1.2	1.2>	Takkar and Mann (1975)
Cu (ppm)	0.2	0.2-2.0	2.0>	Follet and Lindsay (1970)
Mn (ppm)	1.0	-	-	-do-
Fe (ppm)	4.5	-	-	Lindsay and Norvell (1978)

3.6 Leaf analysis

3.6.1 Nitrogen

The leaf samples were digested in concentrated sulphuric acid in presence of digestion mixture comprised of potassium sulphate, copper sulphate iron sulphate and selenium powder in the ratio of 10:5:1:1 and Nitrogen in leaf was estimated by microkjaldhal's distillation method as described by Jackson (1973).

For the determination of Phosphorus, Potassium, Calcium, Magnesium, Sulphur, Zinc, Copper, Manganese and Iron and diacid digestion mixture in the ratio of (HNO_3 : $HClO_4$ = 9:4) was prepared and leaf samples digested (Johnson and Ulrich, 1959).

3.6.2 Phosphorus

It was estimated by Vanadomolybdo phosphoric yellow colour method (Jackson, 1973).

3.6.3 Potassium

It was estimated by Flame photometric procedure as described by Piper (1966).

3.6.4 Sulphur

Sulphur was determined by turbidity method given by Chesnin and Yien (1951).

3.6.5 Calcium and Magnesium

These were determined by versenate method (Jackson, 1973)

3.6.6 Zinc, Copper, Manganese and Iron

Zn, Cu, Mn and Fe content of the leaf samples were estimated by feeding the diacid extract to the atomic absorption spectrophotometer at 213.9, 324.5, 279.8 and 248.1 nm respectively.

3.7 Statistical analysis

All the data pertaining to these investigations were subjected to statistical analysis by the method as described by Panse and Sukhatame (1967).

Simple correlation coefficients were computed between various physico-chemical properties of soil (pH, Organic Carbon, Calcium Carbonate, Electrical

Conductivity, Cation Exchange Capacity) and average soil nutrients (Nitrogen, Phosphorus, Potassium, Sulphur, Calcium, Magnesium, Zinc, Copper, Manganese and Iron).

Also simple correlation coefficients 'r' were computed between available nutrients and leaf nutrient content.

Table 3: Tentative working nutrient standards for apple leaf*

Element	Deficient	Low	Optimum	High (>)
N (%)	1.50	1.5-1.8	1.9-2.4	2.50
P (%)	0.14	0.14-0.18	0.19-0.28	0.30
K (%)	1.00	1.0-1.2	1.3-1.8	1.90
Ca (%)	1.00	1.0-1.2	1.3-1.7	1.80
Mg (%)	0.20	0.20-0.24	0.24-0.36	0.37
S (%)	-	-	0.13-0.84	-
		Micronutrient ranges (ppm dry weight)		
Zn	15	15.0-20.0	20.0-50.0	50.0
Cu	5	5.0-10.0	10.0-20.0	20.0
Mn	25	25-30	31-150	150.0
Fe	30	30-35	35-150	150.0

* Values adopted from plant Analysis Laboratory, Wooster Ohio U.S.A

CHAPTER-IV

EXPERIMENTAL RESULTS

The experimental results pertaining to the studies on “Characterization and Nutrient indexing of apple orchard soils of Bangil area of district Baramulla are presented in this chapter under the following heads:

4.1 Depth-wise distribution of available nutrients in the soils

4.2 Physico-chemical properties of soils

4.3 Relationship between available nutrients and physico-chemical properties

4.4 Leaf nutrient status of apple orchards

4.5 Relationship between available and leaf nutrient content

4.6 Characterization and classification of the soils as per (USDA) soil taxonomy

4.1 Depth-wise distribution of available nutrient elements in the soil

4.1.1 Nitrogen

Perusal of data in table 6 revealed that available Nitrogen content in surface soils varied from 98-122 ppm with a mean value of 110-85 ppm while in subsurface soils it varied from 90-114 ppm with a mean value of 100.42 ppm. The Nitrogen content in soils showed a decreasing trend with an increase in soil depth. The soils were medium in available Nitrogen. Highest available Nitrogen was observed from Shrakwara while lowest from kalantra.

4.1.2 Phosphorus

Examination of data (Table 6) revealed that Phosphorus content ranged from 10-19 and 9-17.12 ppm in surface and subsurface soils with mean values of

14.79 ppm and 13.39 ppm, respectively. The Phosphorus exhibited a decreasing trend with depth in most of the soils under study. The highest available Phosphorus was recorded from Shrakwara and the lowest from Kalantra. The available Phosphorus status of soils was medium (Table 2).

4.1.3 Potassium

The available Potassium content in surface soils varied from 157.7-206.6 ppm with a mean value of 186.95 ppm while in subsurface soils it ranged from 100.3 –167.15 ppm with a mean value of 125.92 ppm (Table 6). The soils were high in available Potassium (Table 2). Highest Potassium was observed from shrakwara and lowest from kalantra.

4.1.4 Calcium

Perusal of data in table 6 showed that in surface and subsurface soils of apple orchards the available Calcium ranged from 2842-3652 ppm and 2838-3982 ppm with mean value of 3320.21 and 3360.21 ppm, respectively. The available Calcium status was high due to the calcareous nature of these soils. The orchard soils in kalantra contained highest Calcium and those of Shrakwara were lowest in their Calcium content (Table 6).

4.1.5 Magnesium

Examination of data (Table 6) indicated that available Magnesium in surface soils varied from 140.2-178.4 ppm with a mean value of 158.2 ppm, where as in subsurface soils it varied from 126-188.6 ppm with a mean value of 153.88 ppm. Highest available Magnesium content was reported from kalantra and lowest from shrakwara. The soils were high in available Magnesium.

4.1.6 Sulphur

The available Sulphur in surface soils ranged from 9.7-13.5 ppm with a mean value of 11.34 ppm where as in subsurface soils it ranged from 6.71-9.68 ppm with a mean value of 7.94 ppm (Table 4). The soils were medium in available Sulphur. Highest Sulphur was observed in shrakwara and lowest in kalantra.

4.1.7 Zinc

An examination of data (Table 5) revealed that the zinc content in surface soils ranged from 0.80-0.89 ppm with a mean value of 0.85 ppm and in subsurface soils it varied from 0.60-0.89 ppm with a mean value of 0.75 ppm. Zinc showed a decreasing trend with the depth. The orchard soils in shrakwara contained highest zinc content whereas lowest zinc content was observed in kalantra. The available zinc status of soils was medium.

4.1.8 Copper

The available Copper in surface soils varied from 0.82-1.27 ppm with a mean value of 1.04 ppm where as in subsurface soils it varied from 0.52-1.23 ppm with a mean value of 0.82 ppm. Copper content decreased with the increase in depth. Soils were medium in available copper. Highest available copper content was observed in shrakwara and lowest in kalantra (Table 5)

4.1.9 Manganese

The available manganese content in apple orchard soils ranged from 32.02-58.02 with a mean value of 44.40 ppm in surface soils whereas in subsurface soils it varied from 26-45.14 ppm with a mean value of 33.86 ppm. Available manganese showed a decreasing trend along the depth with a mean value of 33.86 ppm. The orchard soils in shrakwarra recorded highest available manganese content and lowest was observed from kalantra. The soils were high in available manganese (Table-5).

4.1.10 Iron

Perusal of the data in table 6 revealed that the available Iron varied from 42.8-58.33 ppm with a mean value of 47.79 ppm in surface soils, whereas in subsurface soils it varied from 29-49.50 with a mean value of 38.04 ppm. Like other micro-nutrient cations iron content also decreased with an increase in soil depth. Highest available iron content was reported from shrakwara and lowest from kalantra. The soil were high in available iron.

4.2 Physico-chemical properties of soils

4.2.1 Mechanical composition

The perusal of data (Table 4) revealed that sand, silt and clay content varied from 14.40-26.16, 42.87-56.85 and 26.23-32.29 per cent with mean values of 20.53, 48.16 and 29.26 per cent, respectively in surface soils where as in subsurface soils these ranged from 14.74-28.35, 42.34-58.01 and 24.17-34.77 per cent with mean values of 20.89, 48.72 and 29.31 per cent respectively. Locations like Lalpore, Nihalpora and Shrakwara were medium textured (silt loam). The soils in general were fine textured with silty clay loam to clay loam as the dominant textural class.

4.2.2 Soil reaction

Perusal of table 5 revealed that pH of the surface soils varied from 6.5-7.4 with a mean values of 7.05, while as in subsurface soils it varied from 6.58-7.55 with a mean value of 7.12. The soil pH increased with an increase in depth and in general soils were slightly acidic to slightly alkaline.

4.2.3 Electrical conductivity (EC)

The data in table-7 revealed that Electrical conductivity of surface soils ranged from 0.25 – 0.47 dSm^{-1} and in subsurface soils it varied from 0.32-0.54 dSm^{-1} with a mean value of 0.45 and 0.34 dSm^{-1}, respectively. The EC of the soils was normal.

4.2.4 Calcium carbonate

Examination of data in table 7 showed that $CaCo_3$ was in the range of 3.30-4.33 and 3.32 – 4.67 per cent with mean values of 4.18 and 4.38 per cent in surface and subsurface soils, respectively. The $CaCo_3$ content increased with increase in depth.

4.2.5 Organic carbon

The organic carbon content in surface and subsurface soils ranged between 1.32 – 1.60 and 0.56 – 1.61 per cent with an average content of 1.47 and 0.82 per cent, respectively (Table 7). The soils under study can be rated medium to high with respect to their organic carbon status. The organic carbon content decreased with an increase in depth.

4.2.6 Cation exchange capacity (CEC)

The CEC varied from 16.6-20.8 and 18.98-20.52 Cmol kg^{-1} with mean values of 19.77 and 20.04 Cmol kg^{-1} in surface and subsurface layers, respectively. The soils of Kanloo showed the highest cation exchange capacity (20.80 C mol kg^{-1}) whereas Moghama had lowest cation exchange capacity (1.60 C mol kg^{-1}) Table-7.

4.3 Relationship between available nutrients and physico- chemical properties

It is well known that various soil characteristics, viz. pH, organic carbon, calcium carbonate, texture etc. play major role in controlling the availability of various nutrients. Hence an attempt was made to assess the influence of these properties on different soil nutrient contents. For this purpose correlation coefficient values of different physico-chemical properties with available nutrient elements was worked out for surface and sub-surface soils of apple orchards and are presented in table 8 and 9.

4.3.1 Surface soils

Examination of correlation coefficients (r-values) presented in table 8 indicated that pH of soils had a negatively significant correlation with N (r= -0.535) Zn (r= -0.843), Cu (r= -0.726), Mn (r = -0.878) and Fe (r = -0.977) and positively significant correlation with Ca (r=0.951) and Mg (r=0.912). Organic carbon content revealed a positively significant correlation with N (r=0.523), Zn (r=0.540), Cu (r=0.239), Mn (r=0.374) and Fe (r=0.441) whereas other nutrient contents viz. Phosphorus, Potassium and Sulphur did not exhibit any significant relationship with it. Calcium carbonate exhibited a significant negative correlation with N (r= -0.268), Zn (r=0.296), Cu (r = -0.235), Mn (r= -0.278) and Fe (r= -0.238) whereas it had a positively significant correlation with Ca (r=0.358) and Mg (r = 0.258).

A positively significant correlation was observed between clay content and available Ca (r=0.432), Mg (r=0.384) and Fe (r=0.362), however, rest of the nutrient elements did not show any significant relationship with clay content (Table 8).

4.3.2 Sub-surface soils

Perusal of the data in table 9 indicated that in sub-surface soils pH had negatively significant correlation with Zn (r= -0.659), Cu (r= -0.431), Mn (r=

-0.467) and Fe (r = -0.521) positively significant correlation with Ca (r= 0.496) and Mg (r= 0.554). The calcium carbonate had a negatively significant correlation with Zn (r = -0.703), Cu(r= -0.873), Mn (r= - 0.784) and Fe (r = 0.791) but positively significant with Ca (r = 0.664) and Mg (r = 0.789). The organic carbon of sub-surface soils exhibited a positively significant relationship with S (r= 0.413) and Cu (r = 0.746) (Table 9). Clay content in sub-surface soils was not found to have a significant relationship with any of the nutrient elements (Table 9).

4.4 Leaf nutrient status of apple orchards

Examination of data presented in table 7 showed that the leaf nitrogen content ranged from 1.72-2.40 per cent with a mean value of 2.09 per cent at different locations. Highest nitrogen content was observed at shrakwara whereas lowest nitrogen content was found at kalantra. The Phosphorus content ranged from 0.19-0.28 per cent with a mean value of 0.22 per cent. Highest phosphorus was observed in shrakwara and lowest in kalantra. The leaf phosphorus status of orchards was optimum.

The Potassium content of leaves in red delicious cultivar varied from 1.56 – 1.85 per cent with an average of 1.70 per cent. Highest Potassium content was present in the orchards in shrakwara while kalantra had lowest Potassium content. The leaves showed optimum Potassium content (Table 7).

Calcium content in red delicious cultivar varied from 1.70 – 2.08 per cent with a mean value of 1.82 per cent. Highest Calcium content was observed in kalantra and lowest from shrakwara. Leaf Calcium content of the orchards was high (Table 7).

The leaf Magnesium content varied from 0.23 – 0.43 content with a mean value of 0.29 per cent. Highest Magnesium content was observed in kalantra and lowest in shrakwara. The leaf Magnesium status of orchards was high (Table 7).

The leaf Sulphur content of ranged from 0.42-0.63 per cent with a mean value of 0.50 per cent. The orchards were rated optimum in leaf Sulphur content. Highest Sulphur was reported from Shrakwera and lowest was reported from kalantra (Table 7).

The leaf Zinc content varied from 21-26 ppm with a mean value of 23.92 ppm. Orchards in shrakwara had highest Zinc content whereas lower values were observed from the orchard in kalantra. The orchards were rated optimum with respect to their leaf Zinc content (Table 7).

The data presented in table 7 revealed that the Copper content in the leaves of varied from 5-12 ppm with an average of 8.14 ppm. Highest Copper content was observed in shrakwara and lowest was recorded in kalatra. The orchards were high in leaf Copper status.

The Manganese content ranged from 51-101 ppm with a mean value of 72.35 ppm. Highest leaf Manganese content was recorded from shrakwara and lowest from kalantra. The orchards were optimum in leaf Manganese contents (Table 7).

Examination of data in table 10 manifested that the leaf Iron content of apple orchard ranged from 89-130 ppm with a mean value of 108.64 ppm. Highest Iron content was observed in shrakwara and lowest in kalantra. The orchards were optimum in leaf Iron contents.

4.5 Relationship between available and leaf nutrient content

4.5.1 Surface soils

Examination of data presented in the table 11 revealed that a positively significant relationship was observed between the available Nitrogen content and the leaf Nitrogen content (r=0.970).

The Phosphorus content in the leaves exhibited a positively significant correlation with the available Phosphorus content (r = 0.554) Table-11.

A positively significant correlation coefficient (r = 0.923) was observed between the leaf Potassium content and available Potassium content (Table 11).

Data presented in the table 11 showed that the leaf Calcium content possessed a positively significant relationship (r = 0.875) with available Calcium content. Perusal of the data in table 11 revealed that a positively significant relationship (r = 0.689) existed between leaf Magnesium content and available Magnesium content.

A positively significant relationship (r=0.724) was observed between leaf Sulphur content and available Sulphur.

The Zinc content in the leaves bore a positively significant correlation coefficient (r=0.727) with available Zinc content (Table 11).

The available Copper content exhibited a positively significant correlation (r = 0.682) with the leaf copper content (Table 11). Examination of data in table 10 revealed that the leaf Manganese content exhibited a positively significant correlation coefficient (r = 0.926) with available Manganese content.

Leaf Iron content exhibited a positively significant correlation (r= 0.893) with the available Iron content (Table 11).

4.5.2 Sub-surface soils

Perusal of data presented in table 11 revealed that the leaf Nitrogen content exhibited a positively significant correlation coefficient (r = 0.487) with the available Nitrogen content in sub-surface soils.

A positively significant relationship (r = 0.548) was found between leaf phosphorus content and available Phosphorus (Table 11).

Examination of data presented in Table 11 indicated that the leaf Calcium content bore a positively significant relationship (r = 0.963) with the available Calcium content.

Among the micro-nutrient cations, only leaf Manganese content exhibited a positively significant correlation (r = 0.720) with available Manganese content whereas the leaf Zinc, Copper and Iron content did not exhibit any significant correlation with their respective available contents in sub-surface soils (Table 11).

4.6 Characterization and classification of the soils as per soil taxonomy

4.6.1 Morphological characteristics

Representative soil profiles were selected from the Bangil area of district Baramulla for taxonomic purpose and the field studies are given in table-11.

Profile-1

The data presented in table 11 revealed that colour of the layers varied from (10 YR 3/ 4) dark yellowish brown to dark brown (10YR 3/3). The texture was clay loam and structure sub-angular blocky.

The data (Table 11) revealed that the soil layers were slightly hard to hard when dry and friable when it was moistened. The roots were many and coarse in upper layers and few and fine down below. The effervescence was slight in upper layers and strong in lower layers.

Profile-2

The data presented in table 11 showed that the colour of layers ranged from dark brown (10YR 3/3) to dark yellowish brown (10 YR 4/4). The structure of profile was sub-angular blocky and the texture was clay loam. The upper layers were slightly hard when dry and friable when moistened. The lower layers were hard when dry and friable when moistened. The root distribution ranged from common, many, few and very fine. The reaction with dilute Hcl was slight in upper layers and strong down below.

Profile-3

Perusal of data presented in table 11 revealed that colour of the profile ranged from very dark brown (10 YR 2/2) to yellowish brown (10 YR 5/4).

The structure was sub-angular blocky and the texture clay loam. The consistency ranged between slightly hard to hard when dry and friable when moist. The root distribution was between common many to few and very fine along the depth of profile. The effervescence ranged between slight to strong.

4.6.2 Particle size distribution

Soil samples collected from all the horizons/layers were analyzed for sand, silt and clay fractions and their results are presented in table 12.

Profile-1

The data presented in table 12 revealed that the coarse sand content ranged between 1.27-2.76 per cent and fine sand content between 19.74-20.55 per cent.

Silt content ranged between 41.30-48.57 per cent whereas clay content varied between 29.58-36.48 per cent.

Profile-2

Examination of data in table 12 revealed that coarse sand content ranged from 0.96-2.86 per cent and the fine sand content from 19.30-22.52 per cent. The silt content ranged from 41.10-48.27 per cent. The clay fraction varied between 28.84-38.01 per cent.

Profile 3

Perusal of table 12 showed that the coarse sand content varied between 0.84-1.76 per cent, the fine sand content ranged between 21.64-25.84 per cent. The silt fraction varied from 40.20-44.06 per cent. The clay content ranged between 30.14-36.43 per cent.

4.6.3 Chemical properties of soil profiles

Profile-1

Examination of data presented in table 13 revealed that pH of the profile ranged from 7.20-7.30. The electrical conductivity was between 0.47-0.52 dSm^{-1}. Its organic carbon content and Calcium carbon content ranged between 1.03-1.44 per cent and 4.22-4.53 per cent, respectively. The CEC of this profile varied between 19.40-19.57 C mol kg^{-1}.

Profile-2

The data presented in table 13 revealed that the soil reaction ranged between 7.4-7.58 and its electrical conductivity between 0.30-0.51 dSm^{-1}. The Organic carbon content percentage ranged between 0.58-1.36, whereas, the

Calcium carbonate varied between 4.31-4.68 per cent. The CEC ranged from 19.93-20.00 Cmol kg^{-1}.

Profile-3

The perusal of the data in table 13 revealed that pH was between 7.20 to 7.40 whereas Electrical conductivity ranged from 0.46-0.52 dSm^{-1}. The Organic carbon content ranged between 0.70-1.43 per cent, calcium carbonate varied from 4.21-4.56 per cent. The cation exchange capacity ranged between 20.10-22.20 Cmol kg^{-1}.

4.6.4 Soil taxonomy

The soils of the surveyed area fall in the order Alfisols suborder Udalf and great group Hapludalf (Table 14).

DISCUSSION

The experimental results pertaining to the studies on characterization and nutrient indexing of apple orchard soils of Bangil area of district Baramulla have been discussed under the following heads:

5.1 Depth wise distribution of available nutrient elements in the soils

5.2 Physico-chemical properties of soils

5.3 Relationship between available nutrients and physico-chemical properties.

5.4 Leaf nutrient status of apple orchards

5.5 Relationship between available and leaf nutrient content

5.6 Characterization and classification of the soils as per (USDA) soil taxonomy

5.1 Depth wise distribution of available nutrient elements in the soils

5.1.1 Available Nitrogen

The available Nitrogen content in soils under study varied from 98-122 ppm with a mean value of 110.85 ppm in surface soils, where as in sub-surface soils it varied from 90-114 ppm with a mean value of 100.42 ppm (Table 6). These results are in agreement with those of Mir (1994) for Kashmir soils. A perusal of table 6 revealed that all orchard soils have medium status of available Nitrogen content, similar results have been reported by Ghosh and Hasan (1980) and Misgar (1992). Sahu (2002) reported similar results who worked on pear orchards in U.P. Maximum content of available Nitrogen was found in the surface (0-20 cm) layers of the soils and decreased with an increase in depth. This can be attributed to the low organic matter content and low rate of mineralization in the lower layers of soil. Similar results were reported by Kaistha *et al*. (1990), Singh (1987) and Bhat (2001).

5.1.2 Available phosphorus

The available Phosphorus varied from 10-19 ppm with a mean value of 14.79 ppm in surface soils, where as it varied from 9-17.12 ppm with a mean value of 13.39 ppm in sub-surface soils (Table 6). These values are in agreement with those of Talib (1984) and Misgar (1994). The available Phosphorus status of the soils under study was found to be medium. This is in accordance with those of Ganai *et al*. (1991) and Peer (1994). The available Phosphorus in these soils showed a decreasing trend along the depth of the profiles. The highest content of Phosphorus in surface soils may be attributed to higher amount of organic matter and neutral soil reaction, besides being less mobile to the lower layers. Similar results about the soil of Jammu and Kashmir with respect to available Phosphorus were given by Handoo (1983), Talib (1984), Bhat (2001) and Sahu (2002).

5.1.3 Available potassium

The Potassium content varied from 157.7-206.6 ppm with a mean value of 186.95 ppm in surface soils and from 100.3-167.15 ppm with a mean value of 125.92 ppm in sub-surface soils (Table 6). These results are in accordance with the findings of Bhat (2001). The available Potassium was high (Table 6) which may be due to presence of illite type of clay minerals in these soils. This is supported by the findings of Handoo (1983) and Talib (1984). Available Potassium decreased with increase in depth the higher content of potassium were reported from the surface layers as that of sub-surface layers this can be attributed to the fact that the clay complex of orchard soils of Kashmir valley is a mixture of illite, muscovite, kaolinite etc and high rate of weathering in surface layers due to more exposure of potassium bearing minerals to the weathering agencies (Katoo, 2001).

5.1.4 Available Calcium

Data presented in the table 6 revealed that the exchangeable Calcium ranged from 2842 – 3616 ppm with a mean value of 3320.21 ppm in surface soils and from 2838-3982 ppm with a mean value of 3360.21 ppm in sub-surface soils. These results are in agreement with those of Misgar (1994). The available Calcium content was high which may be due to the calcareous nature of the soils. The calcareous nature of Kashmir soils has been reported by Handoo (1983) and Katoo (2001). The Calcium content increases with increase in depth. Similar observations were reported by Sharma *et al* (2001), Xiubin *et al*. (2002) and Bhargava (2002).

5.1.5 Available Magnesium

A perusal of data (Table 6) indicated that available Magnesium varied from 140.2-178.4 ppm with a mean value of 158.2 ppm in surface soils and 126-188.6 ppm with a mean value of 153.88 ppm in sub-surface soils. Magnesium showed an inconsistent trend with soil depth. These results are in line with those of Peer (1994). The inconsistent trend in its distribution can be due to stratification of these soils. This is in conformity with the findings of Mir (1994), Talib (1984) and Bhat (2001).

5.1.6 Available Sulphur

The available Sulphur in surface soils ranged from 9.7-13.5 ppm with a mean value of 11.34 ppm whereas in sub-surface soils its content ranged from 6.71-9.68 ppm with a mean value of 7.94 ppm (Table 6). The soils under study have medium status of available Sulphur. The available Sulphur showed an inconsistent distribution pattern with the soil depth. The results are in agreement with those of Arora *et al*. (1989), Sharma and Bhandari (1992) and Singh (1987) who also indicated an erratic trend in the distribution of available. Sulphur with the soil depth. Similar inconsistent distribution pattern of Sulphur was also reported by Balanagoudar and Satyanarayana (1990) while working with Karnataka soils.

5.1.7 Available Zinc

DTPA extractable Zinc content varied from 0.80-0.89 ppm with a mean value of 0.85 ppm in surface soils and 0.60-0.89 ppm with a mean value of 0.75 ppm in sub-surface soils (Table 6). The soils were medium in available Zinc content. These results are supported by the findings of Jalali *et al*. (1989) and Mir (1994). The available Zinc content of soils under study decreased with increase in soil depth. The maximum amount of Zinc in surface soils can be due to accumulation of organic matter in surface soils . Similar results were reported by Bhandari and Randhawa (1985) and Jalali *et al*. (1989).

5.1.8 Available Copper

The available Copper in surface soils varied from 0.82-1.27 ppm with the mean value of 1.04 ppm whereas in sub-surface soils it ranged from 0.52-1.23 ppm with a mean value of 0.82 ppm (Table 6). These results are in accordance with the findings of Mir (1994) and Mushki (1994). The available Copper generally decreased with an increase in soil depth with maximum amount in surface layers which may be due to high organic mater in surface layers. These observations are supported by the findings of Jalali *et al*. (1989) and Tripathi *et al*.

(1994). The soils were high in available Copper (Table 6). This can be attributed to the application of Copper containing fungicides.

5.1.9 Available Manganese

Perusal of data (Table 6) revealed that available Manganese content varied between 32.02-58.02 ppm with a mean value of 44.40 ppm in the surface soils whereas it ranged from 26-45.14 ppm with a mean value of 33.86 ppm in sub-surface soils. These results are in accordance with those of Jalali *et al*. (1989) who has worked with Kashmir soils. The soils under study fall in higher category for available Manganese (Table 2). This is in line with those of Mir (1994). The concentration of Manganese decreased with increase in soil depth. These findings are also confirmed by Jalali *et al*. (1989); Chibba and Sekhan (1985) and Bhat (2001).

5.1.10 Available Iron

The DTPA extractable Iron in soils under study revealed a range of 42.8-58.33 ppm with a mean value of 47.79 ppm in surface soils and 29-49.50 ppm with an average value of 38.04 ppm in sub-surface soils (Table 6). The available Iron showed a decreasing trend with an increase in soil depth, with maximum amount in surface soils, which may be due to sufficient natural vegetation and favourable pH of surface soils. This is supported by the findings of Tripathi (1994) and Bhandari and Randhawa (1985) who also observed that available Iron in soils is largely influenced by the organic carbon content.

5.2 Physico-chemical properties of soils

5.2.1 Mechanical composition

A perusal of table 4 indicated that sand content ranged from 14.4-26.16 per cent in surface soils and 14.74-28.35 per cent in sub-surface soils with mean value of 20.53 and 20.89 percent respectively with an inconsistent distribution with depth. Similar observation has been reported in almond orchard soils of Kashmir by Mir (1994). The silt fraction in surface soils varied from 42.87-58.85 and in sub-surface soils ranged between 42.34-58.01 per cent with mean value of 48.16 and 48.72 per cent respectively (Table 4). There was an erratic distribution of silt content with an increase in soil depth. Similar observation were reported by Talib (1984) while working with soils of Kashmir. The clay content ranged from 26.23-32.29 and 24.17-34.77 per cent with mean value of 29.26 and 29.31 per cent in surface and sub-surface soils, respectively with an erratic distribution with depth. This is in accordance with results of Bhat (2001) who studies the high density apple orchard soils. These results are in agreement with the findings of Micheal and Amber (2002) who worked on two alfisols in east central Missouri. Similar observations were reported by Bhargava (2002) who worked on characterization of soil moisture storage and release in soils.

5.2.2 Soil reaction (pH)

The pH in apple orchard soils varied between 6.5-7.4 with a mean value of 7.05 in surface soils and between 6.58-7.55 with a mean value of 7.12 in sub-surface soils (Table 5). The soils were slightly acidic to slightly alkaline in reaction. These observations are in agreement with those of Ganai *et al*. (1991) and Handoo (1983). It was observed that pH increased with depth which is due to the presence of higher amounts of exchangeable bases in sub-surface soils as compared to surface layers. Bhandari and Randhawa (1985) and Mir (1994) have also observed similar trend while working with soils of Shimla (H.P) and Kashmir valley (J&K), respectively. Xiubin *et al*. (2002) also reported the similar observations who worked on paleopedological investigation of three agricultural loess soils on the loess plateau.

5.2.3 Electrical conductivity (EC)

The electrical conductivity of surface soils varied from 0.25-0.47 dSm^{-1} with a mean value of 0.34 dSm^{-1} whereas in sub-surface soils it varied from 0.32-0.54 dSm^{-1} with a mean value of 0.45 dSm^{-1} (Table 5). The electrical conductivity of all the profiles was normal. The electrical conductivity showed an increasing trend with an increase in soil depth. This can be attributed to the leaching of soluble salts and exchangeable bases. This is in accordance with the findings of Balanagoudar and Satyanarayana (1990) and Jalali *et al*. (1989). Similar observations were reproted by Bhargava (2002) who worked on characterization of soil moisture storage and release in soils. Sharma *et al*. (2001) reported similar trend of electrical conductivity along the depth while working with characterization of soils of Kathiawar region of Gujrat as influenced by topography.

5.2.4 Calcium carbonate

The studies revealed that apple orchard soils of Bangil area of district Baramulla are by and large calcareous in nature. The Calcium carbonate content in both surfaces and sub-surfaces soils ranged from 3.30- 4.33 per cent and 3.32 to 4.67 per cent with mean values of 4.18 and 4.39 per cent, respectively (Table-5). The distribution of Calcium carbonate in various profiles under study revealed an increasing trend down the profile. This can be attributed to the leaching of free Calcium carbonate. The results are in agreement with the findings of Handoo (1983) and Mir (1994). Xiubin *et al*. (2002) reported similar results who worked on paleopedological investigation of three agricultural loess soils on the loess plateau of China.

5.2.5 Organic carbon

The organic carbon content ranged from 1.32-1.60 per cent with a mean value of 1.47 per cent in surface soils and 0.56-1.61 per cent with a mean value of 0.82 per cent in sub-surface soils (Table 5). The surface oils showed higher content of organic carbon, which decreased with an increase in soil depth. The high content of organic carbon in these soils is due to natural vegetation, besides the frequent addition of farm yard manure to these orchards. Similar observations were also reported by Talib (1984) and Ganai *et al* (1991) for soils of Kashmir and Singh (1987) for soils of Kinnour district of Himachal Pradesh. These observations are in confirmity with those of Xiubin *et al*. (2002) and Bhargava (2002).

5.3 Relationship between available nutrients and physico-chemical properties of soil

5.3.1 Soil reaction

The surface soil pH showed significant but negative relationship with exchangeable Nitrogen, Zinc, Copper, Manganese and Iron (Table 8), whereas in sub-surface soils it showed significant but negative correlation with Zinc, Copper, Manganese and Iron (Table 9). Since the soils are calcareous, the increase in soil reaction with increase in depth may be due to leaching of Calcium and Magnesium carbonates. A negatively significant and negative relationship between pH and available Nitrogen is confirmed by the findings of Narboo (1994). The inverse relationship between pH and Zinc is well recognized by Haby and Sims (1979)

Lins and Cox, (1988); Katyal and Sharma (1991). As evident from the coefficient of correlation, pH seemed to dominantly influence the Manganese availability in soils. These findings are supported by the work of Lindsay and Cox (1985) who also identified pH as a key factor influencing the Manganese availability in soils. The negatively significant relationship between Iron and pH might be due to the precipitation of soluble Iron and Ferric hydroxide in higher pH which is in confirmity with Prasad and Sakal (1991) and Singh and Ahuja (1990). A negatively significant correlation between pH and DTPA Copper is supported by the findings of Arora and Sekhan (1981); Mir (1994) Bhandari and Randhawa (1985). The availability of Phosphorus also decreased with an increase in pH because of its conversion in to insoluble tricalcium phosphates. A negative relationship between pH and available Phosphorus is also confirmed by Singh in orchard Soils of Kinnuar district of Himachal Pradesh. The negative relationship between pH and available Potassium was observed by Singh (1987) and Ahuja (1990), Mushki (1994) and Narboo (1994).

5.3.2 Organic carbon

Organic carbon content showed a positively significant relationship with available Nitrogen, Zinc, Copper, Manganese and Iron in surface soils (Table-8), while as it bore a positively significant correlation only with available Sulphur and Copper in the subsurface soils (Table 9). The increase in the availability of Nitrogen, Sulphur, Zinc, Copper, Manganese and Iron with an increase in organic carbon content may be attributed to the release of these elements from organic complexes as well as from weathering of minerals containing them due to acidulating action of organic matter. The positive significant relationship of organic carbon with available Nitrogen was also reported by Mushki (1994), Singh and Ahuja (1990) and Dar (1996). The positively significant correlation of organic matter with available Nitrogen may be attributed to the association of Nitrogen with organic matter and adsorption of NH_4-N by humus complex in the soil.

5.3.3 Calcium carbonate

Calcium carbonate showed a negatively significant correlation with Nitrogen, Zinc, Copper, Manganese and Iron besides a positively significant correlation with Calcium and Magnesium in surface soils (Table 8) whereas Calcium carbonate had a negatively significant relationship with, available Zinc, Copper, Manganese and Iron in subsurface soils (Table 9). The negatively significant relationship between Calcium carbonate and available Nitrogen has been also observed by Mir (1994).

The negative correlation of available Phosphorus with Calcium carbonate may be due to adsorption and rapid precipitation of Phosphorus with Calcium carbonate (Tisdale *et al*., 1995).

The negatively significant relationship between Calcium carbonate and available micro-nutrient cations may be attributed to the effect of Calcium carbonate on soil pH which increases with an increase in Calcium carbonate thereby decreasing the availability of micro-nutrient cations. The negatively significant correlation between Calcium carbonate and DTPA extractable cations has been confirmed by the findings of Sakal *et al*. (1985), Rawat and Mathpal (1981), Jalali *et al*. (1989) and Mir (1994).

5.3.4 Clay

The clay content showed a positively significant correlation with available Calcium, Magnesium and Iron in surface soils (Table 8). The significant correlation between clay and Calcium is in agreement with Singh (1987) whereas

Iron showing positively significant correlation with clay is in agreement with Tiwari and Mishra (1993) and Jalali (1989).

The significant correlation between clay and Calcium, Magnesium and Iron is attributed to the increase in retention of Calcium, Magnesium and Iron by the finer fraction of soil.

5.4 Leaf nutrient status of apple orchards

5.4.1 Nitrogen

The Nitrogen content in the leaves varied from 1.72 - 2.40 per cent with a mean value of 2.09 per cent (Table 7). These findings are in agreement with those of Sharma *et al*. (1982) and Mushki (1994) Table 7 revealed that all the leaf samples were medium in their nitrogen content. These results are in accordance with those of Basso and Wilms (1988) Gosh and Malakauti (1992) who attributed it to annual application of this nutrient, decomposition of plant biomass and natural release by soil together with the biological fixation of rhizobia of legumes present in the vegetation of grass alleys of orchards.

5.4.2 Phosphorus

The Phosphorus content varied from 0.19 - 0.28 per cent with a mean value of 0.22 per cent (Table 7). These results are supported by the findings of Singh and Bhandari (1992), Sharma and Bhandari (1995). The Phosphorus content in the leaves was optimum. This can be attributed to the annual application of the nutrient, besides the high quantities of organic mater. These findings are confirmed by the observations of Awasthi *et al*. (1999), Singh and Bhandari (1992) while examining the nutrient status of apple orchards in Kinnuar district of Himachal Pradesh.

5.4.3 Potassium

The Potassium content in the leaves varied from 1.56 -1.85 per cent with a mean value of 1.70 per cent (Table 7). These results are supported by Bhandari and Sharma (1981) and Mushki (1994). Prevalence of optimum potassium content in the leaves is in agreement with the findings of Awasthi *et al*. (1999), Bhandari and sharma (1981). This may be attributed to the sufficient amount of available Potassium in the orchards, these results are supported by the findings of Awsthi *et al*. (1999).

5.4.4 Calcium

The Calcium content of apple leaves was found to vary from 1.71-2.08 per cent with a mean value of 1.82 per cent (Table 7). These results are in agreement with Bhandari and Sharma (1992); Mushki (1994) and Haynes (1990). A perusal of data indicated that apple orchards in Kashmir valley are adequately supplied with Calcium. These results are in conformity with the findings of Bhandari and Sharma (1981) and Bhat (2001)

5.4.5 Magnesium

The magnesium content in varied between 0.23-0.43 per cent with a mean value of 0.29 per cent (Table 7). The data indicated that the leaves are adequately supplied with magnesium at all the locations. Adequacy of Magnesium was reported by Awasthi *et al.* (1998) and Singh (1987). Prevalence of high Magnesium content in valley orchards (Table 7) can be ascribed to their optimum pH that enhances Magnesium availability Sharma *et al.* (1982), Awasthi *et al.* (1979) and Sharma and Bhandari (1992).

5.4.6 Sulphur

The leaf Sulphur content varied from 0.42-0.63 per cent with a mean value of 0.50 per cent (Table 7). Similar results have been also reported by Badyal and Kar (1984) while studying the sulphur content in Santa Rosa cultivar of plum in Himachal Pradesh. Optimum Sulphur contents were observed in these orchards. These can be attributed to the application of Sulphur containing fungicides. Similar results were reported by Awasthi *et al*. (1999).

5.4.7 Zinc

The content of Zinc in leaves varied from 21-26 ppm with a mean value of 23.92 ppm (Table 7). These findings are in agreement with those of Singh (1987) and Mushki (1994). Almost all the orchards studied were medium in the content of Zinc. The results are in agreement with the findings of Bhandari and Sharma (1992) who reported that 90 per cent of samples were medium in Zinc in Himachal Pradesh. Bhat (2001) observed similar results.

5.4.8 Copper

The content of Copper varied from 5-12 ppm with a mean value of 8.14 ppm (Table 7). The results are in agreement with the findings of Sharma and Bhandari (1995); Mushki (1994). The data presented in table 7 revealed that most of the samples were adequate in Copper content. This is in accordance with the findings of Ganai *et al*. (1991). Awasthi *et al*. (1999) and Bhat (2001) observed similar results from Himachal Pradesh and Kashmir valley respectively.

5.4.9 Manganese

The content of Manganese varied from 51-101 ppm with an average value of 72.35 ppm (Table 7). The results are in agreement with those of Singh (1987); Mushki (1994) and Rana *et al*. (1984). The orchards are adequately supplied with Manganese as evident from table 7. Bhandari and Randhawa (1978) and Mushki

(1994) have also reported adequacy of this nutrient content in Himachal Pradesh and Kashmir soils, respectively.

5.4.10 Iron

The Iron content ranged between 89-130 ppm with a mean value of 108.64 ppm (Table 7). These results are in agreement with those of Mushki (1994) and Sharma and Bhandari (1995). The optimum content of Iron in the leaves may be due to favourable soils reaction and adequate quantities of organic matter that form soluble complexes, subsequently available to plants. Similar results have been reported by Rana *et al*. (1984); Sharma *et al* (1982) and Bhat (2001).

5.5 Relationship between available and leaf nutrient content

The information on the nutrient status of fruit trees and the soils is important to serve as a guide for the fertilizer recommendations for economic fruit production and therefore to assess the performance of fruit trees. Thus it is important to correlate the results of soil and plant analysis data to study the relationship existing between them. The data on the subject presented in Table 10 is discussed as under:

The available Nitrogen content in surface and subsurface layers exhibited positively significant relationship with its leaf content (Table 10). Similar results have also been reported by Awasthi *et al*. (1998) and Singh and Bhandari (1992) while working with apple orchard soils of Himachal Pradesh. This is supported by the work of Anderson and Alberigo (1977) who reported that macro-nutrient elements in leaves have more significant correlation with the surface soils as compared to subsurface soils.

The Phosphorus content of leaves exhibited positively significant correlation with available Phosphorus from both surface and subsurface soils (Table 10). These results are supported by Mushki and Mir (1994) and are further confirmed by Mamgain *et al*. (1998).

The Potassium content in the leaves indicated positively significant relationship with available Potassium from surface soils only. These results are in confirmity with the findings of Mushki (1994) and Mir (1994).

A positively significant relationship existed between leaf Calcium and surface as well as subsurface available Calcium content (Table 10). These results are supported by the findings of Mushki (1994); Singh (1987) and Basso and Wilms (1988) in Golden delicious and Fuji cultivars.

The Magnesium content in the surface soils only exhibited Positively significant correlation with its leaf content (Table 10). These results are in confirmity with the findings of Morgan and Hannerty (1979). These results are further supported by the work of Anderson and Alberigo (1977) who reported that leaf Magnesium exhibited more positively significant correlation with the available Magnesium content in the surface soils only.

The leaf micro-nutrient Zinc, Copper and Iron bore a positively significant correlation with their respective available contents from the surface soils whereas Manganese showed a positively significant correlation with its respective contents from both surface as well as subsurface layers (Table 10). These results are in agreement with those of Mushki (1994); Singh (1987). The variation in the degree of relationship of the depth wise available nutrient supply with the plant content may be due to the differences in the tree root ramification or the competition between the tree roots and roots of cover crops and the nutrient ion interactions

(Beattie and Ellenwood, 1950). The vaariable correlations may be also due to the influence of weather and size of the crop as well as orchard management practices (Walter, 1961).

5.6 Characterization and classification of the soils as per soil taxonomy

5.6.1 Morphological characteristics

Perusal of data shown in table 11 revealed that all the profiles qualify for 10 YR hue. Generally the surface horizons were dark yellowish brown (10 YR 3/4) dark brown (10 YR 3/3) and very dark brown (10 YR 2/2) when moist. The B horizons were either dark brown (10 YR 4/3) or dark yellowish brown (10 YR 4/4) which is indicative of more or less well drained conditions in the area which is in line with the observations reported by Gupta and Verma (1992). The dark colour may be due to the organic matter and the dark brown colour may be due to the calcareous nature of the soil which is in agreement with the findings of Gupta *et al*. (1988). These results are also supported by Nayak *et al*. (2001) who worked on characterization and classification of the soils of central Research Station Bhubaneswar. Similar results were also reported by Micheal and Amber (2002).

The structure in all the profiles is by and large moderately developed, i.e. sub-angular blocky. The texture of the soil is generally clay loam, which is in agreement with the observations reported by Sharma *et al*. (1997); Kharche *et al*. (2000); Nayak *et al*. (2001) and Micheal and Amber (2002). The data provided in table 11 revealed that the soil in the surface layers were in general slightly hard when dry and friable when moist. The consistency of these soils appear to have direct correlation with their texture i.e. heavier the soil, more sticky and plastic which is indicative of good water retention characteristic of these soils. The clay content ranged from 29.58-38.01 per cent (Table 12). These findings are in agreement with those of Katoo (2001).

Plenty of roots were found upto a depth of 9-80 cm. The sub soil showed presence of many and fine roots. Increase in the clay content showed an adverse effect on root penetration (Table 12).

The soils of Bangil area are calcareous in nature as free calcium carbonate present showed effervescence with dilute Hcl varying from slight to strong in the surface and subsurface layers. These results are in line with the findings of Katoo (2001).

5.6.2 Physical characteristics

5.6.2.1 Particle size distribution

The study of mechanical composition is of immense importance in knowing the nutrient status, aeration and water retention capacity of soil. The perusal of the data (Table 12) revealed that fine sand varied from 19.3-25.84 per cent whereas coarse sand varied from 0.84-2.86 per cent. More clay content was present in B-horizon. The silt ranged from 40.2-48.57 percent. There is an evidence of down ward movement of clay with maximum enrichment in B2t horizon. The clay content varied from 29.58-38.01 percent. These results are in confirmity with those of Mishra and Ghosh (1995), Sharma *et al*. (1997), Micheal and Amber (2002).

5.6.3 Chemical characteristics

5.6.3.1 Soil reaction (pH)

The soils under study were almost neutral. The results presented in table 13 revealed that pH values ranged from 7.20 - 7.58 and such findings were in line with those of Shinde and Talib (1984) especially for karewas wherein there was an increasing trend in the pH with the increase in the depth since the soils are calcareous in nature, due to the presence of free Calcium carbonate, the soil reaction enhances with the depth. These findings were in line with those of Tripathi and Sharma (1993) Minhas *et al*. (1995), Kharche *et al*. (2000), Sharma *et al*. (2001), Micheal and Amber (2002) and Xiubin *et al*. (2002).

5.6.3.2 Electrical conductivity

The data on electrical conductivity presented in table 13 revealed that the electrical conductivity of the soils under study was between 0.30 and 0.52 dSm^{-1} and was normal thereby indicating low amount of soluble salts. Marazi (1988) and Jalali *et al*. (1989) have also reported a normal range of electrical conductivity while studying the soils of Kashmir. Similar observations were reported by Sharma *et al*. (2001) and Bhargave (2002).

5.6.3.3 Organic carbon

The data (Table 13) revealed that organic carbon content varied from 0.58 - 1.43 per cent. The organic carbon was highest at the surface epipedon and decreased gradually, with the increase in depth. The greater accumulation of organic matter in the epipedon is due to addition of leaf litter organic manures an turn over of previous crop residues. This was in line with the observations of Dhar *et al*. (1988), Gupta and Tripathi (1993). Similar observations were reported by Kaistha and Gupta (1994) and Sharma *et al*. (1999).

5.6.3.4 Calcium carbonate

Data presented in table 13 revealed that the Calcium carbonate content in the profiles varied from 4.21-4.68 per cent. Calcium carbonate showed an increasing trend along the depth of profile. This can be attributed to the leaching of calcium from the upper horizons. These results are in agreement with the findings of Handoo (1983), Mir (1994), Sharma *et al*. (2001), Xiubin *et al*. (2002) and Bhargava (2002).

5.6.3.5 Cation exchange capacity (CEC)

CEC is an important parameter. Its study helps to know the nutrient supplying capacity of soil. The data presented in table 13 suggested that cation exchange capacity of the soils under study ranged from 19.40-20.22 C mol kg^{-1}. This cation exchange capacity showed an erratic trend with the depth, which could be attributed to the variation in clay content and organic matter content. Such observations have also been reported by Mandal *et al*. (1990), Gangopadhyay *et al*. (1990), Sharma *et al*. (2001), Kharche *et al*. (2000), Bhargava (2002), Nayak *et al*. (2001), Xiuibin *et al*. (2002) and Micheal and Amber (2002).

5.6.4 Taxonomic classification

On the basis of morphological, physical and chemical characteristics these soils have been classified (Table 14). The perusal of table revealed that the soils of Bangil area of district Baramulla fall in the order Alfisols, since their epipedon is medium in organic matter, hence the epipedon goes to Ochric diagnostic surface horizon. Moist value is between 3 and 4 and the underlying horizon in which clay has accumulated (Table 12) which qualifies for argillic horizon hence the subsurface diagnostic horizon being argillic. Since the karewas of Bangil area are formed on lacustrine post pleistocene deposits and thus the soils qualify for the order Alfisols (Micheal and Amber, 2002).

These soils do not remain dry for 90 cumulative days due to the well distributed rainfall of the area, hence the udic moisture regime and the suborder will be Udalf and Hapludalf the great group. Similar observations have been reported by Shinde *et al*. (1984). Katoor (2001), Micheal and Amber (2002).

CHAPTER-VI

SUMMARY AND CONCLUSION

The nutrient status and soil characterization of apple orchards of Bangil area of district Baramulla was assessed by studying soil and leaf samples of representative orchards. The soil profiles were studied for their morphological and physico-chemical characteristics. Soil samples were collected from four 0-20, 20-40, 40-60 and 60-80 cm, depths for each orchard and analyzed for the available macro and micro-nutrients in addition to the physico-chemical characteristics. Leaf samples were also collected from red delicious cultivars of apple under neath which the soil samples were collected. These leaf samples were digested and analyzed for estimation of macro and micro-nutrients. Relationships between the available nutrients and the physico-chemical properties and the leaf nutrient contents were also determined. The results thus obtained are summarized as under.

6.1 Depth-wise distribution of available nutrient elements in the soil

The available Nitrogen content in the surface and subsurface soil varied from 98-122 and 90-114 ppm with mean values of 110.85 and 100.42 ppm, respectively. It showed a decreasing trend with soil depth and the soils were medium in available Nitrogen. The available Phosphorus content ranged from 10-19 ppm with a mean value of 14.79 in surface soils and 9-17.12 ppm with a mean value of 13.39 ppm in subsurface soils. All the soils under study were medium to high in available Phosphorus status.

The soils were generally high in available Potassium content and ranged from 157.7-206.6 ppm with a mean value of 186.95 ppm in surface soils whereas it ranged from 100.3 –167.15 ppm with a mean value of 125.92 ppm in subsurface soils.

The available content of Calcium in surface and subsurface soils varied from 2842-3616 ppm and 2838-3982 ppm with mean values of 3320.21 ppm and 336.21 ppm, respectively. The available Magnesium content varied from 140.2 – 178.40 ppm with a mean value of 158.2 ppm in surface soils where as it ranged between 126-188.6 ppm with a mean value of 153.88 ppm in subsurface soils. The available Sulphur content in the soils under study ranged from 9.7-13.50 ppm with a mean value of 11.34 ppm in surface layers whereas it varied from 6.71-9.68 ppm with a mean value of 7.94 ppm in subsurface soils. The soils were medium in available Sulphur content.

The DTPA extractable Zinc, Copper, Manganese and Iron varied from 0.80 – 0.89, 0.82 –1.27, 32.02 – 58.02 and 42.8 – 58.33 ppm with a mean values of 0.85, 1.04, 44.40 and 47.79 ppm in surface soils respectively, whereas in subsurface soils these ranged from 0.60-0.89, 0.52-1.23, 26.0-45.14 and 29-49.50 ppm with mean values of 0.75, 0.82, 33.86 and 38.04 ppm, respectively. The soils had a medium to high status of available micro-nutrients.

6.2 Physico-chemical properties of soils

The Sand silt and clay content varied from 14.4 -26.16, 42.87 -56.85 and 26.23-32.29 per cent with mean values of 20.53, 48.16 and 29.26 per cent, respectively. The texture of soils studied is by and large silty clay loam to clay loam in surface soils whereas in subsurface soils these ranged from 14.74- 28.35, 42.34-58.01 and 24.17-34.77 per cent with mean values of 20.89, 48.72 and 29.31 per cent with mean values of 20.89, 48.72 and 29.31 per cent respectively.

The soils were slightly acidic to slightly alkaline in reaction with pH ranging from 6.5-7.4 and 6.58-7.55 with mean values of 7.05-7.12 in surface and subsurface layers, respectively and a gradual increase in pH was observed with soil depth.

The electrical conductivity was normal and varied from 0.25-0.47 and 0.32-0.54 dSm^{-1} with mean values of 0.34 dSm^{-1} and 0.45 dSm^{-1} in surface and subsurface soils, respectively.

The Calcium carbonate content in surface layers ranged from 3.30-4.33 per cent with a mean values of 4.18 per cent whereas in subsurface soils its content ranged between 4.13-4.67 percent with an average value of 4.38 per cent. It showed an increasing trend with soil depth.

Organic carbon ranged from 1.32-1.60 per cent with a mean value of 1.47 per cent in surface soils whereas it ranged from 0.56-1.61 per cent with a mean value of 0.82 per cent in subsurface soils. Organic carbon showed decreasing trend with increase in depth. Cation exchange capacity was observed in the range of 16.60-20.80 C mol kg^{-1} with a mean value of 19.77 C mol kg^{-1} in surface soils and 18.98-20.52 C mol kg^{-1} with an average of 20.04 C mol kg^{-1} in subsurface soils. All the soils were low in cation exchange capacity.

6.3 Relationship between available nutrients and physico-chemical properties

The soil pH exhibited a negatively significant correlation with available Nitrogen, Zinc, Copper, Manganese and Iron in surface soils whereas in subsurface soils it had a negatively significant relationship with Zinc, Copper, Manganese and Iron and exhibited positively significant relationship with Calcium and Magnesium from both surface and subsurface soils.

Organic carbon in surface soils exhibited a positively significant relationship with available Nitrogen, Zinc, Copper, Manganese and Iron and in subsurface soils it was found to have a positively significant relationship with available Sulphur and Copper only.

The Calcium carbonate content in surface soils had a positively significant relationship with available Calcium and Magnesium and negatively significant correlation with available Nitrogen, Zinc, Copper, Manganese and Iron. Its content in subsurface soils showed a negatively significant relationship with available Zinc, Copper, Manganese and Iron.

The clay content bore a positively significant relationship with available Calcium, Magnesium and Iron from surface layers whereas in subsurface soils it did not show any significant relationship with any available nutrient element.

6.4 Leaf nutrient status of apple orchards

The Nitrogen content in red delicious apple cultivars ranged from 1.72-2.40 per cent with a mean value of 2.09 per cent. The phosphorus content varied from 0.19 – 0.28 per cent with an average of 0.22 per cent. The leaf Potassium, Calcium, Magnesium and Sulphur content observed to vary from 1.56-1.85, 1.71-2.08, 0.23-0.43, 0.42-0.63 per cent with mean values of 1.70, 1.82, 0.29 and 0.50 per cent, respectively.

The micro-nutrient concentration viz Zinc, Copper, Manganese and Iron ranged from 21-26, 5-12, 51-101 and 89-130 ppm with mean values of 23.92, 8.14, 72.35 and 108.64 ppm, respectively. As such the macro- and micro-nutrient were medium to high in the leaves of red delicious cultivar of Bangil area orchards.

6.5 Relationship between available and leaf nutrient content

All the available macro and micro-nutrients like Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Zinc, Copper, Manganese and Iron from the surface layers had a positively significant relationship with their respective contents in the leaves, whereas incase of subsurface soils a positively significant correlation was observed between the available Nitrogen, Phosphorus, Calcium and Manganese with their respective concentrations in the leaves.

6.6 Characterization and classification of the soils as per soil taxonomy

The major findings of this investigation are summarized as follows:

6.6.1 Physical and chemical characteristics

Texture: the texture of Bangil area apple orchard soils was found to be clayey (Table-15)

Soil reaction: The pH was normal and ranged between 7.20 – 7.58 and the soils were slightly acidic to slightly alkaline.

Electrical conductivity: Electrical conductivity showed a normal range of 0.30 – 0.52 dSm^{-1}

Organic carbon: A medium range of organic carbon content ranging from 0.60 – 1.44 per cent was observed.

Calcium carbonate: Calcium carbonate in the profiles studied ranged from 4.21 –4.68 per cent and exhibited an increasing trend along the depth.

Cation exchange capacity: CEC ranged from 19.40-20.22 C mol kg^{-1}.

Taxonomic classification: The apple orchard soils of Bangil area of district Baramulla, on the basis of their morphological, physical and chemical characteristics, have been placed under the order Alfisols suborder Udalf and great group Hapludalfs as per USDA comprehensive classification system.

CONCLUSION

The present investigation revealed that the soils were by and large adequately supplied with available contents of macro and micro-nutrients. The leaf analysis indicated that orchards were optimum in Nitrogen, Phosphorus, Potassium, Sulphur, Zinc, Copper, Manganese and Iron where as Calcium was high. From the correlation coefficient values it was inferred that the cultivar under study absorbed most of the nutrients from the surface soils.

The apple orchard soils of Bangil area are lacustrine deposits. There is a definite elluviation of clay from the upper surface and illuviation in the underlying layers. The layers recognized as genetic horizons have been designated as Ap, A_2. B_1, B_{2t} and C. As per soil taxonomy (USDA), these soils have been classified as Alfisols at the order level, Udalfs at the suborder level and Hapludalfs at the great group level.

Table-4: Particle size distribution

S. No.	Location	Depth (cm)	Fine sand (%)	Coarse sand (%)	Silt (%)	Clay (%)	Textural class
1.	Kalantra	0-20	14.40	1.14	56.84	27.60	Silty clay loam
		20-40	21.20	0.76	51.05	26.99	Silty clay loam
		40-60	14.74	0.73	57.68	26.85	Silty clay loam
		60-80	16.23	1.06	58.01	24.68	Silty loam
2.	Kreeri	0-20	19.72	2.14	48.57	29.55	Clay loam
		20-40	16.63	1.33	49.20	32.84	Silty clay loam
		40-60	17.68	1.42	48.51	32.39	Silty clay loam
		60-80	18.26	0.98	46.20	34.56	Silty clay loam
3.	Tapper	0-20	25.23	1.76	42.87	30.14	Clay loam
		20-40	25.84	1.50	42.34	30.32	Clay loam
		40-60	20.91	0.78	46.29	32.02	Clay loam
		60-80	23.77	0.80	47.45	27.98	Clay loam
4.	Kralweth	0-20	20.55	2.40	47.33	29.72	Clay loam
		20-40	20.19	1.38	50.73	27.70	Silty clay loam
		40-60	20.40	1.08	51.19	27.33	Silty clay loam
		60-80	26.88	1.13	43.14	28.85	Clay loam
5.	Batapora	0-20	26.16	1.21	43.36	29.27	Clay loam
		20-40	28.35	1.28	43.49	26.88	Clay loam
		40-60	21.47	1.15	44.50	32.88	Clay loam
		60-80	27.25	0.68	42.54	29.53	Clay loam
6.	Lalpora	0-20	14.41	1.12	56.85	27.62	Silt loam
		20-40	21.34	0.69	50.98	26.99	Silt loam
		40-60	14.75	0.71	57.67	26.87	Silt loam
		60-80	16.24	1.04	57.99	24.73	Silt loam
7.	Telgam	0-20	19.74	2.11	48.57	29.58	Clay loam
		20-40	16.65	1.31	49.19	32.85	Silty clay loam
		40-60	18.15	1.25	48.34	32.26	Silty clay loam
		60-80	17.75	1.12	46.36	34.77	Silty clay loam
8.	Mamoosa	0-20	21.87	2.86	43.98	31.29	Clay loam
		20-40	22.02	2.76	43.60	31.62	Clay loam
		40-60	20.40	0.96	46.44	32.20	Clay loam
		60-80	21.27	1.62	48.27	28.84	Clay loam
9.	Kanloo	0-20	21.27	2.15	47.08	29.50	Clay loam
		20-40	24.15	1.05	50.25	24.55	Silt loam
		40-60	21.20	0.84	50.95	27.01	Silt loam

		60-80	27.62	0.87	42.88	28.63	Clay loam

Table-4 Continued

10.	Maghama	0-20	17.20	4.19	46.32	32.29	Clay loam
		20-40	23.06	3.04	45.24	28.66	Clay loam
		40-60	16.39	2.83	46.18	34.60	Silty clay loam
		60-80	18.63	3.55	45.40	32.42	Clay loam
11.	Nihalpora	0-20	18.02	0.35	55.31	26.23	Silt loam
		20-40	17.85	1.85	52.16	28.10	Silt clay loam
		40-60	17.29	0.39	56.07	26.25	Silt loam
		60-80	18.17	0.56	57.10	24.17	Silt loam
12.	Sheerpora	0-20	22.72	1.80	48.24	27.24	Loam
		20-40	22.02	1.12	46.82	30.04	Clay loam
		40-60	20.36	1.27	48.09	30.28	Clay loam
		60-80	21.64	0.84	44.06	33.46	Clay loam
13.	Khore	0-20	21.86	2.88	43.98	31.28	Clay loam
		20-40	21.99	2.79	43.61	31.61	Clay loam
		40-60	20.40	0.95	46.45	32.20	Silty clay loam
		60-80	25.25	0.65	47.07	27.03	Loam
14.	Shrakwara	0-20	24.35	2.14	45.07	28.44	Clay loam
		20-40	24.18	1.22	50.01	24.59	Silt loam
		40-60	21.26	1.67	50.98	26.08	Silt loam
		60-80	27.68	0.94	42.93	28.45	Loam
	Surface range		14.40-26.16	0.35-4.19	42.87-56.85	26.23-32.29	
	Mean		**20.53**	**2.01**	**48.16**	**29.26**	
	Surface range		14.74-28.35	0.39-3.55	42.34-58.01	24.17-34.77	
	Mean		**20.89**	**1.28**	**48.72**	**29.31**	

Table- 5: Physico-chemical properties of soil

S.No.	**Depth (cm)**	pH	EC (dSm^{-1})	OC (%)	$CaCo_3$ (%)	CEC ($Cmol\ kg^{-1}$)
1.	0-20	7.40	0.47	1.44	4.22	19.40
	20-40	7.50	0.47	1.09	4.47	19.51
	40-60	7.53	0.49	1.07	4.49	19.53
	60-80	7.55	0.51	1.05	4.52	19.55
2.	0-20	7.30	0.30	1.53	4.08	20.00
	20-40	7.45	0.34	0.73	4.40	18.98
	40-60	7.47	0.36	0.71	4.42	20.04
	60-80	7.48	0.37	0.67	4.44	20.02
3.	0-20	7.30	0.25	1.58	3.92	20.30
	20-40	7.43	0.50	0.63	3.30	20.50
	40-60	7.45	0.52	0.61	3.32	20.48
	60-80	7.47	0.53	0.59	3.34	20.52
4.	0-20	7.20	0.37	1.53	4.12	20.20
	20-40	7.33	0.48	0.76	4.35	20.48
	40-60	7.35	0.50	0.74	4.35	20.44
	60-80	7.37	0.52	0.72	4.37	20.46
5.	0-20	7.20	0.30	1.36	4.31	20.00
	20-40	7.31	0.44	0.64	4.62	19.93
	40-60	7.32	0.46	0.62	4.64	19.91
	60-80	7.33	0.48	0.60	4.66	19.95
6.	0-20	7.10	0.46	1.41	4.27	19.30
	20-40	7.28	0.47	0.73	4.56	19.10
	40-60	7.30	0.49	0.71	4.58	19.08
	60-80	7.31	0.50	0.69	4.60	19.12
7.	0-20	7.20	0.30	1.49	4.18	19.90
	20-40	7.24	0.32	1.61	4.41	19.88
	40-60	7.27	0.34	1.59	4.43	19.90
	60-80		0.36	1.57	4.45	19.92
8.	0-20		0.26	1.52	4.18	20.20
	20-40		0.49	0.78	4.37	20.45
	40-60		0.51	0.76	4.39	20.42
	60-80		0.53	0.74	4.41	20.43
9.	0-20		0.35	1.54	4.06	20.80
	20-40		0.48	0.68	4.34	20.50
	40-60		0.50	0.66	4.36	20.52

	60-80		0.52	0.64	4.38	20.48

Table- 5 Continued

10.	0-20		0.30	1.60	3.92	16.60
	20-40		0.48	1.59	4.13	19.75
	40-60		0.52	1.57	4.15	19.73
	60-80		0.54	1.55	4.17	19.71
11.	0-20		0.28	1.32	4.33	20.00
	20-40		0.44	0.60	4.63	20.02
	40-60		0.46	0.58	4.65	20.04
	60-80		0.48	0.56	4.67	20.00
12.	0-20		0.46	1.39	4.29	20.00
	20-40		0.45	0.69	4.59	20.36
	40-60		0.47	0.67	4.61	20.38
	60-80		0.49	0.65	4.62	20.34
13.	0-20		0.46	1.43	4.21	20.10
	20-40		0.47	0.75	4.50	20.20
	40-60		0.49	0.73	4.52	20.22
	60-80		0.51	0.72	4.54	20.18
14.	0-20		0.30	1.51	4.16	20.00
	20-40		0.32	0.61	4.40	20.03
	40-60		0.34	0.59	4.42	20.05
	60-80		0.36	0.57	4.44	20.01
	Surface range	6.50-7.40	0.25-0.47	1.32-1.60	3.92-4.33	16.60-20.80
	Mean	**7.05**	**0.34**	**1.47**	**4.16**	**19.77**
	Sub-surface range	6.58-7.55	0.32-0.54	0.56-1.61	4.13-4.67	18.98-20.52
	Mean	**7.12**	**0.45**	**0.82**	**4.38**	**20.04**

Table- 5: Physico-chemical properties of soils

S.No.	**Depth (cm)**	pH	EC (dSm^{-1})	OC (%)	$CaCo_3$ (%)	CEC ($Cmol\ kg^{-1}$)
1.	0-20	7.40	0.25	1.32	4.33	19.40
	20-40	7.50	0.50	0.60	4.63	19.51
	40-60	7.53	0.52	0.58	4.65	19.53
	60-80	7.55	0.53	0.56	4.67	19.55
2.	0-20	7.30	0.37	1.51	4.31	20.00
	20-40	7.45	0.48	0.61	4.62	18.98
	40-60	7.47	0.50	0.59	4.64	20.04
	60-80	7.48	0.52	0.57	4.66	20.02
3.	0-20	7.30	0.30	1.36	4.29	20.30
	20-40	7.43	0.48	0.64	4.59	20.50
	40-60	7.45	0.54	0.62	4.61	20.48
	60-80	7.47	0.52	0.60	4.62	20.52
4.	0-20	7.20	0.26	1.58	4.27	20.20
	20-40	7.33	0.49	0.63	4.56	20.48
	40-60	7.35	0.51	0.61	4.58	20.44
	60-80	7.37	0.53	0.59	4.60	20.46
5.	0-20	7.20	0.35	1.39	4.21	20.00
	20-40	7.31	0.48	0.69	4.50	19.93
	40-60	7.32	0.50	0.67	4.52	19.91
	60-80	7.33	0.52	0.65	4.54	19.95
6.	0-20	7.10	0.47	1.54	4.22	19.30
	20-40	7.28	0.47	0.68	4.47	19.10
	40-60	7.30	0.49	0.66	4.49	19.08
	60-80	7.31	0.51	0.64	4.52	19.12
7.	0-20	7.20	0.46	1.41	4.18	19.90
	20-40	7.24	0.47	0.73	4.41	19.88
	40-60	7.27	0.49	0.71	4.43	19.90
	60-80	7.28	0.50	0.69	4.45	19.92
8.	0-20	6.90	0.46	1.53	4.16	20.20
	20-40	7.20	0.47	0.73	4.40	20.45
	40-60	7.22	0.49	0.71	4.42	20.42
	60-80	7.23	0.51	0.67	4.44	20.43
9.	0-20	6.90	0.46	1.53	4.08	20.80
	20-40	7.05	0.45	0.76	4.40	20.50
	40-60	7.08	0.47	0.74	4.42	20.52

	60-80	7.09	0.49	0.72	4.44	20.48

Table – 5 Continued

10.	0-20	6.80	0.30	1.43	4.18	16.60
	20-40	6.86	0.44	0.73	4.37	19.75
	40-60	6.88	0.46	0.73	4.39	19.73
	60-80	6.89	0.48	0.72	4.41	19.71
11.	0-20	7.70	0.28	1.52	4.12	20.00
	20-40	6.83	0.44	0.78	4.35	20.02
	40-60	6.85	0.46	0.76	4.35	20.04
	60-80	6.86	0.48	0.74	4.37	20.00
12.	0-20	6.70	0.30	1.44	4.06	20.00
	20-40	7.74	0.34	1.09	4.34	20.36
	40-60	7.75	0.36	1.07	4.36	20.38
	60-80	7.70	0.37	1.05	4.38	20.34
13.	0-20	6.50	0.30	1.49	4.92	20.10
	20-40	6.68	0.32	1.61	4.13	20.20
	40-60	6.70	0.34	1.59	4.15	20.22
	60-80	6.72	0.36	1.57	4.17	20.18
14.	0-20	6.40	0.30	1.60	3.30	20.00
	20-40	6.58	0.32	1.59	3.32	20.03
	40-60	6.50	0.34	1.57	3.34	20.05
	60-80	6.62	0.36	1.55	3.92	20.01
	Surface range	6.50-7.40	0.25-0.47	1.32-1.60	3.30-4.33	16.60-20.80
	Mean	**(7.05)**	**(0.34)**	**(1.47)**	**(4.18)**	**(19.77)**
	Sub-surface range	6.58-7.55	0.32-0.54	0.56-1.61	3.32-4.67	18.98-20.52
	Mean	**(7.12)**	**(0.45)**	**(0.82)**	**(4.38)**	**(20.04)**

Table- 6: Depth-wise distribution of available macro nutrients (ppm)

Location	Depth (cm)	N	P	K	Ca	Mg	S
1.	0-20	99	10.00	201.50	3652	178.40	9.70
	20-40	92	9.10	100.50	3980	188.60	6.50
	40-60	90	9.06	100.70	3978	188.40	6.90
	60-80	88	9.08	100.30	3982	188.20	6.70
2.	0-20	103	11.00	199.30	3608	174.50	10.80
	20-40	94	9.80	101.50	3612	172.20	6.75
	40-60	92	10.20	101.70	3614	171.80	6.71
	60-80	90	10.00	101.30	3616	172.00	6.73
3.	0-20	98	12.00	199.50	3588	173.20	11.80
	20-40	97	11.10	103.50	3608	169.20	7.08
	40-60	95	10.70	103.48	3608	168.80	7.04
	60-80	93	9.90	103.52	3610	169.00	7.06
4.	0-20	106	12.00	203.60	3580	172.60	12.00
	20-40	100	11.90	103.53	3581	168.00	7.11
	40-60	98	11.00	103.51	3583	167.00	7.15
	60-80	96	9.00	103.55	3612	168.20	7.13
5.	0-20	106	13.00	206.60	3534	163.40	12.00
	20-40	101	11.22	103.20	3332	160.80	7.15
	40-60	99	11.18	103.40	3330	161.20	7.11
	60-80	97	11.20	103.00	3334	161.00	7.13
6.	0-20	120	13.00	203.60	3316	161.80	10.50
	20-40	98	12.80	105.53	3318	157.80	7.66
	40-60	96	12.12	105.51	3320	158.20	7.64
	60-80	94	12.10	105.55	3510	158.00	7.68
7.	0-20	120	14.00	152.70	3286	152.40	10.70
	20-40	98	13.40	130.46	3288	152.00	7.70
	40-60	96	13.80	130.44	3290	151.80	7.50
	60-80	94	13.60	130.48	3410	152.20	7.90
8.	0-20	122	14.00	153.70	3310	152.70	11.80
	20-40	100	13.50	132.48	3312	148.80	7.73
	40-60	98	13.70	132.46	3314	149.00	7.71
	60-80	96	13.90	132.44	3325	149.20	7.75
9.	0-20	110	17.00	154.70	3269	151.30	10.00
	20-40	105	15.12	131.46	3271	150.00	8.66
	40-60	103	15.08	131.44	3273	148.00	8.64
	60-80	101	15.10	134.80	3356	146.00	8.68

Table- 6 Continued

10.	0-20	108	17.20	179.30	3363	153.40	11.50
	20-40	106	15.20	134.80	3359	148.00	6.64
	40-60	104	15.60	135.00	3361	144.00	6.68
	60-80	102	15.40	134.60	3312	146.00	6.66
11.	0-20	118	18.00	193.20	3122	148.50	11.50
	20-40	107	15.90	148.20	3124	148.80	6.66
	40-60	105	15.50	148.24	3126	142.00	6.64
	60-80	103	15.70	148.28	3210	142.20	6.68
12.	0-20	114	18.00	195.20	3095	151.30	13.50
	20-40	112	17.00	149.26	3154	139.00	8.13
	40-60	110	16.80	149.24	3152	138.80	8.11
	60-80	108	16.60	149.28	3156	139.20	8.15
13.	0-20	112	18.90	194.20	3010	141.20	11.00
	20-40	110	16.70	150.20	3012	134.00	9.66
	40-60	108	16.90	150.18	3014	133.80	9.64
	60-80	106	16.11	150.22	3022	134.20	9.68
14.	0-20	116	19.00	180.30	2842	140.20	12.00
	20-40	114	17.08	167.13	2840	126.00	9.64
	40-60	112	7.10	167.11	2838	130.00	9.68
	60-80	110	17.12	167.15	2990	128.00	9.66
	Surface range	98-122	10-19	157.7-206.6	2842-3652	140.20-178.4	9.7-13.50
	Mean	**(110.85)**	**(14.79)**	**(186.95)**	**(3320.21)**	**(158.20)**	**(11.34)**
	Sub-surface range	90-114	9-17.12	100.3-167.15	2838-3982	126-188.6	6.71-9.68

	Mean	**(100.42)**	**(13.39)**	**(125.92)**	**(3360.21)**	**(153.88)**	**(7.94)**

Table- 6: Depth-wise distribution of available micro nutrients (ppm)

Location	Depth (cm)	Zn	Cu	Mn	Fe
1.	0-20	0.80	0.87	39.40	44.20
	20-40	0.64	0.56	30.00	29.35
	40-60	0.62	0.54	28.00	29.33
	60-80	0.60	0.52	26.00	29.32
2.	0-20	0.80	0.94	32.02	44.20
	20-40	0.66	0.62	30.96	33.00
	40-60	0.64	0.60	30.94	31.00
	60-80	0.62	0.58	30.92	29.00
3.	0-20	0.82	0.82	34.23	48.20
	20-40	0.67	0.75	31.03	29.35
	40-60	0.65	0.72	31.01	29.33
	60-80	0.63	0.70	30.99	29.31
4.	0-20	0.83	1.02	40.90	42.80
	20-40	0.70	0.69	31.00	34.00
	40-60	0.68	0.67	29.00	32.00
	60-80	0.66	0.65	27.00	30.00
5.	0-20	0.81	1.14	41.81	34.20
	20-40	0.70	0.69	26.76	34.68
	40-60	0.68	0.67	26.74	34.66
	60-80	0.66	0.65	26.72	34.64
6.	0-20	0.85	0.86	41.10	51.00
	20-40	0.70	0.84	29.70	33.68
	40-60	0.68	0.82	29.68	33.66
	60-80	0.66	0.80	29.66	33.64
7.	0-20	0.86	1.08	42.20	43.50
	20-40	0.77	0.78	31.10	40.00
	40-60	0.75	0.76	30.90	38.00
	60-80	0.73	0.74	30.70	36.00
8.	0-20	0.88	0.88	43.30	50.20
	20-40	0.83	0.88	31.25	41.00
	40-60	0.81	0.86	31.23	39.00
	60-80	0.79	0.84	31.21	37.00
9.	0-20	0.89	0.97	42.93	43.80
	20-40	0.84	0.87	34.89	43.20
	40-60	0.82	0.85	34.85	43.00
	60-80	0.80	0.83	34.83	42.80

Table- 6 Continued

10.	0-20	0.86	1.23	52.02	45.00
	20-40	0.84	0.84	38.00	44.60
	40-60	0.83	0.82	36.00	43.00
	60-80	0.82	0.80	34.00	41.00
11.	0-20	0.87	1.12	56.01	48.50
	20-40	0.87	0.94	34.74	46.00
	40-60	0.85	0.92	34.72	44.00
	60-80	0.83	0.90	34.70	42.00
12.	0-20	0.87	1.15	43.70	49.30
	20-40	0.87	0.97	43.25	44.35
	40-60	0.85	0.95	43.23	44.33
	60-80	0.83	0.93	43.21	44.31
13.	0-20	0.88	1.21	54.01	57.33
	20-40	0.88	1.18	42.70	42.20
	40-60	0.86	1.16	42.68	42.00
	60-80	0.84	1.14	42.66	41.80
14.	0-20	0.89	1.27	58.02	58.33
	20-40	0.89	1.23	45.14	49.50
	40-60	0.87	1.21	45.12	49.30
	60-80	0.85	1.19	45.10	49.28
	Surface range	0.80-0.89	0.82-1.27	32.02-58.02	42.80-58.33
	Mean	**(0.85)**	**(1.04)**	**(44.40)**	**(47.79)**
	Sub-surface range	0.60-0.89	0.52-1.23	26.00-45.14	29-49.50

	Mean	**(0.75)**	**(0.82)**	**(33.86)**	**(38.04)**

Table-11: Some morphological characteristics of soil profiles

Diagnostic Horizons	Depth (cm)	Colour (moist)	Structure	Texture	Consistence	Root distribution	Effervescence
AP	0-29	10 YR 3/4 Dark yellow brown	m1sbk	Cl	dsh mfr wps	c	e
A_3	29-56	10 YR 3/4 Dark yellow brown	m2sbk	Cl	dh mfr wps	m	e
B_1	56-78	10 YR 3/4 Dark yellow brown	m2sbk	Cl	dh mfr wvsp	f	e
B_2t	78-120	10 YR 3/3 Dark brown	m2sbk	Cl	dh mfr wvsp	f	es
C	120-150	10 YR 3/3 Dark brown	m2sbk	Cl	dh mfr wps	vf	es
AP	0-26	10 YR 3/3 Dark brown	m1sbk	Cl	dsh mfr wps	c	e
A_2	26-36	10 YR 4/4 Dark yellow brown	m2sbk	Cl	dh mfr wps	m	e
B_1	36-66	10 YR 4/3 Brown to dark brown	m2sbk	Cl	dh mfr wvsp	f	e
B_2t	66-110	10 YR 3/3 Dark brown	m2sbk	Cl	dh mfr wvsp	f	es
C	110-150	10 YR 3/3 Dark brown	m2sbk	Cl	dh mfr wps	vf	es
AP	0-23	10 YR 2/2 Very dark brown	m1sbk	Cl	dsh mfr wps	c	e
A_2	23-66	10 YR 4/3 Brown to dark brown	m2sbk	Cl	dh mfr wps	m	e
B_1	66-83	10 YR 3/3 Dark brown	m2sbk	Cl	dh mfr wvsp	f	e
B_2t	83-130	10 YR 4/3 Brown to dark brown	m2sbk	Cl	dh mfr wvsp	f	es
C	130-150	10 YR 5/4 Yellow brown	m2sbk	Cl	dh mfr wps	vf	es

Table-14: Taxonomic classification

Diagnostic horizones		Order	Sub-order	Great group
Surface	Sub-surface			
Ochric	Argillic	Alfisols	Udalfs	Hapludalfs

Table-12: Particle size distribution (%)

Diagnostic horizone	Depth (cm)	Coarse sand	Fine sand	Silt	Clay	Textural class
Profile-I						
AP	0-29	2.40	20.55	47.33	29.72	**Cl**
A_2	29-56	2.11	19.74	48.57	29.58	Cl
B_1	56-78	2.76	22.02	43.60	31.62	Cl
B_2t	78-120	2.08	20.20	41.30	36.48	Cl
C	120-150	1.27	20.36	48.09	30.28	Cl
Profile-2						
AP	0-16	2.86	21.87	43.98	31.29	Cl
A_2	16-26	2.76	22.52	43.10	31.62	Cl
B_1	26-57	0.96	20.40	46.44	32.20	Cl
B_2t	57-110	1.59	19.30	41.10	38.01	Cl
C	110-150			48.27	28.84	Cl
Profile-3						

AP	0-12	1.76	25.23	42.87	30.14	Cl
A_2	12-66	1.50	25.84	42.34	30.32	Cl
B_1	66-83	1.60	25.50	42.30	33.60	Cl
B_2t	83-130	1.28	22.09	40.20	36.43	Cl
C	130-150	0.84	21.64	44.06	33.46	Cl

Table-13: Chemical properties of the soil profile

Diagnostic horizones	**Depth (cm)**	**pH (1: 2.5)**	**EC (dSm^{-1})**	**Organic carbon (%)**	**$CaCo_3$ (%)**	**CEC ($Cmol\ kg^{-1}$)**
Profile 1 (Lalpora)						
AP	0-29	7.20	0.47	1.44	4.22	**19.40**
A_2	29-56	7.24	0.47	1.09	4.47	19.51
B_1	56-78	7.27	0.49	1.07	4.49	19.53
B_2t	78-120	7.28	0.51	1.05	4.52	19.55
C	120-150	7.30	0.52	1.03	4.53	19.57
Profile-II (Tilgam)						
AP	0-16	7.40	0.30	1.36	4.31	20.00
A_2	16-26	7.50	0.44	0.64	4.62	19.93
B_1	26-57	7.53	0.46	0.62	4.64	19.91
B_2t	57-110	7.55	0.48	0.60	4.66	19.95
C	110-150	7.58	0.51	0.58	4.68	19.97
Profile-III (Kreeri)						

AP	0-12	7.20	0.46	1.43	4.21	20.10
A_2	12-66	7.33	0.47	0.75	4.50	20.20
B_1	66-83	7.35	0.49	0.73	4.52	20.22
B_2t	83-130	7.37	0.51	0.72	4.54	20.18
C	130-150	7.40	0.52	0.70	4.56	20.21

Table-8: Relationship between physico-chemical properties and available nutrients in surface soils

	N	P	K	Ca	Mg	S	Zn	Cu	Mn	Fe
pH	-0.535*	-0.201	-0.068	0.951*	-0.912*	-0.584	-0.843*	-0.726*	-0.878*	-0.683*
$CaCo_3$	-0.268*	-0.052	0.056	0.358*	0.258*	0.122	-0.296*	-0.235*	-0.278*	-0.238*
OC	0.523*	0.102	-0.245	-0.102	0.120	0.069	0.540*	0.239*	0.374*	0.441*
Clay	-0.231	-0.042	0.110	0.432*	0.384*	-0.274	-0.280	0.103	0.013	0.362*

Significant at 5 per cent level of significance

Table-9: Relationship between physico-chemical properties and available nutrients in sub-surface soils

	N	P	K	Ca	Mg	S	Zn	Cu	Mn	Fe
pH	-0.079	-0.346	-0.027	-0.496*	-0.554*	0.108	-0.659*	-0.431*	-0.467*	-0.521*
$CaCo_3$	-0.215	-0.367	-0.033	-0.664*	-0.789*	0.197	-0.703*	-0.873*	-0.784*	-0.791*
OC	0.220	0.108	0.121	-0.054	-0.022	0.413*	0.222	0.746*	0.047	0.042
Clay	-0.261	-0.226	0.457	0.437	0.441	-0.248	0.363	0.353	0.346	-0.091

*Significant at 5 per cent level of significance

Table-11: Relationship between available and leaf nutrients in surface and subsurface soils

Depth (cm)	N	P	K	Ca	Mg	S	Zn	Cu	Mn	Fe
0-20	0.970*	0.554*	0.923*	0.875*	0.689*	0.724*	0.727*	0.682*	0.926*	0.893*
20-80	0.487*	0.548*	0.027	0.963*	0.018	0.102	0.083	0.050	0.720*	0.046

*Significant at 5% level of significance

Table-7: Leaf nutrient status

Orchard No.	N	P	K	Ca	Mg	S	Zn	Cu	Mn	Fe
1.	1.72	0.19	1.56	2.08	0.43	0.42	21	5	51	89
2.	1.78	0.19	1.57	1.93	0.39	0.44	21	5	55	92
3.	1.80	0.19	1.58	1.90	0.35	0.45	23	6	58	95
4.	1.84	0.19	1.60	1.88	0.33	0.46	23	7	61	92
5.	1.89	0.19	1.62	1.85	0.29	0.48	23	7	63	100
6.	1.90	0.20	1.67	1.83	0.29	0.48	24	7	65	103
7.	2.10	0.21	1.71	1.80	0.29	0.48	24	8	67	108
8.	2.20	0.22	1.74	1.79	0.28	0.51	24	8	70	113
9.	2.28	0.23	1.76	1.78	0.28	0.51	25	8	78	114
10.	2.30	0.24	1.79	1.77	0.27	0.54	25	9	81	116
11.	2.32	0.25	1.80	1.75	0.25	0.54	25	10	82	118
12.	2.35	0.26	1.81	1.73	0.25	0.58	25	11	86	121
13.	2.38	0.27	1.83	1.71	0.24	0.60	26	11	95	126
14.	2.40	0.28	1.85	1.70	0.23	0.63	26	12	101	130
Range	1.72-2.40	0.19-0.28	1.56-1.85	1.70-2.08	0.23-0.43	0.42-0.63	21-26	5-12	51-101	89-130
Mean	**2.09**	**0.22**	**1.70**	**1.82**	**0.29**	**0.50**	**23.92**	**8.14**	**72.35**	**108.64**

Table-6: Depth-wise distribution of available nutrients (ppm)

S. No.	Depth	N	P	K	Ca	Mg	S	Zn	Cu	Mn	Fe
1.	0-20	110	19.00	153.70	3325	152.40	11.00	0.83	1.12	34.23	45.20
	20-40	105	17.08	132.48	3312	152.00	9.66	0.70	0.94	31.03	34.68
	40-60	103	17.10	132.46	3310	151.80	9.64	0.68	0.92	31.01	34.66
	60-80	101	17.12	132.44	3314	152.20	9.68	0.66	0.90	30.99	34.64
2.	0-20	118	10.00	194.20	3588	172.60	11.50	0.87	1.21	54.01	58.33
	20-40	107	9.10	150.20	3608	168.00	8.66	0.87	1.18	42.70	49.50
	40-60	105	9.06	150.18	3606	167.80	8.64	0.85	1.16	42.68	49.30
	60-80	103	9.08	150.22	3610	168.20	8.68	0.83	1.14	42.66	49.28
3.	0-20	120	17.00	203.60	3608	174.50	13.50	0.88	1.23	56.01	50.20
	20-40	98	15.12	103.53	3614	172.20	8.13	0.88	0.84	34.74	41.00
	40-60	96	15.08	103.51	3612	171.80	8.11	0.86	0.82	34.72	39.00
	60-80	94	15.10	103.55	3616	172.00	8.15	0.84	0.80	34.70	37.00
4.	0-20	106	13.00	199.30	3534	163.40	11.80	0.86	1.08	52.02	48.50
	20-40	101	11.22	101.50	3332	160.80	7.73	0.77	0.78	38.00	46.00
	40-60	99	11.18	101.70	3330	161.20	7.71	0.75	0.76	36.00	44.00
	60-80	97	11.20	101.30	3334	161.00	7.75	0.73	0.74	34.00	42.00
5.	0-20	99	18.9	179.30	3022	141.20	10.70	0.80	0.88	39.40	42.80

	20-40	92	16.7	134.80	3012	134.00	7.70	0.66	0.88	30.00	34.00
	40-60	90	16.9	135.00	3010	133.80	7.50	0.64	0.86	28.00	32.00
	60-80	88	16.11	134.60	3014	134.20	7.90	0.62	0.84	26.00	30.00

Table-6 Continued………

6.	0-20	106	12.00	154.70	3095	151.30	10.00	0.82	0.86	40.90	43.80
	20-40	100	9.00	131.46	3154	139.00	8.66	0.67	0.84	31.00	43.20
	40-60	98	11.00	131.44	3152	138.80	8.64	0.65	0.82	29.00	43.00
	60-80	96	11.90	134.80	3156	139.20	8.68	0.63	0.80	27.00	42.80
7.	0-20	112	14.00	195.20	3356	152.70	10.50	0.81	0.97	32.02	44.20
	20-40	110	13.5	149.26	3271	148.80	7.66	0.70	0.87	30.96	29.35
	40-60	108	13.7	149.24	3273	149.00	7.64	0.68	0.85	30.94	29.33
	60-80	106	13.9	149.28	3269	149.20	7.68	0.66	0.83	30.92	29.32
8.	0-20	116	18.00	206.60	3510	161.80	12.00	0.85	1.14	42.93	48.20
	20-40	114	16.60	103.20	3318	157.80	7.15	0.70	0.69	34.87	29.35
	40-60	112	16.80	103.40	3320	158.20	7.11	0.68	0.67	34.85	29.33
	60-80	110	17.00	103.00	3316	158.00	7.13	0.66	0.65	34.83	29.31
9.	0-20	120	14.00	201.50	3612	173.20	10.80	0.87	1.15	43.70	49.30
	20-40	98	13.40	100.50	3581	169.20	6.75	0.87	0.97	43.25	44.35
	40-60	96	13.80	100.70	3583	168.80	6.71	0.85	0.95	43.23	44.33
	60-80	94	13.60	100.30	3580	169.00	6.73	0.83	0.93	43.21	44.31
10.	0-20	122	11.00	180.30	3652	178.40	9.70	0.89	1.27	58.02	51.00
	20-40	100	9.80	167.13	3980	188.60	6.50	0.89	1.23	45.14	33.68
	40-60	98	10.00	167.11	3982	188.40	6.90	0.87	1.21	45.12	33.66
	60-80	96	10.20	167.15	3978	188.20	6.70	0.85	1.19	45.10	33.64

Table-6 Continued………

11.	0-20	98	17.20	152.70	2990	140.20	12.00	0.80	0.82	41.81	57.33
	20-40	97	15.20	130.46	2840	126.00	9.64	0.64	0.75	26.76	42.20
	40-60	95	15.60	130.44	2838	130.00	9.68	0.62	0.72	26.74	42.00
	60-80	93	15.40	130.48	2842	128.00	9.66	0.60	0.70	26.72	41.80
12.	0-20	103	13.00	193.20	3210	148.50	11.50	0.86	0.87	41.10	43.50
	20-40	94	12.10	148.26	3124	141.80	8.64	0.84	0.56	29.70	40.00
	40-60	92	12.80	148.24	3126	142.00	8.68	0.83	0.54	29.68	38.00
	60-80	90	12.12	148.28	3122	142.20	8.66	0.82	0.52	29.66	36.00
13.	0-20	108	18.00	203.60	3312	151.30	12.00	0.89	0.94	43.30	44.60
	20-40	106	15.50	105.53	3261	150.00	7.11	0.84	0.62	31.25	45.00
	40-60	104	15.90	105.51	3263	148.00	7.15	0.82	0.60	31.23	43.00
	60-80	102	15.70	105.55	3259	146.00	7.13	0.80	0.58	31.21	41.00
14.	0-20	114	12.00	199.50	3410	153.40	11.80	0.88	1.02	42.20	44.20
	20-40	112	10.70	103.50	3286	148.00	7.08	0.83	0.69	31.10	33.00
	40-60	110	11.10	103.48	3288	144.00	7.04	0.81	0.67	30.90	31.00
	60-80	108	9.90	103.52	3290	146.00	7.06	0.79	0.65	30.70	29.00
	Surface range (Mean)	98-122 (110.85)	10-19 (14.79)	157.7-206.60 (186.95)	2990-3652 (3373.14)	140.20-178.40 (158.20)	9.7-13.50 (11.34)	0.80-0.89 (0.85)	0.82-1.27 (1.04)	32.02-58.02 (44.40)	42.8-58.33 (47.79)
	Sub-surface range (Mean)	90-114 (100.42)	9-17.12 (13.39)	100.3-167.15 (125.92)	2838-3982 (335.38)	126-188.6 (153.88)	6.71-9.68 (7.94)	0.60-0.89 (0.75)	0.52-1.23 (0.82)	26.00-45.14 (33.86)	29-49.50 (38.04)

LITERATURE CITED

Agarwal, C.B and Tripathi, B.R. 1977. Organic carbon and nitrogen status of typical profiles of Utter Pradesh. *Food Farm Agriculture*, **8** :1-7.

Anantwar, S.G., Babrekar, P.B., Bhaskar, B.P. and Challa, O. 2000. Variability in shrink-swell potentials in two transacts on basaltic plateau of Wardha district, Maharashtra. *Journal of the Indian Society of Soil Science*. **48** (1) :145-151.

Anderson, C.A and Albergo, G.L. 1977. Seasonal changes in the relationship between macro-nutrients in orange leaves and soil analytical data in Florida. *Proceedings of International Society of Citric.*. **1**:125-127.

Anonymous, 2000. Directorate of Horticulture, Jammu and Kashmir Government, Rajbagh, Srinagar, 3 pp.

Arora, C.L., Chibba, I.M., Takkar, P.N. and Brar, J.S. 1989. Nutrient status of soils and plants in some peach orchardsof Punjab. *The Indian Society of Horticulture*. **46** (3) :368-375.

Arora, C.L. and Sekhon, G.S. 1981. Influence of soil characteristics on DTPA-extractable micro-nutrient cations in some soils series of Punjab. *Journal of the Indian Society of Soil Science*. **29**(4): 453-461.

Atkinson, C.J., Taylor, L and Taylor, J.M. 1995. The influence of temperature and water supply on apple fruit growth and the development of orchard grown trees. *Journal of Horticulture Science*. **70**(5):691-703.

Awasthi, R.P. 1993. Apple nutrition. *Advances in Horticulture vol. 2. Fruit Crops Part 2.*

Awasthi, R.P., Bhutani, V.P. Kaith, N.S. and Sharma, J.S. 1999. Mineral nutrient status of Peach orchard in Sirmour district of Himachal Pradesh. *Indian Journal of Horticulture*. **56**(3):194-200.

Awasthi, R.P., Bhutani, V.P., Sharma, J.C. and Kaith, N.S. 1998. Mineral nutrient status of apple orchards in Shimla district of Himachal Pradesh. *Indian Journal of Horticulture*. **55**(4):314-322.

Awasthi, R.P., Karkara, B.K., Dhuria, H.S. and Tripathi, B.B. 1979. Nutritional status of apple orchards in Himachal Pradesh. *Indian Journal of Horticulture Science*. **36**: 154-157.

Badyal, J.M. and Kar, P.L. 1984. Status of calcium, magnesium and sulphur in the foliage of plum cultivar santa Rosa (*Prunus salicina* Lindl) in Himachal Pradesh. *Journal of Tree Science*. **3**(1/2) : 59-62.

Balanagoudar, S.R. and Satyanarayana., T. 1990. Depth distribution of different forms of sulphur in vertisols and alfisols. *Journal of the Indian Society of Soil Science*. **38**:643-640.

Bansal, K.N., Gupta, S.K. and Verma, G.P. 1969. Distribution of micro-nutrients in soil profiles of Adhartal Series. *Journal of the Indian Society of Soil Science*. **17**: 333-336.

Basso, C. and Wilms, F.W.W. 1988. Nutritional status of apple orchards of Southern Brazil. *Acta Horticulturae*. **232**: 187-192.

Basso, C., Wilms, F. W.W. and Stuker, H. 1990. Soil plant fruit nutritional relationship in apple orchards in Southern Brazil. *Acta Horticulturae*. **274**:237-245.

Beattie, J.M. and Ellenwood, C.W. 1950. A survey of the nutrient status of ohio apple trees. *Proceedings of American Society for Horticultural Sciences*. **55**:49-50.

Bhandari, A.R and Randhawa, N.S. 1978. Micro-nutrient status of apple orchards of Shimla Hills. *The Indian Journal of Horticulture*. **35**(4):321-327.

Bhandari, A.R. and Randhawa, N.S. 1985. Distribution of available micro-nutrients in soils of apple orchards in Himachal Pradesh. *Journal of the Indian Society of Soil Science*. **33**:171-174.

Bhandari, A.R. and Sharma, V.S. 1981. Macro-nutrient status of apple orchards of Shimla district. *Indian Journal of Horticulture*. **38** (1-4):16-22.

Bhargava, G.P. 2002. Characterization of soil moisture storage and release in soils. *Agropedology*. **9**:11-21.

Bhaskar, B.P. and subhaiah, G.V. 1995. Genesis characterization and classification of laterites and associated soils along the east coast of Andra Pradesh. *Journal of the Indian Society of Soil Science*. **43** (1) :107-122.

Bhat, M. S. 2001. Nutritional status of high density plantation of apple orchard soils of north Kashmir. *M.Sc thesis Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir*, Srinagar 92 pp.

Bhogal, N.S, Chaudhary, K.C and Sakal, R. 1996. Distribution of different forms of sulphur in calciorthents of North Bihar. *Journal of the Indian Society of Soil Science*. **44**(1): 65-69.

Bhoumik, A.K. and Totey, N.B. 1990. Characteristics of some soils under teak forests. *Journal of the Indian Society of Soil Science*. **38**: 481-487.

Biswas, R.R. 1985. Classification of some typical soils from Dadra and Nagar Haveli. *Journal of the Indian Society of Soil Science*. **33**:945-947.

Black, C.A. 1965. Methods of soil analysis part 1 and 2. *American Society of Agronomy Incharge Publisher, Maidson Wincosin, U.S.A.*

Brady, N.C and Weil, R.R. 2002. The nature and properties of soils. *Macmillian Publishing Company New York*. 937 pp.

Chaudhary, H.P. and Das, S.K. 1990. Nutrient status in relation to intensity of erosion in Ravines of Yamuna. *Journal of the Indian Society of Soil Science*. **38**:126-129.

Chesnin, L and Yien, C.H. 1951. *Proceedings Soil Science Society America*. **15**:149-151.

Chibba, I.M. and Sekhon, G.S. 1985. Effect of pH and organic carbon on availability of nutrients in acid soils. *Journal of the Indian Society of Soil Science*. **36**: 409-411.

Cox, F.R. and Kamprath, E.J. 1972. Micro-nutrient soil tests. *Soil Science Society of America*. **8**: 289-318.

Dar, M.A. 1996. Nutrient status of cherry (*Prunus avium* L.) orchards of Srinagar district. M.Sc. (Agri) thesis. S.K. University of Agricultural Sciences and Technology of Kashmir. 140 pp.

Das, Madhumita., Singh. B.P. and Khan, S.K. 1997. Effect of major land uses on soil characteristics of Alfisols in Meghalaya. *Journal of the Indian Society of Soil Science*. **45** (3): 547-553.

David, R., Walker and Mason, D.D. 1959. Nutritional status of apple orchards in North Carolina. Contribution from the Department of Horticulture and experimental statistics published on paper No. 1060 of Journal series.

Dhar, B.L., Jha, M.N. and Kukretee, S.P. 1988. Mineralogy of soils under forests in the lesser Himalaya. *Journal of the Indian Society of Soil Science*. **36**:151-157.

Dhar, B.L., Jha, M.N. and Kukretee. 1989. Genesis and Mineralogy of associated inceptisols in a forest area. *Journal of the Indian Society of Soil Science*. **37** : 365-374.

Dris, R. and Niskanen, R. 1998. Nutritional status of commercial apple orchards in the A land island.*Soil and Plant Science*. **48** (2) :100-106.

Elahi, S.F., Hossain, M.F. and Kamal, A.S.M.M. 1996. Characterization of some soils developed on Madhupur clay in Bangladesh. *Journal of the Indian Society of Soil Science*. **44**(3) :482-488.

Failla, O., Stringari, G and Mescalchim, E. 1990. Apple and Grape vine leaf analysis in advisory work in Toronto district, Italy. *Acta Horticulturae*. **274**:45-52.

Follet, R.H. and Lindsay W.L. 1970. Profile distribution of zinc, copper, iron and manganese in Colorado soils. *Technical Bulletin*. **110**: 79-80.

Foth, H.D. and Turk, L.M. 1973. Fundamentals of soil Science (5th edition) *Whiley eastern Private Limited*, New Delhi 454 pp.

Gajendragadkar, G.R. and Rathore, G.C. 1988. Evaluation of extractants for predicting soil Mn availability and critical deficiency level in entisols. *Journal of the Indian Society of Soil Science*. **36**: 291-295.

Ganai, M. R., Talib, A.R., and Handoo, G.M. 1991. Nutrient indexing of cherry orchards in Kashmir. *Fertilizer News*. **40** (4) :53-55.

Ganai, M.R. Sinha, M.K. and Prasad, B. 1982. Parameters of availability of zinc in orchard soils in relation to zinc nutrition of apple. *Plant and Soil*. **66** :91-99.

Ganai, M.R., Mir, G.A., Talib, A.R and Bhat, A.R. 1999. Depth-wise distribution of available micronutrients in soils growing almonds in Kashmir valley. *Applied Biological Research*. **1**:19-23.

Gangopadhyay, S.K. Das, P.K., Mukhopadhayay, N., Nath, S and Banerjee, S.K. 1990. Altitudinal pattern of soil characteristics under forest vegetation in Eastern Himalayan Region. *Journal of the Indian Society of Soil Science*. **39**:93-99.

Gangopadhyay, S.K., Das, P.K., Nath, S. and Banerjee, S.K. 1989. Pedogenic characteristics of the soils supporting different forest vegetation in the foot hill region *Journal of the Indian Society of Soil Science*. **37**:775-781.

Gangopadhyay, S.K., Debnath, N.C and Banerjee, S.K. 1986. Characteristics of some high altitude soils of Sikkim Forest Division. *Journal of the Indian Society of Soil Science*. **34**:830-838.

Ghosh, A.B. and Hasan Rehanul. 1980. Nitrogen fertility status of soils of India. *Fertilizer News*. **25** (11):19-24.

Goh, K.M. and Malakouti, M.J. 1992. Preliminary nitrogen, phosphorus, potassium, calcium and magnesium dris norms and indices for apple orchards in Canterbury, New Zealand, *Communication in Soil Science and Plant Analysis*. **23** (3 & 4): 1371-1385.

Gowrisankar, D. and Shukla, L.M. 1999. Sulpher forms and their relationship with properties in inceptisols of Delhi. *Journal of the Indian Society of Soil Science*. **47** (3) : 437-442.

Guleryuz., M., Ercisli, S and Bilen, S. 1998. A study on the nutrient status of starking Delicious apple cultivar grown in Erzinean plains. *Journal of American Society of Horticulture Science*. **130** (6):301-307.

Gunjoo, V. 1994. Studies on the sulphur status in maize growing mid-hill soils of Jammu region. M.Sc. (Agri) thesis S.K. University of Agricultural Sciences and Technology of Kashmir. 97 pp.

Gupta, J.P., Sumbria, N.M. and Raina Ajit. 1987. Nutrient status of the soils of Rajouri district of Jamm and Kashmir in relation to soil properties. *Research and Development Report*. **4** :113-116.

Gupta, R.D 1974. Studies on certain physico-chemical and micro-biological properties of Ranbir Singh Pora soils of Jammu and Kashmir. *Technology*. **11** (2&3) : 227-230.

Gupta, R.D and Verma, S.D. 1992. Characterization and classification of some soils of Kandi Belt in Jammu Siwalik Hills. *Journal of the Indian Society of Soil Science*. **40** :809-815.

Gupta, R.D. and Tripathi, B.R. 1992. Genesis of soil in wet temperate and subalpine/moist alpine climatic zones of the North west Himalayas. *Journal of the Indian Society of Soil Science*. **40** (3) :505-512.

Gupta, R.D. and Tripathi, B.R. 1993. Characterization of rice growing and adjacent virgin soils –1. Morphology, properties, genesis and classification. *Journal of the Indian Society of Soil Science*. **41**: 720-724.

Gupta, R.D., Anand, R.R and Shardra, P.D. 1988. Characteristics and genesis of some alluvium-derived soils of Jammu and Kashmir. *Proceedings of Indian National Science Academy*. **54**, A, (1) : 120-130.

Gupta, R.D., Jha and Sahi, B.P. 1980. Studies on physical, chemical and mineralogical nature of the soils of Jammu and Kashmir. *Current Agriculture*. **4** (3-4) : 133-144.

Gupta, R.D., Jha, K.K. and Sahi, B.P. 1986. Clay Mineralogy of some soil profiels of Jammu and Kashmir State. *Journal of the Indian Society of Soil Science*. **34**:577-584.

Gupta, V.S and Srivastava, P.C. 1990. Distribution of different forms of micro-nutrient cations in some cultivated soils of Sikkim. *Journal of the Indian Society of Soil Science*. **40**(3):505-512.

*Haby, V.S and Sims, J.R. 1979. Availability of micro-nutrients cations in Mentanria soils Bulletin 708, Mantania Agricultural Experimental Station, Biozeman, M.T. [c.f. *Ph.D thesis of Dr. Nirmal Singh* 246 pp.]

Hadwani, G.J., Gandhi, A.P., Patel, M.S. and Yadav, B.S. 1989. Depth-wise distribution of different forms of Born in relation to soil properties in medium black calcareous soils of western Gujrat. *Journal of the Indian Society of Soil Science*. **37**:295-300.

Handoo, G.M. 1983. Organic matter fractionation in some soil profiles of Jammu and Kashmir State developed under different bio and climosequences. *Ph.D (Agri) thesis Himachal Pradesh Krishi Vishva Vidhyalaya Palampur (HP)*. India. 128 pp.

*Hanway, J.J. and Heidal H. 1952. Soil analysis methods as used in lowa state college soil testing laboratory. *Iowa State College of Agriculture Bulletin* **59**:1-31. [c.f. Soils and Fertilizers 1970. 78: 8320].

Haynes., R.J. 1990. Nutrient status of apple orchards in Canterbury, New Zealand. *Communication in soil Science and Plant analysis.* **23** (7&8): 847-860.

Jackson, M.L. 1973. Soil chemical analysis. *Prentice Hall of India private Limited* ,New Delhi, 498 pp.

Jaggi, R.C., Kapur, O.C. and Masand S.S. 1990. Evaluation of methods for available phosphorus for wheat in wheat growing valleys of Himachal Pradesh. *Journal of the Indian Society of Soil Science*. **38**: 56-60.

Jalali, V.K., Talib, A.R. and Takkar, P.N. 1989. Distribution of micro-nutrients in some bench mark soils of Kashmir at different altitudes. *Journal of the Indian Society of Soil Science*. **37**:465-469.

Jassal, H.S., Sidhu, P.S., Sharma, B.D and Mukhopadhyay, S.S. 2000. Mineralogy and Geochemistry of some soils of Siwalik hills. *Journal of the Indian Society of Soil Science*. **48**(1):163-172.

*Johnson, C.M. and Ulrich, A. 1959. Analytical methods for use in Plant analysis. *Bulletin California Agriculture Experiment Station* **54**:776.

Jovanovic, M., Dzamic, R., Velickovic, M. 1998. The major nutrient content in leaves of some apple cultivars grown on M_9, M14 and seedling root stocks under different fertilization conditions. *Indian Horticulture*. **7**:38-47.

Kaishtha, B.P and Gupta, R.D. 1994. Morphology and characteristics of a few entisols and inceptisols of North Western Himalayan Region (H.P). *Journal of the Indian Society of Soil Science*. **42** :100-104.

Kaistha, B.P., Sood, R.D. and Kanwar, B.S. 1990. Distribution of nitrogen in some forest soil profiles of north-western Himalayan region. *Journal of the Indian Society of Soil Science*. **38** :15-20.

Kanthaliya, P.C and Saxena S.N. 1992. Available micro-nutrients in some semi-arid soils of Rajasthan. National Seminar on development in soil Science (Abstract) *57th Convention of Indian Society of Soil Science*. IARI New Delhi 51-52.

Kanthaliya, P.C. and Bhat, P.C 1991. Relation between organic carbon and available nutrients in some soilsof su-humid. *Journal of the Indian Society of Soil Science*. **39**:774-776.

Kanwar, B.B. and Tripathi, B.R. 1986. Distribution of total and DTPA-extractable copper in relation to soil properties in some profiles of north western Himalayas *Journal of the Indian Society of Soil Science*. **34**: 69-75.

Kanwar, J.S. and Mohan, S. 1964. Distribution of forms of sulphur in Punjab soils. Symposium of fertilization in Indian soils. *Bulletin National Institute of Soil Science, India.* **20**:31-36.

Kanwar, S.M. 1988. Apple production technology and economics. *Tata McGraw Hill Publishing Company Limited, New Delhi*. 881 pp.

Katoo, N.A. 2001. Characterization and classification of soils of Letpora Command Area. M.Sc. (Agri.) thesis S.K. University of Agricultural Science and Technology of Kashmir, 94 pp.

Katyal, J.C. and Sharma, B.D. 1991. DTPA extractable and total zinc, copper, Manganese and iron in Indian soils and their association with some soil properties. *Geoderma*. **49**:165-171.

Kenworthy, A.L. 1964. Fruit nut and plantation crops. A guide for collection of foliar samples for nutrient element analysis. Hort. Deptt. Memo. Michigan state Univ. East Lansing. 39 pp.

Kenworthy, A.L. and Gilligan, G.M. 1948. Interrelationship between the nutrient content of soil, leaves and trunk circumference of peach trees. *Proceedings of American Society for Horticultural Science*. **51**:209-215.

Khan, Z.H., Mazumdar, A.R., Hussain, M.S. and Saheed, S.M. 1997. Fertility status and productivity potential of some bench mark soils of Bangladesh. *Journal of the Indian Society of Soil Science*. **45** (1):89-95.

Kharche, V.K. Sehgal, J and Challa, O. 2000. Characterization of coffee growing soils in Karnataka. *Agropedology*. **10**: 59-66.

Kulkarni, P.P. and Vasuki, N. 1991. Evaluation of chemical extractants for available iron in vertisols. *Journal of the Indian Society of Soil Science*. **39**:803-804.

Kumar, R. and Singh, R. 1995. Nutritional status of apple orchards in Kuman region of Utter Pradesh. *Recent Horticulture*. **2** (2):43-46.

Kumar, R., Mahendra, S., Rahul, D.S and Rajendra. 1987. Forms of potassium in some soils of central Haryana. *Haryana Agriculture University Journal of Research*. **17** (4):356-363.

Li, G.L., Su Run-Yu and Shen Tsuin. 1988. The prospect of improving the yield and quality of some major fruits in China as seen from the result of leaf analysis. *Scientia Agriculture Sinica*. **21** (2):56-63.

Lindsay, W.L. and Norvell, W.A. 1978. Development of DTPA soil test of ascertaining available iron, copper manganese and zinc. *Soil Science Society of American Journal*. **42**:421-427.

Lindsey, W.L. and Cox, F.R. 1985. Micro nutrient testing for the tropics. In P.L.G. Vlek (editor). Micronutrients in tropical food corporation. *Fertilizer Research*. **7**:169-200.

Lins, I.D.G. and Cox, F.R. 1988. Effect of soil pH and clay content on the zinc soil test interpretation for corn. *Soil Science Society of American Journal*. **52**:1681-1685.

Ludder, K.M. 1990. Effect of Potassium sulphate on leaf potassium content in sweet cherry. *Recent Horticulture*. **3**: 38-40.

*Magnani, M., Freire, C.J.D., Moraes, E.C. D. 1984. NPK management in peach trees (*Prunus persica Batsch*, L.) *Empresca catarinense de pesquisa S. A*. **4**:188-195. [c.f. Horticultural Abstract. 30: 1986 : 1115].

Mahapatra, P.K. and Sahu, S.K. 1996. Relationship between some major, secondary and micronutrient status of soils growing groundnut and their contents in groundnut plants. *Journal of the Indian Society of soil Science*. **44**:100-103.

Mahrpatra, S.K., Wali, C.S., Sidhu, G.S., Rana, K.P.C and Tarsem Lal. 2000. Characterization and classification of the soils of different physiographic untis in the sub-humid eco-system of Kashmir region. *Journal of Indian Society of Soil Science*, **48** (3) :572-577.

Maji, B.and Bandyopadhyay, B.K. 1996. Characterization and classification of coastal soils of Balasore. Orissa. *Journal of the Indian Socieity of Soil Science*. **44** (4): 722-726.

Makaya, A.S and Bishnoi, S.K. 1990. Effect of lime and phosphate application on some chemical properties of an Alfisol. *Journal of the Indian Society of Soil Science*. **38**:154-157.

Mamgain, S., Verma, H.S. and Kumar, J. 1998. Relationship between fruit yield and foliar and soil nutrient status of apple. *Indian Journal of Horticulture*. **55**(3) :226-231.

Mandal, A.K., Nath, S., Gupta, S.K. and Banerjee, S.K. 1990. Characteristics and nutritional status of soils of mid hill and upper hill forests of eastern Himalayas. *Journal of Indian Society of Soil Science*. **38**:100-106.

Marazi, A.R. 1988. Effect of different nitrogen levels and water regimes on the yield and growth of rice. *M.Sc (Agri) thesis, S.K. Unversity of Agricultural Sciences and Technology of Kashmir*. 120 pp.

*Matzner, F. and Maurer, F. 1982. Mineral content of schattenmorelle leaves, in relation to increasing nitrogen supply *Carbenbauwissenscharf*. **47**(3): 131-135. [c.f. Horticultural Abstract 52 (11).1984: 7161].

Meland, M. 1982. Chemical composition of soil, leaves and fruits in samples from sweet cherry orchards in ullensvang, western Norway. *Meldinger fra Norges Land brukshgskde*. **61** (21):15 pp.

Merwin, H.D. and Peach, M. 1950. Exchangeable of soil potassium in the sand, silt and clay fractions as influenced by the nature of complementary exchangeable cation. *Soil Science Society of American journal.* **15**:125-128.

Merwin, I.A and Warren, C.S. 1994. Orchard ground cover management impacts on apple tree growth and yield and nutrient availability and uptake. *Journal of Amesterdum Horticultural Science.* **119** (2) :20-25.

Micheal, A. and Amber, M. 2002. Fragipan genesis in two alfisols in eastern central Missouri. *Soil Science.* **167** (7): 453-464.

Mihnas, R.S. and Singh, K. 1980. Soils of semi arid high land region of India “A review” *Agriculture Research.* **1** (1) :19-26.

Minhas, P.S. Sharma, D.R. and Singh, Y.P. 1995. Response of Rice and Wheat to applied gypsum and farm yard manure on an alkali water irrigated soil. *Journal of the Indian Society of Soil Science.* **43**:452-455.

Minhas, R.S. and Bora, N.C. 1982. Distribution of organic carbon and forms of nitrogen in a topographic sequence in soils. *Journal of the Indian Society of soil Science*. **30**:135-139.

Mir, G.A. 1994. Studies on almond (*Prunus dulcis* Mill) orchard soils of Kashmir. M.Sc. (Agri.) thesis. *S.K. University of Agricultural Sciences and Technology of Kashmir, Shalimar Srinagar* 115 pp.

Misgar, F.A. 1992. Nutritional status of bearing Amberi apple (*Malus domestica* Borkh) orchards of Pulwama district. *M.Sc (Agri). thesis S.K. University of Agricultural Sciences and Technology of Kashmir, Shalimar Srinagar*. 108 pp.

Mishra, B.and Ghosh, S.K. 1995. Characterization of soil derived from Mica-Rich parent materials in two topo-sequences. *Journal of the Indian Society of Soil Science.* 43:92-98.

Misra, U.K., Das, C.P and Mitra, G.N. 1990. Forms of sulphur in some soils of Orissa in relation to relevant soil properties. *Journal of the Indian Society of Soil Science.* **38** (1) :61-69.

Mokwunye, A.U. and Melsted, S.W. 1973. Interrelationship between the soil magnesium forms. *Communication Soil Science Plant Analysis.* **4**:397-405.

More, S.D., Shinde, J.S and Malewar, C.U. 1988. Characterization of some salt affected soils of parna command area of Maharashtra. *Journal of the Indian Society of Soil Science*. **36**:146-150.

Morgan, M.A. and Hennerty, M.J. 1979. The micro-nutrient status of Golden Delicious orchard in Ireland. Irish *Journal of Agricultural Research* .**18**:55-59.

Mushki, G.M. 1994. Studies on apple (*Malus domestica* Borkh) orchard soils of Kashmir. M.Sc. (Agri.) thesis *S.K. University of Agricultural Sciences and Technology of Kashmir, Shalimar Srinagar*. 129 pp.

Nagi, J.P.; Mitra, L. and Dabas, H.K. 1998. Indian Horticulture database.*National Horticulture board 23 pp.*

Nair, K.M. and Chamuah, B.S. 1988. Characteristics and classification of some pine forest soils of Meghalaya. *Journal of the Indian Society of Soil Science.* **36**:142-145.

Narboo, S. 1994. Nutritional status of apricot plantation in some orchard areas of Kargil district *M.Sc (Agri) thesis S.K. University of Agricultural Sciences and Technology of Kashmir, Shalimar Srinagar* 74 pp.

Nayak, D.C., Dipak, Sarkar., Das, K. and Chaterjee, S. 1999. Studies on pedogenesis in soil chrono-sequence in West Bengal. *Journal of the Indian Society of Soil Science.* **47**(2) :322-328.

Nayak, R.K., Sahu, G.S. and Nanda, S.S.K. 2001. Characterization and classification of the soils of central Research Station, Bhubaneswar. *Agropedology.* **12**:1-8.

Neilson, D., Hoyt, P.B., Drought,B.G. and Neilson, G.H. 1990. Manganese soil tests for both deficient and toxic levels in apple orchards. *Canadian Journal of Soil Science.* **70**:503-507.

Neilson, G.H. and Edwards, T. 1982. Relationship between Ca, Mg and K in soil, leaf and fruit of Okanagan apple orchards . *Canadian Journal of Science.* **62**(2): 365-374.

Olsen, S.R., Cole, C.W., Watanable, F.S. and Dean, L.A. 1954. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. *United States Department of Agriculture circula*r No. 939:19.

Pal, D.K. and Deshpande, S.B. 1987. Parent material, Mineralogy and Genesis of two bench mark soils of Kashmir valley. *Journal of the Indian Society of Soil Science.* **35**:690-698.

Panse, V.G. and Sukhatame, P.V. 1967. Statistical methods for agricultural Workers. *Indian Council of Agricultural Research*, New Delhi 162 pp.

Paul, E.A. and Clark, F.E. 1989. Soil microbiology and bio-chemistry academic Press Inc. London, England 276 pp.

Peer, M.A .1994. Fractionation of potassium, its uptake and critical limits for rice. *M.S. (Agri) thesis*. *S.K. University of Agricultural Sciences and Technology of Kashmir, Shalimar Srinagar*. 108 pp.

Piper, C.S. 1966. Soil and plant analysis. 5th Edition. *Hans Publisher, Bombay* 464 pp.

Prakesh, L. and Singh, V. 1985. Forms of potassium in alluvial soils of Western Utter Pradesh. *Journal of the Indian Society of Soil Science.* **33**: 911-914.

Prasad, R. and Sakal, R. 1991. Availability of iron in calcareous soils in relation to soil properties. *Journal of the Indian Society of Soil Science.* **39**: 658-661.

Rahul, D.S. and Paliwal. 1978. Status and distribution of sulphur in soils of Rajasthan. *Journal of the Indian Society of soil Science.* **26-**352-358.

Raina, J.N. 1988. Physico-chemical properties and available micro nutrient status of citrus growing soils of Dhaulakuan in Himachal Pradesh *Punjab Horticulture Journal*. **28**:1-6.

Rana, R.S., Sharma, R.P and Azad, K.C. 1984. Nutritional status of apple orchards in Himachal Pradesh. Journal *of Horticulture Science.* **41**:244-250.

Rawat, P.S. and Mathpal, K.N. 1981. Micronutrient status of some soils of U.P. hills. *Journal of the Indian Society of Soil Science.* **29** (2) :208-214.

Rawat, S.S. and Ranvir, Singh. 1991. Variation in mineral composition of leaves of apple cultivars “Red Delicious” as affected by sample size. *Haryana Journal of Horticulture Science.* **20** (3-4): 173-175.

Ray, S.K and Reddy, R.S. 1997. Classification of soil burred by Allochthonous material *Journal of the Indian Society of Soil Science.* **45** :542-547.

Rybin, S.S., Koptika, P.G., Prasol, Y.L and Gerkiyal, Z.V. 1979. The relationship between soil content of nutrient elements, leaf chemical composition and aple tree yield. *Visnik sites Kogospoo Nauki*. **5**:121-125.

Sahu, B.K. 2002. Mineral nutrient status of pear orchards in utterpradesh. *Acta Horticulture*. **248**:130-136.

Sahu, B.S., Nandan, S.S.K. and panda, N. 1986. Genesis, characteristics and classification of coastal saline soils of Orissa. *Journal of the Indian Society of Soil Science*. **34**: 322-328.

Sahu, G.C and Patnaik, S.N. 1990. Influece of lime and organic manure on pH and ion exchange phenomenon of some Alfisols. *Journal of the Indian Society of Soil Science*. **38**:389-393.

Sahu, G.C., Mishra, K.N., Parida, R. and Nayak, R.K. 2001. Characterization and classification of some vertisols of western zone in Orissa. *Agropedology*. **11**:78-82.

Sahu, G.C., Patnaik, S.N. and Das, P.K. 1990. Morphology, genesis, mineralogy and classification of soils of northern Plateau zone of Orissa. *Journal of the Indian Society of Soil Science*. **36** (1) :116-121.

Sakal, R. Singh, A.P., Singh, B.P., Sinha, R.B., Jha, S.N. and Singh, S.P. 1985. Distribution of available micro-nutrient cations in calcareous soils as related to certain soil properties. *Journal of the Indian Society of soil Science*. **33**:672-675.

Sakal, R. Singh, B.P., Singh, A.P., Sinha, R.B., Singh, S.P. and Jha, S.N. 1986. Availability of zinc, iron, copper and manganese, in sub-Himalayan hill and forest soils as influenced by certain soil properties. *Journal of the Indian Society of Soil Science*. **34**:191-193.

Sambyal, J.S and Sharma, P.D. 1986. Characterization of some lower Himalayan eroded forest soils. *Journal of the Indian Society of Soil Science*. **34**:142-151.

Sannigrahi, A.K., Gadse, N.G. and Sharanappa. 1990. Characteristics and classification of dominant hill soils of Nilgiri. *Journal of the Indian Society of Soil Science*. **38**:345-348.

Sarkar, Dipak., Das, K. and Sehgal, T.M. 1997. Characterization of some soils developed under varied altitudes in pre humid climate of west Bengal. *Journal of the Indian Society of Soil Science.* **45**(1) : 203 –205.

Sehgal, J.L., Sys. C., Stoops. B and Tavernier R. 1985. Morphology, genesis and classification of two dominant soils of the warm temperate and humid region of the central Himalayas. *Journal of the Indian Society of Soil Science*. **33**: 846-857.

Sharma, B.D., Sidhu, P.S., Rajkumar and Sawhnery, J. 1997. Characteization, classification and land relationship of inceptisols in north west India. *Journal of the Indian Society of Soil Science.* **45** (1):167-174.

Sharma, B.L., Rathore, G.S. and Bapat, P.N. 1997. Status of different forms of manganese and their relationship with physico-chemical properties of entisols. *Journal of the Indian Society of Soil Science.* **45**(2) :390-392.

Sharma, C.R., Dhuria, H.S. and Gautam, D.R. 1982. A surveyof nutrient status of apple orchards in Kulu district of Himachal Pradesh. *Haryana Journal of Horticulture Science.* **11**(1-2): 21-26.

Sharma, J.C. and Bhandari, A.R. 1995. Mineral nutrient status of apple orchards in Himachal Pradesh. *Journal of the Indian Society of Soil Science*. **43** (2):236-241.

Sharma, J.P., Landey, R.J., Kalbande, A.R. and Mandal, C. 2001. Characteristics and classification of soils of Kathiawar region of Gujrat as influenced by topography. *Agropedology*. **11**: 83-90.

Sharma, P.D. and Qaher, A.Q. 1989. Characterization of some outer Himalayan protected and eroded forest soils. *Journal of the Indian Society of Soil Science.* **37**:113-120.

Sharma, R.K., Swami, B.N. Shyampura., R.L. Giri, J.D. and Singh, S.K. 1999. Characterization of some soils of Haldi Ghati Region of Rajasthan in relation to land physiography. *Journal of Indian Society of Soil Science*. **47**: 327-333.

Sharma, S.P., Sharma, P.D., singh, S.P and Minhas, R.S. 1994. Characterization of soan River valley soils in lower shiwaliks of Himachal Pradesh. 11 Piedmont and Flood Plain Soils. *Journal of the Indian Society of Soil Science.* **42**:105-110.

Sharma, U. and Bhandari, A.R. 1992. Survey of the nutrient status of apple orchards in Himahcal Pradesh. *The Indian Journal of Horticulture*. **49**(3) :234-241.

Sharma, Y.K., Gangwar, M.S and Srivastava, P.C. 2000. Sulphur fractions and carbon nitrogen and sulphur in Alfisols, inceptisols and Mollisols in some parts of Uttar Pradesh. *Journal of the Indian Society of Soil Science.* **48** (3): 477-486.

Shear, C.B. and Faust, M. 1980. Nutritional ranges in decidious tree fruits and nuts. *Horticultural Reviews.* **2** :142-163.

Shinde, D.A. and Talib, A.R. 1984. Studies on saffron growing soils of Jammu and Kashmir. *Journal of Indian Society of Soil Science.* **32**:777-780.

Shinde, D.A., Talib, A.R. and Gorantiwar, S.M. 1984. Composition and classification of some typical soils of saffron growing areas of Jammu and Kashmir. *Journal of the Indian Society of Soil Science.* **32**:473-477.

Sidhu, G.S., Rana, K.P.S., Walia, C.S., Mahapatra, S.K. and Lal, T. 1999. Characteristics and classification of some dominant soils of Jammu region for land use planning. *Agropedology.* **9**:22-29.

Sidhu, P.S., Kumar, R. and Sharma, B.D. 1994. Characterization and classification of entisols in different soil moisture regimes of Punjab *Journal of the Indian Society of Soil Science.* **42**:633-640.

Singh, B. and Raman, S.S. 1982. Distribution of nutrients in soil profile under pines of North East Himalayas. *Journal of the Indian Society of Soil Sciense*. **30**(3) :320-333.

Singh, J.P., Dahiya, D.J., Vinod, K. and Singh, M. 1992. Distribution and status of different forms of nitrogen in soils of Haryana. *Journal of the Indian Society of Soil Science.* **40**(4) :698-704.

Singh, K. and Ahuja, R.L. 1990. Distribution of primary nutrients in relation to soil characteristics in the Ghaggar river basin. *Journal of the Indian Society of Soil Science.* **38**(4) : 733-735.

Singh, K., Minhas, R.C. and Tomar, K.P. 1990. Characterization and classification of some Mid Siwalik Soils in different physiographic units. *Journal of Indian Society of Soil Science*. **38**:474-480.

Singh, Nirmal and Bhandari, A.R. 1989. Petiole nutrient status of arid and semi arid high land vineyards of Kinnour in Himachal Pradesh. *Indian Journal of Agricultural Science*s. **59** (12): 805-807.

Singh, Nirmal. 1987. Leaf nutrient status of apple, grape and almond orchards of kinnaur district of Himachal Pradesh and its relationship with physico-chemical characteristics of the soil. *Ph.D.(Agri) thesis Himachal Pradesh Krishi Vishva Vidyalaya Palampur*, 246 pp.

Singh, O.P., Datta, B. and Rao, C.N. 1991. Pedo-chemical characterization and genesis of soils in relation to altitude in Mizoram. *Journal of the Indian Society of Soil Science*. **39**:739-750.

Singh, R.N., Singh, R.N.P. and Diwakar, D.P. 2000. Characterization of alluvial soils of soan basin. *Journal of the Indian Society of Soil Science.* **48** (2) :352-357.

Singh, U. and Bhandari, A.R. 1992. Survey of the nutrient status of apple orchards in Himachal Pradesh. *The Indian Journal of Horticulture.* **49**(3) :234-241.

Sinha, G.S., Verma, KJ.P. and Shastri, P. 1998. Studies on nutritional status of orchards. *Acta Horticulturae*. **34**(2): 18-21.

Sreenarayana, B. and Raju, A.S. 1994. Influence of native and applied sulphur on yield and Sulphure uptake by sunflower at different stages of growth. *Journal of the Indian Society of Soil Science*. **42**(1):80-84.

*Stoilov, G and Vitanov, I. 1979. Stuies on the mineral nutrition of the plurn cultivar kyustendilska sinya sliva in post experiments. Relationship between mineral nutrition level and nitrogen and ash elements in the leaves. *Gradinarska I Lozorska Nauka*. **16** (1): 19-27[c.f. Horticulture Abstract. 32.1982: 2341].

Strain, M.R. and Evans, C.V. 1994. Soil genesis, morphology and classification in New Hampshire. *Soil Science Society of American Journal.* **58**:147-155.

Subba,I.M. and Sekhan, G.S. 1985. Effect of pH and organic carbon on availability of nutrients in acid soils. *Journal of the Indian Society of Soil Science*. **36**:409-411.

Subbiah, B.V. and Asija G.L. 1956. A rapid procedure for estimation of available nitrogen in soils. *Current Science.* **25**:259-260.

Takker, P.N. and Mann, M.S. 1975. Evaluation of analytical methods of estimation of available zinc and response of applied Zn in major soils series of Ludhiana, Punjabe .*Agrochemica*.**19**:420-430.

Talib, A.R. 1984. Studies on the pedogenesis and potassium supplying capacity of the bench mark soils of Kashmir. *Ph.D. (Agri) thesis. Himachal Pradesh Krishi Vishva Vidyalaya Palampur, Himachal Pradesh.198 PP*.

Tan, K.H. 1982. Principles of soil chemistry. *Marcel Dekker, Inc. New York and Basel*. 246 pp.

Thakur, N.R and Bhandar, A.R. 1986. Available nutrient element status of soils of temperate vegetable seed producing valley of Himachal Pradesh. *Journal of the Indian Society of Soil Science.* **34**:428-430.

Thakur, N.R. and Bhandari, A.R. 1986. Available nutrient element status of soils of temperte vegetable seed producing valley of Himachal Pradesh. *Journal of the Indian Society of Soil Science.* **34**:428-430.

Tisdale, S.L. Nelson, W.L., Beaton, J.D. and Havlin, J.L. 1995. Fertility and Fertilizers (5th edition). 805 pp.

Titus, J.S. and Boynta, D. 1953. The relationship between soil analysis and leaf analysis in eighty New York Mcintosh apple orchards. *Proceedings of American Society for Horticulture Science.* **61**:6-26.

Tiwari, J.R. and Mishra, B.B. 1993. Caly minerology of some black soils of Rajmahal trap. *Journal of the Indian Society of Soil S*cience. **41**(3):535-540.

Tripathi, D. and singh, K. 1992. Vertical distribution of sulphur in representative soil groups of Himachal Pradesh. *Journal of the Indian Society of Soil Science.* **40**(3) :447-453.

Tripathi, D., Singh, K and Upadhayay, G.P. 1994. Distributrion of micronutrients in some representative soil profiles of Himachal Pradesh. *Journal of the Indian Society of Soil Science.* **42** (1): 143-145.

Tripathi, S.K., Singh, Kuldeep and Kaswasva, S.P.S. 1997. Forms of sulphur and their distribution in some Aridisols of Haryana state under grape vine yards. *Journal of the Indian Society of Soil Science*. **40**: 447-453.

Tripathi, S.L, Singh, K. and Upadhayay. 1994. Distribution of micro-nutrients in some representative soil profiles of Himachal Pradesh. *Journal of the Indian Society of Soil Science.* **42** (1):143-145.

Tripathi., P.N. and Sharma, N.L. 1993. Pyrite, a good source sulphur in mustard-rice cropping system. *Fertilizer News.* **38** (10): 27-30.

Trivedi, S.K., Bansal, K.N. and Singh, V.B. 1998. Important forms of sulphur in profiles of some soil series of north Madya Pradesh. *Journal of the Indian Society of Soil Science.* **46** (4) :579-583.

Trivedi, S.K., Bansal, K.N., Tomap, R.A.S and Verma, R.S. 2000. Vertical districution of forms of sulphur in some profiles of Morena and Bhind districts of Madhya Pradesh. *Journal of Indian Society of the Soil Science.* **48** (2): 238-241.

Upadhayay, S.K. and Awasthi, R.P. 1993. Leaf nutrient ranges of plus apple trees in Himachal Pradesh. *Indian Journal of Horticulture.* **50**(2):97-102.

Vadivelu, S. and Bandyopadhyay, A.K. 1997. Characterization genesis and classification of soils of Minicoy Island, Lakshadweep. *Journal of the Indian Society of Soil Science.* **45** (4) :796-801.

Veleais, D., Alnaliotis, D., Bladenopoulou, S. and Atanossov, 1. 1998. A nutritional Survey of starcrimson at Kastoria district (North Greece). *Bulgarian Journal of Agriculture Science*. **5** (1):112-116.

Venkatesh, M.S. and Satyanarayana, T. 1999. Sulphur fractions and relationship in oilseed growing vertisols of north Karnataka. *Journal of the Indian Society of Soil Science.* **47** (2):241-248.

Verma, H. S. and Singh Kulbir, S. 1990. Seasonal changes in nutrient composition of Golden Delicious apple leaves. *Indian Journal of Horticulture.* **47** (3) :309-313.

Verma, K.S., Shyampura, R.L. and Jain, S.P. 1990. Characterization of soils under forest of Kashmir valley. *Journal of the Indian Society of Soil Science*. **38**:107-115.

Verma, S.P. and Singh, D. 1993. Leaf nutrient status of red delicious apple orchards in Himachal Pradesh. *Indian Journal of Horticulture*. **55**(1):10-15.

Verma., S.D. Tripathi, B.R. and Kanwar, B.S. 1985. Soils of Himachal Pradesh and their management. The *Fertilizer Association of India* New Delhi, 67:149-169.

Walia, C.S. and Chamuah, G.S. 1990. Characteristics, classification and suitability for land use planning of foot hill soils. *Journal of the Indian Society of Soil Science.* **38**: 286-296.

Walia, C.S. and Rao, Y.S. 1996. Genesis, Characterization and taxonomic classification of some red soils in Budel khand region of Utter Pradesh. Journal of the *Indin Society of Soil Science.* **44**(3) :476-481.

Walia,C.S., Nayan Ahmed., Uppal, K.S. and Rao, Y.S. 1998. Profile distribution of various forms of nitrogen and C/N ratio in some land forms of Bundelkhand region of Utter Pradesh. *Journal of the Indian Society of Soil Science*. **46** (2) :193-198.

Walker, D.R. and Mason, D.D. 1960. Nutritional status of apple orchards in North Carolina. *Journal of American society of Horticulture Science.* **75**:22-31

Walkley, A. and Black, J.A. 1934. An examination of the method for determining soil organic matter and a proposed modification of the chromic acid titration. *Soil Science.* **37** (1-6): 29-39.

Walter, R. 1961. Plant analysis and fertilizer problems. *American Biological Science*, Washington, 6 D.C. Publication No.8.

Wani, G.N. 2001. Studies on distribution of secondary nutrient elements in apple orchard soils of North Kashmir. M.Sc. (Ag) thesis. *S.K. University of Agricultural Sciences and Technology of Kashmir, Shalimar Srinagar* 75 pp.

Wani, M.A. 1994. Distribution and forms of micro-nutrient cations (Zn, Cu, Mn and Fe) in some saffron (*Crocus sativus* L.)growing soils of Kashmir. M.Sc. (Agri.). thesis *S.K. University of Agricultural Sciences and Technology of Kashmir, Shalimar Srinagar* . 119 pp.

West wood, M.N. 1988. Temperate zone Pomology (Revised edition 1988). Freeman San Francisco. 234 pp.

Xiubin, H., Keli, T., Junliang, T and Mathews, A. 2002. Paleopedological investigation of three agricultural loess soils on the loess plateau of China. *Soil Science*, **167**(7): 478-491.

Yarsheemi, A.N, Channal, M.T., Patagundi, M.S and Satayanarayana, T. 1998. Macro and micro-nutrient status of some salt affected vertisols of upper Krishna Command (Karnataka) *Agropedology*. **8**:35-40.

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*Original not seen