Micronutrient Status of Soil from Mango Orchards of Ratnagiri District and their Relationship with Soil Properties

BY

Ms. NANDINI SHYAM JOSHI

B.Sc.(Ag.)

DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY,

FACULTY OF AGRICULTURE,

DR. BALASAHEB SAWANT KONKAN KRISHI VIDYAPEETH,

DAPOLI-415712, DIST. RATNAGIRI (M.S.)

(May, 2012)

Micronutrient Status of Soil from Mango Orchards of Ratnagiri District and their Relationship with Soil Properties

A thesis submitted to the

DR. BALASAHEB SAWANT KONKAN KRISHI VIDAYPEETH, DAPOLI
(Agricultural University)
Dist. Ratnagiri (Maharashtra State), India

in

partial fulfillment of the requirements

for the degree of

MASTER OF SCIENCE (AGRICULTURE)

in

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

by

NANDINI SHYAM JOSHI
B.Sc.(Ag.)

DEPARTMENT OF SOIL SCIENCE AND
AGRICULTURAL CHEMISTRY,
FACULTY OF AGRICULTURE,
DR. BALASAHEB SAWANT KONKAN KRISHI VIDYAPEETH,
DAPOLI-415 712, DIST. RATNAGIRI, MAHARASHTRA

Dr. K.P.Vaidya

M.Sc. (Agri.), Ph.D.
Assistant Professor,
Department of Soil Science and Agril.Chemistry,
College of agriculture, Dapoli,
Dist. Ratnagiri, Maharashtra.

CERTIFICATE

This is to certify that, the thesis entitled **"Micronutrient Status of Soil from Mango Orchards of Ratnagiri District and their Relationship with Soil Properties"** submitted to the Faculty of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra State, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **SOIL SCIENCE AND AGRICULTURAL CHEMISTRY,** embodies the results of a piece of *bonafide* research carried out by **Ms. NANDINI SHYAM JOSHI** under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma or published in other form. All the assistance and help received during the course of investigation and the sources of literature have been duly acknowledged by her.

Place: Dapoli

Date: MAY, 2012

(K.P. Vaidya)

Chairman,
Advisory Committee
and Research Guide

Micronutrient Status of Soil from Mango Orchards of Ratnagiri District and their Relationship with Soil Properties

A thesis submitted to the

DR. BALASAHEB SAWANT KONKAN KRISHI VIDAYPEETH, DAPOLI
(Agricultural University)
Dist. Ratnagiri (Maharashtra State), India

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE (AGRICULTURE)

in

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

by

NANDINI SHYAM JOSHI
B.Sc. (Ag.)

Approved by the Advisory Committee

: Chairman and Research Guide:

(K. P. Vaidya)
Assistant Professor,
Department of Soil Science and Agricultural Chemistry,
College of Agriculture Dapoli.

:Members:

(M. R. Nagrale)
Associate Professor,
Dept.of Soil Science and Agril.Chemistry,
College of Agriculture, Dapoli

(C. D. Pawar)
Assistant Professor,
Department of Horticulture
College of Agriculture, Dapoli

AKNOWLEDGEMENT

It becomes a duty than a customary to express feelings of gratitude after completion of a phenomenal task. In everyone's life, a moment arises, when one has to articulate such feelings into words. At the conclusion of this research work the moment is mine.

It is my proud privilege to express my heart felt indebtedness and deepest sense of gratitude to Dr. K. P. Vaidya, Assistant Professor, Department of Soil Science and Agricultural Chemistry, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli and Chairman of my Advisory committee and Research Guide, whose able guidance, patience, ever willing help, positive criticism and inspiring support throughout the course of my post graduate study gave me a unique experience of planning, conducting and presenting the research.

I take genuine pleasure to express sincere feelings of gratitude to Dr. M. R. Nagrale, Associate Professor, Department of Soil Science and Agricultural Chemistry, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli and Dr. C. D. Pawar, Assistant Professor, Department of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli for their constant encouragement, exemplary enthusiasm and guidance during the course of my research work as the members of my Advisory Committee.

I am grateful to Hon. Vice Chancellor Dr. K. E. Lavande, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dr. C.V. Bhambure, Dean, Faculty of Agriculture and Associate Dean, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli and Dr. R. G. Burte, Head, Department of Soil Science and Agricultural Chemistry, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli for providing all the necessary facilities.

I am highly obliged to Dr. K.D. Patil, Soil Scientist, Regional Fruit Station, Vengurla, Dr. S. B. Dodake, Dy. Director of Research (Agriculture), Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Shri. D.J. Dabke, Soil Scientist, Water Management, Dr. N.B. Gokhale, I/C Biotechnology unit and Dr. V.G. Salvi, Dr. M. C. Kasture, Shri. M. P. Pore, Shri. R. V. Dhopavkar, Shri. N.H. Khobragade, Ms. P.S. Sawant, Assistant Professors, Department of Soil Science and Agricultural Chemistry, for their valuable inspiration and cooperation during course of my post-graduation research work. I find hardly any words to express my feelings towards Dr. J.S. Dhekale, Assistant Professor, Department of Agricultural Economics, for providing sound statistical support to my research work.

I wish to convey my regards to my friends Smita, Gauri, Reshma, Subodh, Amol, Pramod Patil, Swapnil, Dhananjay, Vijay, Sheetal, Sonali, Vishal, Abheejit, Pramod Parte, Pandurang, Julie, Ruchita, Swati, Manisha, Shivaraj and Sagar for their co-operation and excellent company for releasing the tension and making the research work a pleasant journey.

Words are insufficient to place on record my thanks to Dr. Shyam Joshi, Principal, D.B. J. College, Chiplun who has always been my friend, father and philosopher. His precious support for completion of the research work is beyond the words. My mother Anuradha, grandmother Vasudha and sister Sanjeevani have patiently supported me on days and nights too. Their encouragement and kindly blessing could conclude this research work.

Last but not the least was the support given by other members of the department including Mr. Dosani, Mr. Chavan, Sau. Bhosale madam, Ramesh Kaka, Bam Kaka, Mhaskar Kaka, and Sau. Shedge kaki during the course of investigation. I take this opportunity to give them a word of thanks.

Place: Dapoli

Date: May, 2012. **(Nandini Shyam Joshi)**

DEPARTMENT OF SOIL SCIENCE AND AGRIL. CHEMISTRY
COLLEGE OF AGRICULTURE, DAPOLI
DIST.RATNAGIRI, MAHARASHTRA

Title of Thesis	:	Micronutrient Status of Soil from Mango Orchards of Ratnagiri District and their Relationship with Soil Properties.
Name of the student	:	Ms. Nandini Shyam Joshi
Year	:	2010-2012
Regd. No.	:	2101
Name and Designation of Research Guide	:	Dr. K.P. Vaidya Assistant Professor, Department of Soil Science and Agril. Chemistry, College of Agriculture, Dapoli

ABSTRACT

In order to study 'Micronutrient status of soil from mango orchards of Ratnagiri district and their relationship with soil properties' in all hundred surface soil samples (0 to 15 cm) and fourty profile soil samples (0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm) were collected from Dapoli (Dapoli), Dapoli (Wakawali), Khed (Avashi), Ratnagiri (Shirgaon) and Lanja (Lanja) tahsils of Ratnagiri district. These soil samples were processed and analysed for their DTPA-extractable micronutrients (Fe, Mn, Zn and Cu), available macronutrients (N, P, K, Ca and Mg) and physico-chemical properties. The correlations between the physico-chemical properties and available macronutrients with DTPA-extractable micronutrients were also studied.

From the analysis, it could be concluded that the physico-chemical properties of soils of mango orchards characteristically representedtypical lateritic soils in the'Very High Rainfall Lateritic' (VRL) zone in the Konkan region.

In general, the status of DTPA extractable micronutrients (Fe, Mn, Zn and Cu) found to be adequate in all the mango orchards selected for the present investigation. However, 2% and 17% samples from Dapoli (Dapoli) and Dapoli (Wakawali) locations were respectively found to be deficient in available Cu and Zn content. From, the correlation studies it was observed that the availability of micronutrients in the soil was influenced by mechanical composition, maximum water holding capacity, pH, EC, organic carbon, available nitrogen, available phosphorous, available potassium and exchangeable calcium.

CONTENTS

LIST OF FIGURES

Table continued….

LIST OF TABLES

Table continued

LIST OF PLATES

CHAPTER I

INTRODUCTION

Mango (*Mangifera indica* L.) belonging to family Anacardiaceae is the most important commercially grown fruit crop of Indian subcontinent. Mango is one of the delicious tropical seasonal fruit and believed to be originated in the sub-Himalayan plains of Indian subcontinent. It is one of the most popular, nutritionally rich fruit with unique flavour, fragrance, taste and health promoting qualities making it a common ingredient in new functional foods often called "Super fruits'' as well as "The king of the fruits".

Mango is grown in India for over 4000 years with more than 1,500 varieties in existence as on today. India is largest producer of mangoes in the world and constitutes an important sector of the economy of mango growers especially from rural sectors (Anonymous, 2011).

In addition to the unique taste, mango fruit has peculiar medicinal properties. It is rich in pre-biotic dietary fibre, vitamins, minerals, and poly-phenolic flavonoid antioxidant compounds. Mango fruit is an excellent source of vitamin-A and flavonoids like beta-carotene, alpha-carotene and beta-cryptoxanthin. 100 g of fresh fruit provides 765 mg or 25% of recommended daily levels of vitamin A. It is also a very good source of vitamin-B6 (pyridoxine), vitamin-C and vitamin-E. Consumption of foods rich in vitamin C helps to develop body resistance against infectious agents and scavenge harmful oxygen free radicals. An interesting summary of mango contents is tabulated in APPENDIX II (U.S.D.A., 2011).

The mango plantation covers about 2.20 million ha area in India (Ravikumar D. Modi *et al.,* 2010) and about 0.45million ha area in Maharashtra. The Production of mango has reached to approximately 12.75 million tons in India (Ravikumar D. Modi *et al.*, 2010) and about 638,600 tons in Maharashtra

(Anonymous, 2006). The area under mango production in the Ratnagiri district reaches 62836 ha while the Ratnagiri district produces 115,939 tons of mango fruits (Anonymous, 2010).

The Ratnagiri district under study which is a part of Konkan tract and identified as horticulture district of Maharashtra, has humid; sub-tropical climate with high rainfall. The soil of the district is mainly lateritic. The world famous and the prime variety of mango, the Alphanso, is chiefly produced in the district. Here mango is grown on hilly area under rainfed conditions.

In broad sense, there may be three basic reasons for Indian soils having low productivity (FAI, 2001). These are poor fertility of Indian soils, adoption of high yielding varieties without adequate fertilization and imbalanced use of fertilizers. In general, lateritic soils have poor fertility and poor nutrient retention capacity. This soil has deficiency of macro and micronutrients. The soils of Konkan region having high nutrient loss may be due to heavy rainfall and sloppy area, leads to leaching of nutrients. These factors may accentuate to the deficiency of some micronutrients in the soil (Pereira et al., 1986).

In case of mango, micronutrients present in soil play important role in fruit yield, tree development, fruit quality, flowering and fruit size. The deficiency of various micronutrients may cause spongy tissue or delaying maturity of fruits in mango. The fertility status of soil is one of the most important factor governing the yield and quality of mango fruit. In case of mango crop, soil depth, texture, drainage, pH and native fertility are very important for sustaining its productivity. The crop is very sensitive to poor drainage and water logging conditions (Schaffer et al., 1992). In addition, the crop is susceptible to higher salinity levels. (Jindal 1975, Rastogi and Chandra, 1987)

The Indian lateritic soils on other hand have micronutrient deficiencies. The first micronutrient deficiency diagnosed was of Zn in Rice, at Pantnagar. By the year 2000 widespread deficiencies of Fe, Zn, Mn, B and Mo were diagnosed in succession. Further intensification of agriculture necessitated due to increase in food requirement is bound to aggravate the existing deficiencies and progressive emergence of deficiency of other nutrients. This posed a serious soil health hazards. Based on work done under the auspices of the All India Co-ordinated Scheme of Micronutrients in Soils and Plants (ICAR), analysis of 2.52 lakh soil samples drawn from 20 states of the country indicated 49,12,5 and 3 per cent deficiency of Zn, Fe, Mn and Cu, respectively (Anonymous 2004).

Thus, in general dearth of micronutrients in Indian lateritic soils including the soils of Konkan was indicated by several workers. In addition to this, the significance of micronutrients for the fertility of the soil and in turn for the growth of crops like mango was also highlighted. Mango being the most important crop in Konkan, the micronutrient status of mango orchards of Konkan achieves a great consequence.

In the light of prior stated facts, the present investigation entitled "Micronutrient Status of Soil from Mango Orchards of Ratnagiri District and their Relationship with Soil Properties" is undertaken with following objectives.

- To assess DTPA extractable micronutrients (Fe, Mn, Zn, Cu) status of soil from mango orchards of Ratnagiri district.
- To assess macronutrient status of soil.
- To assess physico-chemical properties of soil.
- To study the correlation or interrelationship of soil properties with available micronutrients.

CHAPTER II
REVIEW OF LITERATURE

In the present chapter available literature on the topic entitled "Micronutrient status of soil from mango orchards of Ratnagiri district and their relationship with soil properties", has been briefly reviewed under suitable headings as follows.

2.1 DTPA extractable micronutrient (Fe, Mn, Zn, Cu) status of mango orchards.

2.2 Macronutrient status of mango orchards.

2.3 Physico-chemical properties of mango orchards.

2.4 Correlation or interrelationship of soil properties with available micronutrients.

2.1 DTPA extractable micronutrients (Fe, Mn, Zn, Cu) status of mango orchards.

2.1.1 Iron (Fe):

Suryavanshi (2010) from his studies on 'Micronutrient status and its relationship with soil properties in mound planted mango orchards of Sindhudurga district' observed that the Fe content was in the range of 12.88 to 50.44 mg kg^{-1} with an average value of 30.60 mg kg^{-1}. He also observed a declined trend of Fe content with soil depth.

Diwale (1994), Patil *et al.,* (2003), Patil and Meisheri (2004), Shinde (2006), Gaidhani (2008) and Sankpal (2008) revealed that the Fe content in lateritic soil of Konkan (M.S.) was between 17.42 and 123.30 mg kg^{-1}. Similarly Pereira (1983), Taware (1983), Salvi (1988), Revandkar (1990) and Terse (1989) reported that the Fe content of surface soil samples of lateritic soil of Konkan (M.S.) was in the range of 9.0 to 36.8 while in profile samples it was 3.8 to 26.75 mg kg^{-1}. They observed that Fe content decreased with soil depth.

Somasundaram *et al.,* (2009) found that the top and slope soils of ravines had more Fe deficiency than other soils. This was probably due to accelerated soil erosion.

Bharambe *et al.*, (1990) reported no specific trend of Fe content with the soil depths of Maharashtra. Interestingly, Dabke (1987) observed an increasing trend with soil depth while Nipunge *et al.,* (1996), Dhane and Shukla (1995), Pati and Mukhopadhyay (2011), Verma *et al.*, (2005), Sharma *et al.*, (2007) and Singh *et al.*, (2009) observed a declined trend of Fe content with soil depth.

Avasthe and Avasthe (1995) revealed that higher Fe content at surface soil than profile soil was due to higher acidity and organic matter content at surface layer while Rajeswar *et a.*,(2009) observed higher values of Fe content at the surface layer than that at profile due to more accumulation of humic substances and prevalence of reduced conditions at surface layers. Similarly, Singh *et al.*, (2002) found a declining trend of Fe content from surface layer to subsurface layer due to loss of Fe_2O_3. This loss was because of decomposition of smectite and partial mobilization of Fe bearing material (clay) through subsurface cracks.

Mahajan (2001) observed that the Fe content in surface and profile soils of mango orchards of lateritic soils of Konkan (M.S.) was in the range 10.31 to 44.75 mg $kg^{-1}$with mean value of 21.63 mg kg^{-1} and 5.11 to 47.60 mg $kg^{-1}$with mean value of 15.17 mg kg^{-1}, respectively. He also found a decreasing trend of Fe content with the soil depth which was due to increasing pH and decreasing organic matter content.

Diwan (1982) reported that the higher content of Fe in lateritic soils of Konkan (M.S.) was due to laterization processes in which sesquioxides accumulate to increase the Fe content. In addition, low pH and higher organic matter content of lateritic soil was also responsible for higher Fe values.

In general, several workers reported deficiency of Fe in Indian soils, while Cakmak (2002) reported that the average Fe deficiency in Indian soils was about 30 per cent while Singh (2006) observed that soils of Maharashtra had a deficiency of 19.6 per cent while Anonymous (1996) found that the deficiency of Fe in the soils of Konkan (M.S.) was about 10 per cent.

2.1.2 Manganese (Mn):

Shinde (2006) studied the lateritic soils of mango orchards of Konkan (M.S.) and reported the value of available Mn at surface and profile soil to be 28.90 to 97.70 with an average value of 49.33 mg kg^{-1} and 33.30 to 87.36 with an average value of 48.28 mg kg^{-1}, respectively. He observed an increasing trend of Mn content with slope and a slightly decreasing trend with depth of soil.

Suryavanshi (2010), Mahajan (2001), Sankpal (2008), Yadav (1988), Shah (1992), Andhalkar (1984) and Chavan (1977) found the levels of Mn in the lateritic soils of Konkan (M.S.) in the range of 6.93 to 74 mg kg^{-1} and a decreasing trend of Mn content with soil depth. However, Pereira (1983) reported an increasing trend of Mn content with depth in hill soils of Konkan (M.S.) due to the leaching losses from surface layer.

Vaidya (1988) from his study on ‘Forms of Manganese and their distribution in Rice soil profiles of Konkan (M.S.)’ revealed that lateritic soils were richer in various forms of manganese than black soils.

Patil and Meisheri (2004) reported that the available Mn in soils of Konkan (M.S.) was in the range of 20.0 to 72.35 with mean value of 41.05 mg kg^{-1} while Patil *et al.*, (2010) observed that the level of Mn in the lateritic soils of Konkan (M.S.) was in the range of 6.06 to 68.7 mg kg^{-1}. Similar range of available Mn was also reported by Katyal and Sharma (1991) and Dhane and Shukla (1995) for benchmark soils of India and Maharashtra, respectively.

Singh (2006) found that the average available Mn was in the range of 1.4 to 50 mg kg^{-1} in the soils of Maharashtra. Anonymous (1996) through a survey observed 3 per cent deficiency of Mn content in soils of Konkan (M.S.) while Anonymous (1992) reported 2.8 per cent deficiency in soils of Maharashtra.

Raghupati and Bhargava (1997) observed that the Mn content in mango orchards of soils of Karnataka was from 8.0 to 51.0 mg kg^{-1} while Avashthe and Avasthe (1995) found higher values of available Mn at higher altitude than lower altitude.

Taware (1983), Malvade (1993), Terse (1989) and Salvi (1988) reported a decreasing trend of available Mn with the soil depth. Interestingly, Bharambe *et al.*, (1990) observed no specific trend of Mn content with soil depth. Chinchmalatpure *et al.* (2000) also observed no specific trend of Mn with depth but they found higher available Mn content in some surface soil samples. This may be due the chelating action of organic compounds released during the decomposition of manures.

Somasundaram *et al.*, (2009) observed that the soils under perennial plants like perennial fruit crops had higher Mn content than the soils under cereals. Nipunge *et al.*, (1996) opined a declined trend of available Mn with soil depth due to difference in intensity of pedogenic processes at surface and profile soils and more complexing of Mn with organic matter in the profile soil. Rajeswar *et al.,* (2009) stated an irregular trend of Mn with depth which was due to its presence in reduced forms in the soils while Chavan *et al.*, (1980) observed that the declined trend of Mn with soil depth may be due to decomposition of organic matter and restriction of the movement of bivalent Mn by free lime in profile soils.

Murthy *et al.*, (1997) found higher values of Mn at surface layer than subsurface layer because of higher activity of micro-organisms at the surface layer. Sharma *et al.*, (2007) observed that the micronutrients release with the decomposition of the organic matter in surface soil was due to the low pH and higher amounts of organic matter. They also observed that the low pH values helped to increase the solubility of micronutrient cations from soil material.

2.1.3 Zinc (Zn):

Suryavanshi (2010) from his studies on ‘Micronutrient status and its relationship with soil properties in mound planted mango orchards of Sindhudurga district' found that the Zn content of lateritic surface soil of Konkan (M.S.) was in the range of 0.924 to 1.641 mg kg^{-1} and that in the profile soil it was 0.625 to 1.195 mg kg^{-1}. He also reported a declining trend with soil depth.

Mahajan (2001) from his study on 'status and distribution of micronutrients in relation to the properties of lateritic soils under mango orchards in south Konkan (M.S.)' observed that the available Zn of surface and profile soil was 0.255 to 1.769 with a mean value of 0.607 mg kg^{-1} and 0.142 to 3.750 with a mean of 0.707 mg kg^{-1}, respectively. He also found an increasing trend of available Zn with slope of orchard while a decreasing trend with the soil depth.

Patil *et al.*, (2010) reported that the available Zn of lateritic soil in Konkan (M.S.) was in the range of 0.29 to 2.28 mg kg^{-1}. Diwale (1994) found Zn content in lateritic soils in the range of 1.10 to 1.30, 0.60 to 0.90, 0.65 to 0.85 and 0.50 to 0.60 mg kg^{-1} at respective depths of 0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm.

Cakmak (2002) reported that by and large the soils of India were Zn deficient. Anonymous (1996) supported this observation through his study on the soils of Konkan (M.S.) and Maharashtra and reported that the deficiency was about 28 per cent in Maharashtra and 56 per cent in Konkan (M.S.). Similar observations were also reported by Patil (2001) and Mahajan (2001).

Singh (2006) observed that the values of Zn content of the soils of Maharashtra were 0.14 to 4.16 mg kg^{-1} while Gaidhani (2008) and Sankpal (2008) found that the Zn content of lateritic soil of Konkan (M.S.) varied from 0.10 to 10.40 mg kg^{-1}. Patil *et al.*, (2003) and Patil and Meisheri (2004) observed that the Zn content in the soils of Konkan ranged from 0.29 to 2.28 with an average value of 1.03 mg kg^{-1}.

Shinde (2006) from his study on 'Physico-chemical properties of lateritic soil from Mango orchards in Ratnagiri and Sindhudurga districts' revealed that the Zn content in the lateritic soils of Konkan at depths of 0 to 30 and 30 to 60 cm was in the range of 0.98 to 3.78 with mean value of 1.87 mg kg^{-1} and 0.92 to 3.28 with mean value 1.50 mg kg^{-1}, respectively. A declined trend with soil depth was also reported by him.

Taware (1983), Salvi (1988), Terse (1989), Shah (1992) Malvade (1993) and Pawar (1993) found a declined trend of Zn content with the soil depth. However, Pereira (1983) and Dabke (1987) observed a slight increase in Zn content with depth. However, Bharambe *et al.*, (1990) reported no specific trend.

Pereira *et al.*, (1986) found higher values of Zn content at higher slopes in soils of mango orchards of Ratnagiri district. However, in general they reported the deficiency of Zn content in most of the soil samples. Similarly, Diwan (1982) observed the deficiency of Zn in soils of Konkan (M.S.) due to high amounts of Fe and Cu in the soil.

Jalali *et al.*, (1989) and Nayak *et al.*, (2000) stated that uneven distribution of Zn in surface and profile soils was due to accumulation of comparatively less or more amount of organic matter in surface layer than in subsurface layer. Waghmare *et al.*, (2008) opined that the deficiency of Zn in the soils of Maharashtra was due to charging of Zn cations in alkaline conditions to their oxides or hydroxides and thereby lowering the availability of Zn while Khan *et al.*, (1997) found that the Zn content of terrace type of soil was highest than other types of soil.

Chinchmalatpure *et al.* (2000) observed that most soil profiles on sandstone land forms were deficient in available Zn as compared to soils derived from basalt due to relatively higher organic carbon content.

2.1.4 Copper (Cu):

Pawar (1993) and Sankpal (2008) reported that the available Cu content in the lateritic soils of Konkan was found to be in the range of 0.071 to 16.2 mg kg^{-1}. Diwan (1982), Taware (1983), Yadav (1988), Terse (1989), Revandkar (1990) and Malvade (1993) observed the range of available Cu in the lateritic soils of Konkan (M.S.) as 1.6 to 5.2 ppm. They found a declined trend of available Cu with soil depth. However, Dabke (1987) found a slightly increasing trend and Salvi (1988) reported no specific trend of available copper with soil depth.

Patil *et al.*, (2010) observed that the available Cu content in the lateritic soils of Konkan (M.S.) was from 1.49 to 9.32 mg kg^{-1}. Gaidhani (2008) from his studies on 'Effect of integrated nutrient management on yield, partitioning and uptake by Rice and on fertility' reported that the range of available Cu in lateritic soils of Konkan (M.S.) was varied from 14.75 to 27.08 mg kg^{-1}.

Suryavanshi (2010) observed that the available Cu content of soils of mango orchards of Sidhudurga district varied from 1.147 to 2.680 with an average of 1.820 mg kg^{-1}. He found a declined trend of available Cu with soil depth while Patil and Meisheri (2004) observed the Cu content in the lateritic soil of Konkan (M.S.) in the range of 1.49 to 9.32 mg kg^{-1}.

Shinde (2006) found that the Cu content at two depths of 0 to 30 and 30 to 60 cm, in lateritic soils of mango orchard in Konkan (M.S.) was ranged from 0.72 to 4.32 with mean value of 2.04 mg kg^{-1} and 0.51 to 5.66 with a mean value of 1.67 mg kg^{-1}, respectively. He found a declining trend with soil depth while no specific trend of available Cu with slope of soil. He also observed sufficient Cu content in the soil which was due to high organic matter content present in the soil.

Mahajan (2001) reported that the Cu content of lateritic soil of mango orchards in Konkan (M.S.) at surface soil and profile soil was in the range of 1.14 to 5.09 with a mean value of 2.54 mg kg^{-1} and 0.17 to 5.15 with a mean 2.21 mg kg^{-1}, respectively. No specific trend with age of the orchard and a declining trend with soil depth of available Cu were also found.

Patil (2001) observed the deficiency of available Cu in few pockets of lateritic soils of Konkan (M.S.) while Anonymous (1996) found the deficiency of about 51 per cent. In addition, Singh (2006), in his survey of soils of Maharashtra, observed the overall available Cu in the range of 0.42 to 8.72 mg kg^{-1}. Several deficiency pockets in Maharshtra including Konkan (M.S.) were also observed in this survey.

Avasthe and Avasthe (1995) found that the Cu content was more at higher altitude than at lower. Follet and Lindsay (1970) and Karim *et al.*, (1976) observed that soil from basalt had higher available Cu than that in costal planes. Pereira *et al.*, (1996) observed more available Cu at higher slopes in lateritic soils of Konkan (M.S.).

Rajeswar *et al.*, (2009) found a declining trend of available Cu with soil depth due to decrease in organic carbon content in soil profiles. However according to Mehta *et al.*, (1964) the higher values of available Cu in the surface soil might be due to translocation of Cu from lower layers to the surface layers under the influence of vegetation.

According to Malewar (1995) the wide variation in the content of Cu in profile and surface soil was associated not only with type of parent material and their chemical composition but also with the fractional crystallisation of magma from which parent materials were formed and subsequently soils were derived.

2.2 Macronutrient status of soil:

2.2.1 Available nitrogen:

Chavan *et al.*, (1995) found that the nitrogen content in the lateritic soils of Konkan (M.S.) in the range of 253.10 to 260.10 and 153.10 to 161.60 kg ha^{-1} at 0 to 30 and 30 to 60 cm depth, respectively. They found a decreasing trend of nitrogen content with soil depth.

Kadam (1984), Dabke (1987), Phonde (1987), Salvi (1988), Yadav (1988), Mali (1989), Terse (1989), Revandkar (1990), Shah (1992), Malvade (1993), Pawar (1993), Tupe (1996), Dongre (1997) and Sankpal (2008) observed that the range of available nitrogen in the lateritic soils of Konkan (M.S.) varied from 149.94 to 482.20 kg ha^{-1}. They also reported a declined trend of nitrogen content with soil depth. However, Vaidya (1988) observed no specific trend.

Raghupati and Bhargava (1997) found that the nitrogen content in the lateritic soils of mango orchards of Ratnagiri district was in the range of 58.00 to 134.00 mg kg^{-1}. Gaidhani (2008) from his studies on 'Effect of integrated nutrient management on yield, partitioning and uptake by Rice and on fertility' revealed that the average available nitrogen in the lateritic soils of Konkan (M.S.) was 278.30 kg ha^{-1}.

Mahajan (2001) observed that the available nitrogen in the soils of mango orchards in Konkan (M.S.) varied from 341.20 to 862.40 with an average of 591.90 kg ha^{-1} and 291.60 to 900.00 with mean value of 479.50 kg ha^{-1} at surface and profile soil, respectively. A declining trend with soil depth was also reported. Referring to the rating given by Bangar and Zende (1978), he classified 1.92 per cent samples as moderate, 51.92 per cent samples as moderately high, 28.84 per cent as high and 17.30 per cent as very high. He also found that the high content of nitrogen in the soils of mango orchards was due to leaf fall of mango trees and thereby accumulation of organic matter in the soil which in turn increased the available nitrogen in the soil.

The depth-wise nitrogen content in the lateritic soils of mango orchards of Konkan (M.S.) ranged from 282.24 to 627.00 with a mean value of 398.04 kg ha^{-1} and 263.28 to 577.02 with mean value of 394.92 kg ha^{-1} at 0 to 30 and 30 to 60 cm depth, respectively (Shinde,2006). He also reported a declining trend of nitrogen content with soil depth and increasing trend with slope of soil.

Dongale (1989) found the nitrogen content in the lateritic soils of Konkan (M.S.) in the range of 185.00 to 674.00 kg ha^{-1}. He also observed that the nitrogen content of Sindhudurga district was comparatively less than that of Ratnagiri district.

Suryavanshi (2010) from his studies on 'Micronutrient status and its relationship with soil properties in mound planted mango orchards of Sindhudurga district' revealed that the nitrogen content in lateritic soil of Konkan (M.S.) was varied from 338.94 to 527.62 with mean value of 409.94 kg ha^{-1}. A declining trend with depth was also observed.

Talukdar *et al.*, (2009) opined that the higher values of nitrogen content in the soil might be due to high content of organic carbon which on mineralization released higher nitrogen. Patil and Sonar (1994) observed that the variation of available nitrogen was due to the differences in the physiography of soil as well as differential cultivation and management practices of soils.

Sharma and Bali (2000) found that the higher values of available nitrogen in surface soils could be attributed to the presence of higher organic carbon in the surface soil. Pradeep Kumar *et al.*, (1995) observed that the general irregular distribution of available nitrogen could be due to stratification of soil.

Rajeswar *et al.*, (2009) and Prasunarani *et al.*, (1992) from their studies reported that the available nitrogen was found to be maximum in surface horizons. However, it decreased with soil depths which might be due to accumulation of plant residues, debris and rhizosphere.

2.2.2 Available phosphorous (P_2O_5):

Deshmukh *et al.*, (1982) observed that the available phosphorous in the surface soils of Konkan (M.S.) was in the range of 5.01 to 26.14 ppm. The top layers were found richer than the subsurface layers of the soil.

Pereira *et al.*, (1986) found the available phosphorous in the range of 0.79 to 2.96 with a mean value of 2.17 kg ha^{-1} and 0.39 to 4.10 with average of 2.10 kg ha^{-1} at higher and lower slopes, respectively in the lateritic soils of mango orchards of Ratnagiri district. Chavan *et al.*, (1995) reported that the phosphorous content in the lateritic soils at two depths 0 to 30 and 30 to 60 cm, varied from 11.00 to 12.40 and 10.20 to 11.00 kg ha^{-1}, respectively. However, it decreased with soil depth. Similarly, Raghupati and Bhargava (1997) reported the available phosphorous in the lateritic soils of mango orchards of Ratnagiri district in the range of 10.40 to 15.60 kg ha^{-1}. They categorised 30 per cent of the orchards as ‘very low’ and 16 per cent as ‘low’ in available phosphorous content.

Various researchers namely, Kadam (1984), Patil (1986 a), Patil (1986 b), Bobade (1987), Phonde (1987), Sagane (1987) Tupe (1996), Dongre (1997), Pednekar (1998), Revandkar (1990), Diwale (1994), Gaidhani (2008) and Sankpal (2008) reported the available phosphorous in the range of 0.30 to 38.75 kg ha^{-1} including surface and profile soils in lateritic soils of Konkan (M.S.). They also reported a declining trend with soil depth. However, Vaidya (1988) and Dabke (1987) found no specific trend.

Suryavashi (2010) observed that the phosphorous content in the lateritic soils of mango orchards of Konkan (M.S.) in the range of 3.42 to 15.33 with average of 7.96 kg $ha^{-1}$with a decreasing trend of it with soil depth. Shinde (2006) and Mahajan (2001) from their study on the phosphorous content in the lateritic soils of mango orchards of Konkan (M.S.) revealed that the range for available phosphorous at surface soil as 2.51 to 24.90 kg ha^{-1} while in profile soil it was 1.20 to 27.53 kg ha^{-1} which showed a declining trend with depth of the soil.

According to Prasunarani *et al.*, (1992) the low content of available P_2O_5 in lateritic soils might be due to low native phosphorous content and fixation of released phosphorous by clay minerals and oxides of Fe and Al. Thangaswamy *et al.*, (2005) stated that the higher content of phosphorous in soil was due to confinement of crop cultivation to surface layer and supplementation of the depleted P_2O_5 through fertilizers. Mahesh Kumar *et al.*, (2011) revealed that the coarse texture soils had higher content of phosphorous than fine texture. Sharma and Bali (2000) observed that the declining trend of phosphorous was due to higher fixation of it with depth.

Badrinath *et al.*, (1986) reported that the low available phosphorous in the soils of Maharashtra might be due to high phosphorous fixing capacity of these soils may be preventing its transformations into readily available form in the soil solution. Talukdar *et al.*, (2009) found that available phosphorous content is related with the organic carbon content in the soil while Tiwari *et al.*, (1987) observed that the available phosphorous was more in spring due to higher microbial activity in soil in this season releasing the phosphorous with faster rate.

2.2.3 Available potassium (K_2O):

Chavan *et al.*, (1995) from their study found that the average values of potassium content in the lateritic soils of Konkan (M.S.) were 147.30 and 108.40 kg ha^{-1} at 0 to 30 and 30 to 60 cm depth, respectively. A declining trend with depth was also reported. Pereira *et al.*, (1986) observed the available K_2O content of lateritic soils of mango orchards of Ratnagiri district in the range of 177.90 to 696.80 with an average value of 336.63 kg ha^{-1} at lower slope and 207.60 to 425.00 with mean value of 324.77 kg ha^{-1} at higher slope.

Parab (1990) found that available potassium in the lateritic soils of Konkan (M.S.) had a range of 15.00 to 261.00 ppm. A declined trend with depth was also reported. He also found a higher value of available potassium in Ratnagiri district than that in Sindhudurga district.

Shinde (2006) from his study on 'physico-chemical properties of lateritic soil from mango orchards in Ratnagiri and Sindhudurga district' reported an estimate of potassium content in the range of 212.35 to 302.40 with a mean value of 238.04 kg ha^{-1} and 201.60 to 282.89 with mean value of 233.00 kg ha^{-1} at 0 to 30 and 30 to 60 cm depth, respectively. A decrease in potassium with soil depth was also reported.

Bharambe *et al.*, (1990) reported that the higher values of potassium in soils of Maharashtra due to presence of higher quantity of potassium bearing minerals in the parent material.

Revandkar (1990) observed that available potassium in the lateritic soils of Ratnagiti district had a range of 23.71 to 296.34 kg ha^{-1}. Further, he also observed an increasing trend of potassium content with soil depth due to increase in clay content and decrease in sand and organic carbon content with soil depth while Patil (1981), Pereira (1983), Patil (1986 b) and Vaidya (1988) reported no specific trend of potassium content with soil depth.

Taware (1983) reported the available potassium in the lateritic soils of mango orchards of Ratnagiri at higher and lower slopes each with surface and profile samples. The respective values reported were 202.00 to 410.01, 187.00 to 385.04, 177.90 to 312.20 and 202.00 to 242.20 kg ha^{-1}, respectively. The increasing trend in available potassium was due to more weathering of mica, potash and feldspar in profile.

Sagane (1987), Dongre (1997), Malvade (1993), Pawar (1993), Diwale (1994), Tupe (1996), Pednakar (1998), Gaidhani (2008) and Sankpal (2008) observed that available potassium in the surface and profile lateritic soils of Konkan (M.S.) was in the range of 81.04 to 529.06 kg ha^{-1}. They also reported a decreasing trend with depth. However, Salvi (1988) observed the same range, but a decreasing trend up to 45 cm depth and an increasing trend up to 90 cm depth.

Suryavanshi (2010) observed the potassium content in the lateritic soils of mound planted mango orchards of Konkan (M.S.) as 219.32 to 275.73 with a mean value of 248.75 kg ha^{-1} and no specific trend with soil depth. Mahajan (2001) reported the potassium content in the lateritic soils of mango orchards of Konkan (M.S.) as 86.00 to 556.40 with average value of 185.40 kg ha^{-1} and 80.60 to 1290.20 with average value of 216.23 kg ha^{-1} at surface and profile soil, respectively. He also found an increasing trend with soil depth.

Bhaskar and Subbaiah (1995) observed very low available potassium content in lateritic soils of Andhra Pradesh, either due to low weathering of coarse size mica or due to presence of small amounts of feldspar as source for bases. Bielieski (1973) and Gupta and Rorison (1975) opined that high concentration of available potassium in surface layer might be due to more organic matter content in surface layer.

Pal and Mukhopadhyay (1992) opined that decrease in available potassium content was due to more intensive weathering, release of labile potassium from organic residues, application of potassium fertilizers and upward translocation of potassium from lower depths along with capillary rise of ground water.

2.2.4 Exchangeable Calcium (Ca^{2+})

Sankpal (2008) from his study on ‘Studies on physico-chemical properties of lateritic soils of agriculture research station, Phondaghat (Sindhudurga)’ observed the range of exchangeable calcium as 0.20 to 2.90 with mean of 1.60 cmol (p^+) kg^{-1}.

Chavan *et al.*, (1995) found the exchangeable calcium in the lateritic soils of Konkan (M.S.) in the range of 3.4 to 3.6 cmol (p^+) kg^{-1}at 0 to 30 cm and 2.30 to 2.90 cmol (p^+) kg^{-1}at 30 to 60 cm soil depth. A decreasing trend with depth was also observed. Phonde (1987), Salvi (1988), Yadav (1988), Revandkar (1990) and Shah (1992) reported the range of exchangeable calcium in the lateritic soils of Konkan (M.S.) as 6.24 to 36.00 meq. per 100 gm. They found no specific trend. However, Shah (1992) observed an increasing trend of exchangeable calcium with soil depth.

Mahajan (2001) from his studies on ‘Status and distribution of micronutrients in relation to the properties of lateritic soils of mango orchards in south Konkan (M.S.)’ reported the range of exchangeable calcium in the surface soil as 0.95 to 2.37 with a mean value of 1.56 cmol (p^+) kg^{-1} while at 30 to 60 cm depth it was 0.55 to 3.64 with a mean value 1.61 cmol (p^+) kg^{-1}. Referring to the rating given by Sankaram (1966), he classified all the samples to have ‘low’ class. He also observed a decreasing trend with soil depth.

In Andhra Pradesh, Bhaskar and Subbaiah (1995) found low values of exchangeable calcium with no specific trend of it with soil depth. According to them, the low values were due to low weathering of sources for creation of the base Ca^{2+}.

Shinde (2006) observed the exchangeable calcium in the lateritic soils of mango orchards of Konkan (M.S.) as 1.17 to 2.90 with a mean value of 2.17cmol (p^+) kg^{-1} and 1.10 to 2.90 with mean value of 1.96 cmol (p^+) kg^{-1} at 0 to 30 and 30 to 60 cm depth, respectively. A decreasing trend with soil depth and increasing trend with slope of orchard was also reported. Suryavashi (2010) observed the exchangeable calcium in the lateritic soils of mango orchards of Konkan (M.S.) in the range of 1.72 to 2.32 with mean value of 2.0 cmol (p^+) kg^{-1}. A decreasing trend with soil depth was also reported.

Mohapatra and Kibe (1973) attributed the low content of exchangeable calcium to high percolating nature and intensive leaching of the bases due to high rainfall. Datta *et al.*, (1990) reported a decreasing trend of exchangeable calcium with soil depth while Bandopadhyay *et al.*, (2008) found an increasing trend.

Kadrekar *et al.*, (1981) observed an increasing trend of exchangeable calcium in the lateritic soils of Konkan (M.S.) with soil depth. They observed low but comparatively higher values of exchangeable calcium than magnesium. However, Raghupati and Bhargava (1997) reported adequate values of exchangeable calcium for lateritic soils of Konkan.

2.2.5 Exchangeable magnesium:

Mahajan (2001) reported the content of exchangeable magnesium in lateritic soils of mango orchards of Konkan (M.S.) as 0.33 to 1.53 with mean value of 0.88 cmol (p^+) kg^{-1} and 0.36 to 1.64 with mean value of 0.81 cmol (p^+) kg^{-1} in surface and profile soils, respectively. He categorized all the samples of exchangeable magnesium under 'low' class as per the ratings given by Sankaram (1966). He also found a decreasing trend of exchangeable magnesium with increasing depth of soil. The low values of exchangeable magnesium might be due to the percolative nature of lateritic soils and loss of bases because of heavy precipitation.

Shinde (2006) revealed that exchangeable magnesium in lateritic soils of mango orchards of Konkan (M.S.) varied from 0.58 to 1.67 with a mean value of 1.20 cmol (p^+) kg^{-1} and 0.31 to 1.50 with a mean value of 0.97 cmol (p^+) kg^{-1} at 0 to 30 and 30 to 60 cm soil depth, respectively. He also observed decreasing trend of exchangeable magnesium with soil depth and an increasing trend with slope. All the samples were categorized under 'low' class as per ratings given by Sankaram (1966) and further he opined that low values of exchangeable magnesium may be due to loss magnesium through leaching as a result of heavy rainfall in the region.

Chavan *et al.*, (1995) observed the exchangeable magnesium in lateritic soils of Konkan (M.S.) at 0 to 30 cm depth as 1.60 cmol (p^+) kg^{-1} and at 30 to 60 cm depth as 1.10 to1.40 cmol (p^+) kg^{-1} and also observed a decreasing trend of exchangeable magnesium with soil depth.

Phonde (1987) and Tupe (1996) reported low values of exchangeable magnesium in lateritic soils from mango orchards of Konkan (M.S.). Revandkar (1990) reported the exchangeable magnesium content in lateritic soils of Konkan (M.S.) as 1.07 meq./100g and slightly increasing trend with soil depth due to elluviation of bases and illuviation of them in subsoil layers. Similarly, Suryavanshi (2010) observed the values of exchangeable magnesium in lateritic soils of mango orchards of Konkan as 1.72 to 2.32 with mean value of 2.05 cmol (p^+) kg^{-1}. He also found decreasing trend with soil depth.

Datta *et al.*, (1990) reported the declining trend of exchangeable magnesium with the soil depth in the acid soils of Tripura while Somasundaram *et al.*, (2009) reported the increasing trend of it in the soils of CSWCRTI, research station, Kota.

Bhaskar and Subbaiah (1995) reported very low content of exchangeable magnesium content in lateritic soils of Andhra Pradesh which may be due to low weathering of magnesium bearing minerals in soils. Raghupati and Bhargava (1997) observed that the range of exchangeable magnesium in lateritic soils from mango orchards of Ratnagiri district was 125 to 204 mg kg^{-1}. He also found that majority of soils were low in magnesium which may be due to leaching losses of magnesium in the lateritic soils of the region.

2.3 Physico-chemical properties of lateritic soils:

2.3.1 Particle size distribution

2.3.1.1 Sand content

Suryavanshi (2010) from his studies on 'Micronutrient status and its relationship with soil properties in mound planted mango orchards of Sindhudurga district' observed that the sand content of soil at 0 to15, 15 to 30 and 30 to 45 depths varied from 47.80 to 57.83, 44.26 to 56.80, 42.30 to 54.53 per cent with mean value of 50.63 per cent, respectively. He also reported that the textural class of south Konkan (M.S.) region was sandy clay to sandy clay loam and a decreasing trend of sand content with soil depth.

Mahajan (2001) from his studies on 'Status and distribution of micronutrients in relation to the properties of lateritic soils under mango orchards in south Konkan (M.S.)' observed that the sand content in the surface soils of mango orchards of south Konkan (M.S.) ranged from 23.50 to 65.50 per cent with mean value 47.60 per cent and in profile samples it ranged from 37.00 to 68.80 per cent 50.10 per cent. Many researchers (Pereira (1983), Dabke (1987), Mali (1989), Revandkar (1990), Diwale (1994), Tupe (1996) and Dongre (1997)) reported that the sand content of lateritic soils of Konkan (M.S.) region ranged from 20.24 to 71.35 per cent.

Shinde (2006) from his study on 'physico-chemical properties of lateritic soil from mango orchards in Ratnagiri and Sindhudurga districts' observed that the sand content was found in the range of 42.68 to 67.00 with a mean value of 47.44 per cent and 40.15 to 51.10 with mean value of 44.89 per cent at 0 to 30 and 30 to 60 cm soil depths, respectively. He also found that the sand content was inversely proportional to the soil depth. Further in contrast to this, Yadav (1988) observed that the sand content of the lateritic soil of Konkan (M.S.) region (M.S.) increased up to depth of 45 cm and decreased above 45 cm soil depth. Further, Patil (1986 b) observed no specific trend in distribution of sand content with depths of lateritic soils of Konkan region (M.S.).

Sehgal (1996) stated that the higher sand content in the surface soil than in the profile may be due to less weathering of the parent material in upper surface of the soil.

2.3.1.2 Silt content:

Chinchmalatpure *et al.* (2000) observed that the silt content varied from 5.00 to 47.80 per cent without any specific trend with soil depth in soils of Maharashtra. Pereira *et al.* (1986) found that the silt content showed variation from 13.4 to 48.0 per cent with mean value 26.10 per cent and 16.00 to 39.40 per cent with mean value 23.70 per cent at lower and higher slopes, respectively in soils of mango orchards of Konkan (M.S.). However, Taware (1983) reported no change in silt content with respect to slope in the soils of mango orchards of Konkan (M.S.).

In general, the silt content of the soils of Maharashtra was reported by Chavan *et al.* (1980) and Todmal *et al.* (2008) in the range of 2.45 to 63.27 per cent with uneven distribution with soil depth. Similarly, Patil *et al.* (2003), Dongale and Kadrekar (1992), Deshmukh *et al.* (1982), Taware (1983), Sagane (1987) and Anonymous (1992) observed that the silt content of lateritic soils of Konkan (M.S.) region was in the range of 14.20 to 47.00 per cent.

Suryavanshi (2010) reported the silt content in surface soils of mango orchards of Konkan (M.S.) as 13.41 to 17.11 per cent and 11.08 to 19.10 per cent in profile soils with a mean value of 14.99 per cent. He also reported no specific trend of silt content with soil depth. Similar observations were also recorded by Dabke (1987) and Pednekar (1998). Contrasting to this, Salvi (1988), Mali (1989), Shinde (2006), Revandkar (1990), Avasthe and Avasthe

(1995) observed that the silt content of the soil decreased with increasing depth of soil. Amusingly, Diwale (1994) from his study on 'Distribution of different forms of zinc in rice soil profiles of Konkan (M.S.)' revealed that the silt content in the lateritic soils of Konkan (M.S.) at variable depths like 0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm was seen to be 17.82, 23.46, 23.49 and 29.44 per cent, respectively. This showed an increasing trend of silt content with increasing depth of soil. Similar findings were also noted by Preethi *et al*., (1998) and Mathan (1991).

Mahajan (2001) observed that the silt content in surface soil was 12.40 to 28.90 per cent with a mean value of 21.30 per cent and in profile soil 8.00 to 23.80 per cent with a mean value of 15.70 per cent in lateritic soils of mango orchards of Konkan (M.S.) region. He also observed a slight increase in the silt content with increasing soil depth of soil at few locations.

2.3.1.3 Clay content:

Shinde (2006) studied physico-chemical properties of lateritic soil from mango orchards in Ratnagiri and Sindhudurga districts and reported that the clay content at 0 to 30 cm depth ranged from 23.11 to 44.55 per cent with mean value of 33.92 per cent and at 30 to 60 cm depth it varied from 28.72 to 47.00 per cent with a mean value of 40.89 per cent. Further he observed that the clay content was found to be increased from upper surface to lower surface of soil from 33.92 to 40.89 per cent.

Dhane and Shukla (1995) observed that the clay content of vertisols, inseptisols and entisols of Maharashtra ranged from 29.60 to 55.20, 17.20 to 53.20 and 21.80 to 27.60, respectively.

In addition, many workers (Chavan; 1977, Taware; 1983, Kadam; 1984, Bobade; 1987, Malvade; 1993) observed that the clay content of the lateritic soils of Konkan (M.S.) had a wide variation from 9.90 per cent to as high as 69.70 per cent. Further they reported an increase in the clay content with the soil depth. However, Vaidya (1988) and Yadav (1988) observed that there was no definite trend in case of clay content with soil depth.

With particular reference to, the clay content in lateritic soils of the Ratnagiri district was found in the range of 21.30 to 53.38 per cent as reported by Deshmukh *et al.* (1982), Pereira *et al.* (1986), Dongale and Kadrekar (1992) and Patil *et al.* (2003),.

Interestingly, Subbaiah and Manickam (1992) stated the reason of increase in the clay content with the soil depth was due to the translocation of clay fraction from the surface soil down to the profile. Whereas, Patil *et al.* (2010) reported higher clay content in soils developed on basaltic capping over shell than that developed on basaltic alluvium and sand stone.

Terse (1989) from his study on 'Characterisation of soil potassium in bench mark soils of south Konkan (M.S.)' reported that the clay content of Ratnagiri district at variable depths of 0 to 30, 30 to 60 and 60 to 90 cm was found in the range of 31.04 to 39.00, 31.00 to 47.92 and 29.00 to 45.00 per cent, respectively.

Malewar (1995) observed that the clay content in the inceptisols and vertisols of Maharashtra having a cultivation of fruit crops was found in the range of 18.20 to 20.00 with an average value of 19.30 per cent and 42.80 to 54.80 with an average of 46.60 per cent, respectively.

Datta *et al.,* (1999) found that the clay content in surface and profile soil of higher slopes was lower than that of lower slopes. From these observations they concluded that the topography of soil affects the clay content of the soil.

2.3.2 Particle Density (PD):

Suryavanshi (2010) found that particle density of lateritic soil of mango orchards of Sindhudurga district was ranged from 2.34 to 2.56 with a mean of 2.45 Mg m^{-3}. He further reported that there was no specific trend of particle density with soil depth.

Shinde (2006) from his studies on 'Physico-chemical properties of lateritic soil from Mango orchards in Ratnagiri and Sindhudurga districts' observed that the particle density of lateritic soil of Konkan (M.S.) region at 0 to 30 cm depth varied in the range from 2.31 to 2.64 Mg m $^{-3}$ with a mean value of 2.46 Mg m $^{-3}$ and at 30 to 60 cm depth it was found in the range of 2.12to 2.68 Mg m $^{-3}$ with a mean value of 2.44Mg m $^{-3}$. Further no relation of particle density was observed with soil depth. In addition, there was no definite trend of particle density with slope of soil.

Chavan *et al.*,(1995) revealed that particle density of lateritic soil of Ratnagiri district varied between 2.45 to 2.61Mg m $^{-3}$and 2.48 to 2.74 Mg m $^{-3}$at 0 to 30 and 30 to 60 cm depths, respectively. A slight increase in particle density with soil depth was observed.

Patil (1986 a), Yadav (1988), Revandkar (1990), Dongre (1997) and Sankpal (2008) reported the particle density of lateritic soil in the range of 2.21 to 2.72 Mg m $^{-3}$. They also observed no specific pattern of particle density with soil depth. In contrast to this, Malvade (1993) and Dabke (1987) observed an increase in the particle density with depth of lateritic soils of Konkan (M.S.).

Mahajan (2001) from his studies on 'status and distribution of micronutrients in relation to the properties of lateritic soils under mango orchards in south Konkan (M.S.)' observed that the particle density of surface soil ranged from 2.62 to 2.83Mg m $^{-3}$ with an overall mean value of 2.51Mg m $^{-3}$, while the soil profiles showed particle density in the range of 2.21 to 2.88 Mg m^{-3} with a mean value of 2.61Mg m $^{-3}$. He found that the higher particle density of lateritic soils was due to the presence of kaolinite, haematite and fine grained mica in this soil. He also noticed that there was no appreciable change in particle density with soil depth.

Datta *et al.,* (1990) found that lowland soils have high particle density than upland soils. Patro and Mishra (1985) observed the particle density as 2.60, 2.62, 2.68, 2.66 Mg m $^{-3}$at respective soil depths of 0 to 15 cm, 15 to 30 cm, 30 to 45 cm and 45 to 60 cm in Typichaplustult profile.

2.3.3 Bulk Density (B.D.):

Bharambe *et al.,* (1990) reported the bulk density of soils of Maharashtra in the range of 1.24 to 1.41 Mg m $^{-3}$ at 0 to 30 cm depth and 1.34 to 1.43 Mg m $^{-3}$ at 30 to 60 cm depth. A slight increase in bulk density with depth was also observed. He opined higher bulk density values due to degradation of soil structure due to alkalinity.

Higher values of bulk density in sub-surface soils than surface soils to compaction caused by overburden of surface layers (Ahuja *et al.,*1989), while Rao *et al.,* (2010) reported the lower bulk density of surface soil than soil profile. It may be due to elevated cultivation, organic matter and biotic activities in the surface soil.

Sankpal (2008) revealed from his study that bulk density of surface soil varied from 1.09 to 1.48 Mg m $^{-3}$ with a mean value of 1.25 Mg m $^{-3}$ and in profile soil it ranged between1.39 to 1.52 Mg m $^{-3}$. He found no specific trend of bulk density with soil depth.

Bharambe and Ghonshikar (1985) and Ommala D. Kuchanwar *et al.,* (2005) reported that the bulk density of soils of Maharashtra ranged from 1.15 to 1.27 Mg m $^{-3}$ with an average value of 1.19 Mg m $^{-3}$.

Sarma (1997) found an increase in the bulk density with soil depth. However, Bhaskar and Subbaiah (1995) reported no specific trend whereas Patro and Mishra (1985) observed a decrease in bulk density with soil depth.

Kadam (1984), Dabke (1987), Phonde (1987), Joshi and Kadrekar (1988), Yadav (1988), Revandkar (1990), Shah (1992), Malvade (1993), Pawar (1993), Chavan *et al.,*(1995), Tupe (1996) and Dongare (1997) had studied the lateritic soils of Konkan (M.S.) and reported that the bulk density ranged from 1.04 to 1.79 Mg m $^{-3}$.

Suryavanshi (2010) from his studies on ‘Micronutrient status and its relationship with soil properties in mound planted mango orchards of Sindhudurga district’ observed that the bulk density showed a variation in between 1.20 and 1.31 Mg m^{-3} with a mean value of 1.25 Mg m^{-3} and observed no specific pattern of it with soil depth.

Mahajan (2001) and Shinde (2006) both observed that bulk density of lateritic soil of Konkan (M.S.) at surface and profile varied from 0.99 to 1.47 and 0.98 to 1.38 Mg m^{-3}, respectively. Further no specific trend of bulk density with soil depth was found (Shinde ,2006). However, noted a slight increase in bulk density with depth was also noted (Mahajan (2001).

Patil *et al.*,(2008) observed higher values of bulk density of surface soil (1.83 Mg m^{-3}) and lower values for the profile soil (1.33 Mg m^{-3}). However, at certain places he found higher values of bulk density for profile soils. Similarly, Khan *et al.*,(1998) also observed higher values of bulk density at profile soil might be attributed to dispersion and migration of clays and clogging of pores.

2.3.4 Maximum water holding capacity (MHWC):

Gaidhani (2008) from his studies on ‘Effect of Integrated nutrient management on yield, partitioning and uptake by rice and on fertility status of lateritic soils of Konkan (M.S.)’ reported that the maximum water holding capacity of lateritic soils of Konkan (M.S.) ranged between 50.38 to 52.52 per cent with an average value of 51.34 per cent.

Bhaskar and Subbaiah (1995) found increasing values of water holding capacity with depth of red and lateritic soils of Andhra Pradesh. Revandkar (1990) also observed similar trend and stated that the increase in MWHC may be due to the increasing clay content with depth of the lateritic soils of Ratnagiri district.

Ramteke (1996) and Ommala D. Kuchanwar *et al.,* (2005) documented that maximum water holding capacity of soils of different parts of Maharashtra ranged from 55.60 to 73.58 per cent with an average of 63.47 per cent.

Terse (1989) found the maximum water holding capacity of lateritic soils of Ratnagiri district in the range of 44.68 to 50.40 per cent at 0 to 30 and 45.41 to 52.20 at 30 to 60 cm depth with no specific variation with the depth. Patil (1986 b) also supported no definite trend of maximum water holding capacity of lateritic soils of Konkan (M.S.) with soil depth.

Diwale (1994) from his study on 'Distribution of different forms of Zinc in Rice soil profiles of Konkan (M.S.)' observed that the range of maximum water holding capacity of lateritic soils of Ratnagiri district at variable depths of 0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm varied between 52.94 to 58.74, 54.07 to 60.25, 57.10 to 64.40 and 57.17 to 68.26 per cent, respectively. He further found an increase in maximum water holding capacity with soil depth.

Mahajan (2001) reported that the maximum water holding capacity of lateritic surface soils of Konkan (M.S.) was in the range of 34.80 to 65.70 per cent with average value of 52.10 per cent while for profile soils it was 36.70 to 66.00 with average value of 56.10 per cent. By referring to the ratings of maximum water holding capacities given by Sankaram (1966), he classified 36.53 per cent of his surface samples as 'medium' and 63.46 per cent as 'high'. For profile samples 9 per cent were classified as 'medium' and rest 91 per cent were 'high'. He also observed a declining trend of maximum water holding capacity with soil depth. It may be attributed to decrease in the organic matter with the depth. Salvi (1988) Pawar (1993), Shinde (2006) and Sankpal (2008) observed that the maximum water holding capacity of surface and profile lateritic soils of Konkan (M.S.) showed a variation from 37.82 to 72.97 per cent. All these researchers observed an increase in maximum water holding capacity with depth of soil.

2.3.5 Soil reaction (pH) :

Dongale and Kadrekar (1992) studied the lateritic soils of Konkan (M.S.) and observed that the pH values varied from 5.10 to 7.20 while Dongale (1993) from his study on of the soils of Ratnagiri district found that the soils were acidic in reaction and pH values ranged from 5.70 to 6.90. No specific trend of pH was found with soil depth. Edward Raja (2007) from his study revealed that more soils of Ratnairi district were found to be more acidic with pH values between 4.50 and 5.20. Sawant (2004) observed that the pH of lateritic soils under different plantations ranged between 4.78 and 5.46 while Pereira *et al.,*(1986) reported that pH values of mango orchards of Ratnagiri district on lower slopes was found in the range between 5.40 to 6.30 with an average value of 5.90 while on higher slopes it ranged from 5.00 to 6.10 with an average value of 5.70.

Mali (1989), Terse (1989), Modak (1990) and Parab (1990) observed that the pH of soils of Ratnagiri district ranged from 5.80 to 5.90. In addition, Deshmukh *et al.,* (1982) reported the average pH value of lateritic soil as 5.20 while Chavan *et al.,* (1980) and Malewar and Ghonsikar (1984) found that the pH value ranged from 5.00 to 6.50 for soils of Maharashtra.

Das *et al.,* (2000) noted the pH of red lateritic soil of West Bengal was in between 5.02 to 5.80 which showed the acidic nature of the soil. He also noted that the pH increased with soil depth. Similar observations for the lateritic soils of Maharashtra were also reported by Todmal *et al.,* (2008) and Verma *et al.,* (2005) and also observed similar pattern with soil depth.

Higher values of pH were associated with presence of high degree of base saturation in the soil and vice versa (Shrinivas *et al.,* 2011). Similar findings were stated by Waghmare *et al.,* (2008).

Datta *et al.,* (1990) found that the pH values of upland soils were comparatively lower than that of lowland soils. This may be due to surface run off of upland soils. The pH value of soil was mainly decided by three factors namely the parent material, rainfall and topography (Thangaswamy *et al.,*2005). In addition, they also observed that an increasing trend of with soil depth. This may be due to accumulation of exchangeable Na^+ and $CaCO_3$ in the soil profile. (Chattopadhyay *et al.*1996).

Somasundaram *et al.,* (2009) studied the soils under perennial cultivation and observed low pH values than that of regularly cultivated soils. It may be attributed to higher leaf litter addition to soil which helps in acceleration of mineralization process Sanborn (2001) and Wilson (2007).

Sarkar and Sahoo (2000) and Patil *et al.,* (2008) found that the pH value increased with depth as soil alkalinity increases with depth due to deposition of basic salts by irrigation and eluviations.

Mahajan (2001) Shinde (2006), Sankpal (2008) and Suryavanshi (2010) observed that the pH values of lateritic soils of Konkan (M.S.) region were ranged between 4.33 to 6.44, 4.47 to 6.97 for 0 to 30 and 30 to 60 cm depth, respectively. Further, Patil (1981) also reported similar range of pH for lateritic soils of Konkan region (M.S.). However, he also observed no specific trend of pH with soil depth.

2.3.6 Electrical conductivity (EC):

Dabke (1987) reported electrical conductivity of soils of Konkan (M.S.) to be in the range 0.01 to 0.02 dS m^{-1} with an average value of 0.046 dS m^{-1}, without any specific trend of distribution with soil depth. On other hand, Shah (1992) reported a decrease in electrical conductivity with soil depth.

Raghupati and Bhargava (1997) studied lateritic soils of mango orchards in Ratnagiri district and observed that the electrical conductivity varied from 0.10 to 0.20 dS m^{-1}. Somasundaram *et al.,* (2009) studied the soil under horticultural crops and found a higher value of electrical conductivity. It may be due to the inflow of soluble salts through irrigation water.

Todmal *et al.,*(2008) also observed an increasing trend of electrical conductivity with soil depth. It may be attributed to poor drainage of water at higher depths. Chavan *et al.,* (1980) studied the electrical conductivity of soils of Ratnagiri district and found that it varied from 0.01 to 0.15 dS m^{-1}.

Pereira *et al.,* (1986) observed lower values of electrical conductivity at lower slopes as 0.01 to 0.08 dS m^{-1} with an average value of 0.03 dS m^{-1}than that at higher slopes as 0.01 to 0.15 dS m^{-1} with average of 0.28 dS m^{-1}. The heavy precipitation in this region may be responsible for variation in Sidhu *et al.,* (1994) opined the same reason.

Parab (1990), Anonymous (1992), Dongale (1993) and Pednekar (1998), observed that the electrical conductivity of lateritic soils showed variation between 0.06 to 1.12 dS m^{-1} with an average value of 0.23 dS m^{-1}.

Sagane (1987), Pawar (1993), Diwale (1994), Sankpal (2008) reported lesser values of electrical conductivity (0.01 dS m^{-1}). This may be attributed to the leaching of bases due to heavy rainfall in the region.

Padole and Mahajan (2003) and Waghmare *et al.,* (2008), found lower electrical conductivity for properly managed of soil due to leaching of salts from surface to subsurface caused by downward movement of water.

Taware (1983), Vaidya (1988), Terse (1989) and Mahajan (2001) observed no specific trend of electrical conductivity with soil depth while Revandkar (1990), Diwale (1994), Dongre (1997), Sagane (1997), Varma *et al.,*(2005) and Suryavashi (2010) found a decreasing trend of electrical conductivity with soil depth.

Shinde (2006) from his studies on 'Physico-chemical properties of lateritic soils of mango orchards in Ratnagiri and Sidhudurga districts' observed that electrical conductivity values at 0 to 30 and 30 to 60 cm depths were found in the range of 0.027 to 0.059 dS $m^{-1}$with mean value of 0.038 dS m^{-1} and 0.025 to 0.055 dS m^{-1} with mean value of 0.033 dS m^{-1}, respectively. He also found declined trend of electrical conductivity with increasing soil depth.

2.3.7 Organic Carbon (OC):

Organic carbon content in soil was an important parameter of the soil and was significantly responsible for the fertility and productivity of the soil (Bandopadhayay *et al.,*2008).

Diwale (1994) studied organic carbon content at various depths in the lateritic soils of Konkan (M.S.) and observed the organic carbon in the range of

13.70 to18.90, 8.00 to 16.20, 7.80 to 13.60 and 3.00 to 10.70 g kg^{-1} at 0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm depth of soil, respectively. The organic carbon content decreased with soil depth.

Many researchers had studied organic carbon in the lateritic soils of Konkan (M.S.). Patil (1981), Taware (1983), Bobade (1987), Dabke (1987), Sagane (1987), Yadav (1988), Salvi (1988), Terse (1989), Vaidya (1988), Mali (1989), Parab (1990), Revandkar (1990), Shah (1992) and Sankpal (2008) reported that the organic carbon in the surface and profile soils showed variation between 3.00 to 18.90 g kg^{-1}. All observed a decreasing trend of organic carbon content with the soil depth. It may be due to lack of vegetation and highly percolative nature of the lateritic soil Patil (1986 c).

Sarkar *et al.,* (2002) also reported a decreasing trend of organic carbon with soil depth. Similar trend of organic carbon was also reported by Das *et al.,* (2000), Verma *et al.,* (2005), Sharma *et al.,* (2007), Patil *et al.,* (2008), Patil *et al.,* (2010) and Pati and Mukhopadhyay (2011). The higher value of organic carbon at surface soils may be due to the addition of manure and plant residue at surface than subsurface (Rajeswar *et al.,*2009). Shrinivas *et al.,* (2011) related the low values of organic carbon content in the soil with higher rate of oxidation in the soil at higher temperature and good aeration.

Pednekar (1998) reported no specific trend of organic carbon content with soil depth.

Pharande *et al.,* (1996) and Waghmare *et al.,* (2008) opined that the variation of organic carbon content in the soil was attributed to high temperature responsible for hastening the rate of oxidation as well as addition of organic matter and crop residues in the soil.

Mahajan (2001) from his study on ‘Status and distribution of micronutrients in relation to properties of lateritic soils under mango orchards in south Konkan (M.S.)’ revealed that the surface soil organic carbon had a range of 01.25 to 03.32 per cent with mean value of 02.48 while for profile soil the values ranged from 0.38 to 03.15 per cent with a mean value of 01.60 per cent. Further he referred the ratings given by Bangar and Zende (1978) and classified the samples as 74.07 per cent as very high, 9.26 per cent as high and 11.11 per cent as moderately high. He mentioned a decreasing trend of organic carbon with increasing soil depth. It may be due to high carbon content in the surface soil due to profused root growth of grasses in surface layers.

Pereira *et al.,* (1986) observed that the organic carbon content of lateritic soils in mango orchards of Ratnagiri district at lower slopes to varied from 02.40 to 25.90 g kg^{-1} with a mean value of 12.90 g kg^{-1} while at higher slopes the organic carbon showed variation between 07.30 to 28.80 g kg^{-1} with a mean value of 16.80 g kg^{-1}.

Shinde (2006) and Suryavanshi (2010) reported that the organic carbon content of lateritic surface soils of Konkan (M.S.) found to be 7.80 to 18.30 g kg^{-1} and that for profile soil from 04.20 to 15.70 g kg^{-1}. Organic carbon content exhibited a decreasing trend with the soil depth.

Chinchmalatpure *et al.,* (2000) found that the of organic carbon content of basaltic land form was higher than that sand stone land form. In addition, Sahoo *et al.,* (1995) observed that the organic carbon content of hilly terrain was highest, while the plateau had medium and the plain land had lowest values of organic carbon content.

2.4 Correlation or interrelationship between soil properties and available micronutrients.

2.4.1 Iron:

Mahajan (2001) studied the lateritic soils of mango orchards of Konkan (M.S.) and reported that available Fe had a positive and significant correlation with sand (r = 0.114), silt (r = 0.270), electrical conductivity (r = 0.375), available nitrogen (r = 0.332), available phosphorous (r = 0.380) and available potassium (r = 0.183) contents whereas negative and significant relationship with clay content (r = - 0.313) of soil. Increase in pH was found inversely related to the solubility of iron and consequently the availability of iron got reduced significantly (r = - 0.266). He also reported a positive and non-significant correlation between available iron and exchangeable Ca^{2+}.

Waghmare *et al.,*(2008) observed that the available iron was negatively and significantly correlated with pH (r = - 0.47) due to formation of insoluble higher oxides of Fe at higher pH in soils of Maharashtra while Raj Kumar *et al.,*(1990) also observed negative and significant correlation of available Fe with soil pH in soils of Madhya Pradesh.

Suryavanshi (2010) found a positive and significant correlation of available iron in lateritic soils of mango orchards of Konkan (M.S.) with sand (r = 0.554), available nitrogen (r = 0.377), silt (r = 0.428), clay (r = - 0.373), electrical conductivity (r = 0.267) and available K_2O (r = 0.253) while negative and significant correlation with pH (r = - 0.228) and organic carbon (r = - 0.223). In addition, he also observed the correlation of available iron with exchangeable Ca^{2+}, exchangeable Mg^{2+} and available P_2O_5 as positive but non-significant.

Chinchmalatpure *et al.,*(2000) found a negative and significant relationship of DTPA-Fe with pH in soils of Maharashtra due to increased solubility of insoluble Fe compounds like haematite, goethite and amorphous iron oxides which largely affected the distribution pattern of available Fe. However, Mete and Samanta (1996) reported positive but non-significant correlation of available iron with pH in red and lateritic soils of West Bengal.

Dabke (1987) observed positive and significant relationship of available Fe with pH and maximum water holding capacity but negative significant relationship with clay content while negative but non-significant relationship with electrical conductivity and organic carbon in lateritic soils of Konkan (M.S.). Similarly, Revandkar (1990) for lateritic soils of Konkan (M.S.) found positive and significant correlation of available iron with available nitrogen and phosphorous while non-significant relationship with available K_2O.

Pereira (1983) reported positive and significant correlation of available Fe with electrical conductivity, organic carbon, sand content and negative significant relationship with silt content however negative but non-significant correlation with pH and clay content in lateritic soils of mango orchards of Ratnagiri district.

Verma *et al.,* (2005) found that DTPA-Fe has positive significant correlation with organic carbon (r = 0.998) and negative significant correlation with pH (r = 0.903) in alluvial soils of Punjab. Gupta *et al.,* (2000) observed a negative significant correlation of Fe with pH (r = - 0.503) and a positive significant correlation of Fe with organic carbon (r = 0.154) for red soils of Madhya Pradesh.

Nayak *et al.,* (2000) for alluvial soils of Andhra Pradesh observed a negative significant correlation of available Fe with pH and sand. He also reported a positive significant correlation of Fe content with organic carbon and silt. Sahoo *et al.,* (1995) found that organic carbon had a positive significant correlation and pH had a negative significant correlation with available Fe in soils of Rajasthan.

Dongre (1997) studied the lateritic soils of Konkan (M.S.) and observed that available Fe had a positive significant correlation with K_2O and positive but non-significant relation with organic carbon, available nitrogen and phosphorous. For lateritic soils of Konkan (M.S.), Shah (1992) found a negative significant correlation of Fe with bulk density (r = - 0.30) and clay content (r = - 0.498) while a positive significant correlation of sand content, electrical conductivity, available phosphorous, potassium and nitrogen. He also found a negative but non-significant correlation of DTPA-Fe with particle density and silt content and a positive but non-significant correlation with maximum water holding capacity, while Salvi (1988) reported a positive but non-significant correlation of available Fe with maximum water holding capacity.

Dhane and Shukla (1995) from his studies on soils of Maharashtra, observed a positive significant correlation of available Fe, with organic carbon (r = 0.468) and clay content (r = 0.373). For the soils of Assam, Talukdar *et al.,* (2009) reported a positive significant correlation of available Fe with organic carbon. According to him, this may be due to formation of organic chelating agents which could have transformed insoluble phase of Fe in to soluble metallic complexes. He also stated a negative significant correlation of available Fe with pH. The same observations are reported by Singh *et al.,* (2006).

Patil and Meisheri (2004) and Patil *et al.,* (2003) studied the lateritic soils of Konkan (M.S.) and observed a the negative significant correlation of available Fe with pH (r = - 0.267) which was due to the formation of insoluble higher oxides of Fe at higher pH and a positive significant correlation of Fe content of the soil with organic carbon (r = 0.039). The same correlation was found by Patil and Shingate (1982) for soils of Maharashtra.

For soils of Rajasthan, Somasundram *et al.,* (2009) opined a negative significant correlation of available Fe with pH and electrical conductivity. According to them, the reduction in availability of Fe with increase in pH might be due to conversion of Fe^{2+} to Fe^{3+} ions. At high pH, Fe may also precipitated as insoluble form. They also observed a positive significant correlation of available Fe with organic carbon. Here they observed that, increase in Fe with increase in organic matter content (Organic carbon) might be due to greater availability of chelating agents through organic matter. This reasoning was also revealed by Sharma *et al.,* (2003).

2.4.2 Manganese:

Mahajan (2001) from his study on lateritic soils of mango orchards of Konkan (M.S.) reported a negative and significant correlation of available manganese with sand content (r = - 0.198) and pH (r = - 0.150). The availability of manganese had positive and significant correlation with silt (r = 0.175) and clay (r = 0.120). This may be attributed to more adsorption of divalent manganese (Mn^{2+}) on clay and slit particles. He also observed a positive and significant influence of available Mn on electrical conductivity (r = 0.137), exchangeable Ca^{2+} (r = 0.128) available K_2O (r = 0.173) while a positive but non-significant correlation between available manganese and organic carbon and negative but non-significant correlation with available nitrogen and available P_2O_5.

Nipunge *et al.,* (1996) found a negative and significant correlation of available Mn with pH, electrical conductivity while negative but non-significant correlation with clay content in Maharashtra soils.

Suryavanshi (2010) studied the correlation of available manganese in lateritic soils of mango orchards of Konkan (M.S.) and revealed a positive and significant correation of Mn with sand content (r = 0.257), pH (r = 0.227), available P_2O_5 (r = 0.234) and exchangeable Mg^{2+} (r = 0.272). He also reported a positive and significant correlation of available manganese with exchangeable Ca^{2+} (r = 0.314) and clay content (r = 0.366) and a negative and significant correlation with electrical conductivity (r = - 0.255) silt content and organic carbon while positive but non-significant correlation with available nitrogen and available K_2O.

Waghmare *et al.,* (2008) observed a negative and significant correlation of available Mn with pH (r = -0.33). This may be due to conversion of divalent form of Mn^{2+} into insoluble and unavailable trivalent form that was Mn^{3+} with increase in pH. He also reported a positive and significant correlation of available Mn with organic carbon.

Khan *et al.,* (1997) and Pati and Mukhopadhyay (2011) stated that DTPA-Mn had a positive and significant correlation with clay content. Chinchmalatpure *et al.,* (2000) observed a negative and significant relationship of DTPA-Mn with sand content in soils of Maharashtra indicated that its availability was more in case of fine textured than coarse textured soils.

Verma *et al.,* (2005) observed that DTPA-Mn had positive significant correlation with organic carbon (r = 0.830) and negative significant correlation with pH (r = 0.944), sand (r = 0.857) and electrical conductivity (r = 0.965) in alluvial soils of Punjab. Nayak *et al.,* (2000) reported a negative significant correlation of available manganese with pH and sand content for the alluvial soils of Andhra Pradesh. They also found a positive significant correlation of manganese content with organic carbon and silt content.

Patil and Meisheri (2004) and Patil *et al.,* (2003) observed a positive significant correlation of Mn content with organic carbon (r = 0.219) which indicated that availability of Mn increases with increase of organic matter for the lateritic soils of Konkan (M.S.). They also observed a positive significant correlation of available Mn with clay content (r = 0.259).

For lateritic soils of Kokan, Shah (1992) found a negative significant correlation of DTPA-Mn with sand content, silt content, pH, electrical conductivity, organic carbon and available nitrogen, phosphorous and potassium while a positive significant correlation with particle density. He also found a negative but non-significant correlation with maximum water holding capacity and a positive but non-significant correlation with bulk density of Mn.

Dongre (1997) for the lateritic soils of Konkan (M.S.) reported a positive significant correlation of available Mn with K_2O and available phosphorous while a positive but non-significant relation with available nitrogen.

Pati and Mukhopadhyay (2011) from his study on the acid soils of West Bengal revealed that DTPA Mn had a positive significant correlation with organic carbon (r = 0.518) and clay content (r = 0.254) while a negative significant correlation with pH (r = - 0.473). Mahesh Kumar *et al.,* (2011) for soils of Rajasthan found a positive significant correlation of Mn with organic carbon (r = 0.409) and a negative significant correlation with pH (r = - 0.434). According to them, the availability of Mn increased with increase in organic matter because organic matter acted as a chelating agent.

Shinde (2006) observed a significant positive correlation of available phosphorous, exchangeable of Ca^{2+} and exchangeable Mg^{2+} with DTPA manganese for lateritic soils of mango orchards in Konkan (M.S.). In addition, he also stated a negative and significant correlation of Mn with electrical conductivity and a positive but non-significant correlation with sand content, clay content, organic carbon, available nitrogen and available K_2O. However a negative but non-significant correlation of available Mn with silt content was also observed by him.

Revandkar (1990) observed a negative significant correlation of Mn with available nitrogen (r = - 0.2746) and a positive significant correlation with P_2O_5 (r = 0.4555) while a positive but non-significant correlation with available potassium for lateritic soils of Ratnagiri district.

For lateritic soils of Konkan (M.S.), Salvi (1988) observed a negative significant correlation of pH, electrical conductivity, organic carbon and maximum water holding capacity with DTPA Mn. However, positive and significant correlation of it with clay content was also observed.

2.4.3 Zinc:

Mahajan (2001) reported the positive and significant (r = 0.147) correlation of available Zinc with sand content in the lateritic soils of mango orchards of Konkan (M.S.) as) while with clay content it was negative and significant (r = - 0.172). The inverse relationship of available Zinc with clay content might be due adsorption of Zn^{2+} on surfaces of clay. He also observed the correlation of available Zinc with exchangeable Ca^{2+} (r = 0.132), available K_2O (r = 0.143), P_2O_5 (r = 0.259) and electrical conductivity (r = 0.298) as positive and significant. In addition, a positive but non-significant correlation of available zinc with pH, organic carbon and available nitrogen and a negative and non-significant influence with silt was also observed.

Suryavanshi (2010) observed the correlation of available zinc in lateritic soils of mango orchards of Konkan (M.S.) with sand content (r = 0.307), available K_2O (r = 0.280) and available P_2O_5 (r = 0.272) as positive and significant while negative and significant influence with clay content (r = - 0.60) was also observed. He also reported a negative and non-significant correlation of Zn with silt, pH, organic carbon, electrical conductivity, available nitrogen, exchangeable Ca^{2+}, exchangeable Mg^{2+} and electrical conductivity.

Malewar and Ghonsikar (1984) reported that available zinc was positively correlated with organic carbon in most of the soils of Maharashtra while Mohapatra and Kibe (1973) found negative correlation of available zinc with organic carbon. This might be due to formation of immobile complex of available zinc and dessicated organic matter of higher molecular weight compounds like lignins (Hodgson,1963).

Chinchmalatpure *et al.,* (2000) stated a positive and significant relationship of available Zn with organic carbon in soils of Maharashtra which might be due to its chelating effect of organic compounds. Similarly, Waghmare *et al.,* (2008) and Pharande *et al.,*(1996) found a positive and significant correlation of available Zn with organic carbon and electrical conductivity in soils of Maharashtra.

Verma *et al.,* (2005) revealed that DTPA-Zn had a positive significant correlation with organic carbon (r = 0.979) and a negative significant correlation with sand (r = 0.980), electrical conductivity (r = 0.561) and pH (r = 0.952) in alluvial soils of Punjab. Gupta *et al.,* (2000) observed a negative significant correlation of Fe with pH (r = - 0.155) while a positive significant correlation of Fe with organic carbon (r = 0.139) for red soils of Madhya Pradesh.

Nayak *et al.,* (2000) studied the alluvial soils of Andhra Pradesh and observed a negative significant correlation of available Zn with pH and also reported a positive significant correlation of Zn content with organic carbon and clay. Similar findings were reported by Lins and Cox (1986). Sahoo *et al.,* (1995) observed a positive significant correlation of organic carbon (r = 0.29) and a negative significant correlation with pH (r = - 0.49) of DTPA-Zn in soils of Rajasthan. Similar relationship was found by Sakal (1988).

Shinde (2006) for lateritic soils of mango orchards in Konkan (M.S.) reported a significant positive correlation of available Zn with available phosphorous (r = 0.316) while a negative significant correlation with pH (r = - 0.369), organic carbon (r = -0.375). A positive but non-significant correlation of sand content, silt content, exchangeable Ca^{2+} , exchangeable Mg^{2+}, available nitrogen and available K_2O was seen with DTPA zinc while a negative but non-significant correlation with clay content and electrical conductivity was also observed.

For lateritic soils of Konkan (M.S.) Shah (1992) found a negative non-significant correlation of Zn with particle density and bulk density while a positive but non-significant correlation with maximum water holding capacity. Dabke (1987) reported a negative but non-significant relation of available zinc with maximum water holding capacity of lateritic soils of Konkan (M.S.) but Salvi (1988) observed a positive but non-significant correlation.

Revandkar (1990) studied the lateritic soils of Ratnagiri district and reported a positive but non-significant relation of DTPA zinc with available nitrogen, potassium and phosphorous. Patil and Meisheri (2004) and Patil *et al.,* (2003) for the lateritic soils of Konkan (M.S.) found a positive but non-significant correlation of Zn content with pH, organic carbon and clay content. The relation with pH indicated that the extraction of Zn by DTPA solution was not dependent on soil pH within slightly acidic to neutral range. Similar conclusions were drawn by Rathore *et al.,* (1980).

Dhane and Shukla (1995) from their study on the soils of Maharashtra revealed a positive significant correlation of content of zinc with organic carbon (r = 0.388), clay content (r = 0.475) while positive but non-significant correlation with pH. More *et al.,* (1984) observed a positive significant correlation of available zinc with pH while a negative significant correlation with organic carbon for soils of Maharashtra.

Pati and Mukhopadhyay (2011) for the acid soils of West Bengal stated a positive and significant correlation of DTPA- Zn with organic carbon, clay content, exchangeable Ca^{2+} and Mg^{2+}.

Sankpal (2008) reported a positive significant correlation of available Zinc with organic carbon (r = 0.217), a negative but non-significant correlation with pH and a positive but non-significant correlation with electrical conductivity for lateritic soils of Konkan (M.S.).

2.4.4 Available Copper (Cu):

Mahajan (2001) observed a positive and significant correlation between available copper and silt content (r = 0.158), exchangeable Ca^{2+} (r =0.136), organic carbon (r = 0.117), and electrical conductivity (r = 0.331) while pH had established negative and significant correlation (r = - 0.179). However, a non-significant negative correlation with sand and non-significant but positive correlation with clay, available nitrogen, available P_2O_5 and available K_2O with available copper was also reported in the lateritic soils of mango orchards of Konkan (M.S.).

Suryavanshi (2010) found a positive and significant correlation of available copper with available nitrogen (r = 0.420), organic carbon (r = 0.298) exchangeable Ca^{2+} (r = 0.295) and exchangeable Mg^{2+} (r = 0.262) while non-significant but positive correlation between available copper and sand content, silt content, clay content, pH, electrical conductivity, available $P_2O_5$and available K_2O was observed in lateritic soils of mango orchards of Konkan (M.S.).

Revandkar (1990) revealed that available Cu was positively and non-significantly correlated with organic carbon. However, Yadav (1988) observed a positive and significant correlation with available Cu and organic carbon content in lateritic soils of Konkan (M.S.). Shinde (2006) reported a positive and significant relationship of DTPA-Cu with exchangeable Ca^{2+} (r = 0.348), exchangeable Mg^{2+}(r = 0.273), available nitrogen (r = 0.348) and available potassium (r = 0.354) in lateritic soils of mango orchards of Konkan (M.S.).

Khan *et al.,* (1997) reported that the DTPA-Cu was positively and significantly correlated with pH in soils of Bangladesh. For soils of Orisa, Saha *et al.,* (1996) observed that available Cu was negatively correlated with pH (r = - 0.19) but positively correlated with available phosphorous (r = 0.30). Similarly, Chatterji *et al.,* (1999) observed that DTPA-Cu had positive and significant correlation with pH while Gupta *et al.,* (2000) found a negative significant correlation for soils Madhya Pradesh. Nayak *et al.,*(2000) observed a significant and positive correlation with pH (r = 0.51) and silt content (r = 0.49) but negative and non-significant correlation with sand and clay content in soils of Arunachal Pradesh.

Chinchmalatpure *et al.,* (2000) reported a positive and significant relationship of available Cu with organic carbon and silt content in soils of Maharashtra which indicated that these soil properties affect the availability of copper. Waghmare *et al.,*(2008) observed a non-significant correlation of available Cu with pH, electrical conductivity and organic carbon content for soils of Maharashtra however Katyal and Aggrwala (1982) found inverse relationship of available Cu with pH.

Salvi (1988) observed a positive and significant correlation of available Cu with electrical conductivity and organic carbon, a negative and significant correlation with clay and a positive but non-significant correlation with pH and maxium water holding capacity in lateritic soils of Konkan (M.S.). Dongre (1997) reported a positive but non-significant correlation of available copper with organic carbon, available nitrogen, available phosphorous and available potassium content while Shah (1992) found positive and significant correlation of available copper with organic carbon, available nitrogen, available phosphorous in lateritic soils of Konkan (M.S.).

Patil and Meisheri (2004) and Patil *et al.,*(2003) observed a positive and significant relationship of available copper with clay content and pH and negative non-significant correlation with organic carbon in lateritic soils of Konkan (M.S.). Similarly Sankpal (2008) for lateritic soils of Konkan (M.S.) stated that available Cu had positive and significant correlation with organic carbon and electrical conductivity while positive but non-significant correlation with pH.

Dhane and Shukla (1995) found a positive and significant correlation of available copper with organic carbon (r = 0.496) which showed that an increase in the organic matter was responsible for increase in availability of copper in soils of Maharashtra. Similarly, for soils of Maharashtra, Patil and Shingte (1982) found a positive but non-significant correlation of DTPA-Cu with pH, organic carbon and available phosphorous and negative and non-significant correlation with available potassium.

Patil and Sonar (1994) observed a non-significant correlation of available Cu with organic carbon (r = - 0.472) which might be due to narrow range of variation in the characteristics of the soils of Maharashtra. However, More *et al.,* (1984) found negative significant correlation with pH and positive and significant correlation with organic carbon of available copper in soils of Maharashtra.

Talukdar *et al.*, (2009) observed that DTPA-Cu had negative and significant relationship with sand and positive but significant correlation with silt and clay content due to increase in finer fraction of the soil lead to increase in surface area for ion exchange and contributed larger amounts of Cu in the soil. He also reported positive correlation of DTPA-Cu with available nitrogen, phosphorous and potassium in soils of Assam.

CHAPTER III
MATERIAL AND METHODS

This chapter describes the materials used and the methods followed in the present research work.

3.1 Material:

3.1.1 Geography and Agro-climatic conditions:

The domain of the present research work is the Ratnagiri district, which comes under the Konkan region of Maharashtra state. The Konkan region is located between 15^0 44’ and 20^0 20’ N latitude and 70^0 10’ and 74^0 05’ E longitude. The spread of Konkan is 30846 sq. km. comprising Greater Bombay, Thane, Raigad, Ratnagiri and Sindhudurga districts. The region has warm and humid climate with an average rainfall of 2515 to 3625 mm. An opportune Arabian sea coastline of 720 km with a background of coastal strip of land bounded by Sahyadri hills on the east state the geographical characteristics of Konkan. The temperature of the region ranges from a maximum of 37^0 c to a minimum of 15^0 c.

The district under study ‘Ratnagiri’ literary means the ‘mine of gems’. The district has established its name by proffering four ‘Bharatratna’ to the nation. The province is located in south western part of Maharashtra state on the Arabian sea coast which is part of a greater tract known as Konkan. It is identified as Very High Rainfall Laterite (VRL) zone of agro-climatic regions of Maharashtra. The district extends 180 km in North-South and 64 km in East-West. The region is bounded by Raigad in North, by Satara; Sangli and Kolhapur in East, by Sindhudurga in south and by Arabian sea in West. It is geographically situated in latitude of 16.58^0 to 16.98^0 N and longitude 73.18^0 to 73.30 ^{0}E. The area of the district is 8202 sq.km ,the average altitude is 11 m while the district has a coastline is 237 km. The climate of the region is hot and humid with average daily temperature of 20^0 c. The hottest month is the month of May with temperature of about 33^0 c while months of December and January are coldest with temperature ranging below 16^0 c.

The soil of the district is mainly lateritic and the main cereal crops grown are Rice, finger millet, Lablab bean, Horse gram, Red gram, Red cow pea and Seasame beans. In Horticulture, Mango; Cashew; Coconut; Arecanut; Jack fruit; Kokum and Banana form the main crops. A rapid increase has been observed in the area of cultivation of Horticulture in general and Mango and Cashew in particular. This has raised the agriculture potential of this region (Anonymous, 1992).

3.1.2 Selection of sites and collection of soil samples:

The present investigation was undertaken to study the micronutrient status of the soils of mango orchards of the Ratnagiri district. In all five locations encompassing Ratnagiri district were selected from different tahsils namely Dapoli (Dapoli), Dapoli (Wakawali), Khed (Avashi), Ratnagiri (Shirgaon) and Lanja (Lanja). All the locations are the research stations or

agricultural centers of
Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. At each location two mango orchards were selected. Surface soil samples (0 to 15 cm) were collected from approximately centre of four mango trees. From each of the mentioned mango orchards ten surface samples (0 to 15 cm) and one profile sample (0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm) were collected by following standard procedure of soil sample collection. Thus, in all 100 surface soil samples and 40 profile samples were collected. All the soil samples were collected in the month of April, 2011. The details of the locations from which the soil samples were collected are presented in Table No. 3.1.

3.1.3 Processing of Soil Samples:

The collected soil samples were processed for analysis. All the surface and profile samples were air dried under shade in an open room. Then the impurities like stones, pebbles, roots, dried leaves etc. were removed. After that the soil samples were grinded in wooden mortar and then sieved through 2 mm and 0.5 mm sieve for special determination like soil organic carbon. The soil samples were then labeled properly and used for determination of physico-chemical properties and micronutrients estimation which is mentioned in Table No. 3.2.

3.1.4 Statistical Analysis:

The data were processed statistically by simple correlation coefficients by using the data analysis software SAS 9.3, ICAR- 11601386.

Table 3.1: Details of the locations of mango orchard and number of soil samples collected

Location No.	Name of Region (Tahsil)	Sub-location No.	Name of the Location
I	Dapoli (Dapoli)*	Dapoli I	Horticulture Department Mango Orchard
		Dapoli II	Agronomy Department Mango Orchard
		Dapoli III	Wakawali Research Station Mango Orchard (Rukhi)
		Dapoli IV	Wakawali Research Station Mango Orchard (Pangari)
II	Khed (Avashi)*	Khed I	Avashi Research Station Mango Orchard No.1
		Khed II	Avashi Research Station Mango Orchard No. 2
III	Ratnagiri (Shirgaon)*	Ratnagiri I	Shirgaon Research Station Mango Orchard No. 1
		Ratnagiri II	Shirgaon Research Station Mango Orchard No. 2
IV	Lanja (Lanja)*	Lanja I	Krishi Vidyan Kendra Mango Orchard No. 1
		Lanja II	Krishi Vidyan Kendra Mango Orchard No. 2
Total Number of Soil Samples = 140 Samples			

*From each sub-location 10 surface (0 to 15 cm) and 04 profile soil samples (0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm) were collected.

Table 3.2: Methods for soil analysis:

Sr. No.	Properties	Name of method	Described by
1	**Physical:**		
a	Mechanical Analysis	Bouyoucos hydrometer	Bouyoucos, 1951
b	Maximum water holding capacity	Keen-Rackzowski box	Piper, 1966
c	Bulk density	Soil clod	Black, 1965
d	Particle density	Pychnometer	Black, 1965
2	**Chemical:**		
a	Soil reaction (pH)	Potentiometric	Jackson, 1967
b	Electrical conductivity	Conductometric	Jackson, 1967
c	Organic Carbon	Walkley and Black's rapid titration	Black, 1965
d	Available Nitrogen	Alkaline Potassium permanganate	Subbaiah and Asija, 1956
e	Available Phosphorous	Bray's No. 1 (0.025 N HCl + 0.03 N NH_4F extraction)	Black, 1965

f	Available Potassium	1 N NH_4OAC (pH 7) extraction with flame photometry	Jackson, 1967
g	Exchangeable Ca^{2+} and Mg^{2+}	Drying of leachate of 1 N NH_4OAC, acid treatment with subsequent drying and dissolution in water and titrating with EDTA	Black, 1965
3	**Micronutrients:**		
	DTPA extractable micronutrients (Fe, Mn, Zn and Cu)	Extraction with DTPA-$CaCl_2$-TEA solution and determination with AAS	Lindsay and Norvell, 1978

Table 3.3 **Meteorological data during period of investigation**

MW	Period	Tmax	Tmin	RH-I	RH-II	Wind speed	Rain	RD	BSS	Epan
		(°C)	(°C)	(%)	(%)	(Kmph)	(mm)	day	(hrs.)	(mm)
1	01.01 - 07.01	30.0	12.8	97	57	2.4	0.0	0	7.3	3.0
2	08.01 - 14.01	32.2	9.6	96	52	2.3	0.0	0	9.2	3.2
3	15.01 - 21.01	32.6	10.6	96	57	2.3	0.0	0	9.3	3.0
4	22.01 - 28.01	33.8	11.4	97	82	2.6	0.0	0	9.3	3.2
5	29.01 - 04.02	33.0	12.4	97	66	2.8	0.0	0	8.9	3.2
6	05.02 - 11.02	33.5	11.9	97	55	3.1	0.0	0	9.1	3.6
7	12.02 - 18.02	32.1	10.0	97	51	2.3	0.0	0	9.2	3.1
8	19.02 - 25.02	30.0	13.5	95	55	4.2	0.0	0	9.2	3.9
9	26.02 - 04.03	32.9	16.1	95	50	3.2	0.0	0	8.9	4.0
10	05.03 - 11.03	34.5	15.2	92	50	3.6	0.0	0	9.0	5.0
11	12.03 - 18.03	36.4	14.0	93	63	3.5	0.0	0	9.4	5.0
12	19.03 - 25.03	32.4	16.8	90	74	4.6	0.0	0	9.0	4.9
13	26.03 - 01.04	32.9	17.3	95	60	4.6	0.0	0	8.9	4.8
14	02.04 - 08.04	32.7	21.6	96	67	4.5	0.0	0	8.3	4.9
15	09.04 - 15.04	32.7	21.6	96	67	4.5	0.0	0	8.3	4.9
16	16.04 - 22.04	34.9	15.9	89	67	3.9	0.0	0	9.1	4.8
17	23.04 - 29.04	32.1	22.8	93	62	5.1	0.0	0	8.7	5.4
18	30.04 - 06.05	32.3	22.9	95	63	6.0	0.0	0	8.2	5.4
19	07.05 - 13.05	32.1	21.9	90	61	5.4	0.0	0	8.4	5.4
20	14.05 - 20.05	33.2	23.9	94	64	5.3	0.0	0	6.4	4.6
21	21.05 - 27.05	33.3	24.5	89	69	6.8	1.4	0	9.4	4.9
22	28.05 - 03.06	33.7	24.8	87	68	6.4	16.2	1	8.1	5.1
23	04.06 - 10.06	28.7	24.0	96	92	5.0	199.0	7	1.1	1.1
24	11.06 - 17.06	27.8	23.5	95	92	5.6	580.1	7	1.7	1.9
25	18.06 - 24.06	29.3	26.0	91	88	6.7	73.0	6	2.4	2.3
26	25.06 - 01.07	29.7	25.9	94	84	3.9	52.4	6	3.3	3.4
27	02.07 - 08.07	29.2	23.1	98	81	1.6	163.8	7	2.2	2.7
28	09.07 - 15.07	28.0	22.8	97	97	2.5	515.6	7	2.2	3.1
29	16.07 - 22.07	27.4	23.4	98	97	10.7	592.0	7	0.6	2.0

30	23.07 - 29.07	28.0	23.3	98	93	4.2	412.9	7	1.1	2.9
31	30.07 - 05.08	28.1	22.9	98	97	3.3	715.6	1	0.6	1.8
32	06.08 - 12.08	28.6	23.7	97	93	5.4	57.7	6	1.0	2.8
33	13.08 - 19.08	28.3	23.6	97	94	4.5	126.2	6	2.8	3.9
34	20.08 - 26.08	27.8	23.0	97	95	1.6	170.6	7	1.5	2.3
35	27.08 - 02.09	27.1	23.2	97	98	3.3	779.2	7	0.9	2.1
36	03.09 - 09.09	27.5	24.1	98	92	5.3	213.5	5	1.0	2.5
37	10.09 - 16.09	28.5	23.6	96	87	2.4	131.1	6	2.5	3.4
38	17.09 - 23.09	28.9	22.8	94	77	3.6	14.3	2	5.4	3.2
39	24.09 - 30.09	29.9	20.4	95	77	3.2	0.0	0	7.0	3.7
40	01.10 - 07.10	30.3	22.1	94	71	4.0	14.6	1	7.4	3.3
41	08.10 - 14.10	31.5	21.9	96	70	3.8	80.4	4	6.5	3.1
42	15.10 - 21.10	32.3	22.2	93	65	3.2	16.2	2	7.1	3.5
43	22.10 – 28.10	33.3	16.4	93	63	2.9	0.0	0	8.5	3.7
44	29.10 – 04.11	33.0	21.5	94	85	3.1	4.4	1	7.1	3.4
45	05.11 – 11.11	33.7	19.0	91	49	2.9	0.0	0	8.8	3.7
46	12.11 – 18.11	33.5	16.4	92	41	2.9	0.0	0	9.0	3.2
47	19.11 – 25.11	32.7	13.9	96	43	3.0	0.0	0	8.9	3.6
48	26.11 – 02.12	32.5	21.1	88	56	3.6	2.0	0	5.9	3.4
49	03.12 – 09.12	33.3	16.0	90	57	2.6	0.0	0	8.7	3.6
50	10.12 – 16.12	33.3	15.0	88	53	2.8	0.0	0	8.7	3.7
51	17.12 – 23.12	32.0	12.9	94	52	2.7	0.0	0	7.7	3.9
52	24.12 – 31.12	31.6	11.0	94	49	2.5	0.0	0	8.1	3.5
	Avg	**31.3**	**19.2**	**94.3**	**70.2**	**3.9**	**0.0**	**0**	**6.4**	**3.6**
	Total						**4932.2**	**103**		

Continued……

Weather data during the period of investigation (January 2011 to December 2011) which is presented in Table No. 3.3 indicated that the climatic condition was found to be congenial for the growth of mango.

CHAPTER IV

RESULTS AND DISCUSSION

The present chapter deals with the micronutrient status and its relationship with soil properties in the mango orchards in the Ratnagiri district. The results obtained are presented in appropriate tables, figures and graphs and are presented and discussed under suitable headings as follows.

4.1 DTPA extractable micronutrient (Fe, Mn, Zn, Cu) status of mango orchards.

4.2 Macronutrient (N, P, K, Ca and Mg) status of mango orchards.

4.3 Physico-chemical properties of mango orchards.

4.4 Correlation or interrelationship of soil properties with available micronutrients.

4.1 DTPA extractable micronutrient (Fe, Mn, Zn, Cu) status of mango orchards.

4.1.1 Available iron (Fe)

Dapoli (I and II)

Surface soil samples (0 to 15 cm):

The perusal of data presented in Table No. 4.6 and illustrated in Fig. No.4.1 revealed that available iron of Dapoli (I) mango orchard ranged from 30.65 mg kg^{-1} to 50.41 with an average value of 39.78 mg kg^{-1} while for Dapoli (II) it showed variation from 36.53 to 51.30 with a mean value of 43.92 mg kg^{-1}. The data also showed that Dapoli (II) location had slightly higher values for available iron than Dapoli (I). However, for Dapoli (I and II) the available iron showed variation from 30.65 to 51.30 with a mean value of 41.85 mg kg^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The available iron of Dapoli (I) and Dapoli (II) varied from 31.80 to 41.11

Table 4.1 DTPA-extractable micronutrient (Fe, Mn, Zn, Cu) status of mango orchards (mg kg^{-1})

Mango orchard Soil depth (cm)	Fe	Mn	Zn	Cu
Dapoli (I) (0 to 15)	34.40	55.78	1.03	2.96
	47.27	51.87	2.02	2.47
	33.87	49.98	1.56	3.99
	32.94	60.00	2.03	2.67
	49.77	51.12	0.64	2.41
	30.65	48.77	2.51	2.23
	50.41	54.77	1.74	2.96
	39.88	46.98	3.50	1.99
	34.51	43.90	2.48	1.10
	44.12	56.88	1.97	2.18
Mean	**39.78**	**52.01**	**1.95**	**2.50**
Dapoli (II) (0 to 15)	40.76	54.81	3.60	2.31
	38.67	54.23	0.46	2.15
	51.30	50.09	1.48	1.34
	43.65	48.93	0.23	1.19
	42.09	48.60	1.80	2.24
	37.89	54.27	0.80	3.32
	48.90	55.66	1.69	2.19
	36.53	43.89	1.27	2.07
	50.07	59.88	2.08	1.86
	49.36	51.23	0.50	3.19
Mean	**43.92**	**52.16**	**1.39**	**2.19**
Location mean	**41.85**	**52.08**	**1.67**	**2.34**
Profile(I)				
A	41.11	56.00	2.23	2.60
B	37.84	54.34	1.27	3.52
C	35.70	50.77	1.02	2.56
D	31.80	44.21	0.32	2.37
Mean	**36.61**	**51.33**	**1.21**	**2.76**
Profile (II)				
A	46.75	59.88	0.72	2.34
B	38.88	50.78	0.57	2.06
C	32.23	44.70	0.22	1.06
D	35.19	39.56	0.14	0.86
Mean	**38.26**	**48.73**	**0.41**	**1.58**
Profile mean	**37.27**	**50.29**	**0.89**	**2.17**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

Table 4.2 DTPA-extractable micronutrient (Fe, Mn, Zn, Cu) status of mango orchards (mg kg^{-1}).

Mango orchard Soil depth (cm)	Fe	Mn	Zn	Cu
	mg kg^{-1}			
Dapoli (III) (0 to 15)	30.80	56.66	2.11	1.21
	34.90	48.99	0.48	0.95
	37.96	47.77	0.89	1.22
	41.99	57.43	1.99	1.43
	40.78	59.33	0.82	1.76
	39.55	41.45	3.06	1.23

	41.89	39.03	0.96	1.19
	46.45	48.77	1.70	1.34
	48.08	54.23	2.69	1.71
	35.55	54.98	0.97	1.31
Mean	**39.80**	**50.86**	**1.57**	**1.34**
Dapoli (IV) (0 to 15)	40.32	58.77	0.69	1.85
	36.66	48.99	0.42	1.61
	41.80	45.41	0.41	1.97
	38.70	57.65	1.98	2.79
	47.89	54.69	0.63	1.61
	30.77	57.45	0.69	1.96
	49.70	49.90	1.07	2.16
	38.21	47.78	0.61	1.22
	47.75	49.80	0.50	1.65
	38.66	51.16	0.98	1.30
Mean	**41.05**	**52.16**	**0.80**	**1.81**
Location mean	**40.42**	**51.51**	**1.18**	**1.57**
Profile (III)				
A	49.84	52.67	1.87	1.38
B	42.21	44.56	1.29	1.06
C	37.50	47.90	0.97	0.89
D	30.61	35.50	0.45	0.77
Mean	**40.04**	**45.16**	**1.15**	**1.03**
Profile (IV)				
A	50.01	54.44	1.23	1.98
B	47.63	49.70	0.89	1.62
C	36.00	36.88	0.67	1.50
D	29.55	31.12	0.60	1.01
Mean	**40.80**	**43.04**	**0.85**	**1.53**
Profile mean	**40.42**	**44.10**	**1.00**	**1.28**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

Table 4.3 DTPA-extractable micronutrient (Fe, Mn, Zn, Cu) status of mango orchards (mg kg^{-1}).

Mango orchard Soil depth (cm)	Fe	Mn	Zn	Cu
Khed (I) (0 to 15)	44.44	56.67	1.89	1.77
	50.06	55.34	0.56	2.11
	41.99	49.80	1.61	1.87
	40.76	43.60	1.52	2.33
	48.77	41.34	2.71	1.32
	38.71	52.67	2.50	1.89
	35.50	49.93	0.51	1.55
	32.49	43.66	2.57	2.02
	35.66	58.91	0.65	1.07
	44.66	49.08	1.77	1.33
Mean	**41.30**	**50.10**	**1.63**	**1.73**
Khed (II) (0 to 15)	48.73	60.89	1.28	1.44
	49.34	49.49	1.05	1.65
	37.66	50.02	1.18	1.29
	42.22	53.72	1.24	1.17
	40.06	54.22	1.01	1.64
	43.35	48.76	0.67	1.33
	39.07	49.21	0.80	1.21
	38.60	44.67	1.15	1.56
	40.54	55.45	0.84	1.28
	42.66	48.81	0.79	1.43
Mean	**42.22**	**51.52**	**1.00**	**1.40**
Location mean	**41.76**	**50.81**	**1.32**	**1.57**
Profile(I)				
A	50.14	51.44	1.40	1.66
B	37.80	50.32	1.09	1.21
C	30.72	47.78	0.67	0.98
D	28.61	42.21	0.50	0.70
Mean	**36.82**	**47.94**	**0.92**	**1.14**
Profile (II)				
A	47.66	56.77	2.33	1.87
B	41.30	54.34	1.45	1.77
C	38.72	50.67	1.65	1.54
D	29.51	48.90	0.99	1.41
Mean	**39.30**	**52.67**	**1.61**	**1.65**
Profile mean	**38.06**	**50.31**	**1.27**	**1.40**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

Table 4.4 DTPA-extractable micronutrient (Fe, Mn, Zn, Cu) status of mango orchards (mg kg^{-1}).

Mango orchard Soil depth (cm)	Fe	Mn	Zn	Cu
Ratnagiri (I) (0 to 15)	49.61	60.46	2.10	2.88
	41.16	55.77	2.31	2.12
	38.88	54.09	3.09	3.23
	34.48	46.71	3.25	2.98
	44.90	48.62	1.66	2.66
	40.44	56.00	2.54	3.11
	39.66	51.43	1.00	2.76
	43.40	47.00	1.65	3.23

	43.12	43.93	1.21	4.03
	37.88	60.56	1.50	3.05
Mean	**41.35**	**52.46**	**2.03**	**3.01**
Ratnagiri (II) (0 to 15)	38.65	59.61	1.32	2.88
	30.77	52.00	2.66	2.59
	41.33	54.26	2.10	3.17
	40.97	46.77	2.21	3.42
	38.76	60.23	1.90	1.65
	46.23	56.31	1.17	2.20
	37.51	58.72	1.44	2.31
	34.59	52.33	1.87	2.29
	41.15	45.56	2.12	2.99
	40.55	48.76	1.77	3.07
Mean	**39.05**	**53.46**	**1.86**	**2.66**
Location mean	**40.20**	**52.96**	**1.95**	**2.84**
Profile(I)				
A	36.60	57.71	2.54	3.14
B	42.47	53.12	2.05	2.66
C	38.76	47.76	1.47	2.31
D	32.90	40.25	1.06	2.08
Mean	**37.68**	**49.71**	**1.78**	**2.55**
Profile (II)				
A	46.90	54.66	2.14	3.89
B	40.74	49.71	1.60	3.03
C	34.55	52.30	1.23	2.78
D	32.77	36.67	1.32	2.44
Mean	**38.74**	**48.34**	**1.57**	**3.04**
Profile mean	**38.21**	**49.03**	**1.68**	**2.80**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

Table 4.5 DTPA-extractable micronutrient (Fe, Mn, Zn, Cu) status of mango orchards (mg kg^{-1}).

Mango orchard Soil depth (cm)	Fe	Mn	Zn	Cu
Lanja (I) (0 to 15)	35.54	55.44	1.75	2.14
	38.03	56.90	1.61	3.09
	41.23	48.66	1.03	2.44
	30.77	60.13	1.77	4.67
	36.90	60.55	0.82	3.71
	43.55	60.43	1.08	3.21
	46.02	59.03	1.66	2.95
	37.81	54.44	1.20	2.23
	32.22	60.78	1.41	2.56
	36.78	57.77	1.26	3.42
Mean	**37.89**	**57.41**	**1.36**	**3.04**
Lanja (II) (0 to 15)	41.18	54.35	1.26	2.16
	43.99	55.55	1.50	2.06
	39.82	49.78	1.71	2.55
	34.41	51.45	1.33	2.54
	40.82	56.61	0.88	2.13
	32.29	53.37	1.43	2.50
	39.03	59.60	0.97	2.43
	34.23	58.47	1.88	2.18
	47.78	60.43	1.36	2.77
	45.05	54.64	1.79	2.59
Mean	**39.86**	**55.43**	**1.41**	**2.39**
Location mean	**38.88**	**56.42**	**1.39**	**2.72**
Profile(I)				
A	37.71	60.53	1.90	2.83
B	38.15	55.10	1.66	2.76
C	30.65	43.66	1.35	2.60
D	28.90	46.94	0.54	1.90
Mean	**33.85**	**51.56**	**1.36**	**2.52**
Profile (II)				
A	43.30	59.02	1.47	2.70
B	37.90	51.23	1.23	1.44
C	32.55	47.67	0.81	2.05
D	29.84	41.34	1.00	0.82
Mean	**35.90**	**49.82**	**1.13**	**1.75**
Profile mean	**34.88**	**50.69**	**1.25**	**2.14**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

with an average value of 36.61 mg kg^{-1} and 32.23 to 46.75 with a mean value of 38.26 mg kg^{-1}, respectively. From the data it was also evident that available iron was slightly higher at Dapoli (II) than Dapoli (I) mango orchard. In general, the available iron for both the mango orchards ranged between 31.80 and 46.75 with an average value of 37.27 mg kg^{-1}. A decreasing trend was seen for the available iron at Dapoli (I) while for Dapoli (II) no specific trend was observed (Fig. No.4.2).

Dapoli (III and IV)

Surface soil samples (0 to 15 cm):

As seen from Table No. 4.6 and Fig. No.4.1 the available iron for Dapoli (III) varied from 30.80 to 48.08 with a mean value of 39.80 mg kg^{-1} while 41.05 mg kg^{-1} was an average value of available iron and it ranged between 30.77 and 49.70 mg kg^{-1} for Dapoli (IV). The data further showed that Dapoli (IV) location had slightly higher available iron than Dapoli (III). For both the mango orchards the available iron showed a rage of 30.77 to 49.70 with an average value of 40.42 mg kg^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

For Dapoli (III) mango orchard available Fe ranged between 30.61 and 49.84 with a mean value of 40.04 mg kg^{-1} while for Dapoli (IV) it was 29.55 to 50.01 with an average value of 40.80 mg kg^{-1}. The data further revealed that available Fe content did not show much variation in both the mango orchards. For Dapoli (III and IV - Wakawali) available iron varied from 29.55 to 50.01 with a mean value of 40.42 mg kg^{-1}. Available iron showed a decreasing trend in its distribution with soil depth for both the locations.

Table 4.6 DTPA-extractable micronutrient (Fe) status of mango orchards (mg kg^{-1}).

Mango orchard Soil depth (cm)	DTPA-extractable Fe				
	Dapoli (I and II)	Dapoli (III and IV)	Khed (I and II)	Ratnagiri (I and II)	Lanja (I and II)
Mango orchard I (0 to 15)	34.40	30.80	44.44	49.61	35.54
	47.27	34.90	50.06	41.16	38.03
	33.87	37.96	41.99	38.88	41.23
	32.94	41.99	40.76	34.48	30.77
	49.77	40.78	48.77	44.90	36.90
	30.65	39.55	38.71	40.44	43.55
	50.41	41.89	35.50	39.66	46.02
	39.88	46.45	32.49	43.40	37.81
	34.51	48.08	35.66	43.12	32.22
	44.12	35.55	44.66	37.88	36.78
Mean	**39.78**	**39.80**	**41.30**	**41.35**	**37.89**
Mango orchard II (0 to 15)	40.76	40.32	48.73	38.65	41.18
	38.67	36.66	49.34	30.77	43.99
	51.30	41.80	37.66	41.33	39.82
	43.65	38.70	42.22	40.97	34.41
	42.09	47.89	40.06	38.76	40.82
	37.89	30.77	43.35	46.23	32.29
	48.90	49.70	39.07	37.51	39.03
	36.53	38.21	38.60	34.59	34.23
	50.07	47.75	40.54	41.15	47.78
	49.36	38.66	42.66	40.55	45.05
Mean	**43.92**	**41.05**	**42.22**	**39.05**	**39.86**
Location mean	**41.85**	**40.42**	**41.76**	**40.20**	**38.88**
Profile(I)					
A	41.11	49.84	50.14	36.60	37.71
B	37.84	42.21	37.80	42.47	38.15
C	35.70	37.50	30.72	38.76	30.65
D	31.80	30.61	28.61	32.90	28.90
Mean	**36.61**	**40.04**	**36.82**	**37.68**	**33.85**
Profile (II)					
A	46.75	50.01	47.66	46.90	43.30
B	38.88	47.63	41.30	40.74	37.90
C	32.23	36.00	38.72	34.55	32.55
D	35.19	29.55	29.51	32.77	29.84
Mean	**38.26**	**40.80**	**39.30**	**38.74**	**35.90**
Profile mean	**37.27**	**40.42**	**38.06**	**38.21**	**34.88**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

Khed (I and II)

Surface soil samples (0 to 15 cm):

For Khed (I) and Khed (II) the available iron ranged from 32.49 to 50.06 with a mean value of and 41.30 mg kg^{-1} and from 37.66 to 49.34 with an average value of 42.22 mg kg^{-1}, respectively. At Khed (II) the available iron was found to be slightly higher than Khed (I). In general, for Khed (I and II – Avashi) available iron ranged from 32.49 to 50.06 with a mean value of 41.76 mg kg^{-1}. (Table No.4.6 and Fig.4.1)

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The data presented in Table No. 4.6 and graphically illustrated in Fig.4.2 revealed that the available iron varied from 28.61 to 50.14 with an average value of 36.82 mg kg^{-1} for Khed (I) and 29.51 to 47.66 with a mean value of 39.30 mg kg^{-1} for Khed (II). From the data it was also evident that available iron was slightly higher at Khed (II) than Khed (I) mango orchard. The data further indicated that for Khed (I and II – Avashi) available iron showed variation from 28.61 to 50.14 with a mean value of 38.06 mg kg^{-1}. However, a decreasing trend of available Fe content was found at both the mango orchards.

Ratnagiri (I and II)

Surface soil samples (0 to 15 cm):

For Ratnagiri (I) the available iron ranged between 34.48 and 49.61 with a mean value of 41.35 mg kg^{-1} while for Ratnagiri (II), it showed an average value of 39.05 and varied from 30.77 to 46.23 mg kg^{-1}. Ratnagiri (I) was found to be slightly higher in available iron content than Ratnagiri (II). Both the locations exhibited a range of 30.77 to 49.61 with an average value of 40.20 mg kg^{-1} for available Fe content.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

Ratnagiri (I) showed a variation from 32.90 to 42.47 with an average value of 37.68 mg kg^{-1} while for Ratnagiri (II) it ranged from 32.77 to 46.90 with a mean value of 38.74 mg kg^{-1}.There was no drastic variation in available Fe content for both the locations. In general, for Ratnagiri (I and II) available iron varied between 32.77 and 46.90 with an average value of 38.21 mg kg^{-1}. From the data it was also evident that Ratnagiri (I) mango orchard showed no specific trend in the distribution of iron content however, Ratnagiri (II) showed a decreasing trend with soil depth.(Table No.4.6 and Fig.No.4.2)

Lanja (I and II)

Surface soil samples (0 to 15 cm):

As seen from Table No. 4.6 and illustrated in Fig. No. 4.1 the available iron of Lanja (I) and Lanja (II) ranged from 30.77 to 46.02 with an average value of 37.89 mg kg^{-1} and 32.29 to 47.78 with a mean value of 39.86 mg kg^{-1}, respectively. The data also revealed that there was no much variation in available Fe content for both the mango orchards. In general, for Lanja (I and II) the available iron ranged from 30.77 to 47.78 with a mean value of 34.88 mg kg^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The data (Table No. 4.6 and Fig. No.4.2) indicated that the available iron for Lanja (I) and Lanja (II) mango orchards exhibited a variation in the range of 28.90 to 38.15 with a mean value of 33.85 mg kg^{-1} and 29.84 to 43.30 with an average value of 35.90 mg kg^{-1}, respectively. The data also showed that Lanja (II) location had slightly higher content of available Fe than Lanja (I) while for Lanja (I and II) available iron ranged from 28.90 to 43.30 with a mean value of 34.88 mg kg^{-1}. However, there was no specific trend of available Fe content with soil depth for Lanja (I) whereas available Fe content exhibited a decreasing trend with soil depth in case of Lanja (II) mango orchard.

Available iron (Fe) status of different tahsils of Ratnagiri district:

The data on available iron (Fe) status of different tahsils showed that the available Fe status of surface soil samples of all tahsils varied from 30.65 to 51.30 with a mean value of 40.62 mg kg^{-1}. Available Fe status in similar range was also reported by Patil and Meisheri (2004), Gaidhani (2008) and Sankpal (2008) for lateritic soils of Konkan.

In profile samples the available Fe showed a range of 28.61 to 50.14 with an average value of 37.77 mg kg^{-1}. In general available Fe content decreased with soil depth with exceptions of Dapoli (II), Ratnagiri (I) and Lanja (I) locations. These results are in conformity with Diwale (1994), Mahajan (2001) and Suryavanshi (2010). However, in Dapoli (II), Ratnagiri (I) and Lanja (I) locations available Fe content did not show any specific trend with soil depth. Similar observations were also noticed by Bharambe *et al.*, (1990) for soils of Maharashtra. In general, the decreasing trend of available Fe at most of the profiles might be attributed to increase in pH and decrease in organic matter content at soil profiles (Mahajan, 2001) or due to loss of Fe_2O_3 by decomposition of smectite and partial mobilization of Fe bearing material (clay) through subsurface cracks (Singh *et al.*, 2002).

However, in general all mango orchards were adequately supplied with available Fe as per the ratings given by Gajbhiye (1985). The sufficient amount of available Fe in surface and profiles of lateritic soil may be due to laterization processes in which sesquioxides accumulate to increase the Fe content and also it may be attributed to low pH and higher organic matter content of lateritic soil (Diwan, 1982). At Dapoli (I and II) and Dapoli (III and IV) location the available Fe content was found to be higher for both surface as well as profile samples while content of Fe was found lower at Lanja (I and II) mango orchard for surface as well as profile samples than all other remaining locations.

4.1.2 Available manganese (Mn)

Dapoli (I and II)

Surface soil samples (0 to 15 cm):

The data presented in Table. No. in 4.7 and depicted in Fig. No.4.1 indicated that the available Mn at Dapoli (I) ranged from 43.90 to 60.00 with a mean value of 52.01 mg kg^{-1} and from 43.89 to 59.88 with an average value of 52.16 mg kg^{-1} for Dapoli (II). From the data it was also evident that available manganese content was almost same for both the mango orchards. In general, the available manganese for both the locations showed variation from 43.89 to 60.00 with an average value of 52.08 mg kg^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The available Mn for Dapoli (I) and Dapoli (II) ranged between 44.21 and 56.00 with a mean value of 51.33 mg kg^{-1} and 39.56 to 59.88 with an average value of 48.73 mg kg^{-1}, respectively. The data also showed that Dapoli (I) location had slightly higher content of available Mn than that of Dapoli (II). For Dapoli (I and II) the available manganese was observed in the range of 39.56 to 59.88 with a mean value of 50.29 mg kg^{-1}. A decreasing trend was seen for the available iron in both Dapoli (I) and Dapoli (II) soil profiles.

Dapoli (III and IV)

Surface soil samples (0 to 15 cm):

For Dapoli (III) the available Mn ranged between 39.03 and 59.33 with a mean value of 50.86 mg kg^{-1} while for Dapoli (IV), available manganese showed an average value of 52.16 mg kg^{-1} and it varied from 45.41 to 58.77 mg kg^{-1}.

Table 4.7 DTPA-extractable micronutrient (Mn) status of mango orchards (mg kg^{-1}).

Mango orchard Soil depth (cm)	DTPA-extractable Mn				
	Dapoli (I and II)	Dapoli (III and IV)	Khed (I and II)	Ratnagiri (I and II)	Lanja (I and II)
Mango orchard I (0 to 15)	55.78	56.66	56.67	60.46	55.44
	51.87	48.99	55.34	55.77	56.90
	49.98	47.77	49.80	54.09	48.66
	60.00	57.43	43.60	46.71	60.13
	51.12	59.33	41.34	48.62	60.55
	48.77	41.45	52.67	56.00	60.43
	54.77	39.03	49.93	51.43	59.03
	46.98	48.77	43.66	47.00	54.44
	43.90	54.23	58.91	43.93	60.78
	56.88	54.98	49.08	60.56	57.77
Mean	**52.01**	**50.86**	**50.10**	**52.46**	**57.41**
Mango orchard II (0 to 15)	54.81	58.77	60.89	59.61	54.35
	54.23	48.99	49.49	52.00	55.55
	50.09	45.41	50.02	54.26	49.78
	48.93	57.65	53.72	46.77	51.45
	48.60	54.69	54.22	60.23	56.61

	54.27	57.45	48.76	56.31	53.37
	55.66	49.90	49.21	58.72	59.60
	43.89	47.78	44.67	52.33	58.47
	59.88	49.80	55.45	45.56	60.43
	51.23	51.16	48.81	48.76	54.64
Mean	**52.16**	**52.16**	**51.52**	**53.46**	**55.43**
Location mean	**52.08**	**51.51**	**50.81**	**52.96**	**56.42**
Profile(I)					
A	56.00	52.67	51.44	57.71	60.53
B	54.34	44.56	50.32	53.12	55.10
C	50.77	47.90	47.78	47.76	43.66
D	44.21	35.50	42.21	40.25	46.94
Mean	**51.33**	**45.16**	**47.94**	**49.71**	**51.56**
Profile (II)					
A	59.88	54.44	56.77	54.66	59.02
B	50.78	49.70	54.34	49.71	51.23
C	44.70	36.88	50.67	52.30	47.67
D	39.56	31.12	48.90	36.67	41.34
Mean	**48.73**	**43.04**	**52.67**	**48.34**	**49.82**
Profile mean	**50.29**	**44.10**	**50.31**	**49.03**	**50.69**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

Available Mn content did not show much variation in both the locations. However, both the mango orchards exhibited a range of 39.03 to 59.33 with an average value of 51.51 mg kg^{-1} for available manganese.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

Available manganese of Dapoli (III) showed a variation from 35.50 to 52.67 with an average value of 45.16 mg kg^{-1} while for Dapoli (IV) it ranged from 31.12 to 54.44 with a mean value of 43.04 mg kg^{-1}. Dapoli (III) had shown slightly higher value of available manganese than Dapoli (IV). In general for Dapoli (I and II), available manganese varied between 31.12 and 54.44 with an average value of 44.10. From the data it was also evident that available manganese content did not show any specific trend with depth for Dapoli (III) whereas it was found to be decreased with depth for Dapoli (IV) mango orchard. (Table No.4.7 and Fig. No.4.3)

Khed (I and II)

Surface soil samples (0 to 15 cm):

For Khed (I) and Khed (II) the available manganese status ranged from 41.34 to 58.91 with a mean value of 50.10 mg kg^{-1} and 44.67 to 60.89 with an average value of 51.52 mg kg^{-1}, respectively. The average available Mn status for both the mango orchards remained almost same. In general, for Khed (I and II- Avashi)

available Mn ranged from 41.34 to 60.89 with a mean value of 50.81 mg kg^{-1}. (Table No.4.7 and Fig. No.4.1)

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The available manganese status for Khed (I) varied from 42.21 to 51.44 with

a mean value of 47.94 mg kg^{-1} while 52.67 mg kg^{-1} was an average value of available manganese with range of 48.90 to 56.77 mg kg^{-1} for Khed (II). The data further showed that Khed (II) location had slightly higher available manganese content than Khed (I). For both the mango orchards the available manganese showed a range of 42.21 to 56.77 with an average value of 50.31 mg kg^{-1}. However, available manganese content showed decreasing trend with depth for both the locations (Khed I and Khed II).

Ratnagiri (I and II)

Surface soil samples (0 to 15 cm):

The available manganese of Ratnagiri (I) and (II) mango orchards varied between 43.93 and 60.56 with an average value of 52.46 mg kg^{-1} and 45.56 to 60.23 with a mean value of 53.46 mg kg^{-1}, respectively. At Ratnagiri (II) slightly higher content of available manganese was observed than Ratnagiri (I). In general in Ratnagiri (I and II- Shirgaon) the available Mn content ranged from 43.93 to 60.56 with a mean value of 52.96 mg kg^{-1}. (Table No.4.7 and Fig.No.4.1)

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

Data presented in Table No. 4.7 and depicted in Fig.4.3 showed available manganese content between 40.25 and 57.71 with a mean value of 49.71 mg kg^{-1} for Ratnagiri (I) and 36.67 to 54.66 with an average value of 48.34 mg kg^{-1} for Ratnagiri (II). For Ratnagiri (I) mango orchard available manganese status was found to be slightly higher when compared with Ratnagiri (II). In general, at Ratnagiri (I and II - Shirgaon) the available manganese showed a range of 36.67 to 57.71 with a mean value of 49.03 mg kg^{-1}. No specific trend was observed in Ratnagiri (II) whereas available Mn content decreased with the soil depth in Ratnagiri (I).

Lanja (I and II)

Surface soil samples (0 to 15 cm):

The data from Table No. 4.7 and Fig. No. 4.1 revealed that available manganese for Lanja (I) and Lanja (II) showed variation between 48.66 and 60.78 with a mean value of 57.41 mg kg^{-1} and 49.78 to 60.43 with an average value of 55.43 mg kg^{-1}, respectively. The data also showed that Lanja (I) had shown higher values for available manganese as compared to Lanja (II). For both the mango orchards available manganese varied from 48.66 to 60.78 with a mean value of 56.42 mg kg^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The available Mn status of Lanja (I) had a range of 43.66 to 60.53 with a mean value of 51.56 mg kg^{-1} while for Lanja (II) it ranged between 41.34 and 59.02 with a mean value of 49.82 mg kg^{-1}. At Lanja (I) mango orchard higher available manganese content was observed than Lanja (II) mango orchard while at Lanja (I and II) the available manganese varied from 41.34 to 60.53 with an average value of 50.69 mg kg^{-1}. Available manganese showed no specific trend with soil depth for Lanja (I) however it exhibited a decreasing trend at Lanja (II).

Available manganese (Mn) status of different tahsils of Ratnagiri district:

The data on overall mean for available Mn of different tahsils when studied revealed that the available Mn of surface soil samples of all tahsils ranged between 41.34 and 60.89 with a mean value of 52.76 mg kg^{-1}. Similar range for available manganese was also reported by Patil and Meisheri (2004), Sankpal (2008) and Patil *et al.,* (2010) for lateritic soils of Konkan.

In case of profile soil samples the available manganese of all tahsils varied from 31.12 to 60.53 with an average value of 48.88 mg kg^{-1}. In general almost in all the mango orchards available Mn showed a decreasing trend with soil depth with exceptions of Lanja (I), Ratnagiri (II) and Dapoli (III). These results are in conformity with the findings of Mahajan (2001), Shinde (2006) and Suryavanshi (2010). However, at Lanja (I), Ratnagiri (II) and Dapoli (III) locations available Mn did not show any definite trend with depth. Similar findings were also observed by Bharambe *et al.,* (1990) and Chinchmalatpure *et al.* (2000) for soils of Maharashtra. In general, the decreasing trend of available Mn in most of the profiles might be due to higher activity of micro-organisms at the surface layer than subsurface layers. (Murthy *et al.*, 1997) or it may be due to difference in intensity of pedogenic processes at surface than subsurface soils and in addition to this more complexing of Mn with organic matter in profile soil
(Nipunje *et al.*,1993).

However, all the mango orchards showed sufficient amount of available Mn content on the basis of critical limits given by Gajbhiye (1985). The adequate amount of available Mn in the soils might be due to chelating action of organic compounds released during the decomposition of manures Chinchmalatpure *et al.* (2000). The available Mn content was found to be maximum at Lanja (I and II) for both surface as well as profile samples and found to be minimum at Khed (I and II) and Dapoli (III and IV) for surface and profile samples, respectively than all other locations.

4.2.2 Available zinc (Zn)

Dapoli (I and II)

Surface soil samples (0 to 15 cm):

The data presented in Table. No. in 4.8 and depicted in Fig. No. 4.1 indicated that the available zinc of Dapoli (I) ranged from 0.64 to 3.50 with a mean value of 1.95 mg kg^{-1} and 0.23 to 3.60 with an average value of 1.39 mg kg^{-1} for Dapoli (II). The available Zn content was slightly higher at Dapoli (I) when compared with Dapoli (II) mango orchard. In general, the available zinc for both the locations showed variation from 0.23 to 3.60 with an average value of 1.67 mg kg^{-1}.

Table 4.8 DTPA-extractable micronutrient (Zn) status of mango orchards (mg kg^{-1}).

Mango orchard Soil depth (cm)	DTPA-extractable Zn				
	Dapoli (I and II)	Dapoli (III and IV)	Khed (I and II)	Ratnagiri (I and II)	Lanja (I and II)
Mango orchard I (0 to 15)	1.03	2.11	1.89	2.10	1.75
	2.02	0.48	0.56	2.31	1.61
	1.56	0.89	1.61	3.09	1.03
	2.03	1.99	1.52	3.25	1.77
	0.64	0.82	2.71	1.66	0.82
	2.51	3.06	2.50	2.54	1.08
	1.74	0.96	0.51	1.00	1.66
	3.50	1.70	2.57	1.65	1.20
	2.48	2.69	0.65	1.21	1.41
	1.97	0.97	1.77	1.50	1.26
Mean	**1.95**	**1.57**	**1.63**	**2.03**	**1.36**
Mango orchard II (0 to 15)	3.60	0.69	1.28	1.32	1.26
	0.46	0.42	1.05	2.66	1.50
	1.48	0.41	1.18	2.10	1.71
	0.23	1.98	1.24	2.21	1.33
	1.80	0.63	1.01	1.90	0.88
	0.80	0.69	0.67	1.17	1.43
	1.69	1.07	0.80	1.44	0.97
	1.27	0.61	1.15	1.87	1.88
	2.08	0.50	0.84	2.12	1.36
	0.50	0.98	0.79	1.77	1.79
Mean	**1.39**	**0.80**	**1.00**	**1.86**	**1.41**
Location mean	**1.67**	**1.18**	**1.32**	**1.95**	**1.39**
Profile(I)					
A	1.23	1.87	1.40	2.54	1.90

B	2.27	1.29	1.09	2.05	1.66
C	1.02	0.97	0.67	1.47	1.35
D	0.32	0.45	0.50	1.06	0.54
Mean	**1.21**	**1.15**	**0.92**	**1.78**	**1.36**
Profile (II)					
A	0.72	1.23	2.33	2.14	1.47
B	0.57	0.89	1.45	1.60	1.23
C	0.22	0.60	1.65	1.23	0.81
D	0.14	0.67	0.99	1.32	1.00
Mean	**0.41**	**0.85**	**1.61**	**1.57**	**1.13**
Profile mean	**0.89**	**1.00**	**1.27**	**1.68**	**1.25**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The available zinc for Dapoli (I) and Dapoli (II) ranged between 0.32 and 2.23 with a mean value of 1.21 mg kg^{-1} and 0.14 to 0.72 with an average value of 0.41 mg kg^{-1}, respectively. For Dapoli (I) the available zinc content was higher than Dapoli (II). For Dapoli (I and II) the available Zn was observed in the range of 0.14 to 2.23 with a mean value of 0.89 mg kg^{-1}. For both the mango orchards the available zinc exhibited a decreasing trend with soil depth.

Dapoli (III and IV)

Surface soil samples (0 to 15 cm):

For Dapoli (III) mango orchard available zinc ranged between 0.48 and 3.06 with a mean value of 1.57 mg kg^{-1} while for Dapoli (IV) it was 0.41 to 1.98 with an average value of 0.80 mg kg^{-1}. The data further showed that Dapoli (IV) location had slightly lower available zinc than Dapoli (III). For Dapoli (III and IV - Wakawali) available zinc varied from 0.41 to 3.06 with a mean value of 1.18 mg kg^{-1}.(Table No.4.8 and Fig. No.4.1)

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

0.45 to 1.87 was the range of available zinc and 1.15 mg $kg^{-1}$was the mean value of it for Dapoli (III) while for Dapoli (IV) it varied from 0.60 to 1.23 with an average value of 0.85 mg kg^{-1}(Table No. 4.8 and Fig.No.4.4). The data further showed that available zinc content did not show much variation in both the mango orchards. Further for both the soil profiles available zinc had a variation between 0.45 and 1.87 with an average value of 1.00 mg kg^{-1}. Available zinc content exhibited a decreasing trend of available zinc with soil depth in both the locations.

Khed (I and II)

Surface soil samples (0 to 15 cm):

For Khed (I) and Khed (II) the available Zn ranged from 0.51 to 2.71 with a mean value of 1.63 mg kg^{-1} and 0.67 to 1.28 with an average value of 1.00 mg kg^{-1}, respectively. At Khed (I) the available zinc content was found to be slightly higher than Khed (II). On an average, available zinc ranged from 0.51 to 2.71 with a mean value of 1.32 mg kg^{-1} for Khed (I and II – Avashi).

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

As seen from Table No. 4.8 and Fig. No. 4.4 the available zinc for Khed (I) varied from 0.50 to 1.40 with a mean value of 0.92 mg kg^{-1} while 1.61 mg kg^{-1} was an average value of available zinc with range of 0.99 to 2.33 mg kg^{-1} for Khed (II). The data further revealed that Khed (II) locations had higher content of available zinc than at Khed (I). For both the mango orchards it varied between 0.50 and 2.33 with an average value of 1.27 mg kg^{-1}. Available zinc found to be decreased in Khed (I) with soil depth however no specific trend of available zinc with soil depth was found in Khed (II) mango orchard.

Ratnagiri (I and II)

Surface soil samples (0 to 15 cm):

For Ratnagiri (I) the available zinc ranged between 1.00 to 3.25 with a mean value of 2.03 mg kg^{-1} while for Ratnagiri (II), available zinc showed an average value of 1.86 and it varied from 1.17 to 2.66 mg kg^{-1}. Ratnagiri (I) was found to be slightly higher in value of available zinc content than Ratnagiri (II).

Both the locations exhibited a range of 1.00 to 3.25 with an average value of 1.95 mg kg^{-1} for available Zn. (Table No.4.8 and Fig. No.4.1)

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

Available zinc of Ratnagiri (I) showed a variation from 1.06 to 2.54 with an average value of 1.78 mg kg^{-1} while for Ratnagiri (II) it ranged from 1.23 to 2.14 with a mean value of 1.57 mg kg^{-1}. In general, for Ratnagiri (I and II) available zinc varied between 1.06 and 2.54 with an average value of 1.68 mg kg^{-1}. From the data it was also evident that available Zn content was found to be decreased with soil depth in case Ratnagiri (I) location while there was no specific trend with depth at Ratnagiri (II).

Lanja (I and II)

Surface soil samples (0 to 15 cm):

As seen from Table No. 4.8 and Fig. 4.1 the available zinc of Lanja (I) and (II) ranged from 0.82 to 1.77 with an average value of 1.36 mg kg^{-1} and 0.88 to 1.88 with a mean value of 1.41 mg kg^{-1}, respectively. For Lanja (I and II) the available zinc ranged from 0.82 to 1.88 with a mean value of 1.39 mg kg^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The available zinc content of Lanja (I) mango orchard showed variation from 0.54 to 1.90 with a mean value of 1.36 while for Lanja (II) it ranged from 0.81 to 1.47 with an average of 1.13 mg kg^{-1}. From the data it was also evident that available Zn was slightly higher at Lanja (I) than Lanja (II) mango orchard. On an average, for Lanja (I and II) available zinc varied between 0.54 and 1.90 with a mean value of 1.25 mg kg^{-1}. The data further revealed that Lanja (I) mango orchard showed a decreasing trend of available zinc content with depth while Lanja (II) had no specific trend of it with soil depth.

Available zinc (Zn) status of different tahsils of Ratnagiri district:

Data on overall mean for available zinc of different tahsils showed that the available Zn status of surface soil samples of all tahsils had a variation between 0.41 and 3.60 with an average value of 1.50 mg kg^{-1}. These results are in conformity with Diwale (1994), Patil *et al.*, (2003) and Gaidhani (2008).

For profile soil samples the available zinc ranged from 0.14 to 2.54 with a mean value of 1.22 mg kg^{-1}. At all the profiles available Zn showed a decreasing trend with soil depth with exceptions of Lanja (II), Ratnagiri (II) and Khed (II). Similar observations were also reported by Shinde (2006) Patil *et al.*, (2010) and Suryavanshi (2010) for lateritic soils of mango orchards of Konkan. However, at Lanja (II), Ratnagiri (II) and Khed (II) locations available Zn had no specific trend with soil depth. Similar trend was also noticed by Bharambe *et al.*, (1990) for soils of Maharashtra. In general, the declining trend of available zinc at most of the tahsils may be attributed to accumulation of comparatively less or more amount of organic matter in surface layer than in subsurface layer (Jalali *et al.*, 1989 and Nayak *et al.*, 2000) while its low values in surface and profiles of lateritic soils may be due to high amounts of Fe and Cu in the soil (Diwan, 1982).

Further, from data it was observed that most of the soil samples of mango orchards had sufficient amount of available zinc. However, few soil samples at Dapoli (I and II) and (III and IV) mango orchards were found to be deficient in available zinc content as per the critical limits given by Gajbhiye (1985). The available Zn content was lower at Dapoli (III and IV) and Dapoli (I and II) for surface and profile samples, respectively whereas it was maximum at Ranagiri

(I and II) for both surface and profile samples as compared to other mango orchards.

4.3.4 Available copper (Cu)

Dapoli (I and II)

Surface soil samples (0 to 15 cm):

The available Cu of Dapoli (I) and (II) mango orchards varied between 1.10 to 3.99 with an average value of 2.50 mg kg^{-1} and 1.19 to 3.32 with a mean value of 2.19 mg kg^{-1}, respectively. At Dapoli (I) slightly higher available copper content was observed than Dapoli (II). In general, for Dapoli (I and II) the available copper was ranged from 1.10 to 3.99 with a mean value of 2.34 mg kg^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The available copper of Dapoli (I) mango orchard showed variation from 2.37 to 3.52 with a mean value of 2.76 mg kg^{-1} while for Dapoli (II) it was from 0.86 to 2.34 with an average value of 1.58 mg kg^{-1}. At Dapoli (I) the values for available copper content was found to be slightly higher than Dapoli (II). In general, for Dapoli (I and II) available Cu varied between 0.86 and 3.52 with a mean value of 2.17 mg kg^{-1}. From the data it was also evident that for Dapoli (I) there was no definite trend of available copper content with soil depth while for Dapoli (II) mango orchard available copper content decreased with soil depth.(Table No.4.9 and Fig. No.4.5)

Dapoli (III and IV)

Surface soil samples (0 to 15 cm):

For Dapoli (III) the available copper ranged between 0.95 and 1.76 with a mean value of 1.34 mg kg^{-1} while for Dapoli (IV), available Cu showed an average value of 1.81 mg kg^{-1} and it varied from 1.22 to 2.79 mg kg^{-1}. Dapoli (IV) was found slightly higher in value of available copper than Dapoli (III).

Both the locations exhibited a range of 0.95 to 2.79 with an average value of 1.57 mg kg^{-1} for available copper. (Table 4.9 and Fig. 4.1)

Table 4.9 DTPA-extractable micronutrient (Cu) status of mango orchards (mg kg^{-1}).

Mango orchard Soil depth (cm)	DTPA-extractable Cu				
	Dapoli (I and II)	Dapoli (III and IV)	Khed (I and II)	Ratnagiri (I and II)	Lanja (I and II)
Mango orchard I (0 to 15)	2.96	1.21	1.77	2.88	2.14
	2.47	0.95	2.11	2.12	3.09
	3.99	1.22	1.87	3.23	2.44
	2.67	1.43	2.33	2.98	4.67
	2.41	1.76	1.32	2.66	3.71
	2.23	1.23	1.89	3.11	3.21
	2.96	1.19	1.55	2.76	2.95
	1.99	1.34	2.02	3.23	2.23
	1.10	1.71	1.07	4.03	2.56
	2.18	1.31	1.33	3.05	3.42
Mean	**2.50**	**1.34**	**1.73**	**3.01**	**3.04**
Mango orchard II (0 to 15)	2.31	1.85	1.44	2.88	2.16
	2.15	1.61	1.65	2.59	2.06
	1.34	1.97	1.29	3.17	2.55
	1.19	2.79	1.17	3.42	2.54
	2.24	1.61	1.64	1.65	2.13
	3.32	1.96	1.33	2.20	2.50
	2.19	2.16	1.21	2.31	2.43
	2.07	1.22	1.56	2.29	2.18
	1.86	1.65	1.28	2.99	2.77
	3.19	1.30	1.43	3.07	2.59
Mean	**2.19**	**1.81**	**1.40**	**2.66**	**2.39**
Location mean	**2.34**	**1.57**	**1.57**	**2.84**	**2.72**
Profile(I)					
A	2.60	1.38	1.66	2.14	2.83
B	3.52	1.06	1.21	2.66	2.76
C	2.56	0.89	0.98	2.31	2.60
D	2.37	0.77	0.70	2.08	1.90
Mean	**2.76**	**1.03**	**1.14**	**2.30**	**2.52**
Profile (II)					
A	2.34	1.98	1.87	1.89	2.70
B	2.06	1.62	1.77	3.03	1.44
C	2.06	1.50	1.54	2.78	2.05
D	0.862	1.01	1.41	2.44	0.82
Mean	**1.83**	**1.53**	**1.65**	**2.54**	**1.75**
Profile mean	**2.39**	**1.28**	**1.40**	**2.42**	**2.14**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

Available copper of Dapoli (III) showed a variation from 0.77 to 1.38 with an average value of 1.03 mg kg^{-1} while for Dapoli (IV) it ranged from 1.01 to 1.98 with a mean value of 1.53 mg kg^{-1}. In general for Dapoli (I and II), available Cu varied between 0.77 and 1.98 with an average value of 1.28 mg kg^{-1}. From the data it was also evident that available copper content showed a declined trend with soil depth at both the mango orchards.

Khed (I and II)

Surface soil samples (0 to 15 cm):

For Khed (I) and Khed (II) the available copper ranged from 1.07 to 2.33 with a mean value of 1.73 mg kg^{-1} and 1.17 to 1.65 with an average value of 1.40 mg kg^{-1}, respectively. The available copper content was found to be slightly higher in Khed (I) than Khed (II). In general for Khed (I and II – Avashi), available copper ranged from 1.07 to 2.33 with a mean value of 1.57 mg kg^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

As seen from Table No. 4.9 and Fig. No. 4.5 the available copper for Khed (I) varied from 0.70 to 1.66 with a mean value of 1.14 mg kg^{-1} while 1.65 mg kg^{-1} was an average value of available copper with a range of 1.41 to 1.87 mg kg^{-1} for Khed (II). The data further indicated that available Cu content was slightly higher at Khed (II) than Khed (I) mango orchard. For both the mango orchards the available copper showed a range of 0.70 to 1.87 with an average value of 1.40 mg kg^{-1}. A decreasing trend of available copper content with soil depth was found in both the mango orchards (Khed I and II).

Ratnagiri (I and II)

Surface soil samples (0 to 15 cm):

The available copper of Ratnagiri (I) and (II) mango orchards varied between 2.12 to 4.03 with an average value of 3.01 mg kg^{-1} and 1.65 to 3.42 with a mean value of 2.66 mg kg^{-1}, respectively. At Ratnagiri (I) slightly higher values of available copper were observed than Ratnagiri (II). In general, for

Ratnagiri (I and II -Shirgaon) the available copper ranged from 1.65 to 4.03 with a mean value of 2.84 mg kg^{-1}. (Table No.4.9 and Fig. No.4.1)

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

Data presented in Table No.4.9 and depicted in Fig.4.5 showed a range of 2.08 to 3.14 for the available copper with a mean value of 2.55 mg $kg^{-1}$for Ratnagiri (I) and 2.44 to 3.89 with an average value of 3.04 mg $kg^{-1}$for Ratnagiri (II). For mango orchard Ratnagiri (II) available copper content was observed to be higher when compared with Ratnagiri (I). On an average, at Ratnagiri (I and II - Shirgaon) the available copper showed a range of 2.08 to 3.89 with a mean value of 2.80 mg kg^{-1}. At both the locations of available Cu distribution showed a decreasing trend with soil depth.

Lanja (I and II)

Surface soil samples (0 to 15 cm):

As seen from Table No. 4.9 and Fig.4.1 the available Cu of Lanja (I) and (II) ranged from 2.14 to 4.67 with an average value of 3.04 mg kg^{-1} and 2.13 to 2.77 with a mean value of 2.39 mg kg^{-1}, respectively. The data also revealed that Lanja (I) mango orchard had slightly higher available Cu than that of Lanja (II). For Lanja (I and II) the available copper ranged from 2.13 to 4.67 with a mean value of 2.72 mg kg^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The data (Table No. 4.9 and Fig. No. 4.5) indicated that available copper for Lanja (I) and Lanja (II) mango orchards exhibited a variation in the range of 1.90 to 2.83 with a mean value of 2.52 mg kg^{-1} and 0.82 to 2.70 with an average value of 1.75 mg kg^{-1}, respectively. The data also showed that Lanja (I) location had slightly higher values than Lanja (II) while for Lanja (I and II) available copper ranged from 0.82 to 2.83 with a mean value of 2.14 mg kg^{-1}. Available copper content showed declined trend in case of Lanja (I) whereas there was no definite patteren of distribution of available Cu in Lanja (II) mango orchard.

Available copper (Cu) status of different tahsils of Ratnagiri district:

Data on available copper status of different tahsils revealed that the available Cu of surface soil samples varied from 0.95 to 4.67 with a mean value of 2.21 mg kg^{-1}. Similar findings were also reported by Patil and Meisheri (2004), Sankpal (2008) and Sankpal (2008) for lateritic soils of Konkan.

For profile soil samples the available copper had a range of 0.70 to 3.89 with an average value of 1.96 mg kg^{-1}. In general available copper content showed a decreasing trend with soil depth in profile samples with exceptions of Dapoli (I) and Lanja (II) locations. These observations were also observed by Shinde (2006), Patil *et al.*, (2010) and Suryavanshi (2010). However, at Dapoli (I) and Lanja (II) locations the available copper did not show any definite trend with soil depth. Similar observations were also noticed by Salvi (1988) for lateritic soils of Konkan. In general, the decreasing trend of available Cu at all most all profiles may be attributed to decrease in organic carbon content in subsurface layers (Rajeswar *et al.*, 2009) or it might be due to translocation of Cu from lower layers to the surface layers as a result of vegetation (Mehta *et al.*,1964).

In general, available Cu in most of the soil samples of mango orchards was found to be adequate with exception of only one soil sample at Dapoli (III and IV) according to the critical limit given by Gajbhiye (1985). Ratnagiri (I and II) location was found to be higher and Dapoli (III and IV) was found to be lower in available Cu content for both surface and profile samples than all other locations.

4.2 Macronutrient (N, P, K, Ca and Mg) status of mango orchards:

4.2.1 Available nitrogen (N):

Dapoli (I and II)

Surface soil samples (0 to 15 cm):

The data presented in Table. No. in 4.15 and depicted in Fig. No. 4.6 indicated that the available N at Dapoli (I) ranged from 322.67 to 479.77 with a mean value of 403.71 kg ha^{-1} and from 370.77 to 499.67 with an average value of 436.15 kg ha^{-1} for Dapoli (II). The available N was slightly higher at Dapoli (II) as compared to Dapoli (I) mango orchard. In general, the available nitrogen for both the locations showed variation from 322.67 to 499.67 with an average value of 419.93 kg ha^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The available nitrogen for Dapoli (I) and Dapoli (II) ranged between 300.12 and 400.60 with a mean value of 346.90 kg ha^{-1} and 313.53 to 413.77 with an average value of 377.21 kg ha^{-1}, respectively. The data also showed that Dapoli (II) location had shown higher content of available N than Dapoli (I). For Dapoli (I and II) the available nitrogen was observed in the range of 300.12 to 413.77 with a mean value of 359.02 kg ha^{-1}. In general, for Dapoli (I) mango orchard the

Table 4.10 Available macronutrient (N, P_2O_5, K_2O, Exch. Ca^{2+}, Exch. Mg^{2+}) status of mango orchards.

Mango orchard Soil depth (cm)	N	P_2O_5	K_2O	Exch. Ca^{2+}	Exch. Mg^{2+}
	Kg ha^{-1}			cmol (p^+) kg^{-1}	
Dapoli (I) (0 to 15)	350.89	4.45	234.15	1.32	0.56
	322.67	5.12	288.56	1.19	0.67
	400.78	4.67	251.45	1.23	0.96
	341.67	5.22	289.55	1.89	0.78
	389.76	4.44	265.11	1.44	1.01
	416.98	5.23	251.90	1.56	1.12
	412.89	5.87	256.33	1.23	0.56
	458.87	4.10	302.56	1.89	0.87
	462.77	3.89	230.12	1.54	0.99
	479.77	4.55	267.66	1.34	0.65
Mean	**403.71**	**4.75**	**263.74**	**1.46**	**0.82**
Dapoli (II) (0 to 15)	489.50	3.78	296.45	1.21	0.87
	489.90	5.00	308.34	1.66	0.60
	499.67	4.78	212.66	1.43	0.80
	397.77	5.18	234.67	2.08	0.77
	385.60	4.77	209.67	1.34	0.69

	401.55	3.59	244.77	1.21	0.92
	444.78	5.66	310.10	1.78	1.21
	480.76	3.67	267.77	2.09	0.79
	370.77	4.33	243.12	1.69	0.88
	401.23	5.32	209.67	1.43	0.79
Mean	**436.15**	**4.61**	**253.72**	**1.59**	**0.83**
Location mean	**419.93**	**4.68**	**258.73**	**1.53**	**0.82**
Profile (I)					
A	400.60	4.66	227.87	1.90	0.94
B	365.08	4.77	278.99	1.58	0.80
C	321.78	3.66	297.66	1.36	0.75
D	300.12	3.56	300.00	1.36	0.73
mean	**346.90**	**4.16**	**276.13**	**1.55**	**0.81**
Profile (II)					
A	413.77	4.10	296.66	1.87	1.14
B	350.67	3.05	311.34	1.65	1.02
C	313.53	3.50	300.67	1.38	0.94
D	413.70	5.34	213.76	1.21	0.83
Mean	**377.21**	**4.89**	**291.36**	**1.53**	**0.98**
Profile mean	**359.02**	**4.05**	**282.22**	**1.54**	**0.90**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

Table 4.11 Available macronutrient (N, P_2O_5, K_2O, Exch. Ca^{2+}, Exch. Mg^{2+}) status of mango orchards.

Mango orchard Soil depth (cm)	**N**	**P_2O_5**	**K_2O**	**Exch. Ca^{2+}**	**Exch. Mg^{2+}**
	Kg ha $^{-1}$			**cmol (p^+) kg^{-1}**	
Dapoli (III) (0 to 15)	413.70	5.34	213.76	1.32	0.94
	390.88	5.12	231.44	1.87	0.53
	480.56	5.67	205.77	1.89	0.76
	400.07	4.77	267.55	1.43	1.17
	456.78	4.68	244.65	1.55	1.21
	370.78	5.90	243.00	1.89	1.09
	421.69	5.43	222.13	1.67	1.17
	440.15	5.66	254.66	2.15	1.06
	485.78	5.43	234.77	1.90	0.59
	376.89	4.51	214.56	1.87	0.66
Mean	**423.73**	**5.25**	**233.23**	**1.75**	**0.92**
Dapoli (IV) (0 to 15)	500.34	4.99	247.89	1.50	0.93
	409.89	3.87	256.11	1.77	0.69
	488.90	3.56	243.77	1.96	0.83
	501.34	4.02	215.67	1.34	0.81
	478.09	3.77	231.33	1.65	0.50
	376.66	4.00	241.55	2.00	0.67
	498.67	5.48	254.77	1.76	0.74
	400.80	5.66	219.66	1.80	1.11
	488.88	4.98	231.69	1.40	1.34
	397.05	5.55	240.50	1.73	1.21
Mean	**454.06**	**4.59**	**238.29**	**1.69**	**0.88**
Location mean	**438.90**	**4.92**	**235.76**	**1.72**	**0.90**
Profile (III)					
A	408.89	5.22	256.78	1.80	1.00
B	367.97	4.98	277.88	1.59	0.96
C	367.94	4.66	290.56	1.38	0.71

D	304.65	4.34	290.56	1.06	0.63
Mean	**362.36**	**4.80**	**278.95**	**1.46**	**0.83**
Profile (IV)					
A	509.55	5.09	236.88	2.12	0.89
B	409.78	4.76	255.76	1.78	0.80
C	333.90	4.30	295.77	1.34	0.73
D	299.73	4.01	310.74	1.43	0.68
Mean	**388.24**	**4.54**	**274.79**	**1.67**	**0.78**
Profile mean	**375.30**	**4.67**	**276.87**	**1.56**	**0.81**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

Table 4.12 Available macronutrient (N, P_2O_5, K_2O, Exch. Ca^{2+}, Exch. Mg^{2+}) status of mango orchards.

Mango orchard Soil depth (cm)	**N**	**P_2O_5**	**K_2O**	**Exch. Ca^{2+}**	**Exch. Mg^{2+}**
	Kg ha^{-1}			**cmol (p^+) kg^{-1}**	
Khed (I) (0 to 15)	509.67	5.77	254.89	1.98	1.33
	476.12	5.12	210.66	1.23	1.21
	491.56	5.34	231.56	1.88	1.08
	487.33	5.66	290.77	1.23	1.22
	506.34	5.34	251.55	1.76	1.32
	461.34	5.89	200.66	1.5	1.21
	496.22	4.77	217.43	1.69	0.87
	498.66	4.97	287.44	1.92	0.65
	432.12	5.66	243.09	1.28	1.22
	377.67	3.77	216.67	1.88	1.54
Mean	**473.70**	**5.23**	**240.47**	**1.64**	**1.17**
Khed (II) (0 to 15)	409.12	4.64	246.88	1.87	1.39
	388.88	4.98	231.66	2.12	1.23
	370.67	4.12	210.89	1.95	1.51
	400.12	5.66	217.37	1.60	1.19
	434.67	3.78	216.91	1.59	1.30
	454.12	4.71	245.65	1.90	1.29
	444.19	3.77	263.90	1.65	1.33
	438.60	3.19	234.77	1.34	1.21
	379.90	4.33	214.77	1.21	1.02
	438.70	4.56	234.45	2.23	1.28
Mean	**415.90**	**4.37**	**231.73**	**1.75**	**1.28**
Location mean	**444.80**	**4.80**	**236.10**	**1.70**	**1.23**
Profile (I)					
A	477.77	4.78	222.99	2.21	1.43
B	410.67	4.43	269.81	1.90	1.20
C	356.12	4.21	256.90	1.54	0.96
D	303.44	4.44	300.09	1.10	0.80
Mean	**387.00**	**4.47**	**262.45**	**1.69**	**1.10**
Profile (II)					
A	471.33	5.03	255.78	2.11	1.33
B	408.71	4.61	281.50	1.89	1.22
C	460.88	4.20	313.64	1.32	1.19
D	344.90	3.06	309.45	1.45	1.01
Mean	**421.46**	**4.23**	**290.09**	**1.69**	**1.19**
Profile mean	**404.23**	**4.35**	**276.27**	**1.69**	**1.17**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

Table 4.13 **Available macronutrient (N, P_2O_5, K_2O, Exch. Ca^{2+}, Exch. Mg^{2+}) status of mango orchards.**

Mango orchard Soil depth (cm)	**N**	**P_2O_5**	**K_2O**	**Exch. Ca^{2+}**	**Exch. Mg^{2+}**
	Kg ha^{-1}			**cmol (p^+) kg^{-1}**	
Ratnagiri (I) (0 to 15)	450.78	3.77	278.55	2.34	1.20
	509.78	3.58	261.66	2.32	1.55
	560.78	4.21	202.58	2.17	1.34
	543.78	4.33	256.88	2.65	1.21
	512.90	3.87	284.56	2.55	0.67
	499.66	3.99	213.67	2.43	0.55
	481.56	4.34	216.44	2.12	0.48
	500.98	4.22	225.43	1.89	1.11
	500.23	4.88	231.77	2.65	1.23
	514.34	3.55	219.06	2.13	1.45
Mean	**507.48**	**4.07**	**239.06**	**2.33**	**1.08**
Ratnagiri (II) (0 to 15)	560.76	3.32	209.71	2.43	1.43
	460.78	4.19	209.66	2.31	1.51
	504.34	3.55	231.55	2.44	1.41
	534.89	3.49	210.88	2.09	1.01
	519.56	4.76	201.77	2.05	0.79
	549.58	3.89	204.62	2.11	0.88
	500.44	3.66	218.45	2.44	0.70
	508.78	3.41	221.90	2.38	0.67
	534.55	3.58	265.32	2.00	0.89
	522.17	3.69	215.74	2.17	0.95
Mean	**519.59**	**3.75**	**218.96**	**2.24**	**1.02**
Location mean	**513.54**	**3.91**	**229.01**	**2.29**	**1.05**
Profile (I)					
A	532.18	3.88	218.43	1.90	0.97
B	491.27	3.51	230.54	2.04	0.90
C	420.78	4.12	267.87	1.76	0.85
D	328.51	3.00	301.70	1.21	0.81
Mean	**443.19**	**3.63**	**254.64**	**1.73**	**0.88**
Profile (II)					
A	519.67	4.65	205.76	2.22	1.22
B	480.65	4.13	247.67	2.37	1.15
C	440.55	3.47	265.55	1.65	1.01
D	360.66	3.28	256.90	1.23	0.89
Mean	**450.38**	**3.88**	**243.97**	**1.87**	**1.07**
Profile mean	**446.79**	**3.76**	**249.31**	**1.80**	**0.98**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

Table No. 4.14 **Available macronutrient (N, P_2O_5, K_2O, Exch. Ca^{2+}, Exch. Mg^{2+}) status of mango orchards.**

Mango orchard Soil depth (cm)	**N**	**P_2O_5**	**K_2O**	**Exch. Ca^{2+}**	**Exch. Mg^{2+}**
	Kg ha^{-1}			**cmol (p^+) kg^{-1}**	
Lanja (I) (0 to 15)	568.34	5.60	309.77	2.43	1.43
	543.23	5.33	311.87	2.12	1.60

	512.44	5.44	289.60	2.88	1.52
	494.34	5.91	287.05	2.56	1.25
	519.11	6.23	277.45	2.82	1.45
	548.40	5.88	265.89	2.45	1.48
	539.66	6.32	292.67	2.65	1.37
	450.66	6.11	287.60	2.34	1.22
	500.44	5.44	299.12	2.76	1.55
	518.49	5.77	301.23	2.55	1.47
Mean	**519.51**	**5.80**	**292.23**	**2.56**	**1.43**
	533.55	5.14	267.45	2.74	1.22
	529.78	4.97	271.45	2.87	1.33
	530.51	5.43	281.56	2.34	1.51
	522.43	5.89	295.78	2.71	1.49
Lanja (II)	486.79	5.44	294.78	2.31	1.46
(0 to 15)	529.51	4.99	301.44	2.39	1.29
	495.66	5.77	285.06	2.11	1.41
	469.76	6.21	277.34	2.32	1.55
	466.21	6.42	302.77	2.49	1.56
	480.71	5.34	293.80	2.30	1.26
Mean	**504.49**	**5.56**	**287.14**	**2.46**	**1.41**
Location mean	**512.00**	**5.68**	**289.69**	**2.51**	**1.42**
Profile (I)					
A	555.34	5.66	269.67	2.17	1.36
B	431.34	5.98	298.70	2.67	1.20
C	431.34	4.21	305.71	2.29	1.13
D	400.63	3.90	310.73	1.88	1.05
mean	**454.66**	**4.94**	**296.20**	**2.25**	**1.19**
Profile (II)					
A	555.66	6.00	264.88	2.21	1.40
B	466.56	5.44	235.77	2.05	1.30
C	400.06	5.03	295.70	1.43	1.20
D	377.04	4.26	314.81	1.03	1.10
Mean	**449.83**	**5.18**	**277.79**	**1.68**	**1.25**
Profile mean	**452.25**	**5.06**	**287.00**	**1.97**	**1.22**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

available nitrogen exhibited a decreasing trend with soil depth while for Dapoli (II) any specific trend was not observed.

Dapoli (III and IV)

Surface soil samples (0 to 15 cm):

The data presented in Table No. 4.15 revealed that 423.73 kg ha^{-1} was the average available nitrogen with variation from 370.78 to 485.78 kg ha^{-1} for Dapoli (III) while for Dapoli (IV), 454.06 kg ha^{-1} was the mean value of available nitrogen and it ranged from 376.66 to 501.34 kg ha^{-1}. From the data it was also evident that higher content of available nitrogen was observed in Dapoli (IV) than Dapoli (III). For Dapoli (III and IV- Wakawali) available nitrogen showed variation from 370.78 to 501.34 with a mean value of 438.90 kg ha^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

For Dapoli (III) location available N varied between 304.65 and 408.89 with an average value of 362.36 kg ha^{-1} while for Dapoli (IV) it ranged from 299.73 to 509.55 with a mean value of 388.24 kg ha^{-1}. Dapoli (IV) location showed slightly higher values for available nitrogen content as compared with Dapoli (III). However, available nitrogen at Dapoli (III and IV- Wakawali) showed variation from 299.73 to 509.55 with a mean value of 375.30 kg ha^{-1}. The data further revealed that available nitrogen showed a declined trend with soil depth for both the mango orchards. (Table No. 4.15 and Fig. 4.8).

Khed (I and II)

Surface soil samples (0 to 15 cm):

For Khed (I) and Khed (II) the available nitrogen ranged from 377.67 to 509.67 with a mean value of 473.70 kg ha^{-1} and 370.67 to 454.12 with an average value of 415.90 kg ha^{-1}, respectively. At Khed (I) the available nitrogen was found

Table 4.15 Available macronutrient (N) status of mango orchards (kg ha^{-1}).

Mango orchard Soil depth (cm)	Available Nitrogen (N)				
	Dapoli (I and II)	Dapoli (III and IV)	Khed (I and II)	Ratnagiri (I and II)	Lanja (I and II)
Mango orchard I (0 to 15)	350.89	413.70	509.67	450.78	568.34
	322.67	390.88	476.12	509.78	543.23
	400.78	480.56	491.56	560.78	512.44
	341.67	400.07	487.33	543.78	494.34
	389.76	456.78	506.34	512.90	519.11
	416.98	370.78	461.34	499.66	548.4
	412.89	421.69	496.22	481.56	539.66
	458.87	440.15	498.66	500.98	450.66
	462.77	485.78	432.12	500.23	500.44
	479.77	376.89	377.67	514.34	518.49
Mean	**403.71**	**423.73**	**473.70**	**507.48**	**519.51**
Mango orchard II (0 to 15)	489.50	500.34	409.12	560.76	533.55
	489.90	409.89	388.88	460.78	529.78
	499.67	488.90	370.67	504.34	530.51
	397.77	501.34	400.12	534.89	522.43
	385.60	478.09	434.67	519.56	486.79

	401.55	376.66	454.12	549.58	529.51
	444.78	498.67	444.19	500.44	495.66
	480.76	400.80	438.60	508.78	469.76
	370.77	488.88	379.90	534.55	466.21
	401.23	397.05	438.70	522.17	480.71
Mean	**436.15**	**454.06**	**415.90**	**519.59**	**504.49**
Location mean	**419.93**	**438.90**	**444.80**	**513.54**	**512.00**
Profile(I)					
A	400.60	408.89	477.77	532.18	555.34
B	365.08	367.97	410.67	491.27	431.34
C	321.78	367.94	356.12	420.78	431.34
D	300.12	304.65	303.44	328.51	400.63
Mean	**346.90**	**362.36**	**387.00**	**443.19**	**454.66**
Profile (II)					
A	413.77	509.55	471.33	519.67	555.66
B	350.67	409.78	408.71	480.65	466.56
C	313.53	333.90	460.88	440.55	400.06
D	413.70	299.73	344.90	360.66	377.04
Mean	**377.21**	**388.24**	**421.46**	**450.38**	**449.83**
Profile mean	**359.02**	**375.30**	**404.23**	**446.79**	**452.25**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

to be higher than Khed (II). In general, for Khed (I and II – Avashi) the available nitrogen ranged from 370.67 to 509.67 with a mean value of 444.80 kg ha^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

As seen from Table No. 4.15 and Fig. No.4.8 the available nitrogen for Khed (I) varied from 303.44 to 477.77 with a mean value of 387.00 kg ha^{-1} while 421.46 kg ha^{-1} was an average value of available nitrogen with range of 344.90 to 471.33 kg ha^{-1} for Khed (II). The data further showed that Khed (II) location had slightly higher content of available nitrogen than Khed (I). For both the mango orchards the available nitrogen showed a range of 303.44 to 477.77 with an average value of 404.23 kg ha^{-1}. Available nitrogen content at Khed (I) location exhibited a decreasing trend with soil depth however at Khed (II) location it did not show any definite trend.

Ratnagiri (I and II)

Surface soil samples (0 to 15 cm):

The available nitrogen of Ratnagiri (I) and (II) mango orchards varied between 450.78 and 560.78 with an average value of 507.48 kg ha^{-1} and 460.78

to 560.76 with a mean value of 519.59 kg ha^{-1}, respectively. At Ratnagiri (II) slightly higher values of available nitrogen were observed than Ratnagiri (I). In general, for Ratnagiri (I and II - Shirgaon) the available nitrogen ranged from 450.78 to 560.78 with a mean value of 513.54 kg ha^{-1}. (Table No.4.15 and Fig. No.4.6)

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

Data presented in Table No.4.15 and depicted in Fig. 4.8 showed 328.51 to 532.18 was available nitrogen with a mean value of 443.19 kg ha^{-1} for Ratnagiri (I) and 360.66 to 519.67 with an average value of 450.38 kg ha^{-1} for Ratnagiri (II). For Ratnagiri (II) mango orchard available nitrogen content was found to be higher than Ratnagiri (I). In Ratnagiri (I and II-Shirgaon) the available nitrogen showed a range of 328.51 to 532.18 with a mean value of 446.79 kg ha^{-1}. At both the locations a decreasing trend of available nitrogen with soil depth was observed.

Lanja (I and II)

Surface soil samples (0 to 15 cm):

As seen from Table No.4.15 and Fig. No.4.6 the available nitrogen of Lanja (I) and (II) ranged from 450.66 to 568.34 with an average value of 519.51 kg ha^{-1} and 466.21 to 533.55 with a mean value of 504.49 kg ha^{-1}, respectively. The data also revealed that Lanja (I) mango orchard had slightly higher available nitrogen content than that of Lanja (II). For both Lanja (I and II) the available nitrogen ranged from 450.66 to 568.34 with a mean value of 512.00 kg ha^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The data from Table No. 4.15 and Fig. No.4.8 indicated that available nitrogen for Lanja (I) and Lanja (II) mango orchards exhibited a variation in the range of 400.63 to 555.34 with a mean value of 454.66 kg ha^{-1} and 377.04 to

555.66 with an average value of 449.83 kg ha^{-1}, respectively. Available nitrogen ranged from 377.04 to 555.66 with a mean value of 452.25 kg ha^{-1} in Lanja (I and II). At Lanja (II) location available nitrogen content was found to be decreased with soil depth while at Lanja (I) it did not show any specific trend with soil depth.

Available nitrogen (N) status of different tahsils of Ratnagiri district:

The data on overall mean for available nitrogen of different tahsils showed that the available nitrogen of surface samples of all tahsils varied from 322.67 to 568.34 with an average value of 465.83 kg ha^{-1}. Similar findings were also reported by Tupe (1996), Dongre (1997) and Sankpal (2008) for lateritic soils of Konkan.

In case of profile samples the available nitrogen showed a variation between 300.12 and 555.66 with a mean value of 407.52 kg ha^{-1}. The available nitrogen in general showed a decreasing trend with depth in majority of soil profiles with exceptions of Dapoli (II), Khed (II) and Lanja (I). These observations are in conformity with Terse (1989), Shinde (2006) and Suryavanshi (2010) for lateritic soils of mango orchards of Konkan (MS). However, at Dapoli (II), Khed (II) and Lanja (I) locations the distribution of available nitrogen content found to be different. It did not show any specific trend with soil depth. Similar trend was noticed by Vaidya (1988) for lateritic soils of Konkan. In general, the decreasing trend of available nitrogen with soil depth at most of the tahsils, may be due to more accumulation of plant residues, debris and rhizosphere in surface soil than subsurface (Rajeswar *et al.*, 2009 and Prasuna-Rani *et al.*, 1992) or could be attributed to the presence of higher organic carbon in the surface soil than subsurface (Sharma and Bali, 2000).

In general, all the surface and profile samples were in 'medium to high' class as per the ratings given by Banger and Zende (1978) indicated presence of adequate amount of available nitrogen in all the mango orchards. The higher values of nitrogen content in the soil might be due to high content of organic carbon which on mineralization released higher nitrogen (Talukdar *et al.*, 2009). At Ratnagiri (I and II) and Lanja (I and II) the available nitrogen content was maximum for surface and profile samples, respectively. However, it was observed lowest at Dapoli (I and II) and Dapoli (III and IV) for surface and profile samples, respectively.

4.2.2 Available phosphorous (P_2O_5)

Dapoli (I and II)

Surface soil samples (0 to 15 cm):

The data presented in Table. No. in 4.16 and depicted in Fig.No.4.6 indicated

that the available phosphorus of Dapoli (I) ranged from 3.89 to 5.87 with a mean value of 4.75 kg ha^{-1} and 3.59 to 5.66 with an average value of 4.61 kg ha^{-1} for Dapoli (II). In general, the available phosphorus for both the locations showed variation from 3.59 to 5.87 with an average value of 4.68 kg ha^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The available phosphorus for Dapoli (I) and Dapoli (II) ranged between 3.56 and 4.77 with a mean value of 4.16 kg ha^{-1} and 3.05 to 5.34 with an average value of 4.89 kg ha^{-1}, respectively. For Dapoli (II) the available phosphorus was slightly higher than Dapoli (I). For Dapoli (I and II) the available phosphorus was observed in the range of 3.05 to 5.34 with a mean value of 4.05 kg ha^{-1} and for both the mango orchards the available phosphorus did not exhibit specific trend with soil depth.

Dapoli (III and IV)

Surface soil samples (0 to 15 cm):

The data presented in Table No. 4.16 and illustrated in Fig. No.4.6 revealed that 5.25 kg ha^{-1} was the average available phosphorus with variation from 4.51 to 5.90 kg ha^{-1} for Dapoli (III) while for Dapoli (IV), 4.59 kg ha^{-1} was the mean value of available phosphorus and it ranged from 3.56 to 5.66 kg ha^{-1}. From the data it was also evident that Dapoli (III) mango orchards had showed slightly higher content of available phosphorus than Dapoli (IV). Available phosphorus showed variation from 3.56 to 5.90 with a mean value of 4.92 kg ha^{-1} for both Dapoli (III and IV- Wakawali) mango orchards.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

For Dapoli (III) location, available phosphorus varied between 4.34 and 5.22 with an average value of 4.80 kg ha^{-1} while for Dapoli (IV) it ranged from 4.01 to

Table 4.16 Available macronutrient (P_2O_5) status of mango orchards (kg ha^{-1}).

Mango orchard Soil depth (cm)	Available Phosphorus (P_2O_5)				
	Dapoli (I and II)	Dapoli (III and IV)	Khed (I and II)	Ratnagiri (I and II)	Lanja (I and II)
Mango orchard I (0 to 15)	4.45	5.34	5.77	3.77	5.60
	5.12	5.12	5.12	3.58	5.33
	4.67	5.67	5.34	4.21	5.44
	5.22	4.77	5.66	4.33	5.91
	4.44	4.68	5.34	3.87	6.23
	5.23	5.90	5.89	3.99	5.88
	5.87	5.43	4.77	4.34	6.32
	4.10	5.66	4.97	4.22	6.11
	3.89	5.43	5.66	4.88	5.44
	4.55	4.51	3.77	3.55	5.77
Mean	**4.75**	**5.25**	**5.23**	**4.07**	**5.80**
Mango orchard II (0 to 15)	3.78	4.99	4.64	3.32	5.14
	5.00	3.87	4.98	4.19	4.97
	4.78	3.56	4.12	3.55	5.43
	5.18	4.02	5.66	3.49	5.89
	4.77	3.77	3.78	4.76	5.44
	3.59	4.00	4.71	3.89	4.99
	5.66	5.48	3.77	3.66	5.77
	3.67	5.66	3.19	3.41	6.21
	4.33	4.98	4.33	3.58	6.42
	5.32	5.55	4.56	3.69	5.34
Mean	**4.61**	**4.59**	**4.37**	**3.75**	**5.56**
Location mean	**4.68**	**4.92**	**4.80**	**3.91**	**5.68**
Profile(I)					
A	4.66	5.22	4.78	3.88	5.66
B	4.77	4.98	4.43	3.51	5.98
C	3.66	4.66	4.21	4.12	4.21
D	3.56	4.34	4.44	3.00	3.90
Mean	**4.16**	**4.80**	**4.47**	**3.63**	**4.94**
Profile (II)					
A	4.10	5.09	5.03	4.65	6.00

B	3.05	4.76	4.61	4.13	5.44
C	3.50	4.30	4.2	3.47	5.03
D	5.34	4.01	3.06	3.28	4.26
Mean	**4.89**	**4.54**	**4.23**	**3.88**	**5.18**
Profile mean	**4.05**	**4.67**	**4.35**	**3.76**	**5.06**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

5.09 with a mean value of 4.54 kg ha^{-1}. Dapoli (III) location showed slightly higher values for available phosphorus as compared to Dapoli (IV). The available phosphorus at Dapoli (III and IV- Wakawali) showed variation from 4.01 to 5.22 with a mean value of 4.67 kg ha^{-1}. Available phosphorus showed a declined trend with soil depth for both the mango orchards. (Table 4.16 and Fig.4.9)

Khed (I and II)

Surface soil samples (0 to 15 cm):

For Khed (I) and Khed (II) the available phosphorus ranged from 3.77 to 5.89 with a mean value of 5.23 kg ha^{-1} and 3.19 to 5.66 with an average value of 4.37 kg ha^{-1}, respectively. At Khed (I) the available phosphorus was found to be slightly higher than Khed (II). In general for Khed (I and II – Avashi), available phosphorus ranged from 3.19 to 5.89 with a mean value of 4.80 kg ha^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

As seen from Table No. 4.16 and Fig. No. 4.9 the available phosphorus for Khed (I) varied from 4.21 to 4.78 with a mean value of 4.47 kg ha^{-1} while 4.23 kg ha^{-1} was an average value of available phosphorus with range of 3.06 to 5.03 kg ha^{-1} for Khed (II). For both the mango orchards the available phosphorus showed a range of 3.06 to 5.03 with an average value of 4.35 kg ha^{-1}. Available phosphorous content was found to be decreased with depth in Khed (II). However, there was no definite trend in Khed (I).

Ratnagiri (I and II)

Surface soil samples (0 to 15 cm):

The available phosphorus of Ratnagiri (I) and (II) mango orchards varied between 3.55 to 4.88 with an average value of 4.07 kg ha^{-1} and 3.32 to 4.76 with a mean value of 3.75 kg ha^{-1}, respectively. At Ratnagiri (I) slightly higher values of available phosphorus were observed than Ratnagiri (II). In general, for Ratnagiri
(I and II - Shirgaon) the available phosphorus ranged from 3.32 to 4.88 with a mean value of 3.91 kg ha^{-1}. (Table No.4.16 and Fig.No.4.6)

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

Data presented in Table No. 4.16 and depicted in Fig.4.9 showed a range of 3.00 to 4.12 for the available phosphorus with a mean value of 3.63 kg ha^{-1} at Ratnagiri (I) and 3.28 to 4.65 with an average value of 3.88 kg ha^{-1} for Ratnagiri (II). Available phosphorus was found higher in Ratnagiri (II) mango orchard when compared with Ratnagiri (I). The available phosphorus showed a range of 3.00 to 4.65 with a mean value of 3.76 kg ha^{-1} for Ratnagiri (I and II - Shirgaon).There was no definite trend of available phosphorus with soil depth in Ratnagiri (I) mango orchard while in Ratnagiri (II) it showed a declined trend.

Lanja (I and II)

Surface soil samples (0 to 15 cm):

As seen from Table No.4.16 and Fig. 4.6 the available phosphorus of Lanja (I) and (II) ranged from 5.33 to 6.32 with an average value of 5.80 kg ha^{-1} and 4.97 to 6.42 with a mean value of 5.56 kg ha^{-1}, respectively. The data also revealed that Lanja (I) mango orchard had shown slightly higher available phosphorus content than that of Lanja (II). For both Lanja (I and II) the available phosphorus ranged from 4.97 to 6.42 with a mean value of 5.68 kg ha^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The data (Table No. 4.16 and Fig. No.4.9) indicated that available phosphorus for Lanja (I) and Lanja (II) mango orchards exhibited a variation in the range of 3.90 to 5.98 with a mean value of 4.94 kg ha^{-1} and 4.26 to 6.00 with an average value of 5.18 kg ha^{-1}, respectively. The data also showed that Lanja (II) location had slightly higher values of available phosphorus than Lanja (I) while for Lanja (I and II) it ranged from 3.90 to 6.00 with a mean value of 5.06 kg ha^{-1}. At Lanja (I) there was no definite distribution pattern of available phosphorus with soil depth. A declined trend of available phosphorus with soil depth was found in Lanja (II) location.

Available phosphorous (P_2O_5) status of different tahsils of Ratnagiri district:

Data on available phosphorus status of different tahsils when studied revealed that the available phosphorus of surface samples of all tahsils showed a variation between 3.19 and 6.42 with an average value of 4.80 kg ha^{-1}. Similar range of available phosphorus was observed by Diwale (1994), Dongre (1997) and Gaidhani (2008) for lateritic soils of Konkan.

For profile samples the available phosphorus of all tahsils varied in the range of 3.00 to 6.00 with a mean value of 4.38 kg ha^{-1}. Similar observations were also recorded by Mahajan (2001), Shinde (2006) and Suryavanshi (2010). Distrubution of available phosphorus content showed a declined trend with soil depth at Dapoli (III) and (IV), Khed (II), Ratnagiri (II) and Lanja (II). However, it did not show any definite trend with soil depth in Dapoli (I) and (II), Khed (I), Ratnagiri (I) and Lanja (I) locations. The declining trend of available phosphorous was also observed by Pereira *et al.*, (1986) Chavan *et al.*, (1995) Sankpal (2008) while irregular distribution of available phosphorous with soil depth was also reported Dabke (1987) and Vaidya (1988) for lateritic soils of Konkan. The declining trend of available phosphorous may be attributed to its higher fixation with soil depth (Sharma and Bali, 2000). In general, the low available phosphorous content in surface and profiles of lateritic soil might be due to low native phosphorous content and fixation of released phosphorous by clay minerals and oxides of Fe and Al in these soils (Prasunarani *et al.*, 1992) or might be due to high phosphorous fixing capacity of these soils which prevented its transformation into readily available form in the soil solution. (Badrinath *et al.*, 1986)

In general, according to ratings given by Banger and Zende (1978) all the surface and profile soil samples were belonged to 'very low' class indicating very low status of available phosphorous in all the mango orchards. At Ratnagiri (I and II) location the available phosphorous was lowest while highest at Lanja (I and II) for surface as well as profile samples than all other mango orchards.

4.2.3 Available potassium (K_2O)

Dapoli (I and II)

Surface soil samples (0 to 15 cm):

The data presented in Table. No. in 4.17 and depicted in Fig. No. 4.6 indicated that the available potassium at Dapoli (I) ranged from 230.12 to 302.56 with a mean value of 263.74 kg ha^{-1} and from 209.67 to 310.10 with an average value of 253.72 kg ha^{-1} for Dapoli (II). The available potassium content was observed slightly higher in Dapoli (I) than Dapoli (II) mango orchard. In general, the available potassium for both the locations showed variation from 209.67 to 310.10 with an average value of 258.73 kg ha^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The available potassium for Dapoli (I) and Dapoli (II) ranged between 227.87 and 300.00 with a mean value of 276.13 kg ha^{-1} and 213.76 to 311.34 with an average value of 291.36 kg ha^{-1}, respectively. The data also showed that Dapoli (II) location had slightly higher values for available potassium than Dapoli (I). For Dapoli (I and II) the available potassium was observed in the range of 213.76 to 311.34 with a mean value of 282.22 kg ha^{-1}. Available potassium content was

Table 4.17 **Available macronutrient (K_2O) status of mango orchards (mg kg^{-1}).**

Mango orchard Soil depth (cm)	Available Potassium (K_2O)				
	Dapoli (I and II)	Dapoli (III and IV)	Khed (I and II)	Ratnagiri (I and II)	Lanja (I and II)
Mango orchard I (0 to 15)	234.15	213.76	254.89	278.55	309.77
	288.56	231.44	210.66	261.66	311.87
	251.45	205.77	231.56	202.58	289.60
	289.55	267.55	290.77	256.88	287.05
	265.11	244.65	251.55	284.56	277.45
	251.90	243.00	200.66	213.67	265.89
	256.33	222.13	217.43	216.44	292.67
	302.56	254.66	287.44	225.43	287.6
	230.12	234.77	243.09	231.77	299.12
	267.66	214.56	216.67	219.06	301.23
Mean	**263.74**	**233.23**	**240.47**	**239.06**	**292.23**
Mango orchard II (0 to 15)	296.45	247.89	246.88	209.71	267.45
	308.34	256.11	231.66	209.66	271.45
	212.66	243.77	210.89	231.55	281.56
	234.67	215.67	217.37	210.88	295.78
	209.67	231.33	216.91	201.77	294.78
	244.77	241.55	245.65	204.62	301.44
	310.10	254.77	263.90	218.45	285.06
	267.77	219.66	234.77	221.90	277.34
	243.12	231.69	214.77	265.32	302.77
	209.67	240.50	234.45	215.74	293.80
Mean	**253.72**	**238.29**	**231.73**	**218.96**	**287.14**
Location mean	**258.73**	**235.76**	**236.10**	**229.01**	**289.69**
Profile(I)					
A	227.87	256.78	222.99	218.43	269.67
B	278.99	277.88	269.81	230.54	298.70
C	297.66	290.56	256.9	267.87	305.71
D	300.00	290.56	300.09	301.7	310.73
Mean	**276.13**	**278.95**	**262.45**	**254.64**	**296.20**
Profile (II)					
A	296.66	236.88	255.78	205.76	264.88
B	311.34	255.76	281.5	247.67	235.77
C	300.67	295.77	313.64	265.55	295.70
D	213.76	310.74	309.45	256.9	314.81
Mean	**291.36**	**274.79**	**290.09**	**243.97**	**277.79**
Profile mean	**282.22**	**276.87**	**276.27**	**249.31**	**287.00**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

found to be increased with soil depth for Dapoli (I) mango orchard while no specific trend was observed in case of Dapoli (II).

Dapoli (III and IV)

Surface soil samples (0 to 15 cm):

For Dapoli (III) mango orchard available potassium ranged between 213.76 and 267.55 with a mean value of 233.23 kg ha^{-1} while for Dapoli (IV) it was 215.67 to 256.11with an average value of 238.29 kg ha^{-1}. Available potassium content varied from 213.76 to 267.55 with a mean value of 235.76 kg ha^{-1} for Dapoli (III and IV - Wakawali).

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

256.78 to 290.56 kg ha^{-1} was the range of available potassium and 278.95 kg ha^{-1} was the mean value of it for Dapoli (III) while for Dapoli (IV) it varied from 236.88 to 310.74 with an average value of 274.79 kg ha^{-1}. For both the soil profiles available potassium had shown a variation between 236.88 and 310.74 with a mean value of 276.87 kg ha^{-1}. The data further revealed that available potassium content did not show definite variation with soil depth for Dapoli (III). However, potassium content was found to be increased with soil depth for Dapoli (IV). (Table No.4.17 and Fig.No.4.10)

Khed (I and II)

Surface soil samples (0 to 15 cm):

For Khed (I) and Khed (II) the available potassium showed variation in a range of 200.66 to 290.77 with a mean value of 240.47 kg ha^{-1} and 210.89 to 263.90 with an average value of 231.73 kg ha^{-1}, respectively. Available potassium content ranged from 200.66 to 290.77 with a mean value of 236.10 kg ha^{-1} for Khed (I and II – Avashi).

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

As seen from Table No. 4.17 and Fig. No.4.10 the available potassium for Khed (I) varied from 222.99 to 300.09 with a mean value of 262.45 kg ha^{-1} while 290.09 kg ha^{-1} was an average value of available potassium with range of

255.78 to 313.64 kg ha^{-1} for Khed (II). For both the mango orchards it showed a variation in the range of 222.99 to 313.64 with an average value of 276.27 kg ha^{-1}. Distribution of available potassium content did not follow definite pattern with soil depth for both the mango orchards.

Ratnagiri (I and II)

Surface soil samples (0 to 15 cm):

For Ratnagiri (I) the available potassium ranged between 202.58 and 284.56 with a mean value of 239.06 kg ha^{-1} while for Ratnagiri (II), it showed an average value of 218.96 kg ha^{-1} and varied from 201.77 to 265.32 kg ha^{-1}. Ratnagiri (I) showed slightly higher in content of available potassium than Ratnagiri (II). Both the locations exhibited a range of 201.77 to 284.56 with an average value of 229.01 kg ha^{-1} for available potassium. (Table 4.17 and Fig. 4.6)

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

Ratnagiri (I) showed a variation from 218.43 to 301.70 with an average value of 254.64 kg ha^{-1} while for Ratnagiri (II) it ranged from 205.76 to 265.55 with a mean value of 243.97 kg ha^{-1}. In general, for Ratnagiri (I and II) available potassium varied between 205.76 and 301.70 with an average value of 249.31 kg ha^{-1}. From the data it was also evident that increasing trend of available potassium was exhibited for Ratnagiri (I) mango orchard while Ratnagiri (II) had shown no specific trend of available potassium distribution with soil depth.

Lanja (I and II)

Surface soil samples (0 to 15 cm):

As seen from Table No. 4.17 and Fig.No.4.6 the available potassium at Lanja (I) and (II) ranged from 265.89 to 311.87 with an average value of 292.23 kg ha^{-1} and 267.45 to 302.77 with a mean value of 287.14 kg ha^{-1}, respectively.

For Lanja (I and II) the available potassium ranged from 265.89 to 311.87 with a mean value of 289.69 kg ha^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The available potassium of Lanja (I) mango orchard showed variation from 269.67 to 310.73 with a mean value of 296.20 kg ha^{-1} while for Lanja (II) it ranged from 235.77 to 314.81 with an average of 277.79 kg ha^{-1}. At Lanja (I) the values for available potassium were slightly higher than Lanja (II). Available potassium varied between 235.77 and 314.81 with a mean value of 287.00 kg ha^{-1} for Lanja (I and II). From the data it was also evident that Lanja (I) had increasing trend of available potassium distribution with soil depth while no definite trend of available potassium with soil depth was observed for Lanja (II). (Table No.4.17 and Fig. No.4.10)

Available potassium (K_2O) status of different tahsils of Ratnagiri district:

Data on overall mean for available potassium status of different tahsils showed that for all tahsils available potassium ranged from 200.66 to 311.87 with a mean value 249.86 kg ha^{-1}. Similar findings were also reported by Revandkar (1990), Pawar (1993) and Gaidhani (2008) for lateritic soils of Konkan.

In case of profile samples the available potassium of all tahsils varied between 205.76 and 314.81 with an average value of 274.33 kg ha^{-1}. These results are in conformity with Shinde (2006) and Suryavanshi (2010) for lateritic soils of mango orchards of Konkan. For all the tahsils available potassium had no specific trend with soil depth while Lanja (I), Ratnagiri (I), Dapoli (IV) and Dapoli (I) locations were found as exceptions for this trend. These tasils showed an increasing trend with soil depth which might be due to increase in clay content and decrease in sand and organic carbon content with soil depth (Revandkar ,1990) or may be due to more weathering of mica, potash and feldspar in profile (Taware ,1983). However, irregular distribution of available potassium in soil profiles was also observed by Patil (1981), Pereira (1983) and Vaidya (1988) for lateritic soils of Konkan.

In general, all the surface and profile samples were categorised into ‘moderately high to very high’ in K_2O content indicated adequate amount of potassium content in all mango orchards which may be attributed to presence of higher quantity of potassium bearing minerals in the parent material (Bharambe *et al.*,1990). For Lanja (I and II) the available potassium content was found to be maximum while minimum at Ratnagiri (I and II) location for both surface and profile samples as compared to other locations.

4.2.4 Exchangeable calcium (Ca^{2+})

Dapoli (I and II)

Surface soil samples (0 to 15 cm):

The perusal of data presented in Table 4.18 and Fig.No.4.7 revealed that exchangeable Ca^{2+} of Dapoli (I) mango orchard ranged from 1.19 to 1.89 with an average value of 1.46 cmol (p^+) kg^{-1} while for Dapoli (II) it showed variation from 1.21 to 2.09 with a mean value of 1.59 cmol (p^+) kg^{-1}. In general, the exchangeable Ca^{2+} showed variation from 1.19 to 2.09 with a mean value of 1.53 cmol (p^+) kg^{-1} for Dapoli (I and II).

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The exchangeable Ca^{2+} of Dapoli (I) and Dapoli (II) varied from 1.36 to 1.90 with an average value of 1.55 cmol (p^+) kg^{-1} and 1.21 to 1.87 with an average value of 1.53 cmol (p^+) kg^{-1}, respectively. In general, the exchangeable Ca^{2+} for both the mango orchards ranged between 1.21 and 1.90 with an average value of 1.54 cmol (p^+) kg^{-1}. Exchangeable Ca^{2+} did not register a definite trend with soil depth for Dapoli (I) while it was found to be decreased in Dapoli (II).

Dapoli (III and IV)

Surface soil samples (0 to 15 cm):

The data presented in Table No. 4.18 revealed that 1.75 cmol (p^+) kg^{-1} was the average exchangeable Ca^{2+} with variation from 1.32 to 2.15 cmol (p^+) $kg^{-1}$for Dapoli (III) while for Dapoli (IV), 1.69 cmol (p^+) kg^{-1} was the mean value of exchangeable Ca^{2+} and it ranged from 1.34 to 2.00 cmol (p^+) kg^{-1}. However at Dapoli (III and IV- Wakawali) exchangeable Ca^{2+} showed variation from 1.32 to 2.15 with a mean value of 1.72 cmol (p^+) kg^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

1.06 to 1.80 cmol (p^+) kg^{-1} was the range of exchangeable Ca^{2+} and 1.46 cmol (p^+) kg^{-1} was the mean value of it for Dapoli (III) while for Dapoli (IV) it varied from 1.34 to 2.12 with an average value of 1.67 cmol (p+) kg^{-1} (Table No. 4.7 and Fig. No) Dapoli (IV) had slightly higher values of exchangeable Ca^{2+} than Dapoli (III). For both the soil profiles, exchangeable Ca^{2+} had a variation between 1.06 and 2.12 with an average value of 1.56 cmol (p^+) kg^{-1}. The data further revealed that there was a decreasing trend of exchangeable Ca^{2+} with) soil depth for Dapoli (III) mango orchard while no definite patteren of distribution of exchangeable Ca^{2+} was found in Dapoli (IV). (Table 4.18 and Fig.4.11).

Table 4.18 Available macronutrient (Exch. Ca^{2+}) status of mango orchards (cmol (p^+) kg^{-1}).

Mango orchard Soil depth (cm)	Exchangeable Calcium (Ca^{2+})				
	Dapoli (I and II)	Dapoli (III and IV)	Khed (I and II)	Ratnagiri (I and II)	Lanja (I and II)
Mango orchard I (0 to 15)	1.32	1.32	1.98	2.34	2.43
	1.19	1.87	1.23	2.32	2.12
	1.23	1.89	1.88	2.17	2.88
	1.89	1.43	1.23	2.65	2.56
	1.44	1.55	1.76	2.55	2.82
	1.56	1.89	1.5	2.43	2.45
	1.23	1.67	1.69	2.12	2.65
	1.89	2.15	1.92	1.89	2.34
	1.54	1.90	1.28	2.65	2.76

	1.34	1.87	1.88	2.13	2.55
Mean	**1.46**	**1.75**	**1.64**	**2.33**	**2.56**
Mango orchard II (0 to 15)	1.21	1.50	1.87	2.43	2.74
	1.66	1.77	2.12	2.31	2.87
	1.43	1.96	1.95	2.44	2.34
	2.08	1.34	1.60	2.09	2.71
	1.34	1.65	1.59	2.05	2.31
	1.21	2.00	1.90	2.11	2.39
	1.78	1.76	1.65	2.44	2.11
	2.09	1.80	1.34	2.38	2.32
	1.69	1.40	1.21	2.00	2.49
	1.43	1.73	2.23	2.17	2.30
Mean	**1.59**	**1.69**	**1.75**	**2.24**	**2.46**
Location mean	**1.53**	**1.72**	**1.70**	**2.29**	**2.51**
Profile(I)					
A	1.90	1.80	2.21	1.90	2.17
B	1.58	1.59	1.90	2.04	2.67
C	1.36	1.38	1.54	1.76	2.29
D	1.36	1.06	1.10	1.21	1.88
Mean	**1.55**	**1.46**	**1.69**	**1.73**	**2.25**
Profile (II)					
A	1.87	2.12	2.11	2.22	2.21
B	1.65	1.78	1.89	2.37	2.05
C	1.38	1.34	1.32	1.65	1.43
D	1.21	1.43	1.45	1.23	1.03
Mean	**1.53**	**1.67**	**1.69**	**1.87**	**1.68**
Profile mean	**1.54**	**1.56**	**1.24**	**1.80**	**1.97**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

Khed (I and II)

Surface soil samples (0 to 15 cm):

For Khed (I) and Khed (II) the exchangeable Ca^{2+} ranged from 1.23 to 1.98 with a mean value of 1.64 cmol (p^{+}) kg^{-1} and 1.21 to 2.23 with an average value of 1.75 cmol (p^{+}) kg^{-1}, respectively. At Khed (II) the exchangeable Ca^{2+} content was found to be slightly higher than Khed (I). An average exchangeable Ca^{2+} ranged from 1.21 to 2.23 with a mean value of 1.70 cmol (p^{+}) kg^{-1} for Khed (I) and (II).

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

As seen from Table No. 4.18 and Fig. No. 4.11 the exchangeable Ca^{2+} for Khed (I) varied from 1.10 to 2.21 with a mean value of 1.69 cmol (p^{+}) kg^{-1} while 1.69 cmol (p^{+}) kg^{-1} was an average value of exchangeable Ca^{2+} with range of 1.32 to 2.11 cmol (p^+) kg^{-1} for Khed (II). The data further showed that both Khed (I) and Khed (II) locations had similar values of exchangeable Ca^{2+}. For both the mango orchards it showed a range of 1.10 to 2.21 with an average value of 1.69 cmol (p^+) kg^{-1}. A decreasing trend of exchangeable Ca^{2+} with soil depth was seen in Khed (II) mango orchard while no specific trend of exchangeable Ca^{2+} was observed with soil depth for Khed (II).

Ratnagiri (I and II)

Surface soil samples (0 to 15 cm):

The exchangeable Ca^{2+} of Ratnagiri (I) and (II) mango orchards varied between 2.12 to 2.65 with an average value of 2.33 cmol (p^+) kg^{-1} and 2.00 to 2.44 with a mean value of 2.24 cmol (p^+) kg^{-1}, respectively. In general, for Ratnagiri
(I and II - Shirgaon) the exchangeable Ca^{2+} varied from 2.00 to 2.65 with a mean value of 2.29 cmol (p^+) kg^{-1}. (Table No.4.18 and Fig. No.4.7)

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

Data presented in Table No.4.18 and depicted in Fig.No.4.11 showed a range of 1.21 to 2.04 for the exchangeable Ca^{2+} with a mean value of 1.73 cmol (p^+) kg^{-1} at Ratnagiri (I) and 1.23 to 2.37 with an average value of 1.87 cmol (p^+) kg^{-1} for Ratnagiri (II). For Ratnagiri (II) mango orchard exchangeable Ca^{2+} was found to be slightly higher as compared to Ratnagiri (I). The exchangeable Ca^{2+} showed average variation of 1.21 to 2.37 with a mean value of 1.80 cmol (p^+) kg^{-1} at Ratnagiri (I and II - Shirgaon). However, no definite pattern of distribution of exchangeable Ca^{2+} was seen with soil depth for both the locations.

Lanja (I and II)

Surface soil samples (0 to 15 cm):

As seen from Table No. 4.18 and Fig. No. 4.7 the exchangeable Ca^{2+} of Lanja (I) and (II) ranged from 2.12 to 2.88 with an average value of 2.56 cmol (p^+) kg^{-1} and 2.11 to 2.87 with a mean value of 2.46 cmol (p^+) kg^{-1}, respectively. The exchangeable Ca^{2+} registered an average range of 2.11 to 2.88 with a mean value of 2.51 cmol (p^+) kg^{-1} for Lanja I and II.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The data (Table No. 4.18 and Fig. No.4.11) indicated that exchangeable Ca^{2+} for Lanja (I) and Lanja (II) mango orchards exhibited a variation in the range of 1.88 to 2.67 with a mean value of 2.25 cmol (p^+) kg^{-1} and 1.03 to 2.21 with an average value of 1.68 cmol (p^+) kg^{-1}, respectively. For Lanja (I and II) the exchangeable Ca^{2+} content was observed in the range of 1.03 to 2.67 with a mean value of 1.97 cmol (p^+) kg^{-1}. The exchangeable Ca^{2+} was observed to be decreased with soil depth for Lanja (II). However, there was no definite trend observed in Lanja (I) location.

Exchangeable calcium (Ca^{2+}) status of different tahsils of Ratnagiri district:

Data on overall mean for exchangeable calcium status of different tahsils when studied revealed that exchangeable calcium of surface samples of all tahsils showed a variation from 1.21 to 2.88 with an average value of 1.95 cmol (p^+) kg^{-1}. These results are in conformity with Yadav (1988), Chavan *et al.*, (1995) and Sankpal (2008).

For profile soil samples the exchangeable Ca^{2+} of all tahsils varied between 1.03 and 2.67 with a mean value of 1.71cmol (p^+) kg^{-1}. Similar findings were also observed by Shinde (2006) and Mahajan (2001) for lateritic soils of mango orchards of Konkan (MS). At Lanja (I), Ratnagiri (I) and (II), Khed (II), Dapoli (I) and (IV) locations exchangeable Ca^{2+} did not show any definite trend with soil depth. Similar trend was also noticed by Phonde (1987), Shah (1992), Yadav (1988), Salvi (1988) and Revandkar (1990) for lateritic soils of Konkan.

However, at Lanja (II), Khed (I), Dapoli (III) and (II) exchangeable calcium had a declining trend with soil depth. Similar distribution pattern was also reported by

Chavan *et al.*, (1995) Shinde (2006) and Mahajan (2001). In general, the low value of exchangeable Ca^{2+} in surface and profiles of lateritic soils might be attributed to high percolating nature and intensive leaching of the bases due to heavy precipitation (Mohapatra and Kibe, 1973).

In general, all the surface and profile samples were categorised under 'low' class as per the ratings given by Sankaram (1966) indicated poor status of exchangeable Ca^{2+} in all the mango orchards. Dapoli (I and II) location showed lowest values of exchangeable Mg^{2+} for surface and profile samples. However, Lanja (I and II) mango orchard showed maximum exchangeable Mg^{2+} content for both surface and profile samples than all other locations.

4.3.5 Exchangeable magnesium (Mg^{2+})

Dapoli (I and II)

Surface soil samples (0 to 15 cm):

The perusal of data presented in Table 4.19 and Fig.No.4.7 revealed that exchangeable Mg^{2+} of Dapoli (I) mango orchard ranged from 0.56 to 1.12 with an average value of 0.82 cmol (p^+) kg^{-1} while for Dapoli (II) it showed variation from 0.60 to 1.21 with a mean value of 0.83 cmol (p^+) kg-1. The data also revealed that Dapoli (II) location had slightly higher values for exchangeable Mg^{2+} than Dapoli (I). The exchangeable Mg^{2+} showed variation from 0.56 to 1.21 with a mean value of 0.82 cmol (p^+) kg^{-1} for Dapoli (I and II).

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The exchangeable Mg^{2+} of Dapoli (I) and Dapoli (II) varied from 0.73 to 0.94 with an average value of 0.81 cmol (p^+) kg^{-1} and 0.83 to 1.14 with an average value of 0.98 cmol (p^+) kg^{-1}, respectively. The data also revealed that Dapoli (II) location had slightly higher values for exchangeable Mg^{2+} than Dapoli (I). In general, the exchangeable Mg^{2+} for both the mango orchards ranged between 0.73 and 1.14 with an average value of 0.90 cmol (p^+) kg^{-1}. For both the soil profiles the exchangeable Mg^{2+} had shown a decreasing trend with soil depth.

Dapoli (III and IV)

Surface soil samples (0 to 15 cm):

The data presented in Table No. 4.19 and depicted in Fig. 4.7 revealed that 0.92 cmol (p^+) kg^{-1} was the average exchangeable Mg^{2+} with variation from 0.53 to 1.21 cmol (p^+) kg^{-1} for Dapoli (III) while for Dapoli (IV), 0.88 cmol (p^+) kg^{-1} was the mean value of exchangeable Mg^{2+} and it ranged from 0.50 to 1.34 cmol (p^+) kg^{-1}. In general, for Dapoli (III and IV- Wakawali) exchangeable Mg^{2+} showed variation from 0.50 to 1.34 with a mean value of 0.90 cmol (p^+) kg^{-1}.

Table 4.19 Available macronutrient (Exch. Mg^{2+})status of mango orchards(cmol (p^+) kg^{-1}).

Mango orchard Soil depth (cm)	Exchangeable Magnesium (Mg^{2+})				
	Dapoli (I and II)	Dapoli (III and IV)	Khed (I and II)	Ratnagiri (I and II)	Lanja (I and II)
Mango orchard I (0 to 15)	0.56	0.94	1.33	1.2	1.43
	0.67	0.53	1.21	1.55	1.60
	0.96	0.76	1.08	1.34	1.52
	0.78	1.17	1.22	1.21	1.25
	1.01	1.21	1.32	0.67	1.45
	1.12	1.09	1.21	0.55	1.48
	0.56	1.17	0.87	0.48	1.37
	0.87	1.06	0.65	1.11	1.22
	0.99	0.59	1.22	1.23	1.55
	0.65	0.66	1.54	1.45	1.47
Mean	**0.82**	**0.92**	**1.17**	**1.08**	**1.43**
Mango orchard II (0 to 15)	0.87	0.93	1.39	1.43	1.22
	0.60	0.69	1.23	1.51	1.33
	0.80	0.83	1.51	1.41	1.51
	0.77	0.81	1.19	1.01	1.49
	0.69	0.50	1.30	0.79	1.46
	0.92	0.67	1.29	0.88	1.29
	1.21	0.74	1.33	0.70	1.41
	0.79	1.11	1.21	0.67	1.55
	0.88	1.34	1.02	0.89	1.56
	0.79	1.21	1.28	0.95	1.26
Mean	**0.83**	**0.88**	**1.28**	**1.02**	**1.41**
Location mean	**0.82**	**0.90**	**1.23**	**1.05**	**1.42**

Profile(I)					
A	0.94	1.00	1.43	0.97	1.36
B	0.80	0.96	1.20	0.90	1.20
C	0.75	0.71	0.96	0.85	1.13
D	0.73	0.63	0.80	0.81	1.05
Mean	**0.81**	**0.83**	**1.10**	**0.88**	**1.19**
Profile (II)					
A	1.14	0.89	1.33	1.22	1.40
B	1.02	0.80	1.22	1.15	1.30
C	0.94	0.73	1.19	1.01	1.20
D	0.83	0.68	1.01	0.89	1.10
Mean	**0.98**	**0.78**	**1.19**	**1.07**	**1.25**
Profile mean	**0.90**	**0.81**	**1.17**	**0.98**	**1.22**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

0.63 to 1.00 cmol (p^+) kg^{-1} was the range of exchangeable Mg^{2+} and 0.83 cmol (p^+) kg^{-1} was the mean value of it for Dapoli (III) while for Dapoli (II) it varied from 0.68 to 0.89 with an average value of 0.78 cmol (p^+) kg^{-1}. For both the soil profiles, the exchangeable Mg^{2+} had a variation between 0.63 and 1.00 with an average value of 0.81 cmol (p^+) kg^{-1}. The data further revealed that the exchangeable Mg^{2+} was found to be decreased with soil depth for both the mango orchards. (Table 4.19 and Fig. 4.12)

Khed (I and II)

Surface soil samples (0 to 15 cm):

For Khed (I) and Khed (II) the exchangeable Mg^{2+} ranged from 0.65 to 1.54 with a mean value of 1.17 cmol (p^+) kg^{-1} and 1.02 to 1.51 with an average value of 1.28 cmol (p^+) kg^{-1}, respectively. Exchangeable Mg^{2+} ranged from 0.65 to 1.54 with a mean value of 1.23 cmol (p^+) kg^{-1} for Khed (I and II – Avashi) mango orchard.(Table No.4.19 and Fig.4.7)

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

As seen from Table No. 4.19 and Fig. No. 4.12 the exchangeable Mg^{2+} for Khed (I) varied from 0.80 to 1.43 with a mean value of 1.10 cmol (p^+) kg^{-1}

while 1.19 cmol (p^+) kg^{-1} was an average value of exchangeable Mg^{2+} with range of 1.01 to 1.33 cmol (p^+) kg^{-1} for Khed (II). The data further showed that Khed (II) location had slightly higher exchangeable Mg^{2+} than Khed (I). For both the mango orchards it showed a variation in the range of 0.80 to 1.43 with an average value of 1.19 cmol (p^+) kg^{-1}. A decreasing trend of exchangeable Mg^{2+} with soil depth was found for Khed (I) and Khed (II).

Ratnagiri (I and II)

Surface soil samples (0 to 15 cm):

The exchangeable Mg^{2+} of Ratnagiri (I) and (II) mango orchards varied between 0.48 to 1.55 with an average value of 1.08 cmol (p^+) kg^{-1} and 0.67 to 1.51 with a mean value of 1.02 cmol (p^+) kg^{-1}, respectively. In general, for Ratnagiri (I and II - Shirgaon) the exchangeable Mg^{2+} ranged from 0.48 to 1.55 with a mean value of 1.05 cmol (p^+) kg^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

Data presented in Table No. 4.19 and depicted in Fig.4.12 showed a range of 0.81 to 0.97 for the exchangeable Mg^{2+} with a mean value of 0.88 cmol (p^+) $kg^{-1}$for Ratnagiri (I) and 0.89 to 1.22 with an average value of 1.07 cmol (p^+) kg^{-1} for Ratnagiri (II). Exchangeable Mg^{2+} content was found to be higher in Ratnagiri (II) mango orchard as compared to Ratnagiri (I). At Ratnagiri (I and II - Shirgaon) the exchangeable Mg^{2+} showed a range of 0.81 to 1.22 with a mean value of 0.98 cmol (p^+) kg^{-1}. A decreasing distribution pattern of exchangeable Mg^{2+} was seen for both the locations in its distribution with soil depth.

Lanja (I and II)

Surface soil samples (0 to 15 cm):

As seen from Table No.4.19 and Fig. 4.7 the exchangeable Mg^{2+} of Lanja (I) and (II) ranged from 1.22 to 1.60 with an average value of 1.43 cmol (p^+) kg^{-1} and 1.22 to 1.56 with a mean value of 1.41 cmol (p^+) kg^{-1}, respectively. The exchangeable Mg^{2+} ranged from 1.22 to 1.60 with a mean value of 1.42 cmol (p^+) kg^{-1} for both Lanja (I and II) mango orchards.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The data (Table No. 4.19 and Fig. No.4.12) indicated that exchangeable Mg^{2+} for Lanja (I) and Lanja (II) mango orchards exhibited a variation in the range of 1.05 to 1.36 with a mean value of 1.19 cmol (p^+) kg^{-1} and 1.10 to 1.40 with an average value of 1.25 cmol (p^+) kg^{-1}, respectively while for Lanja (I and II) it ranged from 1.05 to 1.40 with a mean value of 1.22 cmol (p^+) kg^{-1}. In general, a decreasing trend of exchangeable Mg^{2+} was observed with soil depth for both Lanja (I) and Lanja (II) locations.

Exchangeable magnesium (Mg^{2+}) status of different tahsils of Ratnagiri district:

Data on overall mean for exchangeable Mg^{2+} status of different tahsils showed that the exchangeable Mg^{2+} of surface samples of all tahsils had a range of 0.48 to 1.60 with an average value of 1.08 cmol (p^+) kg^{-1}. These findings are in conformity with the findings of Chavan *et al.*, (1995) and Suryavanshi (2010) for lateritic soils of Konkan.

In case of profie soil samples the exchangeable magnesium varied from 0.63 to 1.43 with a mean value of 1.02 cmol (p^+) kg^{-1} and all the locations exchangeable Mg^{2+} showed a decreasing trend with soil depth. Similar results were reported by Tupe (1996), Mahajan (2001) and Shinde (2006). However, the low status of exchangeable Mg^{2+} in surface and profiles of lateritic soils may be due to leaching losses of magnesium as a result of percolative nature of the lateritic soils of the region (Raghupati and Bhargava, 1997) or might be attributed to loss of bases because of high precipitation in the region (Mahajan, 2001).

In general, all the surface and profile samples were categorised under ‘low’ class as per the ratings given by Sankaram (1966) indicating poor status of exchangeable Mg^{2+} in mango orchards. Dapoli (I and II) and Dapoli (III and IV) location showed lowest values of exchangeable Mg^{2+} for surface and profile samples, respectively. However, higher content of exchangeable Mg^{2+} was observed in both surface and profile samples of Lanja (I and II) mango orchard than all other locations.

4.3 Physico-chemical properties of mango orchards:

The soil samples were collected from Dapoli (I and II), Dapoli (III and IV -Wakawali), Khed (I and II - Avashi), Ratnagiri (I and II - Shirgaon) and Lanja (I and II) and various physical and chemical properties of these soil samples namely the mechanical composition (per cent sand, silt and clay), bulk density, particle density, maximum water holding capacity, pH, EC and organic carbon had been determined at various soil depths viz. 0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm and presented in Table Nos. 4.20, 4.21, 4.22, 4.23 and 4.24 and graphically depicted in Figure No. 4.13 to 4.21.

4.3.1 Mechanical composition:

Percent sand, silt and clay content

Dapoli (I and II)

Surface soil samples (0 to 15 cm):

The data presented in Table No. 4.20 and graphically illustrated in Fig.4.13 when studied, revealed that the sand, silt and clay content of Dapoli (I) ranged from 35.16 to 63.65 with a mean value of 51.59 per cent, 11.30 to 20.44 with mean value of 15.49 per cent and 22.68 to 44.40 with a mean value of 33.89 per cent, respectively while for Dapoli (II), the sand, silt and clay content varied between 44.80 to 66.55 with an average value of 53.67 per cent, 11.10 to 22.55 with an average value of 16.48 per cent and 22.35 to 41.54 with an average value of 29.96 per cent, respectively. The mechanical composition of Dapoli (I) and Dapoli (II) indicated sandy clay loam textural class. The data further indicated that the Dapoli (II) location showed slightly higher sand and silt content however slightly lower in clay content than Dapoli (I). Whereas, for Dapoli (I) and (II) the sand, silt and clay content varied from 35.16 to 66.55 with an overall average value of 52.63 per cent,

Table 4.20 Physico-chemical properties of soils from mango orchards.

Mango orchard Soil depth (cm)	Mechanical Composition			Textural class	MWHC %	B.D.	P.D.	pH	E.C. dS m^{-1}	O.C. g kg^{-1}
	Sand	Silt	Clay			Mg m^{-3}				
	%									
Dapoli (I) (0 to 15)	50.52	12.40	37.08	SCL	58.76	1.29	2.24	4.35	0.034	12.34
	48.56	16.56	34.88	SCL	54.90	1.35	2.29	4.67	0.045	13.53
	55.30	18.77	35.53	SCL	61.23	1.18	2.30	4.53	0.055	14.40
	45.66	15.80	38.54	SCL	66.70	1.23	2.27	4.40	0.022	14.38
	60.09	11.30	28.61	SCL	53.56	1.37	2.21	4.42	0.058	13.92
	49.60	19.60	30.80	SCL	49.34	1.15	2.19	4.50	0.065	12.34
	55.44	11.76	32.80	SCL	51.12	1.26	2.44	4.89	0.076	16.67
	63.65	13.67	22.68	SCL	59.09	1.12	2.32	4.90	0.034	11.02
	51.89	14.55	33.56	SCL	69.43	1.19	2.38	4.34	0.048	12.19
	35.16	20.44	44.40	SC	62.55	1.32	2.43	4.27	0.046	12.00
Mean	**51.59**	**15.49**	**33.89**	**SCL**	**58.67**	**1.25**	**2.31**	**4.53**	**0.048**	**13.28**
Dapoli (II) (0 to 15)	46.57	21.43	32.00	SCL	66.54	1.24	2.34	4.67	0.056	13.88
	56.40	11.34	32.26	SCL	61.45	1.21	2.23	5.12	0.034	13.93
	62.20	12.23	25.57	SCL	58.78	1.24	2.34	5.34	0.098	14.95
	52.44	21.34	26.22	SCL	59.76	1.32	2.30	4.56	0.056	15.22
	66.55	11.10	22.35	SCL	55.69	1.11	2.39	4.89	0.045	16.67
	49.90	15.56	34.54	SCL	54.45	1.17	2.27	4.43	0.056	13.90
	54.70	13.66	31.64	SCL	65.78	1.37	2.24	4.20	0.067	12.38
	55.60	22.55	22.85	SCL	59.23	1.28	2.31	4.97	0.028	16.01
	47.50	21.88	30.62	SCL	51.34	1.13	2.38	5.43	0.034	17.09
	44.80	13.66	41.54	SCL	57.67	1.23	2.44	5.34	0.037	17.33
Mean	**53.67**	**16.48**	**29.96**	**SCL**	**59.07**	**1.23**	**2.32**	**4.90**	**0.051**	**15.14**
Location mean	**52.63**	**15.98**	**31.92**	**SCL**	**58.87**	**1.24**	**2.32**	**4.71**	**0.050**	**14.21**
Profile (I)										
A	50.06	19.55	30.39	SCL	48.76	1.36	2.32	4.87	0.056	16.69
B	46.70	17.55	35.75	SCL	56.70	1.20	2.55	4.99	0.068	12.22
C	44.10	15.66	40.24	SC	61.80	1.21	2.32	5.43	0.061	10.36
D	40.77	14.60	44.63	SC	64.43	1.25	2.43	5.70	0.078	08.97
Mean	**45.41**	**16.84**	**37.75**	**SC**	**57.92**	**1.26**	**2.41**	**5.25**	**0.066**	**12.06**
Profile (II)										
A	54.30	19.20	26.50	SCL	58.67	1.31	2.49	4.67	0.023	14.35
B	50.50	15.00	34.50	SCL	62.23	1.22	2.43	4.98	0.034	12.22
C	43.40	12.00	44.60	SC	64.37	1.26	2.23	5.30	0.055	08.99
D	38.67	15.30	46.03	CL	69.88	1.23	2.29	5.66	0.048	08.12
Mean	**46.72**	**15.38**	**37.91**	**SC**	**63.79**	**1.26**	**2.36**	**5.15**	**0.040**	**10.92**
Profile mean	**45.93**	**16.25**	**37.81**	**SC**	**60.27**	**1.26**	**2.39**	**5.21**	**0.055**	**11.49**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

Table No. 4.21 Physico-chemical properties of soils from mango orchards.

Mango orchard Soil depth (cm)	Mechanical Composition			Textural class	MWHC %	B.D.	P.D.	pH	E.C. dS m^{-1}	O.C. gkg^{-1}
	Sand	Silt	Clay			Mg m^{-3}				
	(%)									
Dapoli (III) (0 to 15)	41.35	20.56	38.09	SC	61.23	1.28	2.26	4.44	0.069	17.61
	45.30	22.44	32.26	SCL	55.76	1.33	2.48	4.32	0.044	16.04
	50.34	16.58	33.08	SCL	58.70	1.31	2.38	4.10	0.038	15.43
	52.29	12.65	35.06	SCL	64.34	1.27	2.33	4.56	0.066	13.38
	43.37	18.55	38.08	SCL	57.56	1.24	2.43	5.46	0.059	12.02
	45.20	23.50	31.30	SCL	54.34	1.21	2.18	5.32	0.059	16.54
	59.44	14.40	26.16	SCL	59.00	1.19	2.27	4.23	0.054	15.52
	42.50	22.12	35.38	SCL	49.80	1.29	2.44	4.67	0.048	13.83
	57.60	16.10	26.30	SCL	55.78	1.20	2.49	4.99	0.059	14.96
	54.80	13.20	32.00	SCL	56.09	1.12	2.48	4.56	0.064	17.67
Mean	**49.22**	**18.01**	**32.77**	**SCL**	**57.26**	**1.24**	**2.37**	**4.67**	**0.056**	**15.30**
Dapoli (IV) (0 to 15)	55.79	19.55	24.66	SCL	60.87	1.32	2.43	4.87	0.063	14.04
	57.87	13.50	28.63	SCL	55.89	1.13	2.39	4.32	0.047	13.96
	48.98	18.20	32.82	SCL	53.56	1.26	2.53	4.77	0.034	15.04
	41.67	23.20	35.13	SC	48.78	1.16	2.32	4.65	0.028	16.02
	43.78	16.20	40.02	SC	57.89	1.19	2.37	4.66	0.055	14.90
	44.65	20.20	35.13	SCL	56.43	1.23	2.22	4.98	0.047	16.90
	39.57	18.60	41.83	SC	67.12	1.35	2.29	5.12	0.067	16.77
	41.30	20.55	38.05	SCL	61.55	1.23	2.27	5.23	0.041	15.40
	46.78	19.65	33.57	SCL	54.98	1.29	2.43	5.43	0.038	15.54
	45.80	16.20	35.30	SCL	53.77	1.27	2.33	5.12	0.048	14.83
Mean	**46.62**	**18.59**	**34.51**	**SCL**	**57.08**	**1.24**	**2.36**	**4.92**	**0.047**	**15.34**
Location mean	**47.92**	**18.30**	**33.64**	**SCL**	**57.17**	**1.24**	**2.37**	**4.79**	**0.051**	**15.32**
Profile (I)										
A	49.80	19.20	31.00	SCL	51.34	1.25	2.51	4.45	0.059	14.55
B	45.87	15.22	38.99	SC	59.76	1.18	2.24	4.69	0.068	13.03
C	47.60	11.15	41.43	SCL	60.69	1.14	2.18	5.60	0.039	11.52
D	41.30	12.55	46.15	CL	65.55	1.18	2.26	5.87	0.055	09.20
Mean	**46.14**	**14.53**	**39.39**	**SC**	**59.34**	**1.19**	**2.30**	**5.15**	**0.055**	**12.08**
Profile (II)										
A	49.56	20.45	29.99	SCL	61.25	1.18	2.26	4.55	0.039	17.76
B	46.90	18.80	34.30	SCL	63.88	1.19	2.36	4.67	0.045	17.62
C	42.90	17.78	39.32	SCL	67.99	1.22	2.39	5.00	0.049	15.48
D	39.65	19.25	41.10	SC	69.77	1.23	2.25	5.45	0.061	16.52
Mean	**44.75**	**19.07**	**36.18**	**SC**	**65.72**	**1.21**	**2.32**	**4.92**	**0.049**	**16.85**
Profile mean	**45.45**	**16.80**	**37.79**	**SC**	**62.53**	**1.20**	**2.31**	**5.04**	**0.052**	**14.47**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

Table 4.22 Physico-chemical properties of soils from mango orchards.

Mango orchard Soil depth (cm)	Mechanical Composition			Textural class	MWHC %	B.D.	P.D.	pH	E.C. dS m^{-1}	O.C. g kg^{-1}
	Sand	Silt	Clay			Mg m^{-3}				
	%									
Khed (I) (0 to 15)	60.56	15.13	24.41	SCL	56.87	1.29	2.22	4.20	0.028	14.92
	55.30	17.65	27.05	SCL	48.66	1.26	2.27	4.59	0.049	14.23
	49.78	15.60	34.62	SCL	51.23	1.34	2.29	4.60	0.037	13.95
	54.40	14.43	31.17	SCL	53.55	1.32	2.20	4.91	0.067	16.61
	44.10	18.76	37.14	SC	59.67	1.24	2.44	4.23	0.056	17.80
	45.76	14.60	39.64	SC	58.78	1.21	2.40	4.32	0.054	14.76
	43.89	13.66	42.45	SC	56.78	1.20	2.53	4.51	0.045	14.93
	50.67	17.88	31.45	SCL	50.34	1.21	2.33	4.23	0.063	15.89
	45.40	20.65	33.95	SCL	60.66	1.29	2.56	4.46	0.048	15.61
	50.10	23.66	26.34	SCL	63.44	1.22	2.57	4.96	0.055	16.08
Mean	**50.00**	**17.20**	**32.82**	**SCL**	**56.00**	**1.26**	**2.38**	**4.50**	**0.050**	**15.48**
Khed (II) (0 to 15)	49.60	16.77	33.36	SCL	62.44	1.35	2.49	4.87	0.045	16.28
	44.76	15.50	39.74	SC	54.69	1.23	2.39	4.86	0.059	15.89
	50.67	14.76	34.57	SC	58.70	1.18	2.28	4.57	0.057	14.81
	52.39	14.33	33.28	SC	58.80	1.15	2.26	4.43	0.034	14.83
	50.30	20.30	29.40	SCL	56.90	1.19	2.55	4.42	0.051	16.57
	46.90	13.90	39.20	SC	59.12	1.32	2.54	4.77	0.037	13.96
	41.30	22.14	36.56	SC	58.23	1.36	2.34	5.40	0.054	12.94
	44.44	14.12	41.44	SC	60.23	1.13	2.59	5.23	0.044	12.03
	45.40	19.80	34.80	SC	60.45	1.12	2.48	4.55	0.037	17.79
	51.30	18.56	30.16	SCL	49.90	1.19	2.43	5.16	0.048	14.38
Mean	**47.71**	**17.02**	**35.25**	**SCL**	**57.95**	**1.22**	**2.44**	**4.83**	**0.047**	**14.95**
Location mean	**48.86**	**17.11**	**34.04**	**SCL**	**56.98**	**1.24**	**2.41**	**4.67**	**0.049**	**15.22**
Profile (I)										
A	49.70	16.58	33.72	SCL	48.67	1.23	2.29	5.33	0.064	16.87
B	47.60	15.47	36.93	SCL	56.90	1.20	2.28	5.33	0.057	15.56
C	48.21	13.68	38.11	SCL	60.34	1.33	2.49	5.67	0.027	10.94
D	38.90	16.40	44.70	CL	66.66	1.23	2.48	5.67	0.033	07.92
Mean	**46.10**	**15.53**	**38.37**	**SCL**	**58.14**	**1.25**	**2.39**	**5.50**	**0.045**	**12.82**
Profile (II)										
A	52.44	18.22	29.34	SCL	58.79	1.27	2.56	4.77	0.048	13.05
B	48.98	15.87	35.15	SCL	60.67	1.21	2.43	4.94	0.049	14.58
C	43.43	11.16	45.41	SC	65.45	1.32	2.59	5.48	0.055	10.20
D	39.60	14.90	45.41	SC	64.23	1.18	2.63	5.70	0.059	06.54
Mean	**46.11**	**15.04**	**38.83**	**SC**	**62.29**	**1.25**	**2.55**	**5.22**	**0.050**	**11.09**
Profile mean	**46.11**	**15.29**	**38.60**	**SC**	**60.22**	**1.25**	**2.47**	**5.36**	**0.048**	**11.96**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

Table 4.23 Physico-chemical properties of soils from mango orchards.

Mango orchard Soil depth (cm)	Mechanical Composition			Textural class	MWHC	B.D.	P.D.	pH	E.C.	O.C.
	Sand	Silt	Clay			Mg m^{-3}			dS m^{-1}	g kg^{-1}
	%				%					
Ratnagiri (I) (0 to 15)	55.66	20.12	24.22	SCL	59.08	1.22	2.33	4.12	0.066	14.43
	50.80	19.76	30.16	SCL	58.78	1.26	2.28	4.44	0.052	17.35
	60.76	23.40	25.84	SCL	66.78	1.23	2.27	4.12	0.059	13.36
	66.90	15.87	17.23	SCL	61.23	1.27	2.39	4.89	0.047	15.62
	61.30	21.87	16.83	SCL	56.78	1.38	2.34	4.54	0.048	16.56
	65.50	16.98	17.52	SCL	49.00	1.28	2.31	4.89	0.052	13.74
	62.44	16.40	21.16	SCL	65.78	1.32	2.43	4.19	0.031	14.28
	61.55	16.70	21.75	SCL	64.56	1.30	2.36	5.23	0.071	14.96
	53.87	22.10	24.09	SCL	59.34	1.21	2.32	5.22	0.041	13.92
	56.90	20.76	22.34	SCL	59.70	1.12	2.67	4.25	0.055	15.89
Mean	**59.57**	**19.40**	**22.11**	**SCL**	**60.10**	**1.26**	**2.37**	**4.59**	**0.052**	**15.01**
Ratnagiri (II) (0 to 15)	54.67	15.97	29.36	SCL	54.56	1.14	2.44	5.10	0.067	16.72
	55.90	18.66	25.44	SCL	51.23	1.29	2.40	5.18	0.049	16.15
	58.76	20.68	20.56	SCL	53.56	1.28	2.49	4.88	0.059	15.38
	51.30	21.89	26.81	SCL	59.77	1.20	2.52	5.22	0.045	15.40
	56.76	24.59	18.65	SCL	60.45	1.31	2.41	5.27	0.033	15.52
	49.67	23.76	26.57	SCL	56.89	1.33	2.39	4.79	0.049	15.13
	56.80	14.32	28.88	SCL	60.99	1.17	2.35	4.38	0.027	13.44
	53.70	18.65	27.65	SCL	65.45	1.18	2.37	4.90	0.036	13.66
	58.76	20.90	20.33	SCL	47.68	1.26	2.28	4.87	0.056	12.84
	50.55	17.70	31.75	SCL	50.88	1.29	2.45	4.66	0.072	18.18
Mean	**54.69**	**19.71**	**25.60**	**SCL**	**56.15**	**1.25**	**2.41**	**4.93**	**0.049**	**15.24**
Location mean	**57.13**	**19.56**	**23.86**	**SCL**	**58.13**	**1.26**	**2.39**	**4.76**	**0.051**	**15.13**
Profile (I)										
A	51.90	19.50	28.60	SCL	53.55	1.25	2.48	4.41	0.038	14.94
B	52.65	14.71	32.64	SCL	54.45	1.18	2.56	4.49	0.048	16.66
C	49.88	15.20	34.92	SCL	58.77	1.10	2.24	4.99	0.059	08.80
D	49.88	11.54	38.58	SC	63.89	1.23	2.18	5.19	0.053	08.80
Mean	**51.08**	**15.24**	**33.69**	**SCL**	**57.67**	**1.19**	**2.37**	**4.77**	**0.050**	**12.30**
Profile (II)										
A	56.60	20.78	22.62	SCL	58.80	1.26	2.20	4.23	0.066	16.73
B	51.66	23.60	24.74	SCL	64.78	1.20	2.47	4.90	0.038	12.10
C	48.70	22.23	29.07	SCL	60.60	1.30	2.59	5.12	0.051	09.83
D	44.66	28.24	27.10	SCL	65.70	1.32	2.61	5.12	0.036	05.96
Mean	**50.41**	**23.71**	**25.88**	**SCL**	**62.47**	**1.27**	**2.47**	**4.84**	**0.048**	**11.16**
Profile mean	**50.75**	**19.48**	**29.79**	**SCL**	**60.07**	**1.23**	**2.42**	**4.81**	**0.049**	**11.73**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

Table No. 4.24 Physico-chemical properties of soils from mango orchards.

Mango orchard Soil depth (cm)	Mechanical Composition			Textural class	MWHC %	B.D.	P.D.	pH	E.C. dS m^{-1}	O.C. g kg^{-1}
	Sand	Silt	Clay			Mg m^{-3}				
	%									
Lanja (I) (0 to 15)	50.70	17.40	31.90	SCL	59.22	1.28	2.26	4.28	0.061	15.53
	55.90	13.65	30.45	SCL	60.78	1.27	2.29	4.60	0.064	13.24
	54.77	11.45	33.80	SCL	66.54	1.28	2.26	4.51	0.069	16.66
	58.79	14.20	27.01	SCL	56.67	1.23	2.16	4.26	0.049	12.92
	60.00	10.55	29.45	SCL	63.20	1.24	2.38	4.90	0.072	15.28
	52.80	12.36	34.84	SCL	65.45	1.28	2.40	4.88	0.051	14.02
	46.90	16.52	36.58	SCL	61.23	1.19	2.39	4.76	0.044	14.80
	61.34	10.12	28.54	SCL	59.00	1.35	2.25	4.69	0.038	15.45
	54.34	19.70	25.96	SCL	55.43	1.28	2.27	4.52	0.059	15.02
	51.88	12.23	35.89	SCL	58.66	1.29	2.38	5.12	0.061	12.07
Mean	**54.74**	**13.82**	**31.44**	**SCL**	**60.62**	**1.27**	**2.30**	**4.65**	**0.057**	**14.50**
Lanja (II) (0 to 15)	53.36	17.55	29.09	SCL	60.44	1.23	2.48	5.10	0.064	17.67
	52.45	20.68	26.87	SCL	57.66	1.26	2.52	4.33	0.061	14.50
	55.80	14.34	29.86	SCL	56.90	1.24	2.40	4.44	0.049	16.62
	60.45	16.70	27.01	SCL	60.67	1.25	2.57	4.58	0.058	14.93
	52.55	12.54	34.91	SCL	60.45	1.20	2.54	4.66	0.057	15.55
	54.67	20.76	24.28	SCL	61.36	1.16	2.48	4.69	0.049	13.06
	53.78	13.87	32.35	SCL	58.67	1.33	2.37	4.88	0.063	17.62
	51.60	21.66	26.74	SCL	59.90	1.32	2.32	4.30	0.051	16.68
	59.78	15.60	24.62	SCL	61.34	1.12	2.22	4.56	0.054	14.51
	50.66	12.90	31.44	SCL	62.34	1.25	2.56	5.13	0.063	16.63
Mean	**54.51**	**16.66**	**28.72**	**SCL**	**59.97**	**1.24**	**2.45**	**4.67**	**0.057**	**15.78**
Location mean	**54.63**	**15.24**	**30.08**	**SCL**	**60.30**	**1.26**	**2.38**	**4.66**	**0.057**	**15.14**
Profile (I)										
A	53.36	11.52	35.12	SCL	59.05	1.25	2.28	4.67	0.027	14.52
B	51.88	12.56	35.56	SCL	60.88	1.18	2.54	5.19	0.047	13.43
C	54.67	11.77	33.56	SCL	62.44	1.10	2.39	5.66	0.034	13.97
D	41.65	10.50	47.85	CL	68.78	1.23	2.36	5.66	0.044	10.95
Mean	**50.39**	**11.59**	**38.02**	**SC**	**62.79**	**1.19**	**2.39**	**5.30**	**0.038**	**13.22**
Profile (II)										
A	54.46	13.32	32.22	SCL	58.70	1.19	2.45	4.54	0.058	16.02
B	47.89	11.56	40.55	SC	65.46	1.32	2.42	4.97	0.054	15.09
C	43.67	11.56	44.77	SC	65.46	1.22	2.21	5.13	0.056	14.46
D	40.80	13.44	45.76	CL	68.90	1.24	2.30	5.44	0.072	10.57
Mean	**46.71**	**12.47**	**40.83**	**SC**	**64.63**	**1.24**	**2.35**	**5.02**	**0.060**	**14.04**
Profile mean	**48.55**	**12.03**	**39.43**	**SC**	**63.71**	**1.22**	**2.37**	**5.16**	**0.049**	**13.63**

A -0 to 15, B-15 to 30, C-30 to 45, D-45 to 60 cm

11.10 to 22.55 with an average value of 15.98 per cent and 22.35 to 44.40 with an average value of 31.92 per cent, respectively. Sandy clay loam textural class was common for both the locations.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

For Dapoli (I) mango orchard the per cent sand content varied from 40.77 to 50.06 with a mean value of 45.41 while the silt content showed a mean value of 16.84 per cent and it ranged between 14.60 and 19.55 per cent whereas the clay content showed variation from 30.39 to 44.63 with an average value of 37.75 per cent. Similarly, for Dapoli (II), the sand, slit and clay content ranged from 38.67 to 54.30 with a mean value of 46.72 per cent, 12.00 to 19.20 with average value of 15.38 per cent and 26.50 to 46.03 with mean value of 37.91 per cent, respectively. The Dapoli (II) showed slightly higher sand, clay content and lower silt content than that of Dapoli (I). For both the locations the textural class was sandy clay. In general, the sand, silt and clay content of Dapoli (I) and (II) showed a variation of 38.67 to 54.30 with an overall mean value of 45.93 per cent, 12.00 to 19.55 with mean value of 16.25 per cent and 26.50 to 46.03 with an average value of 37.81 per cent, respectively. Sandy clay was textural class for both the locations. For both the soil profiles per cent sand content decreased with soil depth, while clay content increased with soil depth. Silt content decreased with depth at Dapoli (I) however, silt content showed no definite trend at Dapoli (II). (Table 4.20 and Fig.4.14 (a)).

Dapoli (III and IV)

Surface soil samples (0 to 15 cm):

Data on mechanical composition (Table No. 4.21 and Fig.4.13) showed that 41.35 to 59.44 was per cent sand content and 49.22 per cent was the mean value for Dapoli (III) while silt content showed variation in the range of 12.65 to 23.50 with an average value of 18.01 per cent. Similarly, average clay was 32.77 per cent and it ranged between 26.16 to 38.09 per cent for Dapoli (III) while for Dapoli (IV), the sand, silt and clay content ranged between 39.57 and 57.87 with a mean value of 46.62 per cent, 13.50 and 23.20 with a mean value of 18.59 per cent and from 24.66 to 41.83 with a mean value of 34.51 per cent, respectively. The textural class for both the locations was found to be sandy clay loam. The data also showed that the Dapoli (III) location had slightly higher sand content while slightly lower in clay and silt content when compared with Dapoli (IV). However, for Dapoli (III and IV - Wakawali), the sand content showed variation from 39.57 to 59.44 with an overall mean value of 47.92 per cent while silt and clay content ranged between 12.65 to 23.50 with an average value of 18.30 per cent and 24.66 to 41.83 with a mean value of 33.64 per cent, respectively. Mechanical composition of both the locations indicated sandy clay loam textural class.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The sand, silt and clay content of Dapoli (III) exhibited a variation in the range of 41.30 to 49.80 with a mean value of 46.14 per cent, 11.15 to 19.20 with a mean value of 14.53 per cent and 31.00 to 46.15 with an average value of 39.39 per cent, respectively. Similarly, Dapoli (IV) mango orchard showed a variation between 39.65 to 49.56 with a mean value of 44.75 per cent for sand, 17.78 to 20.45 with a mean value of 19.07 per cent for slit and 29.99 to 41.10 with a mean value of 36.18 per cent clay content. The Dapoli (III) showed slightly higher sand and clay content but found slightly lower in silt content than that of Dapoli (IV). For both the locations the textural class was observed as sandy clay. In general, the sand, silt and clay content of Dapoli (III and IV - Wakawali) showed a range of 39.65 to 49.80 with an overall mean value of 45.45 per cent, 11.15 to 20.45 with mean value of 16.80 per cent and 29.99 to 46.15 with an average value of 37.79 per cent, respectively. Sandy clay textural class was dominant in both the mango orchards. For both the soil profiles per cent silt content did not show any definite trend with soil depth while clay content increased with soil depth. In case of sand content at profile (IV) it decreased with soil depth with exception of profile (III). (Table No. 4.21 and Fig. No.4.14 (a))

Khed (I and II)

Surface soil samples (0 to 15 cm):

The data presented in Table No. 4.22 revealed that the sand content ranged from 43.89 to 60.56 with a mean value of 50.00 per cent while silt content showed a variation from 13.66 to 23.66 with mean value of 17.20 whereas clay content varied from 24.41 to 42.45 with an average value of 32.82 per cent, for Khed (I). For Khed (II) mango orchard per cent sand was 41.30 to 52.39 with a mean value of 47.71 while silt content ranged from 13.90 to 22.14 with an average value of 17.02 per cent and clay content showed variation from 29.40 to 41.44 with a mean value of 35.25 per cent. The textural class for both the locations was found to be sandy clay loam. From the data it was also evident that Khed (I) location showed slightly higher sand and silt content while slightly lower in clay content than Khed (II). For Khed (I and II - Avashi), the sand, silt and clay content varied from 41.30 to 60.56 with an overall mean value of 48.86 per cent, 13.66 to 23.66 with an average value of 17.11 per cent and 24.41 to 42.45 with an average value of 34.04 per cent, respectively. Textural class of both the locations was found as sandy clay loam.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The sand, silt and clay content of Khed (I) showed variation in the range of 38.90 to 49.70 with a mean value of 46.10 per cent, 13.68 to 16.58 with a mean value of 15.53 per cent and 33.72 to 44.70 with an average value of 38.37 per cent, respectively. For Khed (II), the sand, slit and clay content ranged from 39.60 to 52.44 with a mean value of 46.11 per cent, 11.16 to 18.22 with a mean value of 15.04 per cent and 29.34 to 45.41 with mean value of 38.83 per cent, respectively. The Khed (II) location was lower in silt content than Khed (I). For Khed (I) the textural class was sandy clay loam however for Khed (II) it was sandy clay. In general, the sand content of Khed (I and II - Avashi) showed a variation of 38.90 to 49.70 with an overall mean value of 46.11 per cent, the silt content ranged from 11.16 to 18.22 with mean value of 15.29 per cent and clay varied from 29.34 to 45.41 with an average value of 38.60 per cent with sandy clay textural class. The per cent sand and silt content showed no definite trend with soil depth while clay content increased with depth for Khed (I). For Khed (II) silt and clay content showed no definite trend with soil depth while sand content decreased with depth.

Ratnagiri (I and II)

Surface soil samples (0 to 15 cm):

Data on mechanical composition presented in Table No. 4.23 and depicted in Fig. 4.13 showed that the sand content of Ratnagiri (I) varied from 53.87 to 66.90 with a mean value of 59.57 per cent, the silt content had a range of 15.87 to 22.10 with mean value of 19.40 per cent while clay content was 16.83 to 30.16 with a mean value of 22.11 per cent. Similarly, Ratnagiri (II) mango orchard showed a variation between 49.67 and 58.76 with a mean value of 54.69 per cent for sand, 14.32 to 24.59 with a mean value of 19.71 per cent for silt and 18.65 to 31.75 with a mean value of 25.60 per cent for clay content. Sandy clay loam was the textural class for Ratnagiri (I) and Ratnagiri (II). The data further revealed that the Ratnagiri (I) location had slightly higher sand content while slightly lower in clay and silt content than Ratnagiri (II). However, for Ratnagiri (I and II - Shirgaon), the sand, silt and clay content showed variation from 49.67 to 66.90 with an overall mean value of 57.13 per cent, 14.32 to 24.59 with an average value of 19.56 per cent and 16.83 to 31.75 with an average value of 23.86 per cent, respectively. Mechanical composition of both the locations showed sandy clay loam textural class.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The data revealed that the sand content ranged from 49.88 to 52.65 with a mean value of 51.08 per cent, the silt content varied from 11.54 to 19.50 with a mean value of 15.24 per cent whereas clay content showed a variation from 28.60 to 38.58 with an average value of 33.69 per cent, for Ratnagiri (I). Ratnagiri (II) mango orchard showed variation between 44.66 to 56.60 with a mean value of 50.41 per cent for sand, 20.78 to 28.24 with a mean value of 23.71 per cent for silt and 22.62 to 29.07 with an average value of 25.88 per cent for clay. The Ratnagiri (I) showed slightly higher sand and clay content while it was lower in silt content as compared to Ratnagiri (II). The mechanical composition for both the locations indicated sandy clay loam textural class. In general, the sand, silt and clay content of Ratnagiri (I and II - Shirgaon) had a variation of 44.66 to 56.60 with an overall mean value of 50.75 per cent, 11.54 to 28.24 with mean value of 19.48 per cent and 22.62 to 38.58 with an average value of 29.79 per cent, respectively. Sandy clay loam textural class was common for Ratnagiri (I) and Ratnagiri (II). For both the soil profiles per cent silt content did not show any definite trend with soil depth. In case of profile (I) sand content showed no definite trend while clay content increased with soil depth. At profile (II) clay content showed no definite trend while sand content decreased with soil depth (Table No. 4.23 and Fig. No.4.14 (b)).

Lanja (I and II)

Surface soil samples (0 to 15 cm):

The data presented in Table No. 4.24 revealed that the 54.74 per cent was the average sand content with variation from 46.90 to 61.34 per cent. 13.82 per cent was the mean value of silt and it ranged from 10.12 to 19.70 per cent and clay content varied from 25.96 to 36.58 with an average value of 31.44 per cent for Lanja (I). For Lanja (II), the sand, silt and clay content varied between 50.66 and 60.45 with a mean value of 54.51 per cent, 12.54 to 21.66 with a mean value of 16.66 per cent and 24.28 to 34.91 with a mean value of 28.72 per cent, respectively. Sandy clay loam textural class was dominant for both the mango orchards. From the data it was also evident that Lanja (I) location showed slightly higher sand and clay content and slightly lower slit content than Lanja (II). Further, the sand, silt and clay content ranged from 46.90 to 61.34 with an overall mean value of 54.63 per cent, 10.12 to 21.66 with an average value of 15.24 per cent and 24.28 to 36.58 with an average value of 30.08 per cent for Lanja (I and II), respectively. It was evident from the data that sandy clay loam was the textural class for both the locations.

Profile soil samples
(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The Lanja (I) mango orchard showed a variation from 41.65 to 54.67 with a mean value of 50.39 per cent for sand, 10.50 to 12.56 with a mean value of 11.59 per cent for silt and for clay content from 33.56 to 47.85 with an average value of 38.02 per cent. For Lanja (II), the sand showed variation from 40.80 to 54.46 with a mean value of 46.71 per cent, silt had a range from 11.56 to 13.44 with a mean value of 12.47 per cent while clay content ranged between 32.22 and 45.76 with a mean value of 40.83 per cent. The Lanja (I) location showed slightly higher sand content but found lower in clay and silt content than that of Lanja (II). For both the locations, the textural class was sandy clay. On an average, the sand, silt and clay content of Lanja (I and II) had a variation of 40.80 to 54.67 with an overall mean value of 48.55 per cent, 10.50 to 13.44 with mean value of 12.03 per cent and 32.22 to 47.85 with an average value of 39.43 per cent, respectively. Sandy clay textural class was common for both the mango orchards. For Lanja (I) the per cent sand, silt and clay showed no specific trend with soil depth while at Lanja (II) silt content showed no definite trend whereas clay content found to be increased however, the sand content decreased with soil depth.(Table 4.24 and Fig.4.14(b))

Mechanical composition of different tahsils of Ratnagiri district:

Data on overall mean for mechanical composition of different tahsils when studied revealed that sandy clay loam textural class was dominant for surface samples. In general, the sand, silt and clay content of all tahsils of surface samples ranged from 35.16 to 66.90 with a mean value of 52.23 per cent, 10.12 to 23.76 with an average value of 17.24 per cent and 16.83 to 44.40 with a mean of 30.71 per cent, respectively. Similar findings were reported by Mahajan (2001), Shinde (2006) and Suryavanshi (2010) for lateritic soil of mango orchards of Konkan (MS).

In case of profile samples, in general the dominant textural class for all tahsils was sandy clay with exception of Khed (I), Ratnagiri (I) and (II) mango orchards. The per cent sand varied between 38.90 and 56.60 with a mean value of 47.36, the silt content showed a variation from 10.50 to 28.24 with an average value of 15.97 per cent while clay content ranged from 22.62 to 47.85 with a mean value of 36.68 per cent. Similar results were observed by Diwale (1994), Sankpal (2008) and Suryavanshi (2010) for lateritic soils of Konkan. In general, for all the profiles the sand content showed a decreasing trend with soil depth with exception of Dapoli (III), Khed (I), Ratnagiri (I) and Lanja (I) locations. At these locations sand content showed no specific trend with soil depth. Similar trend was also observed by Patil (1986 b) for lateritic soils of Konkan. However, the higher sand content in the surface soil than in the profile may be due to less weathering of the parent material in upper surface of the soil (Sehgal, 1996). Especially, in the Konkan region decrease in sand content attributed to leaching of finer particles by surface run-off as a result of heavy rainfall. However, silt content did not show definite trend in its distribution with soil depth with an exception of Dapoli (I), whereas an increasing trend of clay content with soil depth was seen for all tahsils, while Lanja (I), Ratnagiri (II) and Khed (II) were found as exception for these findings. These results are in conformity with Patil *et al.* (2003), Shinde (2006) and Suryavanshi (2010). At Dapoli (I) a decresing trend of silt content with soil depth was observed. Similar trend was also noticed by Salvi (1988) for lateritic soils of Konkan while for Lanja (I), Ratnagiri (II) and Khed (II) locations clay content showed no specific trend. Similar findings were also reported by Vaidya (1988) and Yadav (1988). However, increase in the clay content with the soil depth might be due to translocation of clay fraction from the surface soil down to the profile (Subbaiah and Manickam, 1992).

In general, the sand and silt content was found to be highest at Ratnagiri (I and II) mango orchard for surface and profile samples while the higher clay content was observed at (Khed I and II) for surface samples and at Lanja (I and II) it was maximum for profile samples than all other remaining mango orchards. For surface as well as profile samples lowest sand, silt and clay content was observed at Dapoli (III and IV), Lanja (I and II) and Ratnagiri (I and II) locations, respectively as compared to other locations.

4.3.2 Bulk density

Dapoli (I and II)

Surface soil samples (0 to 15 cm):

The perusal of data presented in Table 4.20 and Fig.No.4.15 revealed that bulk density of Dapoli (I) mango orchard ranged from 1.12 to 1.37 with an average value of 1.25 Mg m^{-3} while for Dapoli (II) it showed variation from 1.11 to 1.37 with a mean value of 1.23 Mg m^{-3}. However, for Dapoli (I and II) the bulk density showed variation from 1.11 to 1.37 with a mean value of 1.24 Mg m^{-3}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The bulk density of Dapoli (I) and Dapoli (II) varied from 1.21 to 1.36 with an average value of 1.26 Mg m^{-3} and 1.22 to 1.31 with an average value of 1.26

Mg m^{-3}, respectively. Both these locations showed similar values for bulk density. In general, the bulk density for both the mango orchards ranged between 1.21 and 1.36 with an average value of 1.26 Mg m^{-3}. For both the soil profiles the bulk density did not register any definite pattern with soil depth.

Dapoli (III and IV)

Surface soil samples (0 to 15 cm):

The data presented in Table No. 4.21 revealed that 1.24 Mg m^{-3} was the average bulk density with variation from 1.12 to 1.33 Mg m^{-3} for Dapoli (III) while for Dapoli (IV) 1.24 Mg m^{-3} was the mean value of bulk density and it ranged from 1.13 to 1.35 Mg m^{-3}. From the data it was also evident that both the mango orchards had similar values for bulk density. However, for Dapoli (III and IV- Wakawali) bulk density showed variation from 1.12 to 1.35 with a mean value of 1.24 Mg m^{-3}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

For Dapoli (III) location bulk density varied between 1.14 and 1.25 with an average value of 1.19 Mg m^{-3} while for Dapoli (IV) it ranged from 1.18 to 1.23 with a mean value of 1.21 Mg m^{-3}. Dapoli (IV) location showed slightly higher values for bulk density when compared with Dapoli (III). However, bulk density for Dapoli (III and IV- Wakawali) showed variation from 1.14 to 1.25 with a mean value of 1.20 Mg m^{-3}. At Dapoli (III) mango orchard bulk density did not any definite trend with soil depth. However, bulk density was found to be increasing with soil depth for Dapoli (IV) mango orchard. (Table No. 4.22 and Fig. No.4.16 (a))

Khed (I and II)

Surface soil samples (0 to 15 cm):

For Khed (I) and Khed (II) the bulk density ranged from 1.20 to 1.34 with a mean value of 1.26 Mg m^{-3} and 1.12 to 1.36 with an average value of 1.22 Mg m^{-3}, respectively. At Khed (I) the bulk density was found to be slightly higher than that of Khed (II). In general, for Khed (I and II –Avashi) bulk density ranged from 1.12 to 1.36 with a mean value of 1.24 Mg m^{-3}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The data presented in Table No. 4.22 and graphically illustrated in Fig.No.4.16 (a) revealed that the bulk density varied from 1.20 to 1.33 with an average value of 1.25 Mg m^{-3} for Khed (I) and 1.18 to 1.32 with a mean value of 1.25 Mg m^{-3} for Khed (II). For both the locations similar values for bulk density were observed. The data further indicated that for Khed (I and II – Avashi) bulk density showed variation from 1.18 to 1.33 with a mean value of 1.25 Mg m^{-3}. However, no definite trend of bulk density was found at both the mango orchards.

Ratnagiri (I and II)

Surface soil samples (0 to 15 cm):

The bulk density of Ratnagiri (I) and (II) mango orchards varied between 1.12 and 1.38 with an average value of 1.26 Mg m^{-3} and 1.14 to 1.33 with a mean value of 1.25 Mg m^{-3}, respectively. The bulk density ranged from 1.12 to 1.38 with a mean value of 1.26 Mg m^{-3} for Ratnagiri (I and II- Shirgaon). (Table No.4.23 and Fig No. 4.15)

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

Data presented in Table No. 4.23 and depicted in Fig.4.16 (b) showed bulk density between 1.10 and 1.25 with a mean value of 1.19 Mg m^{-3} for Ratnagiri (I) and 1.20 to 1.32 with an average value of 1.27 Mg m^{-3} for Ratnagiri (II). For Ratnagiri (II) mango orchard bulk density was found higher when compared with Ratnagiri (I). In general, at Ratnagiri (I and II - Shirgaon) the bulk density showed a range of 1.10 to 1.32 with a mean value of 1.23 Mg m^{-3}.The bulk density did not register any specific distribution pattern with soil depth for both the mango orchards.

Lanja (I and II)

Surface soil samples (0 to 15 cm):

As seen from Table No. 4.24 and Fig.4.15 the bulk density of Lanja (I) and (II) ranged from 1.19 to 1.35 with an average value of 1.27 Mg m^{-3} and 1.12 to 1.33 with a mean value of 1.24 Mg m^{-3}, respectively. The data further revealed that Lanja (I) mango orchard had slightly higher bulk density than that of Lanja (II). However, for Lanja (I and II) the bulk density ranged from 1.12 to 1.35 with a mean value of 1.26 Mg m^{-3}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The bulk density of Lanja (I) mango orchard showed variation from 1.10 to 1.25 with a mean value of 1.19 Mg m^{-3} while for Lanja (II) it ranged from 1.22 to 1.32 with an average of 1.24 Mg m^{-3}. At Lanja (I) the average value for bulk density was slightly higher than Lanja (II). For Lanja (I and II) bulk density varied between 1.10 and 1.32 with a mean value of 1.22 Mg m^{-3}. From the data it was also evident that for both the profiles bulk density did not follow any specific pattern of distribution with soil depth. (Table No.4.24 and Fig. No.4.16 (b))

Bulk density of different tahsils of Ratnagiri district:

Data on overall mean for bulk density of different tahsils when studied revealed that the bulk density of surface soil samples of all tahsils varied from 1.11 to 1.38 with an average value of 1.25 Mg m^{-3}. Similar findings were also reported by Chavan *et al.*,(1995), Malvade (1993) and Mahajan (2001) for lateritic soils of Konkan.

In case of profile samples the bulk density of all tahsils showed variation between 1.10 and 1.36 with a mean value of 1.23 Mg m^{-3}. At all profiles bulk density did not show any definite trend with exception of Dapoli (IV) mango orchard. These results are in conformity with the findings of Shinde (2006), Sankpal (2008) and Suryavanshi (2010). The increasing trend of bulk density at Dapoli (IV) may be due to elevated cultivation, organic matter and biotic activities in the surface soil than subsurface. (Rao *et al.,*2008).

In general, bulk density for surface samples showed no much variation for all the mango orchards. However in case of profile samples the maximum bulk density was observed in Dapoli (I and II) location and minimum at Dapoli (III and IV) location than all other mango orchards.

4.3.3 Particle density

Dapoli (I and II)

Surface soil samples (0 to 15 cm):

The data presented in Table. No. in 4.20 and depicted in Fig. No.4.15 indicated that the particle density of Dapoli (I) ranged from 2.19 to 2.44 with a mean value of 2.31 Mg m^{-3} and 2.24 to 2.44 with an average value of 2.32 Mg m^{-3} for Dapoli (II). In general, the particle density for both the locations showed variation from 2.19 to 2.44 with an average value of 2.32 Mg m^{-3}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The particle density for Dapoli (I) and Dapoli (II) ranged between 2.32 and 2.55 with a mean value of 2.41 Mg m^{-3} and 2.23 to 2.49 with an average value of 2.36 Mg m^{-3}, respectively. For Dapoli (I) the particle density was slightly higher than Dapoli (II). For Dapoli (I and II) the particle density was observed in the range of 2.23 to 2.49 with a mean value of 2.39 Mg m^{-3}. For both the mango orchards the particle density exhibited no specific trend with soil depth. (Table No.4.20 and Fig. No.4.16 (a))

Dapoli (III and IV)

Surface soil samples (0 to 15 cm):

As seen from Table No. 4.21 and Fig. No.4.15 the particle density for Dapoli (III) varied from 2.18 to 2.49 with a mean value of 2.37 Mg m^{-3} while 2.36 Mg m^{-3} was an average value of particle density with range of 2.27 to 2.53 Mg m^{-3} for Dapoli (IV). For both the mango orchards the particle density showed a range of 2.18 to 2.53 with an average value of 2.37 Mg m^{-3}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

For Dapoli (III) mango orchard particle density ranged between 2.18 to 2.51 with a mean value of 2.30 Mg m^{-3} while for Dapoli (IV) it was 2.25 to 2.39 with an average value of 2.32 Mg m^{-3}. For Dapoli (III and IV - Wakawali) particle density varied from 2.18 to 2.51 with a mean value of 2.31 Mg m^{-3}. However, at both soil profiles particle density did not show any definite trend in its distribution with soil depth. (Table No.4.21 and Fig.No.4.16 (a))

Khed (I and II)

Surface soil samples (0 to 15 cm):

The data (Table No. 4.22 and Fig. No.4.15) indicated that particle density for Khed (I) and Khed (II) mango orchards exhibited a variation in the range of 2.20 to 2.57 with a mean value of 2.38 Mg m^{-3} and 2.26 to 2.59 with an average value of 2.44 Mg m^{-3}, respectively. The data also showed that Khed (II) location had slightly higher values of particle density than Khed (I) while for Khed (I and II) particle density ranged from 2.20 to 2.59 with a mean value of 2.41 Mg m^{-3}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

2.28 to 2.49 Mg m^{-3} was the range of particle density and 2.39 Mg m^{-3} was the mean value of it for Khed (I) while for Khed (II) it varied from 2.43 to

2.63 with an average value of 2.55 Mg m^{-3} (Table No. 4.22 and Fig. No. 4.16 (a)). The comparison showed higher values of particle density for Khed (II) than Khed (I). For both the locations particle density showed a variation between 2.28 to 2.63 with an average value of 2.47 Mg m^{-3}. The data further revealed that the particle density did not show any specific trend with soil depth for both the soil profiles.

Ratnagiri (I and II)

Surface soil samples (0 to 15 cm):

For Ratnagiri (I) the particle density ranged between 2.27 to 2.67 with a mean value of 2.37 Mg m^{-3} while for Ratnagiri (II), particle density showed an average value of 2.41 Mg m^{-3} and it varied from 2.28 to 2.52 Mg m^{-3}. Ratnagiri (II) was found slightly higher in value of particle density than Ratnagiri (I). Both the locations exhibited a range of 2.27 to 2.67 with an average value of 2.39 Mg m^{-3} for particle density. (Table No.4.23 and Fig. No. 4.15)

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

Particle density of Ratnagiri (I) showed a variation from 2.18 to 2.56 with an average value of 2.37 Mg m^{-3} while for Ratnagiri (II) it ranged from 2.20 to 2.61 with a mean value of 2.47 Mg m^{-3}. Ratnagiri (II) had shown slightly higher value of particle density than Ratnagiri (I). In general, for Ratnagiri (I and II) particle density varied between 2.18 and 2.61 with an average value of 2.42 Mg m^{-3}. From the data it was also evident that Ratnagiri (I) mango orchard showed no specific trend of particle density while in Ratnagiri (II) particle density increased with soil depth. (Table 4.23 and Fig.4.16 (b))

Lanja (I and II)

Surface soil samples (0 to 15 cm):

The data from Table No. 4.24 and Fig.No.4.15 revealed that particle density for Lanja (I) and Lanja (II) showed variation between 2.16 and 2.40 with a mean value of 2.30 Mg m^{-3} and 2.22 to 2.57 with an average value of 2.45 Mg m^{-3}, respectively. The data also showed that Lanja (II) had slightly higher average values for particle density as compared to Lanja (I). For both the mango orchards particle density varied from 2.16 to 2.57 with a mean value of 2.38 Mg m^{-3}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The particle density of Lanja (I) had a range of 2.28 to 2.54 with a mean value of 2.39 Mg m^{-3} while for Lanja (II) it ranged between 2.21 and 2.45 with a mean value of 2.35 Mg m^{-3}. At Lanja (I) mango orchard slightly higher particle density was observed than Lanja (II) mango orchard while at Lanja (I and II) the particle density varied from 2.21 to 2.54 with an average value of 2.37 Mg m^{-3}. At both the soil profiles the particle density did not follow any specific trend with soil depth. (Table No.4.24 and Fig.No.4.16 (b))

Particle density of different tahsils of Ratnagiri district:

Data on particle density of different tahsils revealed that the particle density for surface samples of all tahsils had a range of 2.16 to 2.67 with a mean value of 2.37 Mg m^{-3}. Similar range for particle density was observed by Mahajan (2001), Shinde (2006) and Suryavanshi (2010) for lateritic soils of mango orchards of Konkan (MS).

For profile soil samples the particle density of all tahsils had a range of 2.18 to 2.63 with an average value of 2.39 Mg m^{-3}. In general, all the profiles did not show any definite trend with soil depth with exception of Ratnagiri (II) location. These observations are in conformity with Dongre (1997), Revandkar (1990) and Sankpal (2008). However, at Ratnagiri (II) an increasing trend of particle density with soil depth was seen. Similar trend was also noticed by

Dabke (1987), Malvade (1993) and Chavan *et al.*,(1995) for lateritic soils of Konkan.

In general, at Khed (I and II) the particle density was observed as highest for surface and profile samples. However, particle density was found lowest in Dapoli
(I and II) for surface samples and at Dapoli (III and IV) it was found to be lowest for profile samples as compared to all other locations.

4.3.4 Maximum water holding capacity

Dapoli (I and II)

Surface soil samples (0 to 15 cm):

The maximum water holding capacity of Dapoli (I) and (II) mango orchards varied between 49.34 to 69.43 with an average value of 58.67 per cent and 51.34 to 66.54 with a mean value of 59.07 per cent, respectively. In general, for Dapoli
(I and II) the maximum water holding capacity ranged from 49.34 to 69.43 with a mean value of 58.87 per cent. (Table 4.20 and Fig.4.17)

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The maximum water holding capacity of Dapoli (I) mango orchard showed variation from 48.76 to 64.43 with a mean value of 57.92 per cent while for Dapoli (II) it was from 58.67 to 69.88 with an average value of 63.79 per cent. Maximum water holding capacity was found to be higher for Dapoli (II) than Dapoli (I). In general, for Dapoli (I and II) maximum water holding capacity varied between 48.76 and 69.88 with a mean value of 60.27 per cent. From the data it was also evident that maximum water holding capacity was found to be increased with soil depth for both the profiles. (Table 4.20 and Fig.4.18)

Dapoli (III and IV)

Surface soil samples (0 to 15 cm):

The data presented in Table No. 4.21 and illustrated in Fig. No. 4.17 revealed that 57.26 per cent was the average maximum water holding capacity with variation from 49.80 to 64.34 per cent for Dapoli (III) while for Dapoli (IV), 57.08 per cent was the mean value of maximum water holding capacity and it ranged from 48.78 to 67.12 per cent. From the data it was also evident that Dapoli (III) showed slightly higher average value for maximum water holding capacity than Dapoli (IV) mango orchard. However, for Dapoli (III and IV- Wakawali) maximum water holding capacity showed variation from 48.78 to 67.12 with a mean value of 57.17 per cent.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

51.34 to 65.55 per cent was the range of maximum water holding capacity and 59.34 per cent was the mean value of it for Dapoli (III) while for Dapoli (II) it varied from 61.25 to 69.77 with an average value of 65.72 per cent (Table No. 4.12 and Fig.No.). For both the soil profiles, maximum water holding capacity had a variation between 51.34 and 69.77 with an average value of 62.53 per cent. The data further revealed that maximum water holding capacity increased with soil depth for both the soil profiles.

Khed (I and II)

Surface soil samples (0 to 15 cm):

For Khed (I) and Khed (II) the maximum water holding capacity ranged from 48.66 to 63.44 with a mean value of 56.00 per cent and 49.90 to 62.44 with an average value of 57.95 per cent, respectively. At Khed (II) the maximum water holding capacity was found to be slightly higher than Khed (I). In general, for Khed (I and II – Avashi) maximum water holding capacity ranged from 48.66 to 63.44 with a mean value of 56.98 per cent.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

As seen from Table No. 4.22 and Fig. No.4.18 the maximum water holding capacity for Khed (I) varied from 48.67 to 66.66 with a mean value of 58.14 per cent while 62.29 per cent was an average value of maximum water holding capacity with range of 58.79 to 65.45 per cent for Khed (II). The data further showed that Khed (II) location had slightly higher maximum water holding capacity than Khed (I). For both the mango orchards the maximum water holding capacity showed a range of 48.67 to 66.66 with an average value of 60.22 per cent. At Khed (I) mango orchard an increasing trend of maximum water holding capacity with soil depth was seen while Khed (II) was found to be exception for this trend.

Ratnagiri (I and II)

Surface soil samples (0 to 15 cm):

For Ratnagiri (I) the maximum water holding capacity ranged between 49.00 and 66.78 with a mean value of 60.10 per cent while for Ratnagiri (II), it showed an average value of 56.15 per cent and varied from 47.68 to 65.45 per cent. Ratnagiri (I) was found slightly higher in value of maximum water holding capacity than Ratnagiri (II). Both the locations exhibited a range of 47.68 to 66.78 with an average value of 58.13 per cent for maximum water holding capacity.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

Ratnagiri (I) showed a variation from 53.55 to 63.89 with an average value of 57.67 per cent while for Ratnagiri (II) it ranged from 58.80 to 65.70 with a mean value of 62.47 per cent. Ratnagiri (II) had shown higher maximum water holding capacity than Ratnagiri (I). In general, for Ratnagiri (I and II) maximum water holding capacity varied between 53.55 and 65.70 with an average value of 60.07 per cent. From the data it was also evident that no specific trend of maximum water holding capacity was observed for Ratnagiri

(II) mango orchard while it increased with depth for Ratnagiri (I). (Table No.4.23 and Fig. 4.18).

Lanja (I and II)

Surface soil samples (0 to 15 cm):

As seen from Table No.4.24 and Fig. No.4.17 the maximum water holding capacity of Lanja (I) and (II) ranged from 55.43 to 66.54 with an average value of 60.62 per cent and 56.90 to 62.34 with a mean value of 59.97 per cent, respectively. The data also revealed that Lanja (I) mango orchard had slightly higher maximum water holding capacity than that of Lanja (II) while for Lanja (I and II) the maximum water holding capacity ranged from 55.43 to 66.54 with a mean value of 60.30 per cent.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The data (Table No. 4.24 and Fig. No.4.18) indicated that maximum water holding capacity for Lanja (I) and Lanja (II) mango orchards exhibited a variation in the range of 59.05 to 68.78 with a mean value of 62.79 per cent and 58.70 to 68.90 with an average value of 64.63 per cent, respectively. The data also showed that Lanja (II) location had shown slightly higher maximum water holding capacity than Lanja (I). For Lanja (I and II) maximum water holding capacity ranged from 58.70 to 68.90 with a mean value of 63.71 per cent. However, at Lanja (I) location an increasing trend of maximum water holding capacity was observed with soil depth but no specific trend was observed in Lanja (II).

Maximum water holding capacity of different tahsils of Ratnagiri district:

Data for maximum water holding capacity of different tahsils showed that the maximum water holding capacity of surface soil samples of all tahsils was in a range of 47.68 to 69.43 with an average value of 58.29 per cent. Similar observations were also reported by Diwale (1994), Mahajan (2001) and Suryavanshi (2010) for lateritic soils of Konkan (MS).

Maximum water holding capacity of profile samples of all tahsils showed a variation from 48.67 to 69.88 with a mean value of 61.36 per cent. At Khed (II), Lanja (II) and Ratnagiri (II) mango orchards the maximum water holding capacity showed no specific trend with soil depth. Similar observations were also recorded by Patil (1986 b) and Terse (1989) for lateritic soils of Konkan. For other soil profiles maximum water holding capacity had an increasing trend with soil depth. These results are in conformity with Salvi (1988), Shinde (2006) and Sankpal (2008). The increasing trend of maximum water holding capacity may be due to increase in clay content with soil depth (Revandkar, 1990).

In general, all the surface and profile soil samples were categorized into 'medium to high' class on the basis of ratings given by Sankaram (1996) indicted good maximum water holding capacity of mango orchards. For Khed (I and II) mango orchard the maximum water holding capacity was found lowest in surface samples while for Ratnagiri (I and II) it was lowest for profile samples however, for Lanja (I and II) maximum water holding capacity was found to be the highest for both surface and profile samples than all other locations.

4.3.5 Soil reaction (pH)

Dapoli (I and II)

Surface soil samples (0 to 15 cm):

The data presented in Table. No. 4.20 and depicted in Fig. No. 4.17 indicated that the pH of Dapoli (I) ranged from 4.27 to 4.90 with a mean value of 4.53 and 4.20 to 5.34 with an average value of 4.90 for Dapoli (II). The pH value was observed slightly higher at Dapoli (II) as compared to Dapoli (I) mango orchard. In general, the pH for both the locations showed variation from 4.20 to 5.34 with an average value of 4.71.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

As seen from Table No. 4.20 and Fig. No.4.19 the pH for Dapoli (I) varied from 4.87 to 5.70 with a mean value of 5.25 while 5.15 was an average value of pH with range of 4.67 to 5.66 for Dapoli (II). The data further showed that Dapoli (I) location had slightly higher pH than Dapoli (II). For both the mango orchards the pH showed a range of 4.67 to 5.70 with an average value of 5.21. At both Dapoli (I) and Dapoli (II) an increasing trend of pH with soil depth was seen.

Dapoli (III and IV)

Surface soil samples (0 to 15 cm):

For Dapoli (III) the pH ranged between 4.10 and 5.46 with a mean value of 4.67 while for Dapoli (IV), pH showed an average value of 4.92 and it varied from 4.32 to 5.43. Slightly higher pH was found in Dapoli (IV) than in Dapoli (III). Both the locations exhibited a range of 4.10 to 5.46 with an average value of 4.79 for pH. (Table 4.21 and Fig.4.17)

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

pH of Dapoli (III) showed a variation from 4.45 to 5.87 with an average value of 5.15 while for Dapoli (IV) it ranged from 4.55 to 5.45 with a mean value of 4.92. Dapoli (III) had shown slightly higher value of pH than Dapoli (IV). In general for Dapoli (I and II), pH varied between 4.45 and 5.87 with an average value of 5.04. From the data it was also evident that pH showed an increasing trend with soil depth for Dapoli (III) and Dapoli (IV) mango orchards. (Table No.4.21 and Fig. No.4.19)

Khed (I and II)

Surface soil samples (0 to 15 cm):

For Khed (I) and Khed (II) the pH ranged from 4.20 to 4.96 with a mean value of 4.50 and 4.42 to 5.40 with an average value of 4.83, respectively. At Khed (II) the pH value was observed to be slightly higher than Khed (I). On an average, pH ranged from 4.20 to 5.40 with a mean value of 4.67 for Khed (I and II – Avashi).

Profile soil samples

(0 to 15, 15 to 30, 30 to 4nd 45 to 60 cm):

As seen from Table No. 4.22 and Fig. No. 4.19 the pH for Khed (I) varied

from 5.33 to 5.67 with a mean value of 5.50 while 5.22 was an average value of pH with range of 4.77 to 5.70 for Khed (II). The data further showed that Khed (I) location had slightly higher average pH value than Khed (II). For both the mango orchards it showed a range of 4.77 to 5.70 with an average value of 5.36. At Khed (II) mango orchard an increasing trend of pH with soil depth was seen while pH did not show any definite trend with soil depth for Khed (II) mango orchard.

Ratnagiri (I and II)

Surface soil samples (0 to 15 cm):

The pH of Ratnagiri (I) and (II) mango orchards varied between 4.12 to 5.23 with an average value of 4.59 and 4.38 to 5.27 with a mean value of 4.93, respectively. At Ratnagiri (II) higher average value of pH was observed than Ratnagiri (I). In general, for Ratnagiri (I and II - Shirgaon) the pH ranged from 4.12 to 5.27 with a mean value of 4.76. (Table No.4.23 and Fig.No.4.17)

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

Data presented in Table No.4.23 and depicted in Fig. 4.19 pH showed a range of 4.41 to 5.19 with a mean value of 4.77 at Ratnagiri (I) and 4.23 to 5.12 with an average value of 4.84 for Ratnagiri (II). For Ratnagiri (II) mango orchard average pH value was higher when compared with Ratnagiri (I). At

Ratnagiri

(I and II - Shirgaon) the pH showed a variation between 4.23 and 5.19 with a mean value of 4.81. At both locations pH was increased with soil depth.

Lanja (I and II)

Surface soil samples (0 to 15 cm):

As seen from Table No.4.24 and Fig.4.17 the pH of Lanja (I) and (II) ranged from 4.26 to 5.12 with an average value of 4.65 and 4.30 to 5.13 with a mean value of 4.67, respectively. For Lanja (I and II) the pH showed variation from 4.26 to 5.13 with a mean value of 4.66.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The pH of Lanja (I) mango orchard showed variation from 4.67 to 5.66 with a mean value of 5.30 while for Lanja (II) it was 4.54 to 5.44 with an average of 5.02. At Lanja (I) the average pH value was slightly higher than Lanja (II). In general, for Lanja (I and II) pH varied between 4.54 and 5.66 with a mean value of 5.16. From the data it was also evident that no definite trend of pH was observed with soil depth for Lanja (I). However, pH showed an increasing trend with depth for Lanja (II) location. (Table No.4.24 and Fig. No.4.19)

Soil reaction (pH) of different tahsils of Ratnagiri district:

Data on overall mean for pH of different tahsils when studied revealed that the pH of all tahsils of surface samples had a range of 4.10 to 5.46 with an average value of 4.72. Similar observations were also observed by Modak (1990), Parab (1990), Sawant (2004) and Edward Raja (2007) for lateritic soils of Konkan.

In case of profile samples the pH of all tahsils varied from 4.23 to 5.87 with a mean value of 5.12. Tha data further revealed that pH showed an increasing trend with soil depth at all tahsils while Khed (I), Lanja (I) and Ratnagiri (II) locations were found as exceptions for these findings. These results are in conformity with Mahajan (2001), Shinde (2006) and Suryavanshi (2010) for lateritic soil of mango orchards of Konkan (M.S.). However, at Khed (I), Lanja (I) and Ratnagiri (II) locations pH did not show any specific trend with soil depth. Similar findings were also observed by Patil (1981) and Dongale (1992) for lateritic soil of Konkan. In general, the increasing trend of pH for most of the tahsils attributed to increase in soil alkalinity with depth due to deposition of basic salts by irrigation and eluviations (Patil *et al.*,2008).

In general, all the surface and profile samples were 'moderately to strongly acidic' in reaction. At Lanja (I and II) the pH was observed as minimum for surface samples and at Ratnagiri (I and II) pH was minimum for profile samples. However, at Dapoli (III and IV) the pH was found to be maximum for surface samples and in Khed (I and II) pH was found to be maximum for profile samples as compared to all other mango orchards from different tahsils. The low pH values of all mango orchards might be due to higher leaf litter addition to soil which helps in acceleration of mineralization process (Sanborn, 2001 and Wilson, 2007).

4.3.6 Electrical conductivity (E.C.)

Dapoli (I and II)

Surface soil samples (0 to 15 cm):

The perusal of data presented in Table 4.20 and illustrated in Fig.4.17 revealed that electrical conductivity of Dapoli (I) mango orchard ranged from 0.022 to 0.076 with an average value of 0.048 dS m^{-1} while for Dapoli (II) it showed variation from 0.034 to 0.098 with a mean value of 0.051 dS m^{-1}. The data also showed that Dapoli (II) location had slightly higher average value for electrical conductivity than Dapoli (I). For Dapoli (I and II) the electrical conductivity showed variation from 0.022 to 0.098 with a mean value of 0.050 dS m^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The electrical conductivity of Dapoli (I) and Dapoli (II) varied from 0.061 to 0.078 with an average value of 0.066 dS m^{-1} and 0.023 to 0.055 with an average value of 0.040 dS m^{-1}, respectively. The data also showed that Dapoli (I) location had slightly higher average value for electrical conductivity than Dapoli (II). In general, the electrical conductivity for both the mango orchards ranged between 0.023 and 0.078 with an average value of 0.055 dS m^{-1}. For both the soil profiles the electrical conductivity did not follow any definite pattern with soil depth (Table No. 4.20 and Fig. No.4.17)

Dapoli (III and IV)

Surface soil samples (0 to 15 cm):

For Dapoli (III) mango orchard electrical conductivity ranged between 0.038 and 0.069 with a mean value of 0.056 dS m^{-1} while for Dapoli (IV) it was 0.028 to 0.067 with an average value of 0.047 dS m^{-1}. The data further showed that Dapoli (III) location had slightly higher average electrical conductivity than Dapoli (IV). For Dapoli (III and IV - Wakawali) electrical conductivity varied from 0.028 to 0.069 with a mean value of 0.051 dS m^{-1}. (Fig.No.4.21 and Table No.4.17)

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

0.039 to 0.068 dS m^{-1} was the range of electrical conductivity and 0.055 dS m^{-1} was the mean value of it for Dapoli (III) while for Dapoli (IV) it varied from 0.039 to 0.061 with an average value of 0.049 dS m^{-1} (Table No. 4.21 and Fig.No.4.20). The data further showed that Dapoli (III) location had slightly higher average electrical conductivity than Dapoli (IV). For both the soil profiles electrical conductivity had a variation between 0.039 and 0.068 with an average value of 0.052 dS m^{-1}. The data further revealed that electrical conductivity was increased with soil depth for Dapoli (IV). However, it did not show any definite trend with soil depth for Dapoli (III) mango orchard.

Khed (I and II)

Surface soil samples (0 to 15 cm):

For Khed (I) and Khed (II) the electrical conductivity ranged from 0.028 to 0.067 with a mean value of 0.050 dS m^{-1} and 0.034 to 0.059 with an average value of 0.047 dS m^{-1}, respectively. In general, for Khed (I and II – Avashi), electrical conductivity ranged from 0.028 to 0.067 with a mean value of 0.049 dS m^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

As seen from Table No. 4.22 and Fig. No.4.20 the electrical conductivity for Khed (I) varied from 0.027 to 0.064 with a mean value of 0.045 dS m^{-1} while 0.050 dS m^{-1} was an average value of electrical conductivity with a range of 0.048 to 0.059 dS m^{-1} for Khed (II). For both the mango orchards the electrical conductivity showed variation from 0.027 to 0.064 with an average value of 0.048 dS m^{-1}. At Khed (II) mango orchard an increasing trend of electrical conductivity with soil depth was seen while for Khed (I) no specific trend was observed.

Ratnagiri (I and II)

Surface soil samples (0 to 15 cm):

The electrical conductivity of Ratnagiri (I) and (II) mango orchards varied between 0.031 to 0.071 with an average value of 0.052 dS m^{-1} and 0.027 to 0.072 with a mean value of 0.049 dS m^{-1}, respectively. At Ratnagiri (I) slightly higher average value of electrical conductivity was observed than Ratnagiri (II). In general, for Ratnagiri (I and II -Shirgaon) the electrical conductivity ranged from 0.027 to 0.072 with a mean value of 0.051 dS m^{-1}. (Table No.4.23 and Fig.No.4.17)

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

Data presented in Table No.4.23 and depicted in Fig.4.20 showed a range of 0.038 to 0.059 for the electrical conductivity with a mean value of 0.050 dS m^{-1} for Ratnagiri (I) and 0.036 to 0.066 with an average value of 0.048 dS m^{-1} for Ratnagiri (II). For Ratnagiri (I and II - Shirgaon) the electrical conductivity showed a range of 0.036 to 0.066 with a mean value of 0.049 dS m^{-1}. At both the locations electrical conductivity did not exhibit any definite pattern with soil depth.

Lanja (I and II)

Surface soil samples (0 to 15 cm):

As seen from Table No.4.24 and Fig.4.17 the electrical conductivity of Lanja (I) and Lanja (II) ranged from 0.038 to 0.072 with an average value of 0.057 dS m^{-1} and 0.049 to 0.064 with a mean value of 0.057 dS m^{-1}, respectively. The data also revealed that both the mango orchards had similar average values of electrical conductivity. In general, for Lanja (I and II) the electrical conductivity ranged from 0.038 to 0.072 with a mean value of 0.057 dS m^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The data (Table No. 4.24 and Fig. No.4.20) indicated that the electrical conductivity for Lanja (I) and Lanja (II) mango orchards exhibited a variation in the range of 0.027 to 0.047 with a mean value of 0.038 dS m^{-1} and 0.054 to 0.072 with an average value of 0.060 dS m^{-1}, respectively. The data also showed that Lanja (II) location had slightly higher average value than Lanja (I) while for Lanja (I and II) electrical conductivity ranged from 0.027 to 0.072 with a mean value of 0.049 dS m^{-1}. No specific trend of electrical conductivity with soil depth was observed for both Lanja (I) and Lanja (II) locations.

Electrical conductivity (E.C.) status of different tahsils of Ratnagiri district:

Data on overall mean for electrical conductivity of different tahsils revealed that the electrical conductivity of all tahsils of surface samples had a variation from 0.027 to 0.098 with a mean value of 0.052 dS m^{-1}. These results are in conformity with Diwale (1994), Pednekar (1998) and Sankpal (2008).

For profile samples of all mango orchards the electrical conductivity ranged from 0.023 to 0.078 with an average value of 0.051 dS m^{-1} and showed no definite trend with soil depth with exceptions of Dapoli (IV) and Khed (II) locations. Similar observations were observed by Dabke (1987), Mahajan (2001) and Suryavanshi (2010) for lateritic soils of Konkan. However, at Dapoli (IV) and Khed (II) locations electrical conductivity showed an increasing trend with soil depth. It may be attributed to due to poor drainage of water at higher depths. (Todmal *et al.*,2008)

In general, all the surface and profile samples were found under 'normal' class of electrical conductivity based on the ratings given by Seth (1967). Khed (I and II) location showed minimum electrical conductivity while Dapoli (I and II) had maximum electrical conductivity for both surface and profile samples than all other locations. So from the data, it could be concluded that all the mango orchards had low salt concentration which might be due to the leaching of bases due to heavy rainfall in the region.

4.3.9 Organic carbon (O.C.)

Dapoli (I and II)

Surface soil samples (0 to 15 cm):

The data presented in Table. No. in 4.20 and depicted in Fig. No. 4.17 indicated that the organic carbon for Dapoli (I) ranged from 11.02 to 14.40 with a mean value of 13.28 g kg^{-1} and from 12.38 to 17.33 with an average value of 15.14 g kg^{-1} for Dapoli (II). The average organic carbon value was slightly higher at Dapoli (II) as compared to Dapoli (I) mango orchard. In general, the organic carbon for both the locations showed variation from 11.02 to 17.33 with an average value of 14.21 g kg^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The organic carbon for Dapoli (I) and Dapoli (II) ranged between 08.97 and 16.69 with a mean value of 12.06 g kg^{-1} and 08.12 to 14.35 with an average value of 10.92 g kg^{-1}, respectively. The data also showed that Dapoli (I) location had slightly higher average value for organic carbon than Dapoli (II). For Dapoli (I and II) the variation in organic carbon was observed in the range of 08.12 to 16.69 with a mean value of 11.49 g kg^{-1}. The organic carbon exhibited declining trend with soil depth for both the mango orchards. (Table No.4.20 and Fig. 4.21)

Dapoli (III and IV)

Surface soil samples (0 to 15 cm):

The data presented in Table No. 4.21 revealed that 15.30 g kg^{-1} was the average organic carbon and it showed variation from 12.02 to 17.67 g kg^{-1} for Dapoli (III) while for Dapoli (IV), 15.34 g kg^{-1} was the mean value of organic carbon and it ranged from 13.96 to 16.90 g kg^{-1}. From the data it was also evident that Dapoli (IV) had slightly higher average values for organic carbon than Dapoli (III). However, for Dapoli (III and IV- Wakawali) organic carbon showed variation from 12.02 to 17.67 with a mean value of 15.32 g kg^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

For Dapoli (III) location organic carbon varied between 09.20 and 14.55 with an average value of 12.08 g kg^{-1} while for Dapoli (IV) it ranged from 15.48 to 17.76 with a mean value of 16.85 g kg^{-1}. Dapoli (IV) location showed higher average organic carbon as compared to Dapoli (III). However, organic carbon at Dapoli (III and IV- Wakawali) showed variation from 09.20 to 17.76 with a mean value of 14.47 g kg^{-1}. Dapoli (III) mango orchard organic carbon showed a declined trend with soil depth however for Dapoli (IV) mango orchard it did not follow any specific trend with soil depth. (Table No.4.21 and Fig. No.4.21)

Khed (I and II)

Surface soil samples (0 to 15 cm):

For Khed (I) and Khed (II) the organic carbon ranged from 13.95 to 17.80 with a mean value of 15.48 g kg^{-1} and 12.03 to 17.79 with an average value of 14.95 g kg^{-1}, respectively. At Khed (I) the organic carbon was found to be slightly higher than Khed (II). In general for Khed (I and II – Avashi) organic carbon ranged from 12.03 to 17.80 with a mean value of 15.22 g kg^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

As seen from Table No. 4.22 and Fig. No.4.21 the organic carbon for Khed (I) varied from 07.92 to 16.87 with a mean value of 12.82 g kg^{-1} while 11.09 was an average value of organic carbon with range of 06.54 to 14.58 g kg^{-1} for Khed (II). The data further showed that Khed (I) location had slightly higher organic carbon content than Khed (II). For both the locations organic carbon showed a range of 6.54 to 16.87 with an average value of 11.96 g kg^{-1}. Further organic carbon exhibited a decreasing trend with soil depth for Khed (I) mango orchard. However, it did not show any specific pattern in its distribution in Khed (II) mango orchard.

Ratnagiri (I and II)

Surface soil samples (0 to 15 cm):

The organic carbon of Ratnagiri (I) and (II) mango orchards varied between 13.36 and 17.35 with an average value of 15.01 g kg^{-1} and 12.84 to 18.18 with a mean value of 15.24 g kg^{-1}, respectively. For Ratnagiri (II) slightly higher average value of organic carbon was observed than Ratnagiri (I). In general, for Ratnagiri

(I and II - Shirgaon) the organic carbon ranged from 12.84 to 18.18 with a mean value of 15.13 g kg^{-1}. (Table No.4.23 and Fig. No.4.17)

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

Data presented in Table No.4.23 and depicted in Fig. No.4.21 showed a range of 08.80 to 16.66 of organic carbon with a mean value of 12.30 g kg^{-1} for Ratnagiri (I) and 05.96 to 16.73 with an average value of 11.16 g kg^{-1} for Ratnagiri (II). For Ratnagiri (I) mango orchard average organic carbon content was found higher than Ratnagiri (II). On an average, at Ratnagiri (I and II-Shirgaon) the organic carbon showed a range of 05.96 to 16.73 with a mean value of 11.73 g kg^{-1}. At Ratnagiri (I) no specific trend of organic carbon was seen in its distribution with soil depth while it was found to be decreased with soil depth in Ratnagiri (II).

Lanja (I and II)

Surface soil samples (0 to 15 cm):

As seen from Table No.4.24 and Fig.4.17 the organic carbon of Lanja (I) and (II) ranged from 12.07 to 16.66 with an average value of 14.50 g kg^{-1} and 13.06 to 17.67 with a mean value of 15.78 g kg^{-1}, respectively. The data also revealed that Lanja (II) mango orchard had slightly higher average organic carbon than that of Lanja (I). For both Lanja (I and II) the organic carbon ranged from 12.07 to 17.67 with a mean value of 15.14 g kg^{-1}.

Profile soil samples

(0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm):

The data (Table No. 4.24 and Fig. No.4.21) indicated that organic carbon for Lanja (I) and Lanja (II) mango orchards exhibited a variation in the range of 10.95 to 14.52 with a mean value of 13.22 g kg^{-1} and 10.57 to 16.02 with an average value of 14.04 g kg^{-1}, respectively. The data also showed that Lanja (II) location had slightly higher average organic carbon content than Lanja (I), while for Lanja (I and II) it ranged from 10.57 to 16.02 with a mean value of 13.63 g kg^{-1}. Organic carbon was decreased with soil depth for Lanja (II) mango orchard. However, it did not register any definite pattern of its distribution with soil depth for Lanja (I).

Organic carbon (O.C.) content of different tahsils of Ratnagiri district:

Data on overall mean for organic carbon status of different tahsils when studied revealed that the organic carbon content of surface samples of all tahsils showed a variation between 11.02 and 18.18 with an average value of 15.00 g kg^{-1}.These observations are in conformity with the observations of Mali (1989), Shah (1992) and Shinde (2006) for lateritic soils of Konkan.

In case of profile samples of all tahsils the organic carbon content had a rage of 05.96 to 17.76 with a mean value of 12.66 g kg^{-1}. The data further showed that all mango orchards had a decreasing trend of organic carbon with depth of soil with exceptions of Dapoli (IV), Khed (II) Ratnagiri (I) and Lanja (I) locations. Similar findings were also observed by Diwale (1994), Mahajan (2001) and Suryavanshi (2010). At Dapoli (IV) and Ratnagiri (I) and Lanja (I) locations organic carbon did not show any specific trend with soil depth. Similar findings were also observed by Pedanekar (1998). However, high carbon content in the surface soil than subsurface layers may be attributed to profused root growth of grasses in surface layers than subsurface (Mahajan, 2001) or addition of manure and plant residue at surface than subsurface (Rajeswar *et al.*,2009).

In general, all the samples (surface and profile) were categorised as “Very high” as per the ratings given by Banger and Zende (1978), indicated presence of sufficient amount of organic carbon content in the soils of mango orchards. In Dapoli (I and II) the organic carbon content was found to be minimum while it was maximum at Dapoli (III and IV) for surface as well as profile samples as compared to all locations. However, the high amount of organic carbon content in the soils may be attributed to luxurious growth of grasses and vegetation due to heavy rainfall and thus addition of organic matter through litter, residues and cover crops and thereby subsequent increased humification (Preethi *et al.,*1998)

4.4 Correlation or interrelationship of soil properties with available micronutrients.

The relationships of available micronutrients with various physico-chemical properties were studied for different mango orchards of Ratnagiri district irrespective of depth of profile and presented in Table No. 4.25.

4.4.1 Available Fe

From Table No. 4.25 it was observed that available Fe exhibited positive and significant correlation with sand (r = 0.1909) whereas negative and significant relationship was found with clay content (r = - 0.2609). Similar relationship of available Fe with sand and clay content was also observed by Suryavanshi (2010). The maximum water holding capacity was found to be negatively and significantly correlated with available iron content in the soil. (r = - 0.29758). In case of pH (r = - 0.20724) negative but significant correlation with available Fe was observed. However, organic carbon was positively and significantly correlated with available iron content(r = - 0.267). Negative but significant correlation of available Fe may be due to formation of insoluble higher oxides of Fe at higher pH (Patil and Meisheri, 2004 and Patil *et al.,*2003). In addition to this they also reported positive and significant relationship of Fe content with organic carbon (r = 0.039) for lateritic soils of Konkan. However, increase in Fe with increase in organic matter content (organic carbon) might be due to greater availability of chelating agents through organic matter (Somasundram *et al.,*2009).

The available Fe content established positive significant relationship with available nitrogen (r = 0.25712) and available phosphorus (r = 0.22904) whereas with available K_2O negative but significant relationship was observed (r = - 0.28627). Similar findings were also reported by Revandkar (1990) and

Shah (1992). Contrast to this, the remaining physico-chemical properties viz. silt content, bulk density, particle density, electrical conductivity, exchangeable Ca^{2+} and exchangeable Mg^{2+} did not register any statistical relationship with available iron content in the soil.

Table No. 4.25

Correlation or interrelationship between available micronutrients and physico-chemical properties of soil:

Soil properties	Available Fe	Available Mn	Available Zn	Available Cu
Sand	0.1909*	0.2715*	0.32829*	0.45573*
Silt	0.10786	0.01343	0.23729*	0.00283
Clay	-0.2609*	-0.26659*	-0.41563*	-0.38993*
BD	0.12209	0.06933	-0.05239	0.03658
PD	0.07325	0.09987	-0.03124	-0.01555
MHWC	-0.29758*	-0.21659*	-0.18375*	-0.13112
pH	-0.20724*	-0.37774*	-0.30068*	-0.17814*
EC	0.09086	-0.0335	0.09053	0.0579
OC	0.39211*	0.31064*	0.16076	0.05536
Available Nitrogen	0.25712*	0.43193*	0.36915*	0.43598*
Available P_2O_5	0.22904*	0.30171*	0.04811	0.03121
Available K_2O	-0.28627*	-0.14527	-0.11109	0.06024
Exchangeable Ca^{2+}	0.10941	0.35989*	0.2282*	0.42045*
Exchangeable Mg^{2+}	-0.08485	0.10031	0.03779	0.07727

*Significant at 5 per cent level

4.4.2 Available Mn:

The sand content had shown positive and significant influence on the availability of Mn in the soil (r = 0.2715) while clay content showed negative and significant correlation with available Mn (r = - 0.26659). Similar correlation of available Mn with sand content was also reported by Mahajan (2001) and Suryavanshi (2010). Increase in maximum water holding capacity (r = - 0.22659) and pH (r = - 0.37774) were found to have inverse effect on availability of Mn. These observations are in conformity with Salvi (1988) for lateritic soils of Konkan, while decrease in available Mn increases pH (r = - 0.46). It might be due to conversion of divalent form (Mn^{2+}) into insoluble and unavailable trivalent form (Mn^{3+}) as a result of increase in soil pH (Waghmare *et al.*,2008).

Further data on correlationship also revealed that available Mn exhibited positive and significant correlation with organic carbon (r = 0.31064), available nitrogen (r = 0.43193), available phosphorus (r = 0.30171) and exchangeable Ca^{2+}(r = 0.35989). Shinde (2006) also reported similar relationship of available Fe content with available phosphorus and exchangeable Ca^{2+}. The positive correlation of available Mn with organic carbon indicated that availability of Mn increases with increase in organic matter for the lateritic soils of Konkan (Patil *et al.,* 2003 and Patil and Meisheri 2004). It may be also attributed to effect of organic matter as a chealating agent on availability of Mn (Mahesh Kumar *et al.,* 2011).

However, silt content, bulk density, particle density, electrical conductivity, available potassium and exchangeable magnesium did not show any significant relationship with available Mn in soil.

4.4.3 Available Zn:

As seen from Table 4.25 available zinc was found to be positively and significantly correlated with sand (r = 0.32829) and silt content (r = 0.23729) while it showed negative but significant relationship with clay content (r= -0.41563). Mahajan (2001) and Suryavanshi (2010) were also reported positive and significant correlation of sand content and negative but significant correlation with clay content with available Zn for lateritic soils of mango orchards of Konkan. The inverse relationship of available Zinc with clay content might be due adsorption of Zn^{2+} on surfaces of clay (Mahajan, 2001).

Available Zn had a positive but significant correlation (r = 0.16076) with organic carbon content in soil. Positive but significant relationship of available Zn with organic carbon was also reported by Dhane and Shukla (1995), Waghmare *et al.,* (2000) and Pharande *et al.,* and Sankpal (2008). However, positive but significant relationship of available Zn with organic carbon might be due to formation of immobile complex of available zinc and dessicated organic matter of higher molecular weight compounds like lignins (Hodgson,1963) or attributed to its chelating effect of organic compounds (Chinchmalatpure *et al.*,2000). Increase in maximum water holding capacity (r = - 0.18375) and pH (r = - 0.30068) resulted in decrease in available zinc content in soil. Shinde (2006) also observed negative but significant correlation of pH with available zinc content for lateritic soil of Konkan.

Available nitrogen (r = 0.36915) and exchangeable calcium (r = 0.0067) were found to be positively and significantly correlated with available Zn content in soil. Shah (1992) also reported positive and significant correlation between exchangeable calcium and available Zn while Dongre (1997) also showed positive and significant relationship of available zinc with nitrogen for lateritic soils.

Other remaining properties like bulk density, particle density, EC, available P_20_5, available K_2O and exchangeable Mg^{2+} did not exhibit any statistical correlationship with the available Zn content.

4.4.4 Available copper:

Available copper was found to increase significantly with sand content in the soil (r = 0.45573) while clay content (r = - 0.38993) had negative but significant correlation with Available Cu. Salvi (1988) also observed negative and significant relationship of copper content with clay for lateritic soils.

From table 4.25 it was observed available copper content had a negative but significant correlation with pH (r = - 0.17814). Similar findings were also reported by Mahajan (2001) for lateritic soils of Konkan, Gupta *et al.,* (2000) for soils Madhya Pradesh, Saha *et al.,* (1996) for soils of Orisa (r = - 0.19).

Available nitrogen (r = 0.43598) and exchangeable calcium (r = 0.42045) correlate positively and significantly with available Cu content in soil. These findings are in conformity with Shinde (2006) and Suryavanshi (2010).

Further data on correlation studies did not show any statistical relationship of available Cu with remaining properties viz, silt content, bulk density, particle density, maximum water holding capacity, pH, organic carbon, available nitrogen, available phosphorous, available potassium and exchangeable Mg^{2+}.

Chapter V

SUMMARY AND CONCLUSION

The present investigation was undertaken to study micronutrient status and its relationship with soil properties in mango orchards of Ratnagiri district (Konkan region, M.S.). An attempt was also made to find out co-relation or inter-relationship amongst some of the important physico-chemical properties and available DTPA- extractable micronutrients (Fe, Mn, Zn, Cu) in soils of mango orchard of Ratnagiri district.

An effort had been also made to study the influence of soil depth on distribution of various physico-chemical properties and available micronutrients in soil of mango orchards of Ratnagiri district.

For the present investigation in all five locations encompassing Ratnagiri district were selected from different tahsils namely Dapoli (Dapoli), Dapoli (Wakawali), Khed (Avashi), Ratnagiri (Shirgaon) and Lanja (Lanja). All the locations selected for present investigation are the research stations or agricultural centers of Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. At each location two mango orchards were selected. Surface soil samples (0 to 15 cm) were collected from approximately centre of four mango trees. From each of the mentioned mango orchards ten surface samples (0 to 15 cm) and one profile sample (0 to 15, 15 to 30, 30 to 45 and 45 to 60 cm) were collected by following standard procedure of soil sample collection. Thus, in all 100 surface soil samples and 40 profile samples were collected. All the soil samples were collected in the month of April, 2011. The results obtained from present investigation are briefly summarised below.

Micronutrient status of mango orchards of Ratnagiri district:

1) Available Fe content of surface soil samples of all tahsils varied from 30.65 to 51.30 with a mean value of 40.62 mg kg^{-1}. In profile samples the available Fe showed a range of 28.61 to 50.14 with an average value of 37.77 mg kg^{-1}. The Fe content showed declined trend with increase in depth for all the mango orchards with exceptions of Dapoli (II), Ratnagiri (I) and Lanja (I) locations. In general, all the soil samples were found to be adequate in available Fe content. However, at Dapoli (I and II) and Dapoli (III and IV) location the available Fe content was found to be higher for surface and profile samples, respectively while it was at lower Lanja (I and II) mango orchard for surface as well as profile samples than all other locations.

2) The available Mn of surface soil samples ranged between 41.34 and 60.89 with a mean value of 52.76 mg kg^{-1} of all locations while in case of profile soil samples the available manganese of all tahsils varied from 31.12 to 60.53 with an average value of 48.88 mg kg^{-1}. In general, almost in all the mango orchards available Mn showed a decreasing trend with soil depth with exceptions of Lanja (I), Ratnagiri (II) and Dapoli (III). All the mango orchards showed sufficient amount of available Mn content. The available Mn content was found to be maximum at Lanja (I and II) for both surface as well as profile samples and found to be minimum at Khed (I and II) and Dapoli (III and IV) for surface and profile samples, respectively than all other locations.

3) The available Zn content of all tahsils had a variation between 0.41 and 3.60 with an average value of 1.50 mg kg^{-1} and 0.14 to 2.54 with a mean value of 1.22 mg kg^{-1} for surface and profile samples, respectively. At all the profiles available Zn showed a decreasing trend with soil depth with exceptions of Lanja (II), Ratnagiri (II) and Khed (II). Further, from data it was observed that most of the soil samples of mango orchards had sufficient amount of available zinc. However, few soil samples at Dapoli (I and II) and (III and IV) mango orchards were found to be deficient in available zinc content. The available Zn content was lower at Dapoli (III and IV) and Dapoli (I and II) for surface and profile samples, respectively whereas it was maximum at Ranagiri (I and II) for both surface and profile samples as compared to other mango orchards.

4) The available Cu of surface soil samples varied from 0.95 to 4.67 with a mean value of 2.21 mg kg^{-1} and for profile soil samples the available copper had a range of 0.70 to 3.89 with an average value of 1.96 mg kg^{-1} of all mango orchards. In general, available copper content showed a decreasing trend with soil depth in profile samples with exceptions of Dapoli (I) and Lanja (II) locations. Available Cu in most of the soil samples of mango orchards was found to be adequate with exception of only one soil sample at Dapoli (III and IV) while Ratnagiri (I and II) location was found to be higher and Dapoli (III and IV) was found to be lower in available Cu content for both surface and profile samples than all other locations.

Macronutrient status of mango orchards of Ratnagiri district:

1) Available nitrogen of surface samples of all locations varied from 322.67 to 568.34 with an average value of 465.83 kg ha^{-1} while in profile samples the available nitrogen showed a variation between 300.12 and 555.66 with a mean value of 407.52 kg ha^{-1}. The available nitrogen in general showed a decreasing trend with depth in majority of soil profiles with exceptions of Dapoli (II), Khed (II) and Lanja (I). In general, all the surface and profile samples were in 'medium to high' class indicated presence of adequate amount of available nitrogen in all the mango orchards. However, At Ratnagiri (I and II) and Lanja (I and II) the available nitrogen content was maximum for surface and profile samples, respectively. However, it was observed lowest at Dapoli (I and II) and Dapoli (III and IV) for surface and profile samples, respectively.

2) The available phosphorus of all tahsils showed a variation between 3.19 and 6.42 with an average value of 4.80 kg ha^{-1} and 3.00 to 6.00 with a mean value of 4.38 kg ha^{-1} for surface and profile samples, respectively. Distribution of available phosphorus content showed a declined trend with soil depth at Dapoli (III) and (IV), Khed (II), Ratnagiri (II) and Lanja (II). All the surface and profile soil samples were categorised into ‘very low’ class indicted very low status of available phosphorous in all the mango orchards. In general, at Ratnagiri (I and II) location the available phosphorous was lowest while highest at Lanja (I and II) for surface as well as profile samples than all other mango orchards.

3) For all mango orchards available potassium ranged from 200.66 to 311.87 with a mean value 249.86 kg ha^{-1}. In case of profile samples the available potassium of all tahsils varied between 205.76 and 314.81 with an average value of 274.33 kg ha^{-1}. For all the locations available potassium had no specific trend with soil depth while it showed an increasing trend at Lanja (I), Ratnagiri (I), Dapoli (IV) and Dapoli (I) locations. In general, all the surface and profile samples were categorised into ‘moderately high to very high’ class indicated adequate amount of potassium content in all mango orchards. For Lanja (I and II) the available potassium content was found to be maximum while minimum at Ratnagiri (I and II) location for both surface and profile samples as compared to other locations.

4) Exchangeable calcium of all locations showed a variation from 1.21 to 2.88 with an average value of 1.95 cmol (p^+) kg^{-1} and 1.03 to 2.67 with a mean value of 1.71cmol (p^+) kg^{-1} for surface and profile samples, respectively. At Lanja (I), Ratnagiri (I) and (II), Khed (II), Dapoli (I) and (IV) locations exchangeable Ca^{2+} did not show any definite trend with soil depth. However, at Lanja (II), Khed (I), Dapoli (III) and (II) exchangeable calcium had a declining trend with soil depth. In general, all the surface and profile samples were categorised under ‘low’ class indicated poor status of exchangeable Ca^{2+} in all the mango orchards. Dapoli (I and II) location showed lowest values of exchangeable Mg^{2+} for surface and profile samples. However, Lanja (I and II) mango orchard showed maximum exchangeable Mg^{2+} content for both surface and profile samples than all other locations.

5) Exchangeable Mg^{2+} of surface samples of all tahsils had a range of 0.48 to 1.60 with an average value of 1.08 cmol (p^+) kg^{-1} while in case of profie soil samples the exchangeable magnesium varied from 0.63 to 1.43 with a mean value of 1.02 cmol (p^+) kg^{-1}. At all the locations exchangeable Mg^{2+} showed a decreasing trend with soil depth. All the surface and profile samples were categorised under 'low' class indicated poor status of exchangeable Mg^{2+} in mango orchards. In general, Dapoli (I and II) and Dapoli (III and IV) location showed lowest values of exchangeable Mg^{2+} for surface and profile samples, respectively. However, Lanja (I and II) mango orchard was observed as highest in case of exchangeable Mg^{2+} for both surface and profile samples than all other locations.

Physical properties of mango orchards of Ratnagiri district:

1) The sand, silt and clay content of all tahsils of surface samples ranged from 35.16 to 66.90 with a mean value of 52.23 per cent, 10.12 to 23.76 with an average value of 17.24 per cent and 16.83 to 44.40 with a mean of 30.71 per cent, respectively. 'Sandy clay loam' textural class was dominant for surface samples. In case of profile samples, the dominant textural class for all tahsils was 'sandy clay' with exception of Khed (I), Ratnagiri (I) and (II) mango orchards. The per cent sand varied between 38.90 and 56.60 with a mean value of 47.36, the silt content showed a variation from 10.50 to 28.24 with an average value of 15.97 per cent while clay content ranged from 22.62 to 47.85 with a mean value of 36.68 per cent. . In general, for all the profiles the sand content showed a decreasing trend with soil depth with exception of Dapoli (III), Khed (I), Ratnagiri (I) and Lanja (I) locations. Silt content did not show definite trend in its distribution with soil depth in all the mango orchards while with an exception of Dapoli (I), where a decreasing trend of silt content was observed. Increasing trend of clay content with soil depth was seen for all tahsils, while Lanja (I), Ratnagiri (II) and Khed (II) were found as exception for these findings. Per cent sand and silt content was found to be highest at

Ratnagiri

(I and II) mango orchard for surface and profile samples while clay content was observed as highest at (Khed I and II) for surface samples and at Lanja (I and II) it was maximum for profile samples than all other mango orchards. For surface as well as profile samples lowest sand, silt and clay content was observed at Dapoli (III and IV), Lanja (I and II) and Ratnagiri (I and II) locations, respectively as compared to other locations.

2) The bulk density of surface soil samples of all tahsils varied from 1.11 to 1.38 with an average value of 1.25 Mg m^{-3}. In case of profile samples the bulk density of all locations showed variation between 1.10 and 1.36 with a mean value of 1.23 Mg m^{-3}. At all profiles bulk density did not show any definite trend with exception of Dapoli (IV) mango orchard. At Dapoli (IV) increasing trend of bulk density was observed. In general, all the mango orchards showed no much variation in case of bulk density for surface samples, however in case of profile samples the bulk density was observed maximum in Dapoli (I and II) location and minimum at Dapoli (III and IV) location than all other mango orchards.

3) Particle density of all mango orchards had a range of 2.16 to 2.67 with a mean value of 2.37 Mg m^{-3} and 2.18 to 2.63 with an average value of 2.39 Mg m^{-3} for surface and profile soil samples, respectively. All the profiles did not show any definite trend with soil depth with exception of Ratnagiri (II) location. However, at Ratnagiri (II) an increasing trend of particle density with soil depth was seen. In general, at Khed (I and II) the particle density was observed as highest for surface and profile samples however, particle density was lowest at Dapoli (I and II) for surface samples and at Dapoli (III and IV) it was found to be lowest for profile samples as compared to all other locations.

4) Maximum water holding capacity of surface soil samples was in a range of 47.68 to 69.43 with an average value of 58.29 per cent and in profile samples it showed a variation from 48.67 to 69.88 with a mean value of 61.36 per cent for all tahsils. In all the soil profiles maximum water holding capacity had an increasing trend with soil depth with exceptions of Khed (II), Lanja (II) and Ratnagiri (II) mango orchards. In general, all the surface and profile soil samples were categorized into ‘medium to high’ class indicted good maximum water holding capacity of mango orchards. In general, at Khed (I and II) mango orchard the maximum water holding capacity was lowest in surface samples while at Ratnagiri (I and II) it was lowest for profile samples however, at Lanja (I and II) maximum water holding capacity was found to be highest for both surface and profile samples than all other locations.

Chemical properties of mango orchards of Ratnagiri district:

1) The pH of surface samples had a range of 4.10 to 5.46 with an average value of 4.72 while in case of profile samples it varied from 4.23 to 5.87 with a mean value of 5.12 for all tahsils. Tha data further revealed that pH showed an increasing trend with soil depth at all tahsils while Khed (I), Lanja (I) and Ratnagiri (II) locations were found as exceptions for these findings. In general, all the surface and profile samples were ‘moderately to strongly acidic’ in reaction indicated acidic nature of soils of mango orchards. At Lanja (I and II) the pH was observed as minimum for surface samples and at Ratnagiri (I and II) minimum for profile samples however, at Dapoli (III and IV) the pH was found to be maximum for surface samples and at Khed (I and II) maximum for profile samples as compared to all tahsils.

2) Electrical conductivity of all locations had a variation from 0.027 to 0.098 with a mean value of 0.052 dS m^{-1} and 0.023 to 0.078 with an average value of 0.051 dS m^{-1} for surface and profile samples, respectively. Electrical conductivity showed no definite trend with soil depth at all mango orchards with exceptions of Dapoli (IV) and Khed (II) locations. In general, all the surface and profile samples were found under ‘normal’ class of electrical conductivity indicated that all the mango orchards had low salt concentration. Khed (I and II) location showed minimum values of electrical conductivity while Dapoli (I and II) had maximum values of electrical conductivity for both surface and profile samples than all other locations.

3) The organic carbon content of surface samples of all tahsils showed a variation between 11.02 and 18.18 with an average value of 15.00 g kg^{-1} while in case of profile samples of all tahsils the organic carbon content had a rage of 05.96 to 17.76 with a mean value of 12.66 g kg^{-1}. The data further showed that all mango orchards had a decreasing trend of organic carbon with depth of soil with exceptions of Dapoli (IV), Khed (II) Ratnagiri (I) and Lanja (I) locations. In general, all the samples (surface and profile) were categorised as “Very high” indicated presence of sufficient amount of organic carbon content in the soils of mango orchards. In general, at Dapoli (I and II) the organic carbon content was found to be minimum while it was maximum at Dapoli (III and IV) for surface as well as profile samples as compared to all locations.

Correlation or interrelationship of available micronutrients with soil properties.

1) Available Fe was found to be positively and significantly correlated with sand content ($r = 0.1909^*$), organic carbon ($r = 0.39211^*$), available nitrogen ($r = 0.25712^*$) and available phosphorous ($r = 0.0065^*$) while it showed negative and significant relationship with clay content ($r = -0.0018^*$), maximum water holding capacity ($r = -0.29758^*$), pH ($r = -0.20724^*$) and available potassium ($r = -0.28627^*$).

2) The available Fe exhibited positive and significant correlation with sand content ($r = 0.0012^*$), organic carbon ($r = 0.31064^*$), available nitrogen, available phosphorous ($r= 0.22904^*$) and exchangeable calcium ($r = 0.359899^*$), whereas, negative but significant relationship with clay content ($r = -.26659^*$), maximum water holding capacity ($r = -0.21659^*$) and pH ($r = -0.37774^*$).

3) Available Zn had shown positive and significant relationship with sand content ($r = 0.32829^*$), silt content ($r = 0.0048^*$), available nitrogen (r = 0.36915*) and exchangeable calcium (r = 0.2282*). However, it showed negative and significant correlation with clay content (r = - 0.41563*), maximum water holding capacity (r = 0.39211*) and pH (r = - 0.30068*).

4) Available Cu showed positive and significant correlation with sand content (r = 0.45573*), available nitrogen (r = 0.43598*) and exchangeable calcium (r = 0.42045*) while negative but significant relationship with clay content (r = - 0.38993*) and pH (r = - 0.17814*).

Conclusion:

From the data it could be concluded that the physico-chemical properties of soils of mango orchards characteristically represented typical lateritic soils in the 'Very High Rainfall Laterite' (VRL) zone in the Konkan region.

In general, the status of DTPA extractable (Fe, Mn, Zn and Cu) micronutrients found to be adequate in all the mango orchards selected for the present investigation. However, 2% and 17% samples from Dapoli (Dapoli) and Dapoli (Wakawali) locations were respectively found to be deficient in available Cu and Zn content. From, the correlation studies it was observed that the availability of micronutrients in soil get influenced by mechanical composition, maximum water holding capacity, pH, EC, organic carbon, available nitrogen, available phosphorous, available potassium and exchangeable calcium. Considering the findings, in future, balanced fertilizer application through integrated nutrient management should be followed to sustain fertility status especially in relation to phosphorous (P_2O_5), calcium (Ca^{2+}), magnesium (Mg^{2+}), zinc (Zn) and copper (Cu).

LITERATURE CITED

Ahuja, P. A., Ojanuga and K. R. Olsen (1989). Soil landscape relationship in the Sokota Rima basin on a small watershed. *Journal of Hydrology,***99**:307-318.

Andhalkar, S. V. (1984). Micronutrient status of the coastal saline soils of Maharashtra state. M.Sc. (Agri.) Thesis submitted to KonkanKrishiVidyapeeth, Dapoli (Maharashtra).

Anonymous (1992). Potassium soil status and crop response, Research Bulletin-4, KonkanKrishiVidyapeethDapoli.

Anonymous (1996). Market Survey of micronutrient fertilizers in India. Job No.3886.

Anonymous (2004). Fertilizer News Issued by FCI, 11.

Anonymous (2006). Indian Horticulture Database, 1-2.

Anonymous (2010). KrishiSandesh published by government of Maharashtra, 3-4.

Anonymous, (2011). International Journal of Biological Technology.,**2**(2):12-18.

AvastheYashoda and R. K. Avasthe (1995). Altitudinal distribution of micronutrients in the soils of Sikkim. *J. Indian Soc. Soil Sci.,* **43**: 374-377.

Badrinath, A.M., Krishnappa, B.N., Patil, K.Kenchaiah and K.B. Rao (1986). Fertility status of some typical soils of coastal Karnataka. *J. Indian Soc. Soil Sci.,* **34**(2): 436-438.

Bandopadhayay B.K., Burman, D. and D. Pal(2008). Management of soil fertility for sustaining crop productivity in coastal agroecosystem in India. *J.Indian Soc. Coastal agric.Res.,***26** (2):102-110.

Bangar, A.R. and G.K. Zende (1978). Soil Testing: A new basis for efficient fertilizer use. *J. Maharashtra Agric. Univ.* **3**(2): 81-84.

Bharambe, P.R., Awasarmal, B.C., Ambegaonkar, P.R. and R.P.Rodge (1990). Characterisation of soils in relation to irrigation in Jayakawadi command area. *J. Indian Soc. Soil Sci.,* **38**: 488-494.

Bharambe, P. R. and C. P. Ghonsikar (1985). Physico-chemical characteristics of soil in Jayakwadi command. *J.Maharashtra Agric.Univ.***10**(3):247-249

Bhaskar, B.P. and G.V. Subbaiah (1995). Genesis characterization and classification of lateritic and associated soils along the east coast of Andhra Pradesh. *J. Indian Soc. Soil Sci.,***43**: 107-112.

Bielieski, R.L. (1973). *A.Rev.*Pl.Physicol.**24**, 252.

Black, C.A. (1965). Methods of Soil Analysis, Part-I, *Amer. Soc. Agron. Inc.,* Madison, Wisconsin, U.S.A.

Bobade, S.V. (1987). Assessment of different extractants, equillibrium phosphate potential, soil depths, parts of leaf and period of sampling for predicting availability of soil phosphorus for Alphonso mango in lateritic soil. M.Sc. (Agri.) Thesis submitted to KonkanKrishiVidyapeeth, Dapoli.

Bouyoucos G. J. (1951). A recalibration of the hydrometer method for making mechanical analysis of soil. *Agron. J.* **43**: 435-438.

Cakmak, I. (2002). Plant nutrition research: Priorities to meet human needs for food in sustainable ways. *Plant and Soil***247**: 3-24.

Chatterji, S., DipakSarkar., Das, T.H. and A.K. Halder (1999). Available iron, manganese and copper in different agro-ecological sub-regions of West Bengal in relation to soil characteristics. *J. Indian Soc. Soil Sci.,* **47**(3): 463-465.

Chattopadhyay,T., Sahoo, A.K., Singh, R.S. and R. L. Shyampura (1996). Available micronutrient status in soils of VindhyanScarplands of Rajasthan in relation to soil characteristics. *J. Indian Soc. Soil Sci.,* **44**(4):678-681.

Chavan, A.S. (1977). Micronutrient availability to rice in black and red soils of

Konkan region. M.Sc.(Agri.) Thesis submitted to BalasahebsawantKonkanKrishiVidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished).

Chavan, D.P., A.R. Bangar and A.K. Shingte (1980). Zn, Mn, B and Mo distribution in soil profiles of different Agroclimatic zones of Maharashtra. *J. Maharashtra Agric. Univ.,* **5**(3):183-189.

Chavan, K. N., R. Y. Kenjale and A. S. Chavan (1995). Effect of forest tree species on properties of lateritic soil. *J. Indian Soc. Soil Sci.,* **43**: 43-46.

Chinchmalatpure, A.R., BrijLal., Challa, O. and J. Sehgal (2000). Available micronutrient status of soils on different parent materials and landforms in a micro-watershed of Wunna catchment near Nagpur (Maharashtra). *Agropedology,* **10**:53-58.

Dabke, D.J. (1987). Studies on the physico-chemical properties and available micronutrient status of the rice soils from Agricultural Research Station, Phondaghat (Sindhudurg). M.Sc. (Agri.) Thesis submitted to KonkanKrishiVidyapeeth, Dapoli (Maharashtra).

Das,K., DipakSarkar and D.C.Nayak (2000). Forms of Potassium and their Distribution in some soils representing red and laterite ecosystem of West Bengal.*Journal of Potassium Research* **16**:1-6.

Datta, M., Saha*, P.K. and H. P. Chaudhury** (1990). Erodibility characteristics of soils in relation to soil characteristics and topography. *J. Indian Soc. Soil Sci.,* **38**:495-498.

Datta, Dipak.,Sah, K.D., DipakSarkar and R.S.Reddy(1999). Quantitative evaluation of soil development in some alfisols of Andhra Pradesh. *J. Indian Soc. Soil Sci.,* **47**(2):311-315.

Deshmukh, G.K., Kadrekar, S.B. and J.H. Dongale (1982). Verticle distribution of different forms of phosphrous in soils of Konkan. *J. Maharashtra Agril.*

Univ.,**7**(3): 210-213.

Dhane, S.S. and L.M. Shukla (1995). Distribution of DTPA-extractable Zn, Cu, Mn and Fe in some soil series of Maharashtra and their relationship with some soil properties. *J. Indian Soc. Soil Sci.*,**43**(4): 597-600.

Diwale, S. R. (1994). Distribution of different forms of zinc in rice soil profiles of Konkan. M.Sc.(Agri.) Thesis submitted to KonkanKrishiVidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished).

Diwan, P. M. (1982). Micronutrient status of the soils from bench terraced area of the Central Farm, Wakawali. M.Sc.(Agri.) Thesis submitted to KonkanKrishiVidyapeeth, Dapoli, Dist. Ratnagiri (Maharashtra).

Dongale, J.H. (1993). Depth distribution of different forms of phosphorous in lateritic soils of coastal region. *J. Indian Soc. Soil Sci.,* **41**(1): 62-66.

Dongale, J.H. (1989). Phosphorus fractions in relation to P availability and response of crops to fertilizer phosphorus in lateritic soil of KonKan. Ph.D. Thesis submitted to KonkanKrishiVidyapeeth, Dapoli, Dist. Ratnagiri.

Dongale, J.H. and S.B.Kadrekar (1992). Phosphorous fractions in lateritic soils of Konkan region. *J.Maharashtraagric Univ.*,**17** (3): 357-362.

Dongre,V.T. (1997). Studies on long influence of application of manures and fertilizers on the changes in physic-chemical properties of lateritic soil. M.Sc.(Agri.) Thesis submitted to BalasahebsawantKonkanKrishiVidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished).

Edward Raja, M. (2007): Screening B sources for suitability under different rainfall and soil condition for mango in India. *Advances in Plant and Animal Boron Nutrition*,355-364.

FAI (2001). Fertility index of Indian soil, *fertilizers statistics*, 2000-2001.

Follet, R.H. and W.L. Lindsay (1970). *Tech.Bull.Col.St.Univ.Expt.Sta.*,**110**, 79.

Gaidhani, S.M. (2008). Effect of integrated nutrient management on yield, partitioning and uptake by rice and on fertility status of lateritic soils of Konkan. M.Sc.(Agri.) Thesis submitted to BalasahebsawantKonkanKrishiVidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished).

Gupta,G.P., Khamparia, R.S., Sharma, B.L. and Y.M.Sharma (2000). Extractable micronutrients in relation to properties of some red and yellow soils of Madhya Pradesh. *Ann.agric.Res.***21**(4): 522-526.

Gupta, R. L. and Rorison, L.H. (1975). *J Ecol.***63**, 534.

Hodgson, J.F. (1963). Chemistry of micronutrient elements in soils. *Advances In Agronomy.***15** : 69-94.

Jackson, M.L. (1967). Soil Chemical Analysis, Prentice Hall of India Pvt. Ltd., New Delhi.

Jalali, V.K., Talib, A.R., and Takkar, P.N.(1989). Distribution of micronutrients in some bench mark soils of Kasmir at different altitudes. *J. Indian Soc. Soil Sci.,* **37**:465-469.

Jindal, P.C., Singh, J.P. and O.P Gupta (1975). Haryana *J.hort.Sci.***(4)**: 112. Rastogi, S.K. and A.Chandra (1987). *Fertil.News*,**32**(2): 47.

Joshi, R.K. and S.B. Kadrekar (1988). Physicochemical characteristics of protected lateritic coastal salt affected soils of Maharashtra. *J. Maharashtra Agric. Univ.,* **13**(1):1-4.

Kadam, B.S. (1984). Physico- chemical properties of the soils of Konkan region. M.Sc.(Agri.) Thesis submitted to BalasahebsawantKonkanKrishiVidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished).

Kadrekar, S.B., A.S. Chavan and J.H. Dongale (1981). Laterite and lateritic soils of Maharashtra. *J. Indian Soc. Soil Sci.,* **14**(1-2): 73-92.

Karim, M., Sedberry, Jr. J.R. and B. J. Miller (1976). *Commun. Soil Sci.***45**:89.

Katyal, J.C. and S.C. Aggrwala (1982). Micronutrient research in India. *Fert.News.* **27** (2): 66-68.

Katyal, J.C. and B.D. Sharma (1991). DTPA-extractable and total Zn, Cu,Mn and Fe in Indian soils and their association with some soil properties. *Geoderma***49**: 165-179.

Khan, Z.H., Mazumdar, A.R., Hussain, M.S. and A. S. M. Mohiuddin(1997). Toal and DTPA- extractable Fe, Mn, Cu and Zn contents in some soils of Bangladesh. *J. Indian Soc. Soil Sci.,* **45**(3): 485-489.

Khan, Z. H., Mazumdar, A.R., A. S. M. Mohiuddin., Hussain, M.S. and S. M. Saheed (1998). Physical properties of some benchmark soils from the flood plains of Bangladesh. *J. Indian Soc. Soil Sci.,* **46**:442-446.

Lindsay, W.L. and W.A. Norvell (1978). Development of DTPA soil test for Zn, Fe, Mn and Cu. *Proc. Soil Sci. Soc. Amer.* **42**:421-428.

Lins I.D.G.* and Cox, F.R. (1988). *Soil Sci.Soc.Am. J.* **52**, 1681.

Mahajan, T.S. (2001). Status and distribution of micronutrients in relation to the properties of lateritic soils under mango orchards in South Konkan. M.Sc.(Agri.) Thesis submitted to BalasahebSawantKonkanKrishiVidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra.

Mahesh Kumar*, Singh, S.K., Raina, P. and B.K.Sharma (2011). Status of available major and micronutrients in arid soils of Churu district of Western Rajasthan. *J. Indian Soc. Soil Sci.,* **59**(2): 188-192.

Malvade, S.S. (1993). DTPA extractable micronutrients, their distribution and relationship with soil properties in rice soil profiles of Konkan region.

M. Sc. (Agri.) Thesis submitted to KonkanKrishiVidyapeeth,Dapoli, Maharashtra(Unpublished).

Malewar G. U. (1994). Two decades of soils science research at MararthwadaAgril. University, Parbhani. In souvenir(2 decades of soil science research). Published by Parbhani chapter of ISSS, M.A.U., Parbhani PP: 17-52.

Malewar, G.U. (1995). Micronutrient availability as influenced by cropping patterns in Marathwada region of Maharashtra. *J. Maharashtra Agric. Univ.*,**20**(3):330-333.

Malewar, G.U. and C.P. Ghonsikar. (1984). Maharashtra Soils and their Zinc Chemistry. *J. Maharashtra Agric. Univ.* **9**(1):1-7.

Mali, V.S. (1989).Characterisation of soil potassium in benchmark soils of north Konkan. M.Sc.(Agri.) Thesis submitted to BalasahebSawantKonkanKrishiVidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished).

Mathan, K.K. (1991). Infiltration studies in alfisols. *J. Indian Soc. Soil Sci.,* **39**:344-347.

Mehta, B.V*., Reddy, G.R., Nair, S. C., Gandhi, Neelkanthan, V. and K. G. Reddy (1964). Micronutrient studies on the Gujarat soils and plants. *J. Indian Soc. Soil Sci.,* **12**(4):329-332.

Mete, P.K. and A. Samanta (1996). Distribution of iron fractions in red and lateritic soils of West Bengal. *J. Maharashtra Agric. Univ.*,**21**(3):327-329.

Modak, S.J. (1990). Response of rice to zinc to zinc and iron applied in combination with FYM in black calcareous soil from Agricultural Research Station Farm, Palghar (Thane). M.Sc.(Agri.) Thesis submitted to KonkanKrishiVidyapeeth, Dapoli.

Mohapatra, A. R. and M. M. Kibe (1973). Effect of rainfall on the physic-chemical properties of the basaltic soils of Maharashtra State. *Madrisagric .J.*

60(3):164-169.

More, S.D., Patil, J.D.andA.K.Shingte(1984). Micronutrient status of soils of rice growing areas of Pune region and its correlation with important soil properties. *J. Maharashtra Agril. Univ.,***9**(3): 240-242.

Murthy, I.Y.L.N., Saatry, T.G., Datta, S.C., Narayanasamy, G. and R.K.Rattan (1997). *J. Indian Soc. Soil Sci.,* **45**: 577-580.

NBBS* and LUP (1981). *Res. Bull.***3**, Nagpur.

Nayak, D.C., Mukhopadhyay and D. Sarkar (2000). Distribution of some available nutrients in alluvial soil of Arunachal Pradesh in relation to soil characteristics. *Indian J. Soc. Soil Sci.,* **48**(3): 612-614.

Nipunage, M.V., A.L. Pharande and R.S. Wadkar (1996). Distribution of total and DTPA-micronutrient cations in Inceptisol soil series of Maharashtra. *J. Indian Soc. Soil Sci.,* **44**(4): 779-781.

Ommala D. Kuchanwar, Tirthakar,S.S., Wagh, S. P. and N. K. Chopde (2005). Characterization and classification of Some Typical Acid Lime Growing Soils of Akola District.*PKV Res. J.Vol.* **29**(2):194:197.

Pal, S.K. and A. K. Mukhopadhyay (1992). Distribution of different forms of potassium in profiles of some entisols. *J. Indian Soc.Soil Sci.,***40**:371-73

Parab, D.D. (1990). Potassium fixation, its release and mineralogical composition of some benchmark soils in South Konkan. M. Sc.(Agri.) Thesis submitted to KonkanKrishiVidyapeeth, Dapoli (Unpublished).

Pati, R. and D. Mukhopadhyay *(2011). Distribution of cationic micronutrients in some acid soils of West Bengal. *J. Indian Soc. Soil Sci.,* **59**(2):125-133.

Patil, C.H. (1981). To study the physico-chemical properties of the soils from bench terraced area of Agronomy block of the Central Farm, Wakawali. M.Sc. (Agri.) Thesis submitted to KonkanKrishiVidyapeeth, Dapoli

(Maharashtra).

Patil K.A. (1986 b). Physico- chemical characterization of the rice soils from Agricultural Research Station, Shirgaon, Dist. Ratnagiri. M.Sc. (Agri.) Thesis submitted to BalasahebsawantKonkanKrishiVidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished).

Patil, S.V. (1986 c).Physico-chemical properties of the soils of the Regional Coconut Reasearch Station Bhatye (Ratnagiri). M.Sc.(Agri.) Thesis submitted to BalasahebsawantKonkanKrishiVidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished).

Patil, J.M. (1986 a). Nitrogen fractions in lateritic and medium black soils of Konkan. M. Sc. (Agri.) Thesis submitted to KonkanKrishiVidyapeeth, Dapoli (Unpublished).

Patil, K.D. (2001). Clay mineralogy, dynamics of zinc, its direct and residual effect on rice soils of Konkan, Ph.D. thesis, G.A.U. SardarKrishi Nagar.**24** (2):130-132.

Patil, K.D. and M.B. Meisheri (2004). Minerological studies and DTPA-Extractable Zn, Cu, Mn and Fe in representative soils of Konkan region. *J. Maharashtra Agril. Univ.*,**29**(1): 4-8.

Patil, J.D. and A.K. Shingate (1982). Micronutrient status of soils from draught prone area of Pune region (Maharashtra). *J. Indian Soc. Soil Sci.*, **7**(3): 216-218.

Patil, Y.M. and K.R. Sonar (1994). Status of major and micronutrients of swell-shrink soils of Maharashtra. *J. Maharashtra Agric. Univ.*, **19**(2): 169-172.

Patil, K.D., Meisheri M.B., Dabke, D.J. and D.S. Bagade(2003). Distribution of DTPA- extractable cinc, Copper, iron and manganese contents in rice soils of Konkan. *J.Soils and Crops*.**13** (1): 85-90.

Patil, G.D., Khedkar, V.R., Tathe, A.S. and A.N. Deshpande (2008). Characterisation and classification of soils of Agricultural College Farm, Pune. *J. Maharashtra agric. Univ.*,**33** (2): 143-148.

Patil, K.D., Chavan S.A. and N.B.Gokhale. (2010). Present status of micronutrient research and future strategies for research in Konkan region. 9th National Symposium of ICAR, Goa. 27-30.

Patro, T. G. and C. Misra (1985). In situ studies on the water balance of rainfed cereal and legume root zones in a TypicHaplustult. I. Determination of hydraulic properties of the experimental field. *J. Indian Soc. Soil Sci.*, **33**(3): 469-477.

Pawar, S. L. (1993). Soil physico-chemical properties and fertility maps of the rice fields of the farms of the Department of Agronomy, College of Agriculture, Dapoli, Dist. Ratnagiri. M.Sc.(Agri.) Thesis submitted to KonkanKrishiVidyapeeth, Dapoli (Unpublished).

Pednekar, R.L. (1998). Studies on status and forms of sulphur in some soil series in Khedtahsil of Ratnagiri district. M.Sc.(Agri.) Thesis submitted to KonkanKrishiVidyapeeth, Dapoli, Dist. Ratnagiri (Maharashtra).

Padole, V.R. and S.B.Mahajan (2003). Status and release of potassium in some swell-shrink soils of Vidharbha, Maharashtra. *J. Maharashtra Agric. Univ.*, **28**(1) : 3-7.

Pereira, A.J. (1983). Studies on the physico-chemical properties and available micronutrient status of the mango hill (no.2) soil of the Wakawali block. M.Sc.(Agri.) Thesis submitted to KonkanKrishiVidyapeeth, Dapoli (Unpublished).

Pereira, A.J., A.S. Chavan and P.A. Varade (1986). Physico-chemical properties and micronutrients status of the mango orchard hill soils of Konkan. *J.*

Maharashtra Agric. Univ., **11**(2): 134-136.

Pharande, A.L., Raskar, B.N. and Nipunje, M. V. (1996). Micronutrient status of important vertisoil and alfisol soil series of western Maharashtra. *J. Maharashtra Agric. Univ.,* **21**(2):182-185.

Phonde, D.B. (1987). Phosphorous fixation capacity as influenced by soil properties of rice soils of Konkan. M.Sc.(Agri.) Thesis submitted to BalasahebsawantKonkanKrishiVidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished).

Piper, C.S. (1966). Soil and Plant Analysis. Hans Publishers, Bombay.

Prasunarani, P., R.N. Pillai, V.Bhanuprasad and G.V. Subbaiah (1992). Nutrient status of some red and associated soils of Nellore district under Somasila project in Andhra Pradesh. *The Andhra Agric. J.,* **39**:1-5.

Preethi, P., P. Raja, J. Sehgal and K.S. Gajbhiye (1998). Study on mineralogy of some selected soils from hot humid to per humid ecosystem of Kozhikode, Palaghat and Emalkulam areas in Kerala. *J.Indian Soc. Soil Sci.,***46**: 430-435.

Pradeep Kumar., Sharma S. P. and P.D. Sharma (1995). Distribution of N, P and K in Soan river valley soils of lower Shiwaliks. *J. Indian Soc. Soil Sci.,* **43**(3): 360-364.

Raghupati, H.B. and B.S. Bhargava (1997). Preliminary diagnostic soil fertility normss for Alphonso mango. *J. Indian Soc. Soil Sci.,* **45**:534-536.

Rajeswar, M., Ch. SujiniRao., Balaguravaiah and M.A. Aariff Khan*(2009). Distribution of available macro and micronutrients in soils of Garikapadu of Krishna district of Andhra Pradesh. *J. Indian Soc. Soil Sci.,* **57**(2): 210-213.

Rao, A.P., U. P., Naidu, M.V.S., Ramavatharam, N. and G.R.Rao (2010). Characterization, classification and evaluation of soils on different landforms in RamachandrapuramMandal of Chittor district in Andhra Pradesh for sustainable land use planning. *J. Indian Soc. Soil Sci.,* **56**:23-33.

Ramteke, C. F. (1996). Characterization of soils of Dapura village, district Akola in Pune valley of Vidarbha. M.Sc.(Agri.) Thesis submitted to Dr. PDKV, Akola. (Unpublished).

Raj Kumar, V.K. Nayyar, G.S. Sidhu and S.N. Deshmukh (1990). Distribution of available micronutrient cations in some dominant soil series in different physiographic units of Bundelkhand region of Madhya Pradesh. *J. Indian Soc. Soil Sci.,* **38**(3): 410-415.

Rathore, G.S., R.S.Khamparia., Gupta, G.P. and S.B. Sinha (1980). Availability of micronutrient in some alluvial soils and their effect on wheat. *J. Indian Soc. Soil Sci.,* **28**(2): 248-250.

Ravikumar D. Modi.,Bheemappa,A., Manjunath, L., Hedge, R.V. and J.A. Handigol(2010). *Karnataka J.Agric. Sci.,***23**(4): 606-611.

Revandkar, N.S. (1990). Physico-chemical properties and fertility maps of the soils from the Soil Conservation Research Station, Awashi (Dist. Ratnagiri). M.Sc.(Agri.) Thesis submitted to KonkanKrishiVidyapeeth, Dapoli (Unpublished).

Talukdar, M.C., Basumatary, A. and S.K. Dutta (2009). Status of DTPA-extractable cationic micronutrients in soils under rice and sugarcane ecosystems of Golaghat district in Assam. *J. Indian Soc. Soil Sci.,* **57**(3): 313-316.

Tiwari, S. C., Tiwari, B. K. and Mishra (1987). *Proc. Indian natn.Sci.Acad.***53B**, 176.

Sagane, N.A. (1987). Assessment of different extractants, Q/I parameters, soil depth, part of leaf and period of sampling for predicting availability of soil potassium for Alphonso mango in lateritic soil. M.Sc.(Agri.) Thesis submitted to KonkanKrishiVidyapeeth, Dapoli (Maharashtra).

Saha, P. K., Adhikari, S. and D. K. Chatterjee (1996). Available iron, copper, zinc and manganese in some fresh water pond soils of Orissa in relation to soil characteristics. *J. Indian Soc. Soil Sci.,* **44**(4): 681-684.

Sahoo, A.K., T. Chattopadhyay, R.S. Singh and R.L. Shyampura (1995). Available micronutrient status in the soils of Malwa plateau (Rajasthan). *J. lndian Soc. Soil Sci.,* **43**(4):698-700.

Sakal, R., Singh, A.P. and S.P. Singh (1988). *J. Indian Soc. Soil Sci.,* **36**: 59.

Salvi, V. G. (1988). Physico-chemical properties and available micronutrient status of the rice soils from Agricultural Research Station, Palghar (Thane).

Sanborn, P. (2001). Influence of broad leaf trees on soil chemical properties: A retrospective study in the sub- boreal spruce zone, British Columbia, Canada. Plant and Soil **236**, 75-82.

Sankaram, A. (1966). A laboratory Manual for Agricultural Chemistry, Published by Asia Publishing House, Bombay, pp.41-149.

Sankpal, A.A. (2008). Studies on physico-chemical properties of lateritic soils of Agriculture Research Station, Phondaghat (Sindhudurg). M.Sc.(Agri.) Thesis submitted to BalasahebSawantKonkanKrishiVidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra. (unpublished)

Sarkar, D. and A. K. Sahoo (2000). Aquepts of Indo-Gangetic plain of Bihar and their suitability for some major crops. *J. Indian Soc. Soil Sci.,* **48**(3): 561-566.

Sarkar, D., Haldar, A., Majumdar and M. Velayutham (2002). Distribution of micronutrients cations in some inceptisols and entisols of Madhubani district, Bihar. *J. Indian Soc. Soil Sci.,* **48**(1):202-205.

Sarma, P.K., Bardoli, T. C., Baruah, K.N., Das and N. Borah (1997). Physical characterization of soils in two command areas of Assam. *J. Indian Soc. Soil Sci.,* **45**(1):709-712.

Sawant, U.S. (2004). Effect of some forest tree species on the physico-chemical properties of lateritic soils of Konkan region. M.Sc.(Agri.) Thesis submitted to BalasahebsawantKonkanKrishiVidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra.

Schaffer, B., P.C. Anderson and R.C. Ploetz (1992). Response of fruit crops to flooding. *Hort. Rev.* **13**: 257-301.

Sehgal, J. (1996). Pedology- Concepts and applications. 1st edition Kalyani publication, New Delhi, pp.488.

Seth, S.P.* (1967). Indices for diagnosis and salinity in soils of Rajasthan canal area.

Shah,Y.K. (1992). Characterisation of soils and preparation of fertility maps of the farm of Agricultural School, Roha. M.Sc.(Agri.) Thesis submitted to BalasahebsawantKonkanKrishiVidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished).

Shrinivas, D.,* Prasad, P. R. K., SubbaRao, G. and T. V. Satyanarayana (2011). Physico-chemical properties and major nutrient status in some soils of Krishna western delta, Andhra Pradesh. *J. Indian Soc. Coastal agric. Res.,***29** (1): 35-39.

Sharma, M.P. and S.V. Bali (2000). Long term effect of different cropping system on physico-chemical properties and soil fertility. *J. Indian Soc. Soil Sci.,* **48**(1): 183.

Sharma, R. P., Singh, M. and J. P. Sharma (2003). Correlation studies on micronutrients vis-à-vis soil properties in some soils of Nagpur district in semi-arid region of Rajsthan. *J. Indian Soc. Soil Sci.,* **51**:522-527.

Sharma, J.C. and SanjeevK.Chaudhary (2007). Vertical distribution of micronutrient cations in relation to soil characteristics in lower Shiwaliks of Solan district in North-West Himalayas. *J. Indian Soc. Soil Sci.,* **55**(1):40-44.

Shinde, S.B. (2006). Physico-chemical properties of lateritic soils from mango orchards in Ratnagiri and Sindhudurg districts. M.Sc.(Agri.) Thesis submitted to BalasahebSawantKonkanKrishiVidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra.

Sidhu, P.S., Raj-Kumar and B.D. Sharma (1994). Characteristics and classification of entisoils in different moisture regimes of India. *J. Indian Soc. Soil Sci.,* **42**:633-640.

Singh, R. D., Sanjay Kumar and HaritPande (2006). Micronutrient status of soils under different vegetation in Uttaranchal hills. *J. Indian Soc. Soil Sci.,* **54**:115-116.

Singh, M.V.(2006). All India co-ordinated research project of micro and secondary nutrients and pollutant elements in soils and plants by Indian Institute of Soil Science Bhopal. 17-37.

Singh, S. K., Baser, B.L. and Shyampura, R.L.(2002). Chemical composition and charge behaviour of smectites in vertisols of Rajasthan. *J. Indian Soc. Soil Sci.,* **50**:106-111.

Singh, V.K., Agrawal, H.P. and Prasad S. (2009). Distribution of DTPA-extractable micronutrients in the soils of district Ghazipur, Uttar Pradesh. *J. Indian Soc. Soil Sci.,* **57**(3):370-372.

Somasundaram, J., Singh, R.K., Parandiyal, A.K. and S.N. Prasad (2009). Micronutrient status of soils under different land use systems in Chambal ravines. *J. Indian Soc. Soil Sci.,* **57**(3): 307-312.

Subbaiah, B.V. and G.I,.Asija (1956). A rapid procedure for the estimates of available nitrogen in soil. *Curr. Sci.* **25**(8): 259-260.

Subbaiah, G.V. and T.S. Manickam (1992). Gnesis and morphology of vertisols developed on different parent materials.*J. Indian Soc. Soil Sci.,* **40**(1): 150-155.

Suryavanshi, A.V. (2010).Micronutrient status and it's relationship with soil properties in mound planted mango orchards of Sindhudurg district (Konkan region, M.S.). M.Sc.(Agri.) Thesis submitted to BalasahebsawantKonkanKrishiVidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra.

Taware, H.M. (1983). Studies on the physico-chemical properties and available micronutrient status of the mango hill (No. l and 3) soils of the Wakawali block. M.Sc.(Agri.) Thesis submitted to KonkanKrishiVidyapeeth, Dapoli (Maharashtra).

Terse, G.V. (1989). Characterization of soil potassium in benchmark soils of South Konkan. M. Sc.(Agri.) Thesis submitted to KonkanKrishiVidyapeeth, Dapoli (Unpublished).

Thangaswamy, A., Naidu, M.V.S., Ramavatharam, M. and C. Raghavareddy (2005). *J. Indian Soc. Soil Sci.,* ***53***: 11-2.

Todmal, S.M., Patil, B.D. and B.D. Tamboli (2008). Characterisation and Classification of soils in Agriculture College Farm, Kolhapur. *J. Maharashtra Agric. Univ.*,**33**(3):287-291.

Tupe, S.A. (1996). Studies on effect of bio-organic soil enricher (elrich) application on growth and yield of Okra (Abelmoschusesculentus (L.) Monech) and physico-chemical changes in lateritic soils of Konkan. M.Sc.(Agri.) Thesis submitted to BalasahebsawantKonkanKrishiVidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished).

U.S.D.A. National Nutrient Data Base (2011).

Vaidya, K.P. (1988). Forms of manganese and their distribution in rice soil profiles in Konkan. M.Sc.(Agri.) Thesis submitted to KonkanKrishiVidyapeeth, Dapoli (Maharashtra).

Varma,V.K., Setia, R.K., Sharma, P.K., Singh,Charanjit and Ashok Kumar. (2005). *Agropedology*, **15** (1): 70-75.

Waghmare, M.S., Indulkar, B.S., Mali, C. V., Takankhar, V. G. and V. G. Bavalgave (2008). Chemical properties and micronutrient status of some soils of Ausa tehsil of Latur, Maharashtra. *An Asian Journal of Soil Science*, **3**(2): 236-241.

Wilson, Brian R. (2007). Scattered native trees and soil patterns in grazing land on the northern table lands of New South Wales, Australia. *Australian Journal of Soil Research,* **45**:199-205.

Yadav, A.N. (1988). Characterisation of soils from sapota garden at Dahanu (Thane). M.Sc. (Agri.) Thesis submitted to BalasahebsawantKonkanKrishiVidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra (Unpublished).

Fig. 4.13 : Variation in physico-chemical properties (mechanical composition) of soils from mango orchards.

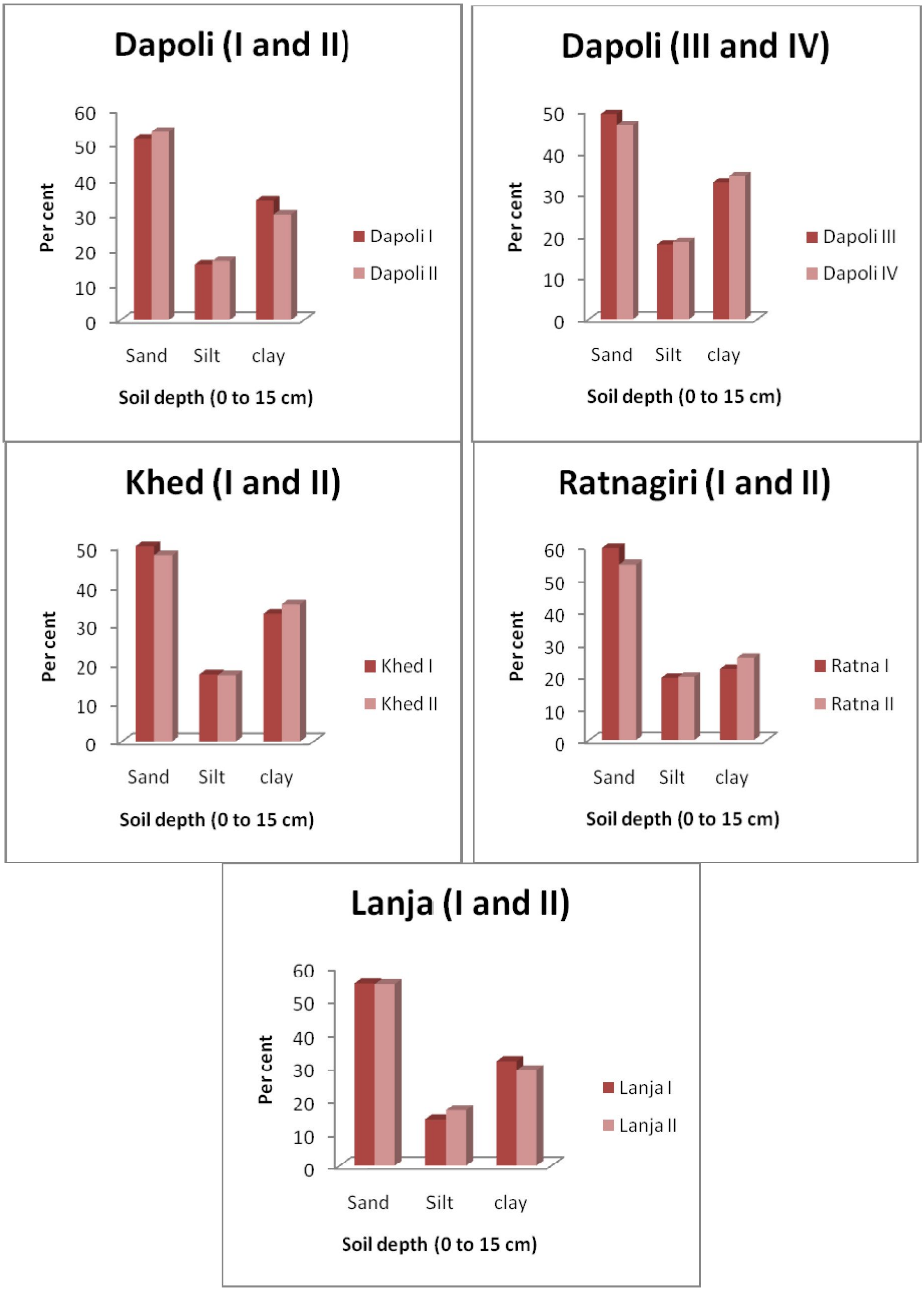


Fig. 4.14 (a) : Influence of soil depth on physico-chemical properties (mechanical composition) of soils from mango orchards.

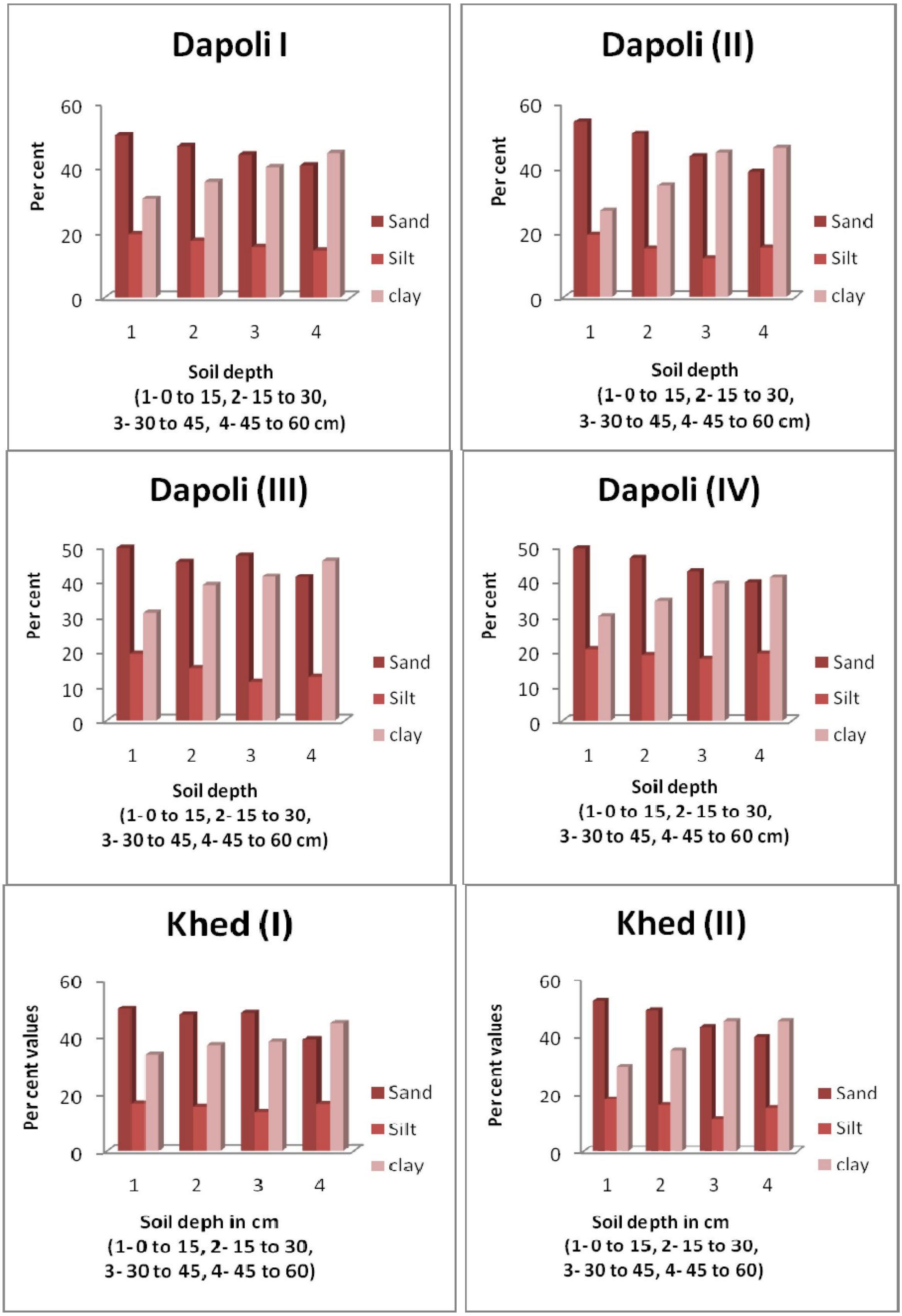
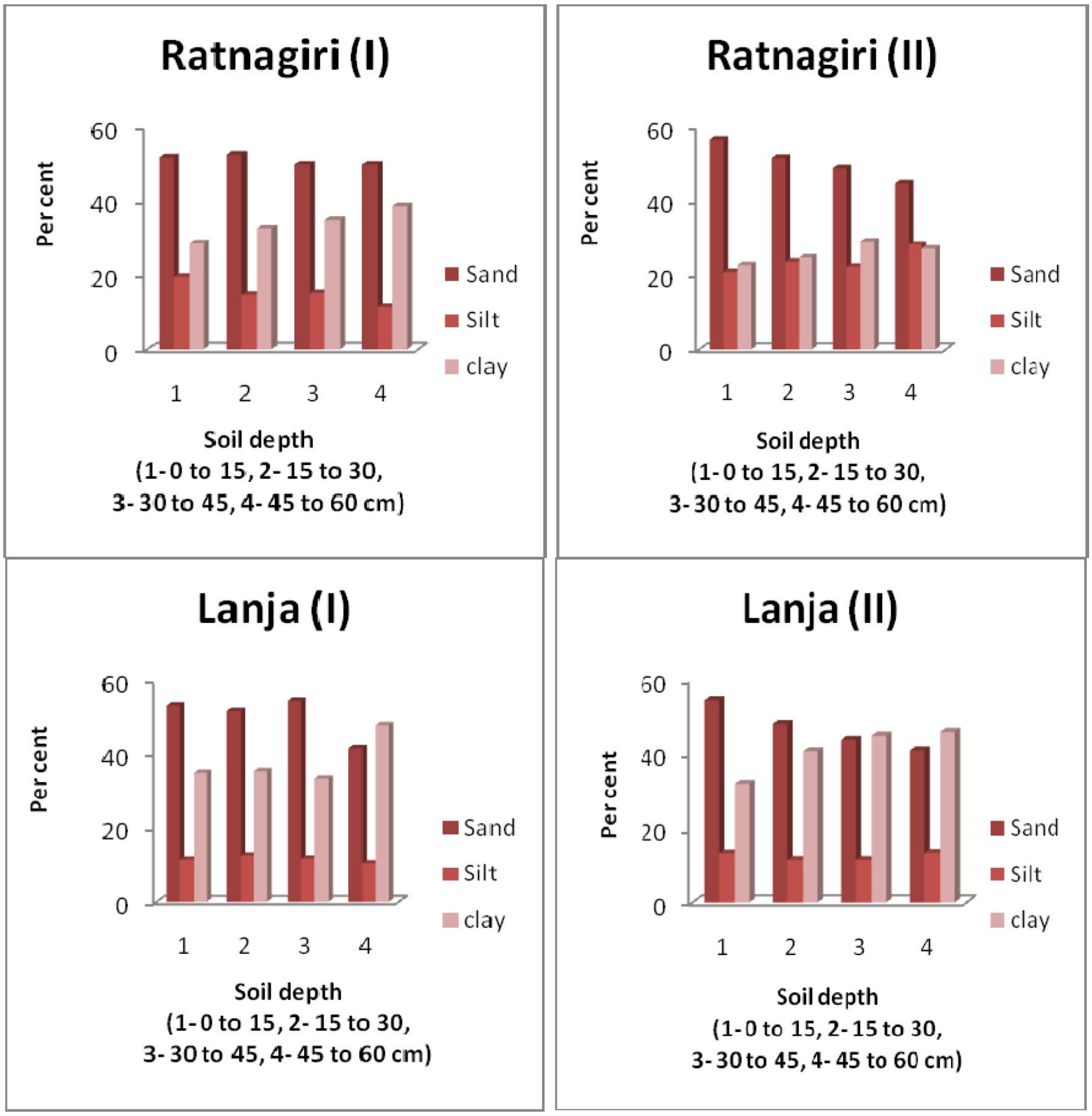


Fig. 4.14(b) : Influence of soil depth on physico-chemical properties (mechanical composition) of soils from mango orchards.



Ratnagiri (I)
Per cent
60
40
20
0
1
2
3
4
Sand
Silt
clay
Soil depth
(1- 0 to 15, 2- 15 to 30,
3- 30 to 45, 4- 45 to 60 cm)
Ratnagiri (II)
Per cent
60
40
20
0
1
2
3
4
Sand
Silt
clay
Soil depth
(1- 0 to 15, 2- 15 to 30,
3- 30 to 45, 4- 45 to 60 cm)
Lanja (I)
Per cent
60
40
20
0
1
2
3
4
Sand
Silt
clay
Soil depth
(1- 0 to 15, 2- 15 to 30,
3- 30 to 45, 4- 45 to 60 cm)
Lanja (II)
Per cent
60
40
20
0
1
2
3
4
Sand
Silt
clay
Soil depth
(1- 0 to 15, 2- 15 to 30,
3- 30 to 45, 4- 45 to 60 cm)

Fig. 4.15 : Variation in physico-chemical properties (B.D. and P.D.) of soils from mango orchards.

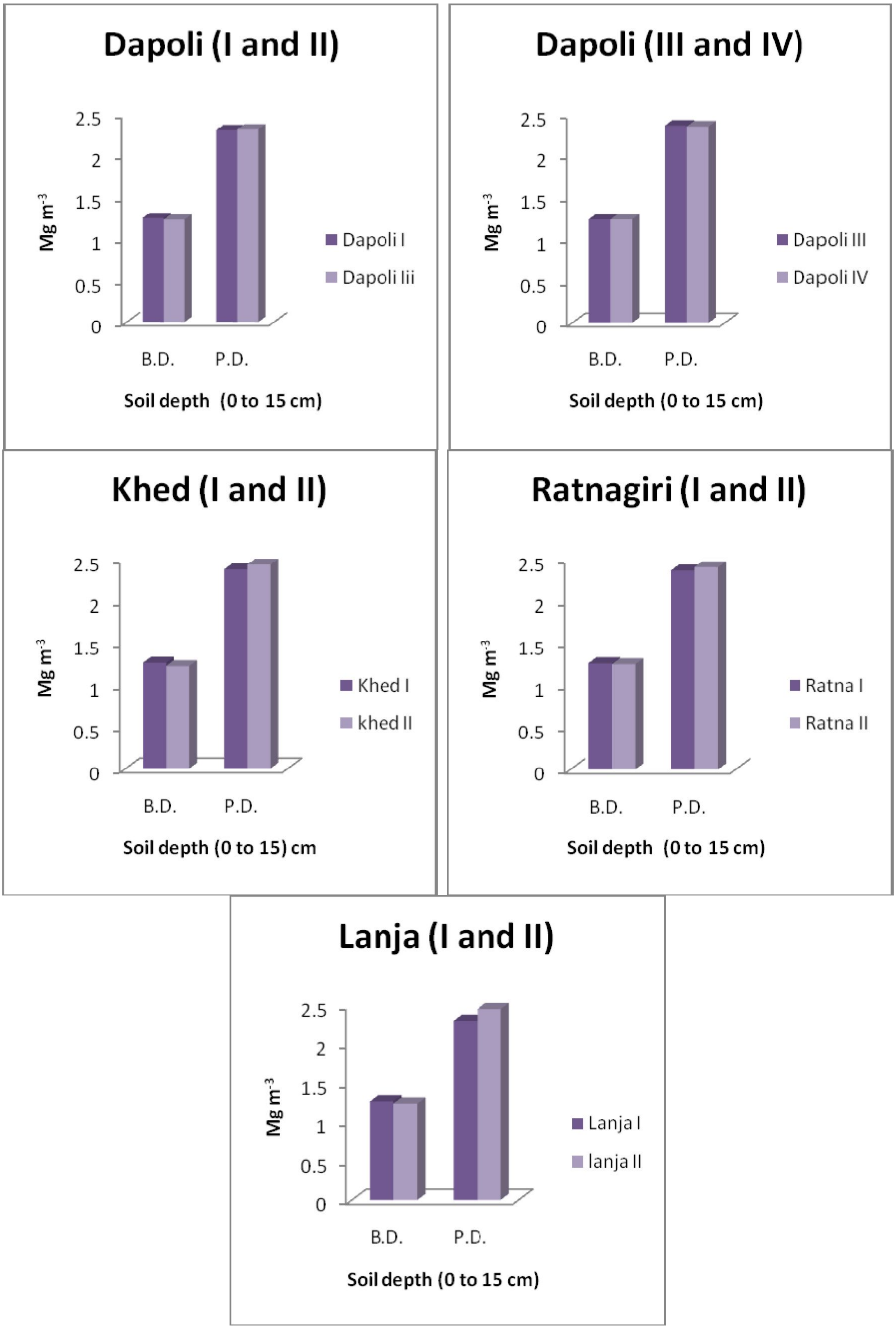


Fig. 4.16(a) : Influence of soil depth on physico-chemical (B.D. and P.D.) of soils from mango orchards.

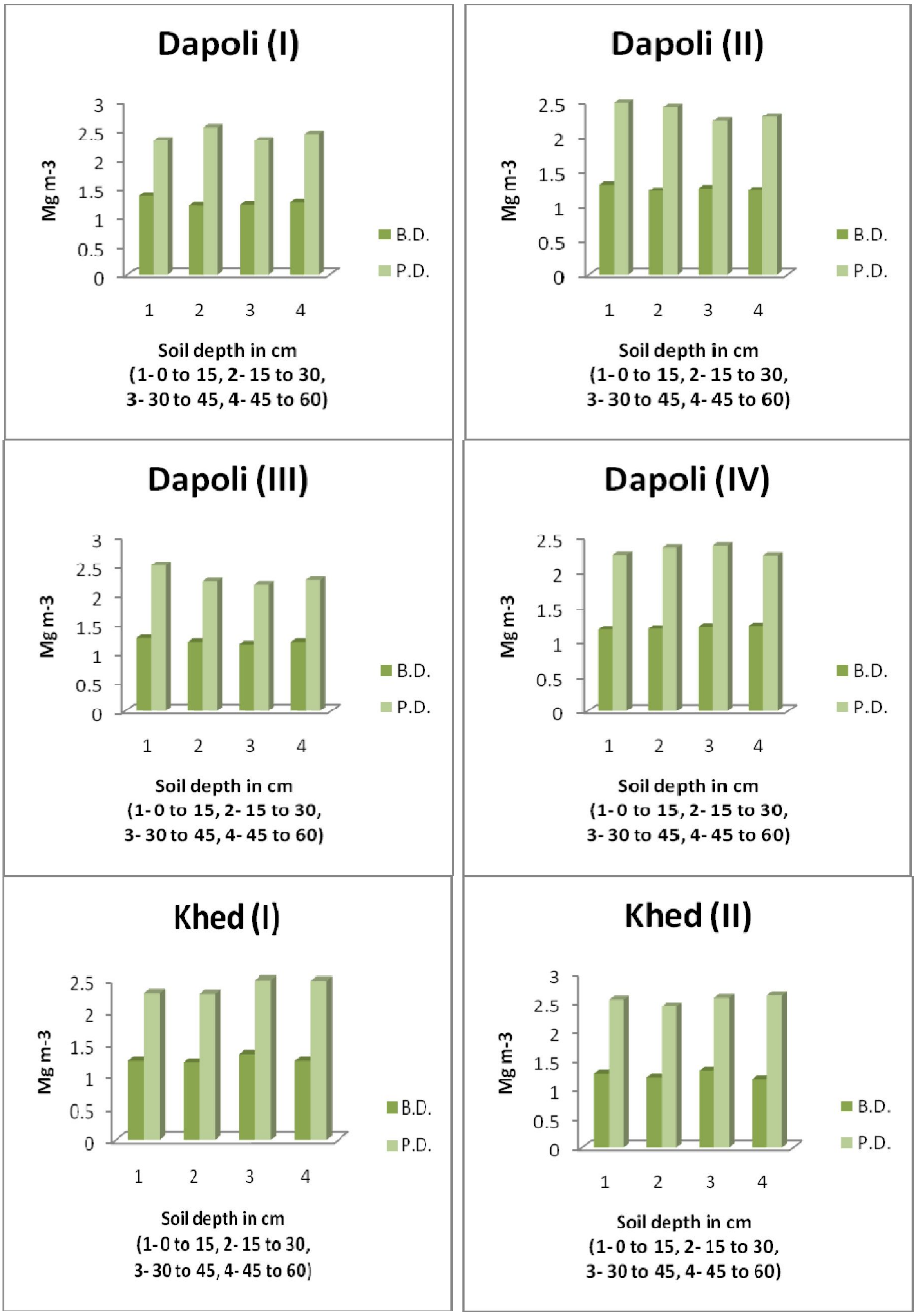
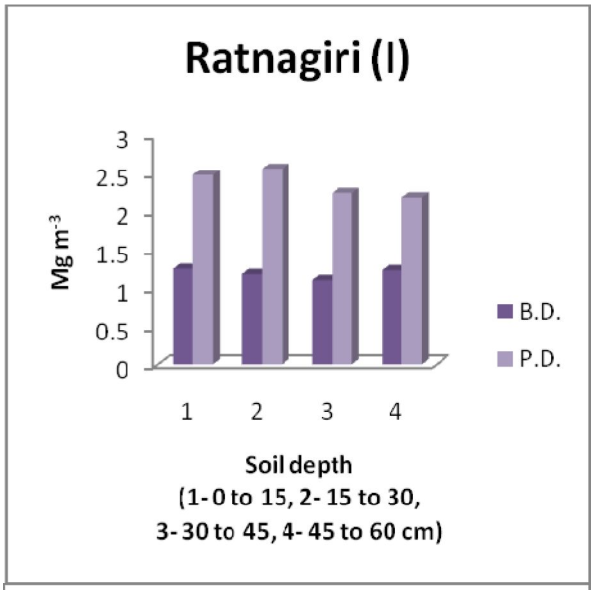
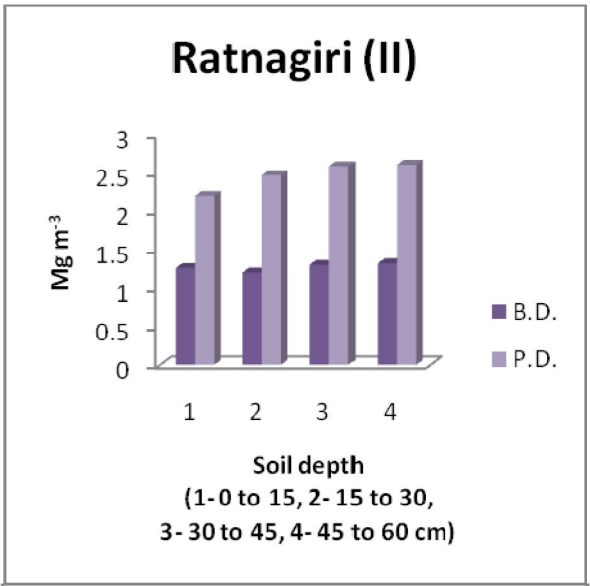
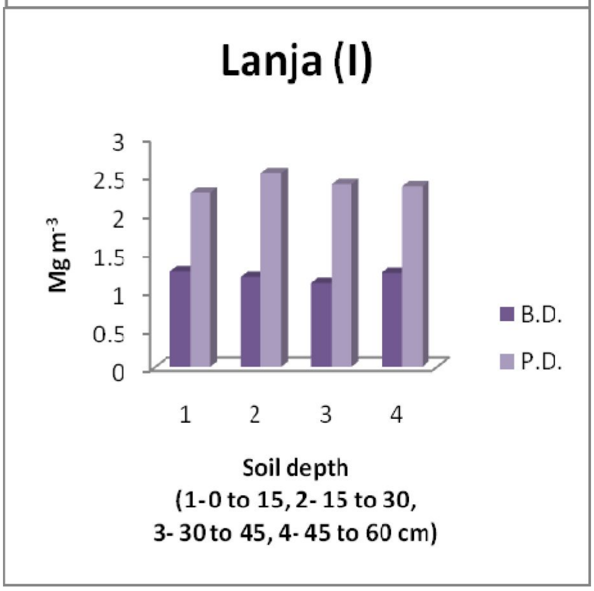


Fig. 4.16(b) : Influence of soil depth on physico-chemical properties (B.D. and P.D.) of soils from mango orchards.


Ratnagiri (I)
Mg m-3
3
2.5
2
1.5
1
0.5
0
1
2
3
4
B.D.
P.D.
Soil depth
(1- 0 to 15, 2- 15 to 30,
3- 30 to 45, 4- 45 to 60 cm)


Ratnagiri (II)
Mg m-3
3
2.5
2
1.5
1
0.5
0
1
2
3
4
B.D.
P.D.
Soil depth
(1- 0 to 15, 2- 15 to 30,
3- 30 to 45, 4- 45 to 60 cm)


Lanja (I)
Mg m-3
3
2.5
2
1.5
1
0.5
0
1
2
3
4
B.D.
P.D.
Soil depth
(1- 0 to 15, 2- 15 to 30,
3- 30 to 45, 4- 45 to 60 cm)

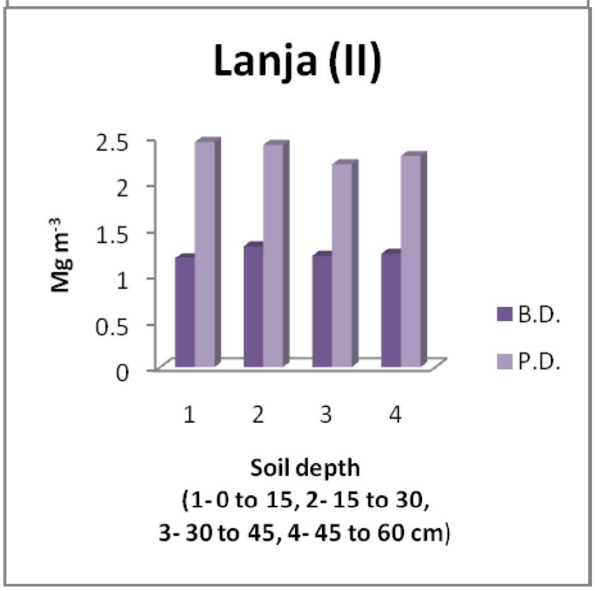

Lanja (II)
Mg m-3
2.5
2
1.5
1
0.5
0
1
2
3
4
B.D.
P.D.
Soil depth
(1- 0 to 15, 2- 15 to 30,
3- 30 to 45, 4- 45 to 60 cm)

Fig. 4.17 : Variation in physico-chemical properties (M.W.H.C., pH, E.C., O.C.) of soils from mango orchards.

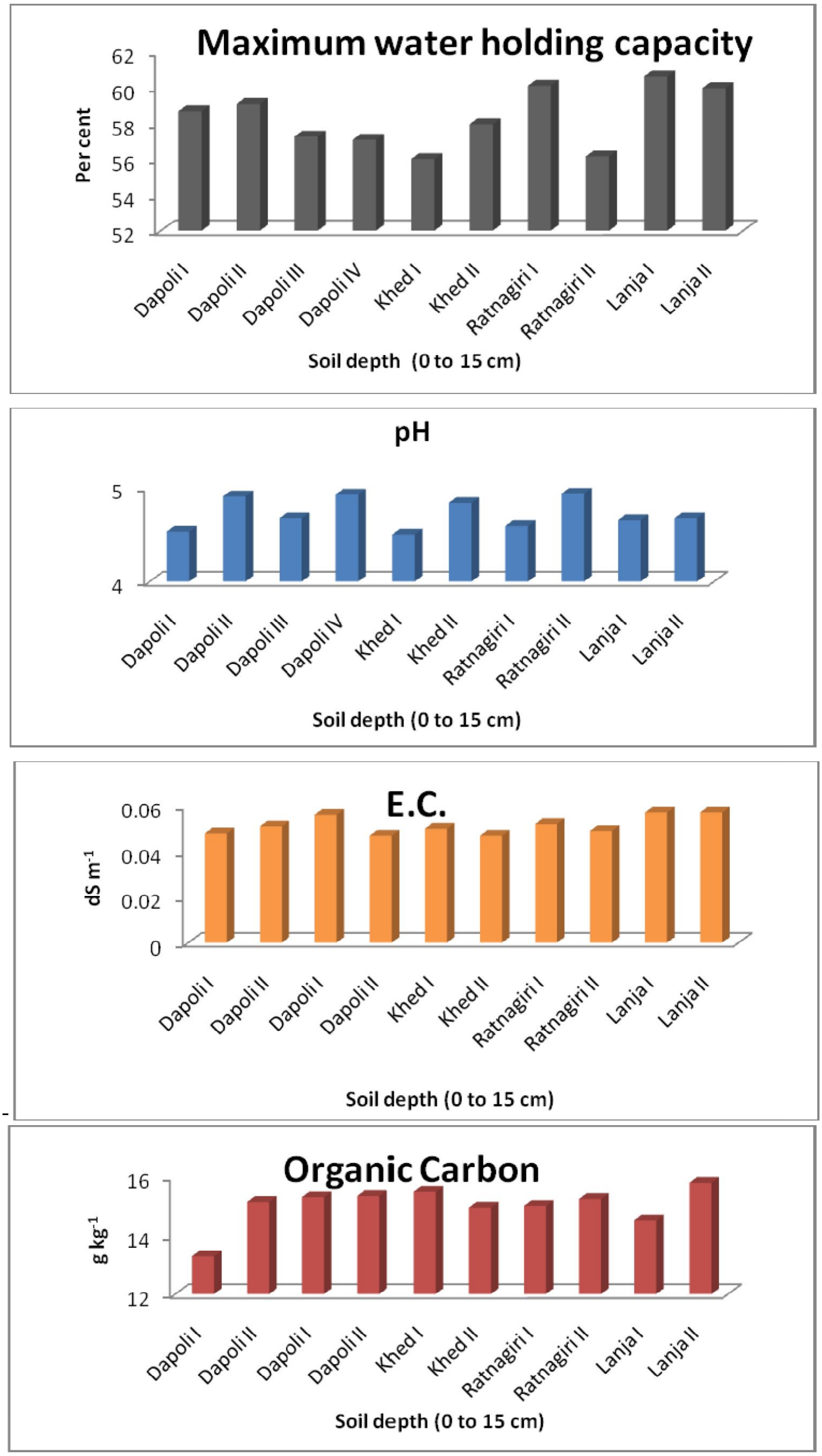


Fig. 4.18 : Influence of soil depth on physico-chemical properties (M.W.H.C.) of soils from mango orchards.

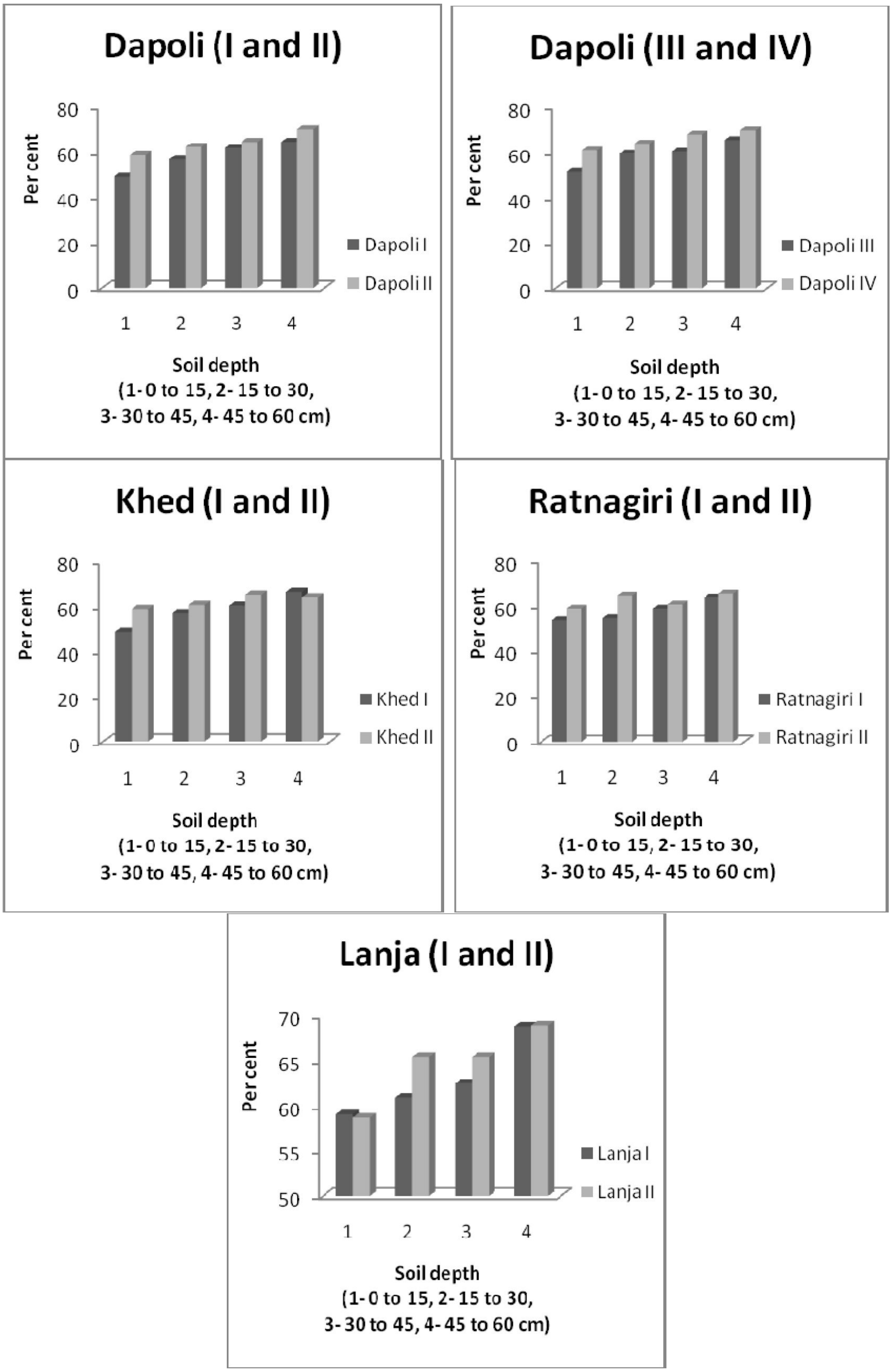


Fig. 4.19 : Influence of soil depth on physico-chemical properties (pH) of soils from mango orchards.

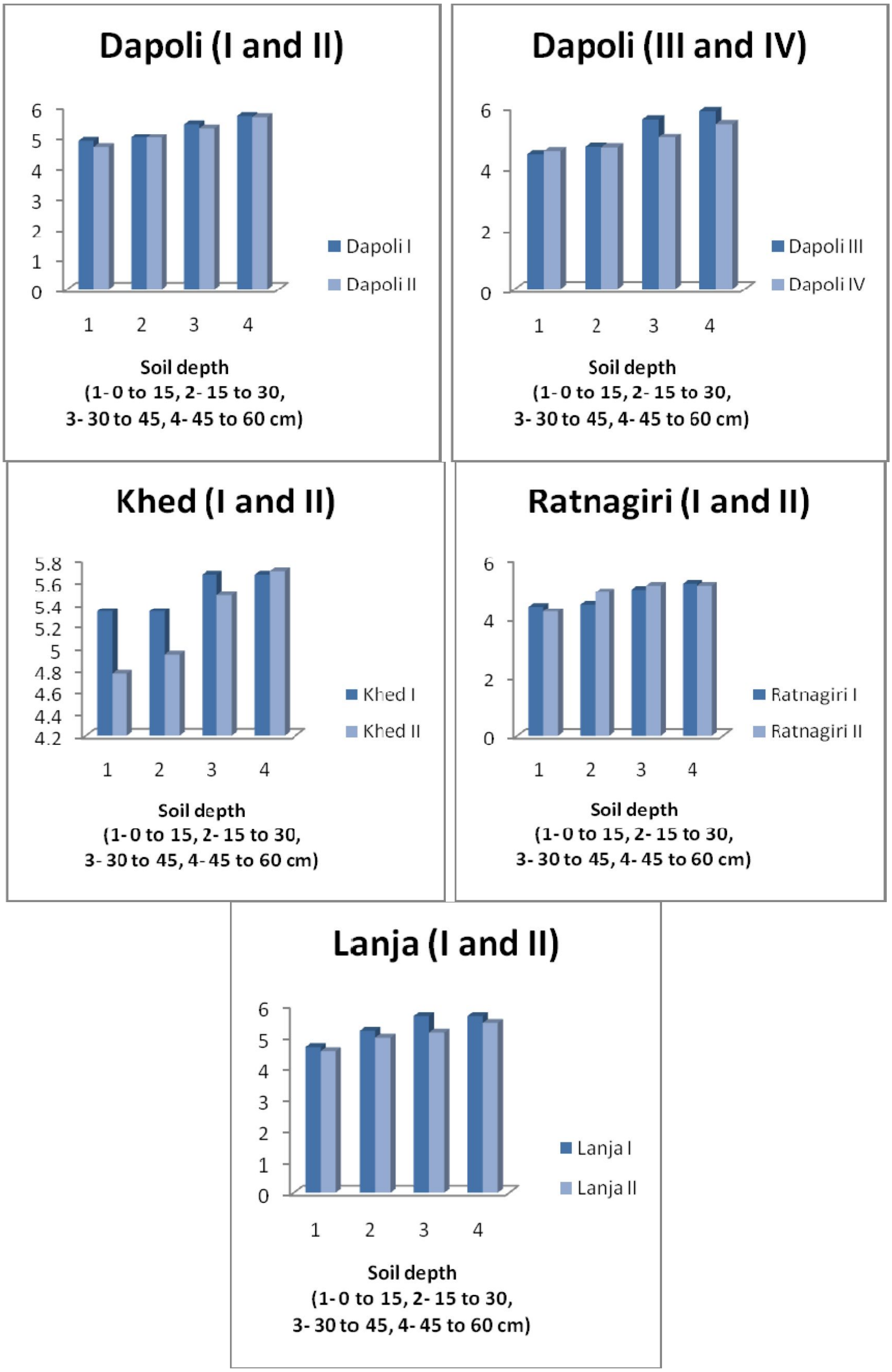


Fig. 4.20 : Influence of soil depth on physico-chemical properties (E.C.) of soils from mango orchards.

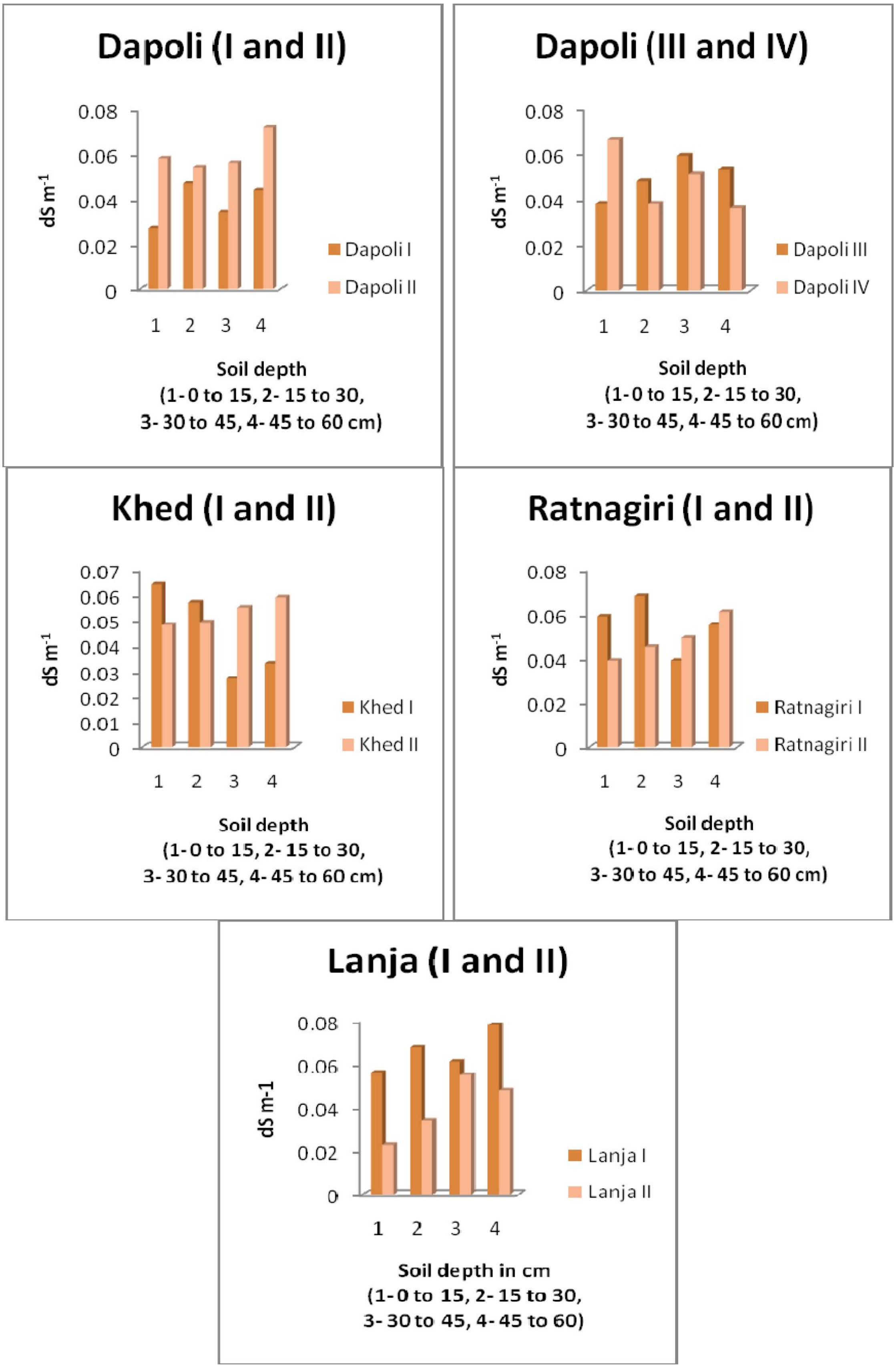


Fig. 4.21 : Influence of soil depth on physico-chemical properties (O.C.) of soils from mango orchards.

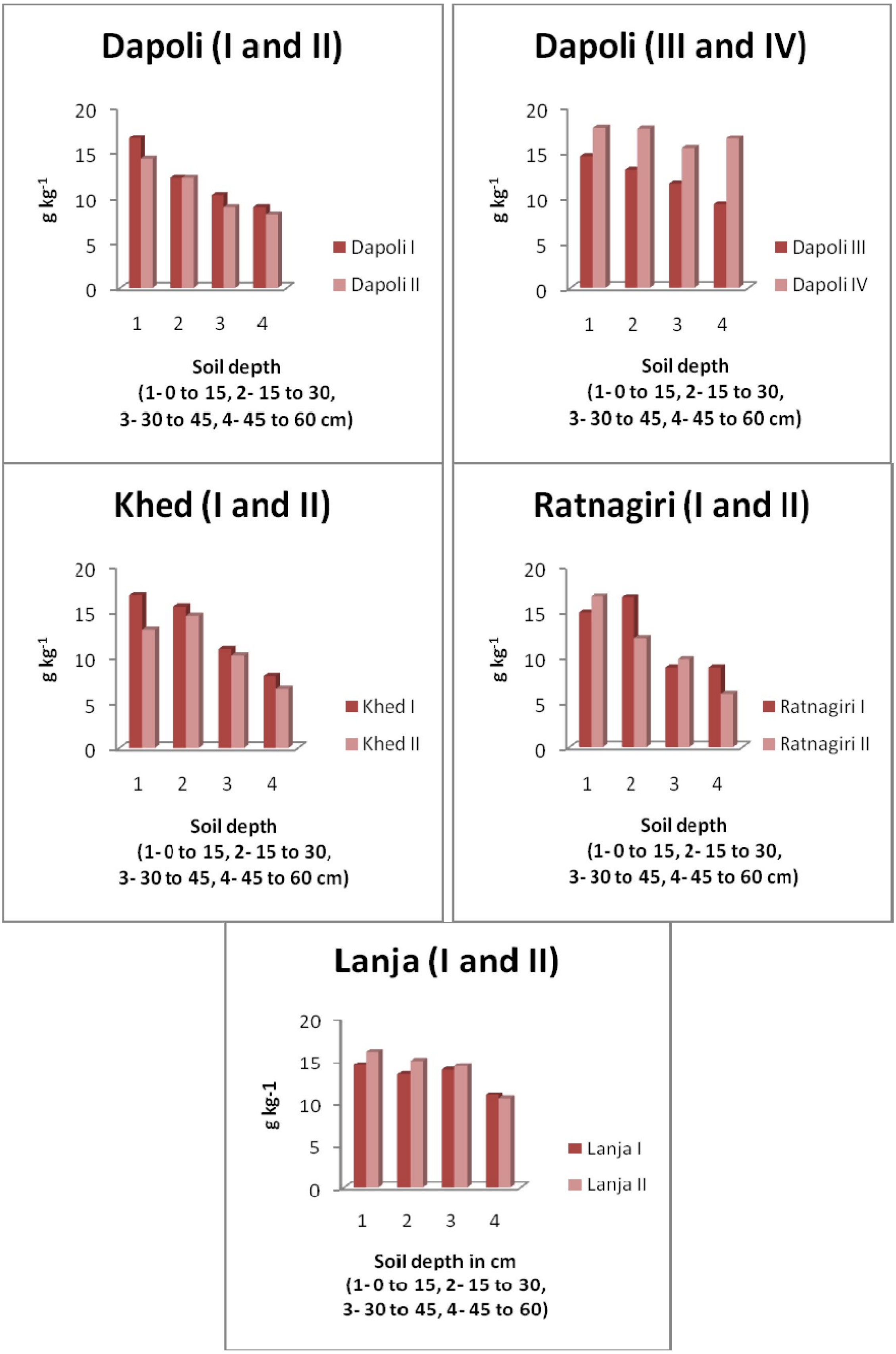


Fig. 4.6 : Variation in available macronutrient status (N, P_2O_5, K_2O) of soils from mango orchards.

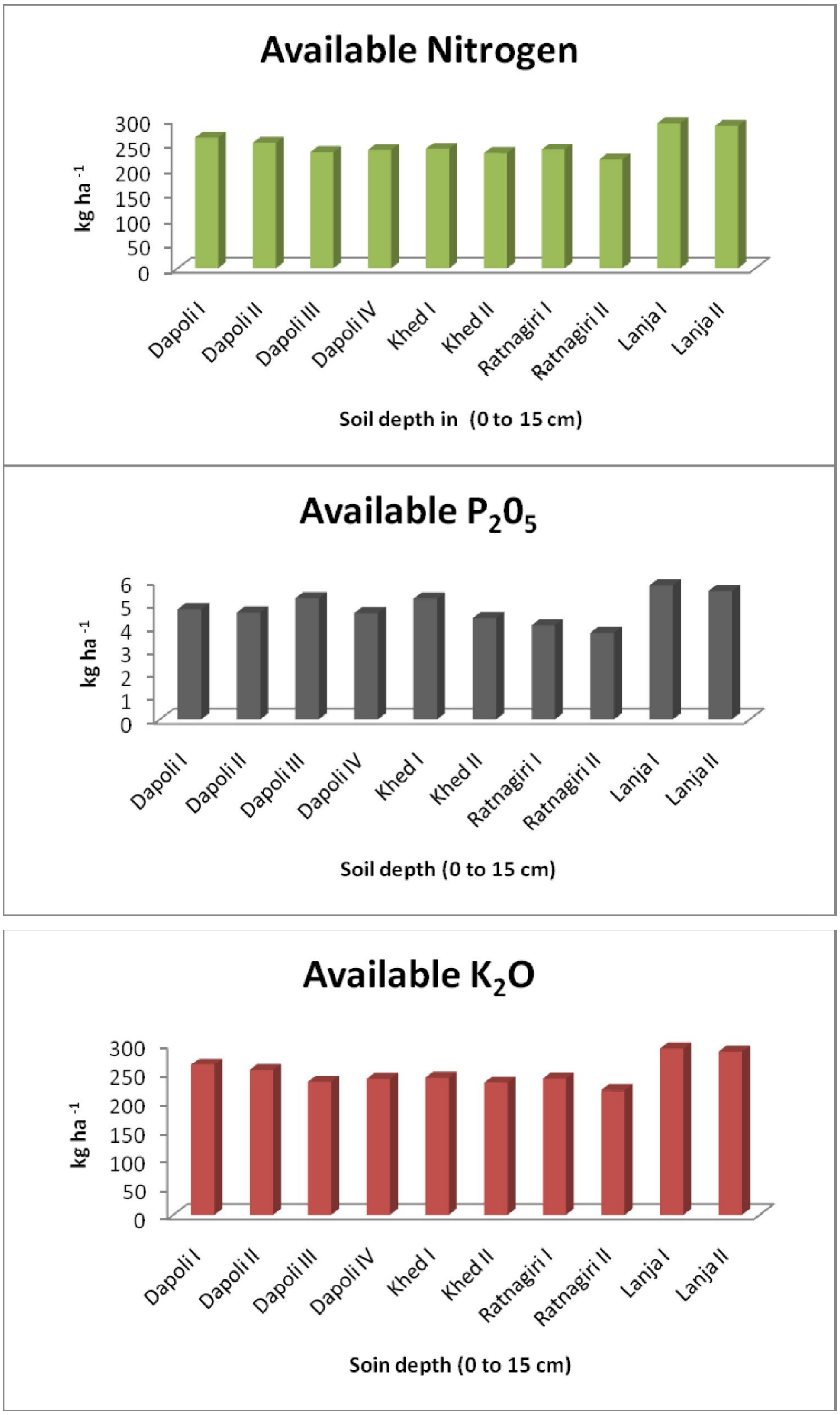
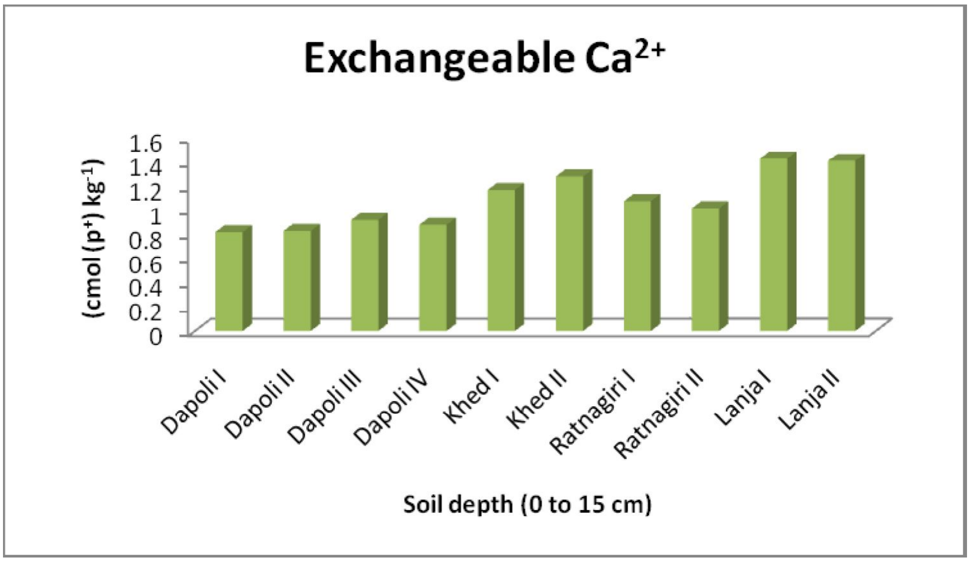


Fig. 4.10 : Variation in available macronutrient status(Exch. $Ca^{2+}$and Exch. Mg^{2+}) of soils from mango orchards.


Exchangeable Ca2+
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
(cmol (p+) kg-1)
Dapoli I
Dapoli II
Dapoli III
Dapoli IV
Khed I
Khed II
Ratnagiri I
Ratnagiri II
Lanja I
Lanja II
Soil depth (0 to 15 cm)

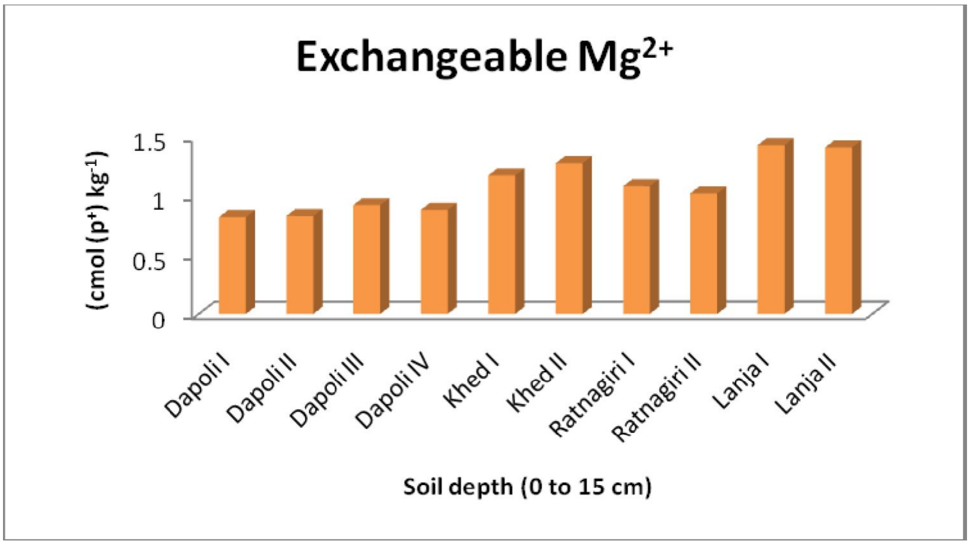

Exchangeable Mg2+
1.5
1
0.5
0
(cmol (p+) kg-1)
Dapoli I
Dapoli II
Dapoli III
Dapoli IV
Khed I
Khed II
Ratnagiri I
Ratnagiri II
Lanja I
Lanja II
Soil depth (0 to 15 cm)

Fig. 4.7 : Influence of soil depth on available macronutrient (N) status of soils from mango orchards.

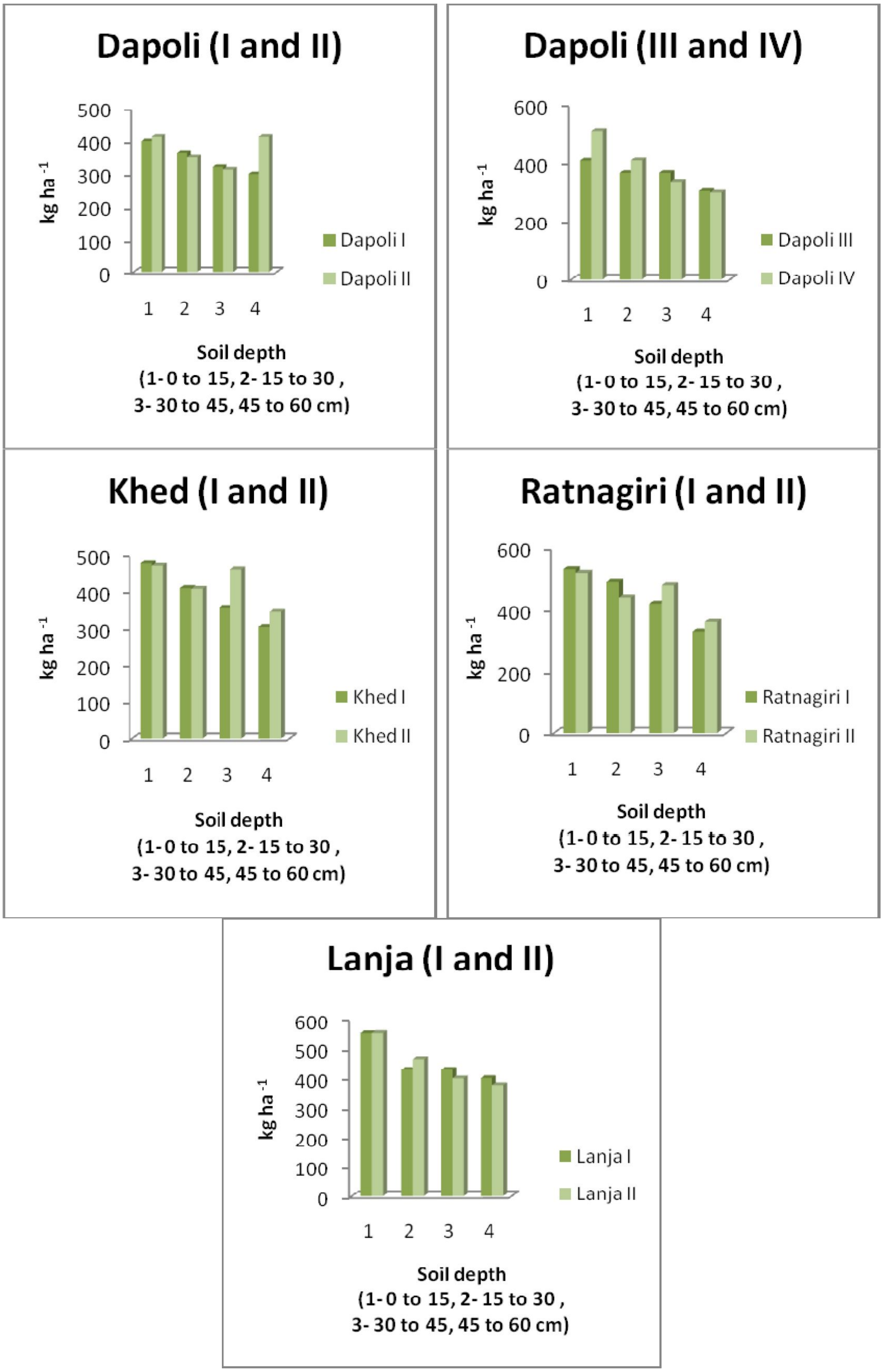


Fig. 4.8 : Influence of soil depth on available macronutrient (P_2O_5) status of soils from mango orchards.

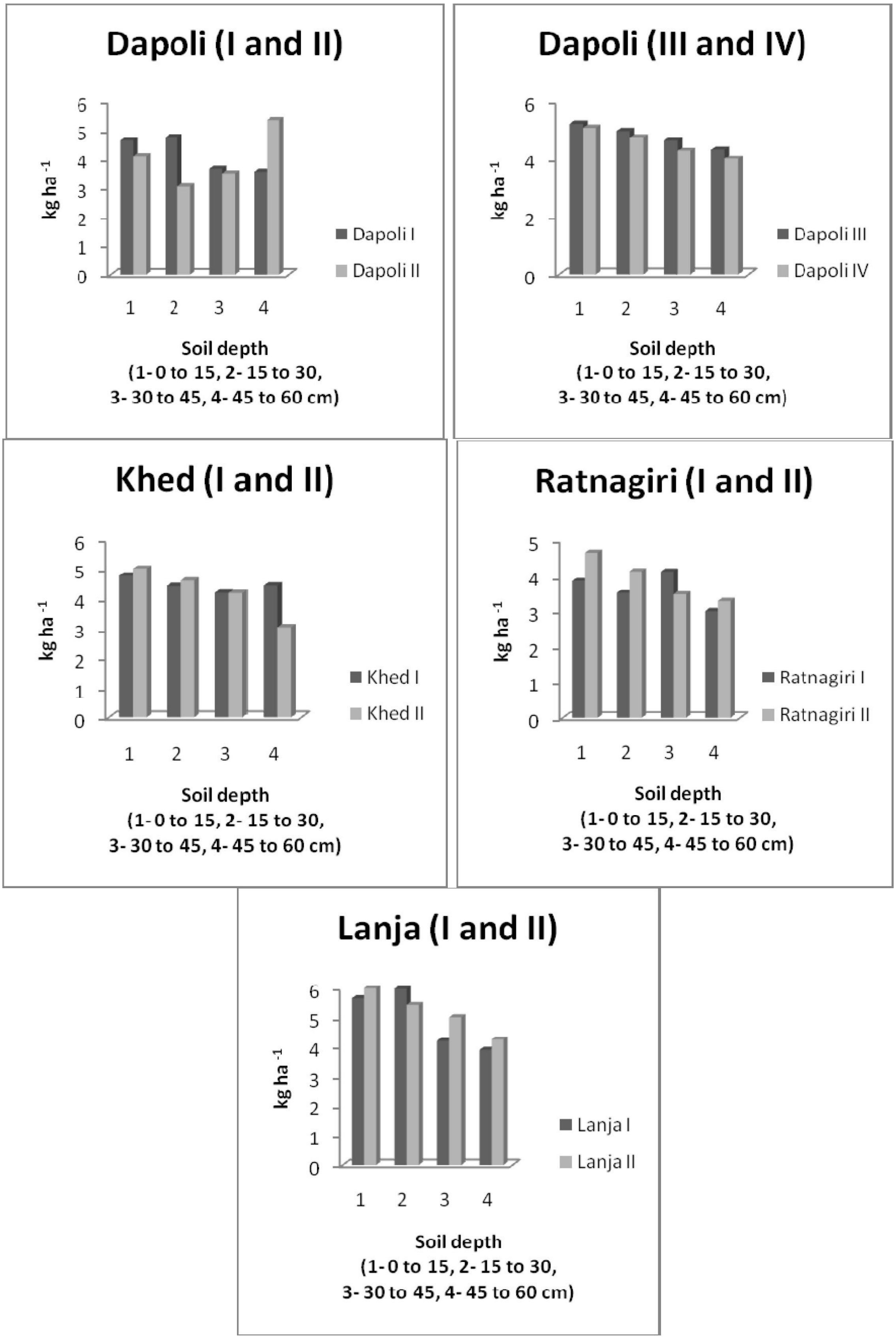


Fig. 4.9 : Influence of soil depth on available macronutrient (K_2O) status of soils from mango orchards.

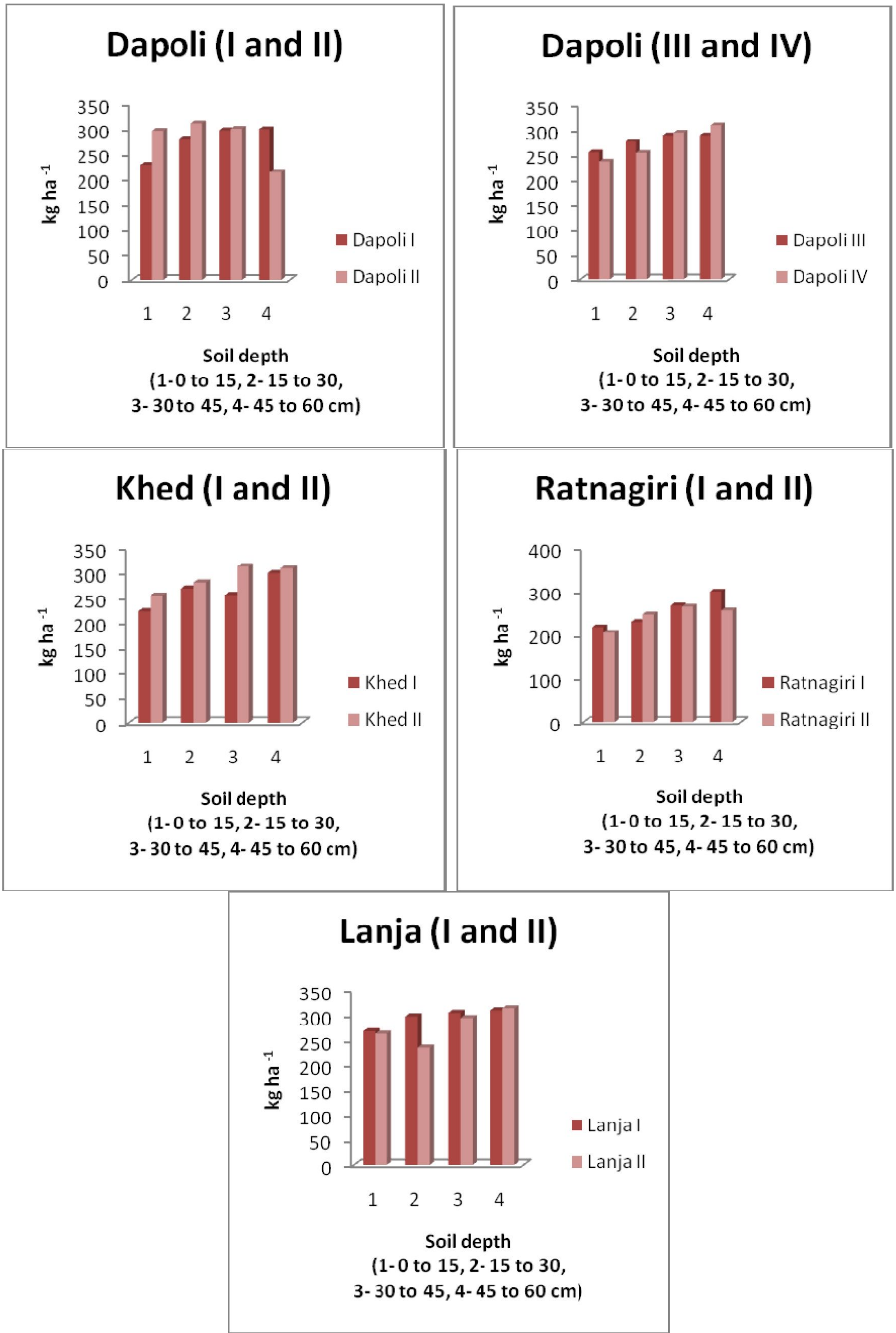


Fig. 4.11 : Influence of available macronutrient (Exchangeable Ca^{2+}) status of soils from mango orchards.

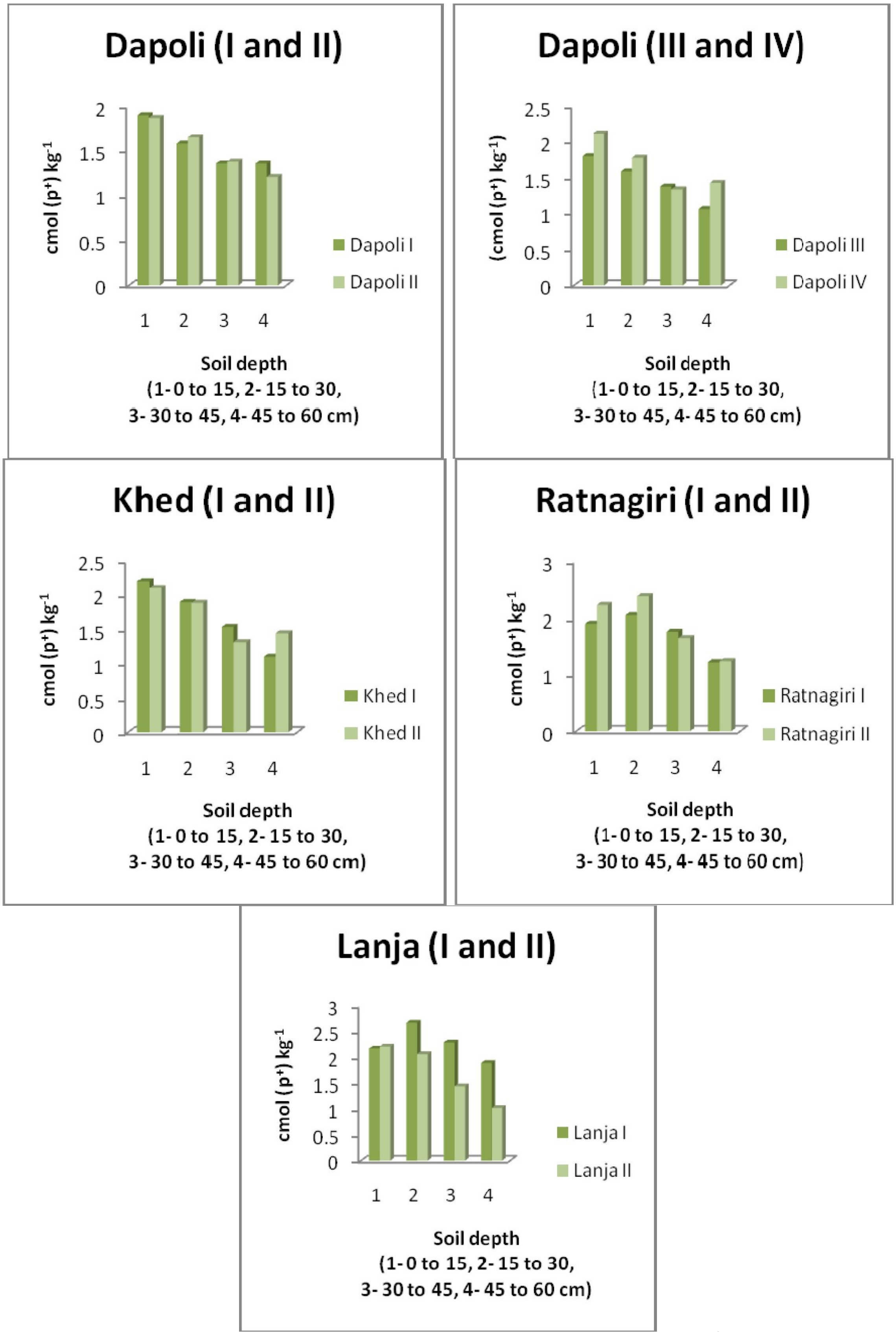


Fig. 4.12 : Influence of soil depth on available macronutrient (Exchangeable Mg^{2+}) status of soils from mango orchards.

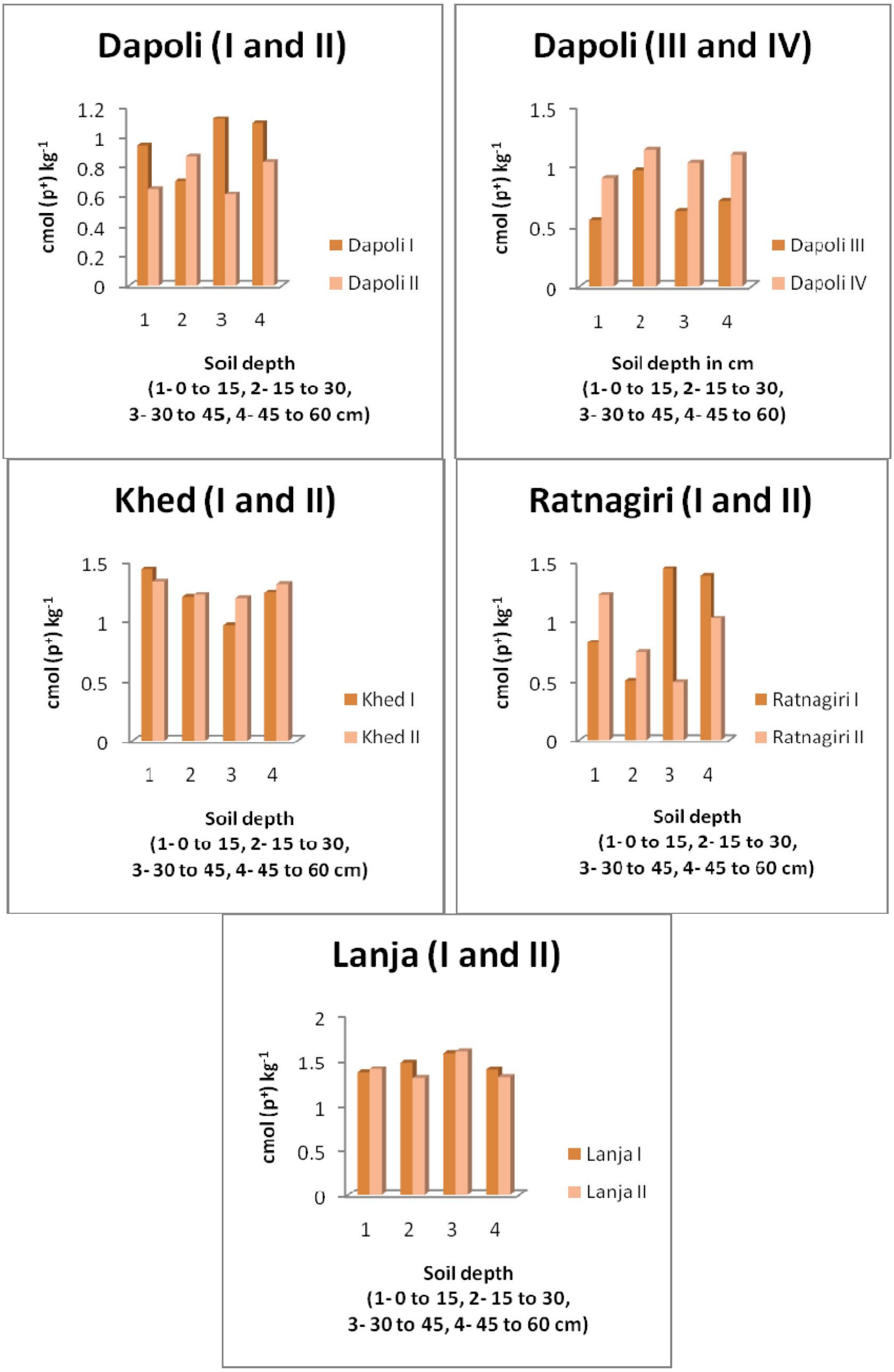
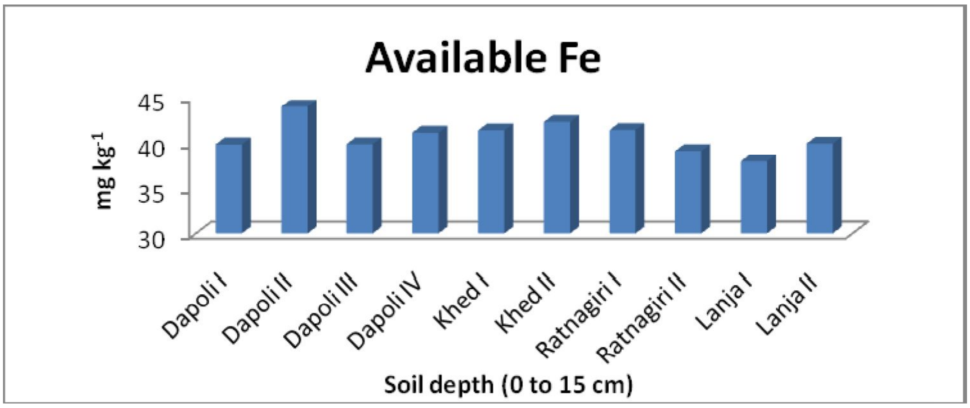
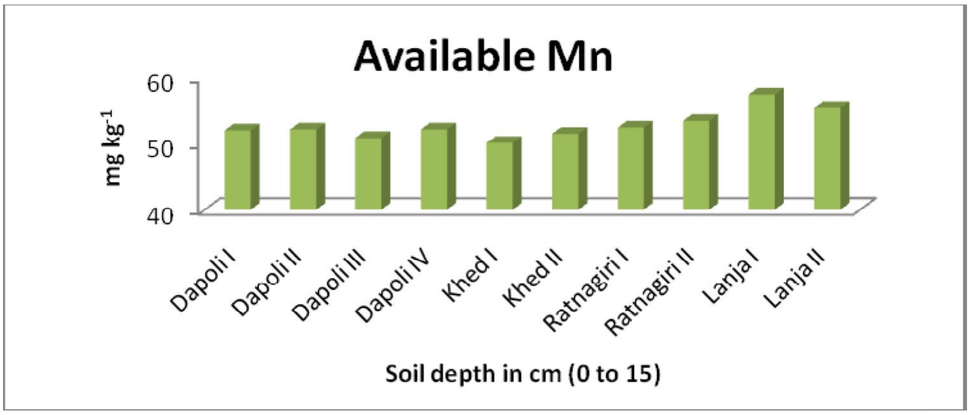
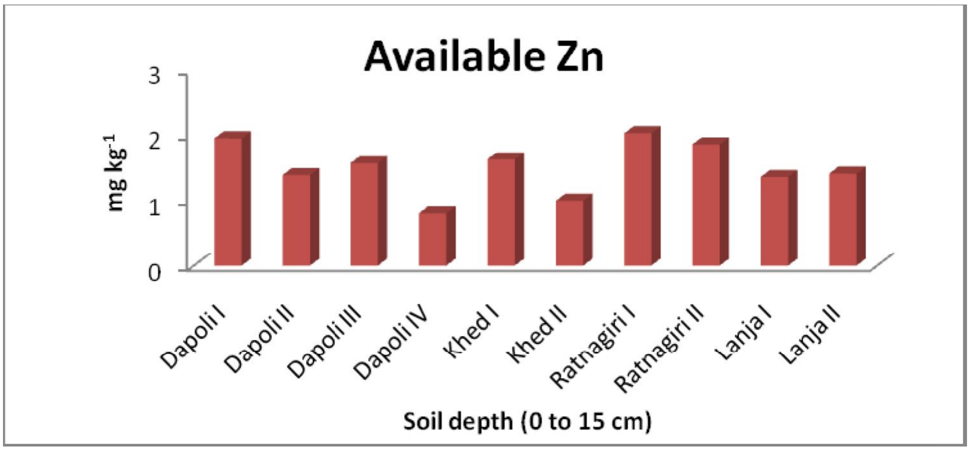


Fig. 4.1 : Variation in available micronutrient (Fe, Mn, Zn, Cu) status of soils of mango orchards







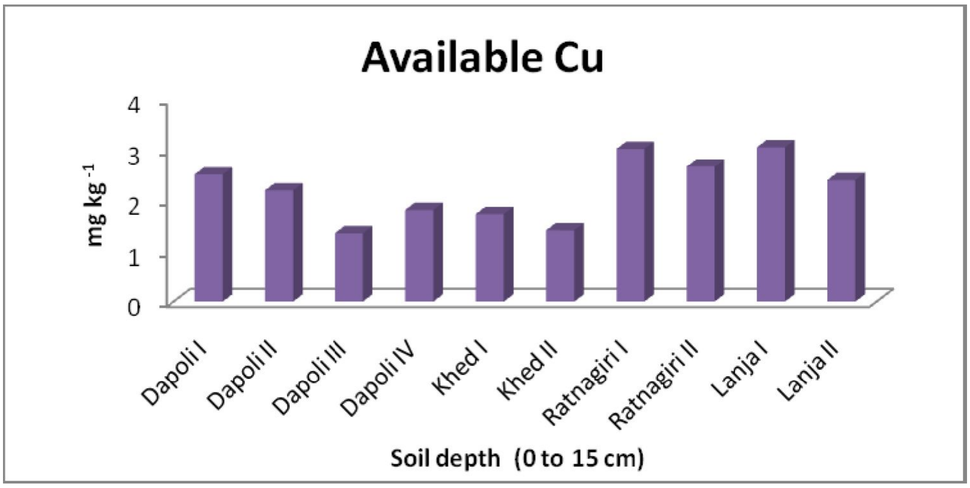


Fig. 4.2 : Influence of soil depth on available micronutrient (Fe) status of soils from mango orchards.

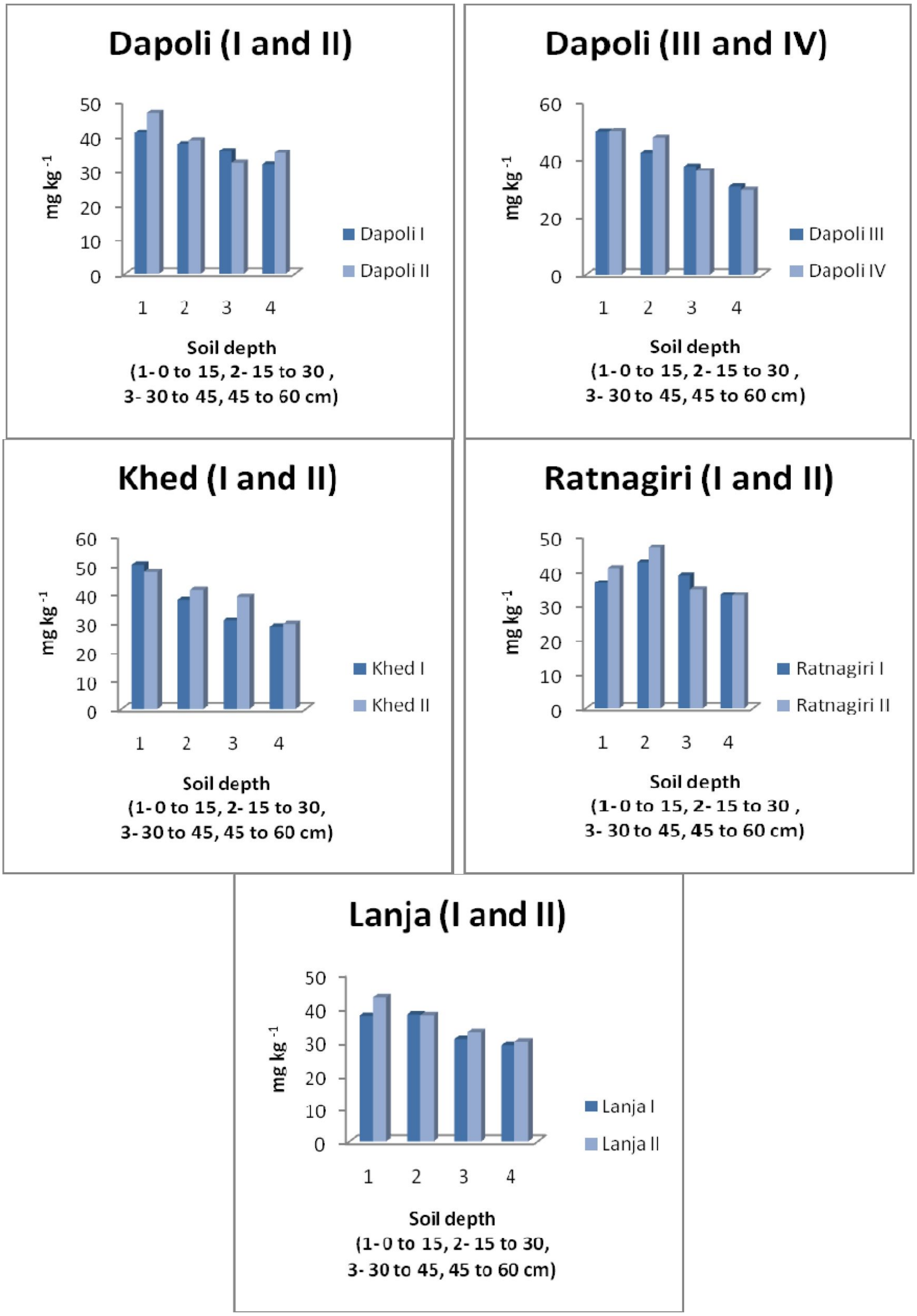


Fig. 4.3 : Influence of soil depth on available micronutrient (Mn) status of soils of mango orchards.

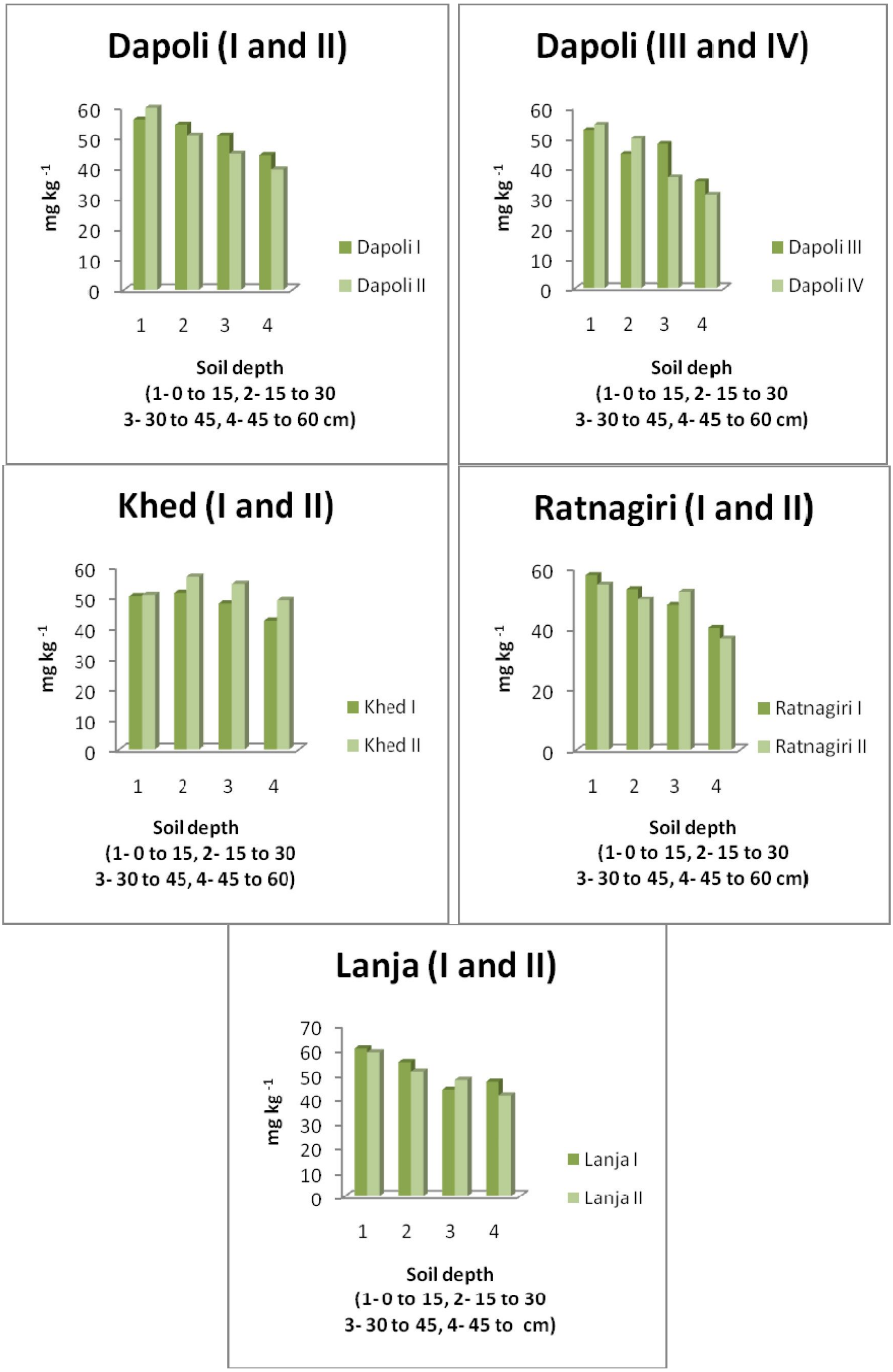


Fig. 4.4 : Influence of soil depth on available micronutrient (Zn) status of soils of mango orchards.

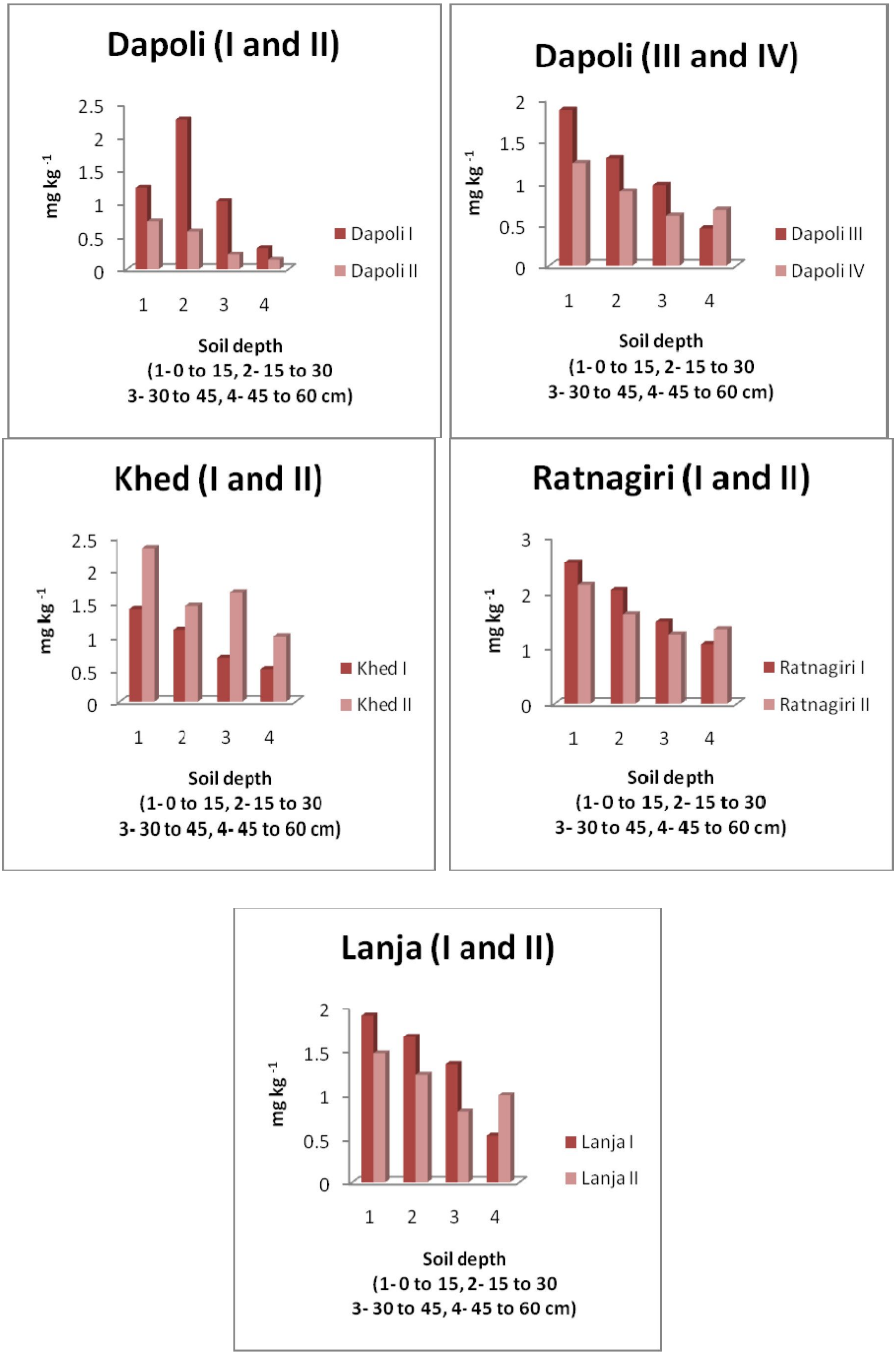
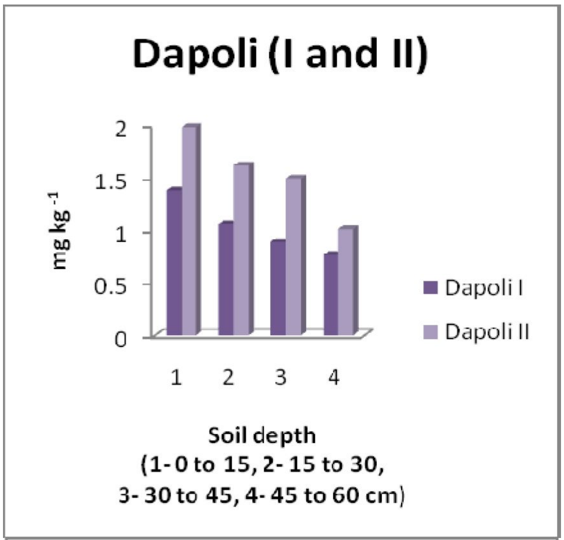
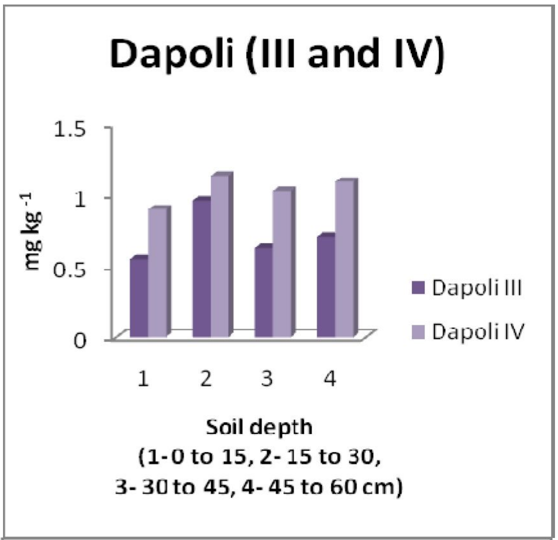
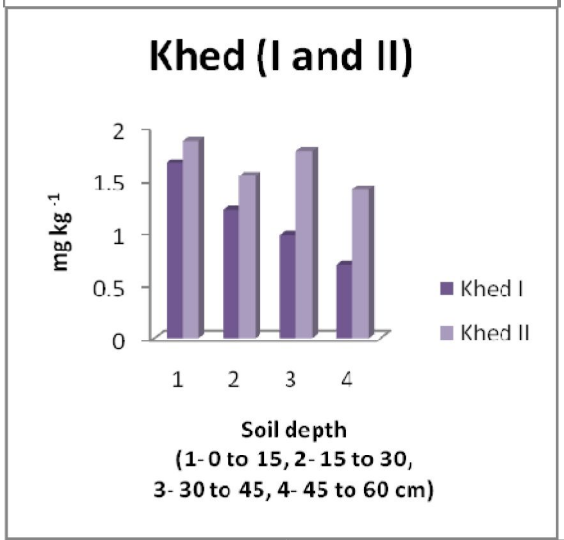
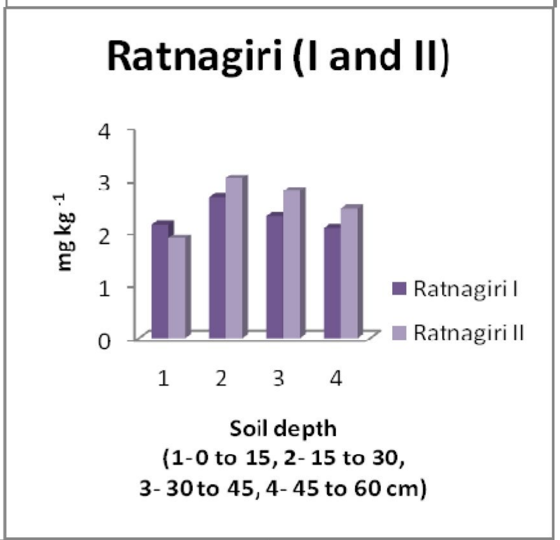


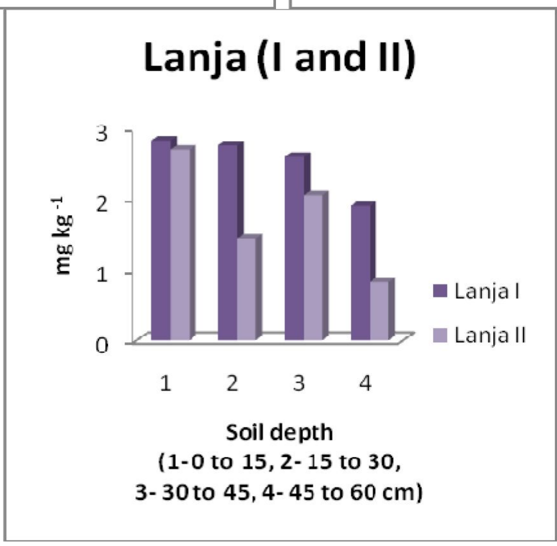
Fig. 4.5 : Influence of soil depth on available micronutrient (Cu) status of soils of mango orchards.


Dapoli (I and II)
mg kg -1
2
1.5
1
0.5
0
1
2
3
4
Dapoli I
Dapoli II
Soil depth
(1- 0 to 15, 2- 15 to 30,
3- 30 to 45, 4- 45 to 60 cm)


Dapoli (III and IV)
mg kg -1
1.5
1
0.5
0
1
2
3
4
Dapoli III
Dapoli IV
Soil depth
(1- 0 to 15, 2- 15 to 30,
3- 30 to 45, 4- 45 to 60 cm)


Khed (I and II)
mg kg -1
2
1.5
1
0.5
0
1
2
3
4
Khed I
Khed II
Soil depth
(1- 0 to 15, 2- 15 to 30,
3- 30 to 45, 4- 45 to 60 cm)


Ratnagiri (I and II)
mg kg -1
4
3
2
1
0
1
2
3
4
Ratnagiri I
Ratnagiri II
Soil depth
(1- 0 to 15, 2- 15 to 30,
3- 30 to 45, 4- 45 to 60 cm)


Lanja (I and II)
mg kg -1
3
2
1
0
1
2
3
4
Lanja I
Lanja II
Soil depth
(1- 0 to 15, 2- 15 to 30,
3- 30 to 45, 4- 45 to 60 cm)