HIGH INTENSITY DETAILED SOIL SURVEY OF AGRICULTURE RESEARCH STATION, FARM, MAHABALESHWAR, DISRTICT SATARA

By

VISHAL GULABRAO ATHAWALE
(Reg. No. 011/089)

A Thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPITH,
RAHURI-413 722, DIST. AHMEDNAGAR,
MAHARASHTRA, INDIA

In partial fulfilment of the requirements for the degree
Of

MASTER OF SCIENCE (AGRICULTURE)
in
SOIL SCIENCE AND AGRICULTURE CHEMISTRY

DEPARTMENT OF SOIL SCIENCE AND AGRICULTURE CHEMISTRY
POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH,
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2014

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part

thereof has not been submitted by me

or any other person to any other

university or Institute

for Degree or

Deploma

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Date: / /2014 (V.G. ATHAWALE)

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CERTIFICATE

This is to certify that the thesis entitled, “HIGH INTENSITY DETAILED SOIL SURVEY OF AGRICULTURE RESEARCH STATION FARM, MAHABALESHWAR, DITRICT SATARA” submitted to the faculty of Agriculture, mahatma phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar in partial fulfilment for the degree of **MASTER OF SCIENCE** (AGRICULTURE) in **SOIL SCIENCE AND AGRICULTURE CHEMISTRY**, embodies the result of a piece of *bona fide* research work carried out by **SHRI. VISHAL GULABRAO ATHAWALE** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma. The assistance and help receive during the course of investigation have been acknowledged.

Place: MPKV, Rahuri

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Place : MPKV, Rahuri (Dr. B.R. Ulmekh)

Dated : / /2014

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Place: MPKV,Rahuri

Date: / /2014 (V.G. Athawale)

TABLE OF CONTENT				Page No.

LIST OF TABLES

LIST OF PLATES

LIST OF ABBREVIATIONS

%	per cent
°c	Degree Celsius
cm	Centimeter
CEC	Cation exchange capacity
dSm^{-1}	Deci Siemens per meter
EC	Electrical conductivity
et al.	*Et alii* (and others)
Fig.	Figure
g	Gram (s)
ha	Hectare
i. e.	That is
kg ha^{-1}	Kilogram per hectare
Kg	Kilogram
Km/hr	kilometer per hour
LCC	Land capability classification
Mgm^{-3}	Mega gram per cubic meter
mm	Millimeter
NA	Non applicable
OC	Organic carbon
ppm	Parts per million
Viz.,	Videlicet (namely)

ABSTRACT

HIGH INTENSITY DETAILED SOIL SURVEY OF AGRICULTURE RESEARCH STATION, FARM, MAHABALESHWAR DIST. SATSRA

BY

MR. ATHAWALE VISHAL GULABRAO

A candidate for a degree of

Of

MASTER OF SCIENCE (AGRICULTURE)

In

SOIL SCIENCE AND AGRICULTURE CHEMISTRY

2014

Research guide	:	Dr. A.G. Durgude
Department	:	Soil Science and Agriculture Chemistry

The study entitled GPS based high intensity detailed soil survey of Agriculture Research Station Farm, Mahabaleshwar was conducted during the year 2013 at Department Soil Science and Agriculture Chemistry, Post Graduate Institute MPKV, Rahuri with an objective to identify soil series and delineate the GIS based map of fertility status of macro and micro nutrients of soils of Agriculture Research Station Farm, Mahabaleshwar. The geo-referenced soil samples were collected by using Global positioning system (GPS).

The analysis reports of surface soils were reported that the texture ranged from clay to clay loam, the bulk density of soil were ranged from 1.09 to 1.46 which were categorised as normal to slightly higher.

The pH of soils were extremely to strongly acidic which varied from 4.18 to 5.53 while, EC of soils were normal which varied from 0.02 to 0.28 dSm^{-1} respectively. The organic carbon content in soil was high in category which varied from 0.82 to1.35 per cent were calcium carbonate content in soil was found nil. The available nitrogen, phosphorus and potassium ranged from 175.61 to 324.78, 7.48 to 22.46 and 49.28 to 217.2 kg ha^{-1} respectively. Soils of Agriculture Research Station, Farm, Mahabaleshwar recorded low in available nitrogen, low to medium in available phosphorus and low to very low in potassium status.

The exchangeable calcium and magnesium ranged from 0.54 to 0.98 and 0.37 to 0.67 [cmol (p+) kg^{-1}] respectively in which all the soil samples were deficient in exchangeable calcium and magnesium.

The available sulphur, boron and molybdenum in soils were ranged from 20.69 to 40.58, 0.28 to 0.51 and 0.15 to 0.42 mg kg^{-1} respectively. The sulphur and molybdenum were found sufficient whereas, boron was deficient.

The available iron, manganese, zinc and copper in soils were ranged from 7.88 to 10.40, 6.15 to 10.29, 0.52 to 7.74 and 0.55 to 1.69 mg kg^{-1} respectively. All the soil samples were sufficient in available iron, manganese and copper whereas 38.63 per cent area were deficient in available zinc.

The soil fertility status of Parkar index showed that available nitrogen, phosphorus and potassium categorised as medium category.

The soil pH was positively and non-significantly correlates with available N, P, S, Fe and exchangeable Mg. Negatively correlate with available K, B, Mo, Zn, Cu, Mn, and exchangeable calcium. EC was negative and significantly correlate with exchangeable Mg. positive correlate with available Mn and sulphur. Negatively and non-significantly correlate with available N, K, Cu, B and molybdenum. Whereas, positively and non-significantly correlate with available P, Fe, Zn, and Mn.

Taxonomically soils were classified as Lithic Ustorthent, Typic Haplustept and Udic Rhodustalf. The soils of all three pedons were categorised under clay loam texture. The bulk density was low in all three soil pedons which ranged from 1.14 to1.38 Mg m^{-3}. The data on chemical properties of soil pedons categorised under extremely acidic to strongly acidic in reaction. The EC values of soils were normal and which increased with increase in depth of profile. The EC of soils were ranged from 0.04 to 0.14 dSm^{-1}. The organic carbon ccontent in all soil pedons were found decreased with increase in depth. The value of organic carbon varied from 0.91 to 1.18 per cent. $CaCO_3$ were found nil in all three soil pedons under study.

The available N, P and K in soils of all pedons were ranged from 224.15 to 256.12, 7.48 to16.03 and 98.32 to154.25 kg ha^{-1} respectively. The available N, P and K showed higher nutrient status in upper layer while, decreased with increase in depth. The available sulphur ranged from 21.18 to 40.58 mg kg^{-1}. It shows increasing trend of nutrient status with increasing depth. Boron and Molybdenum ranged from 0.31 to 0.49 mg kg^{-1} and 0.25 to 0.37 mg kg^{-1}. The B content in soils were low while, Mo content was high. The available Fe, Mn, Zn and Cu were categorised sufficient in category.

It is concluded from above soil survey study that the soils of Agriculture Research Station, Farm, Mahabaleshwar were low in available Nitrogen, phosphorus and potassium, $CaCO_3$ was absent, deficient in exchangeable Ca and Mg and available boron. The soils are sufficient in available Fe, Mn, Zn and Cu. Management of fertilizer schedules needs to modify as per status of nutrients in soil for maintaining soil fertility and achieving sustainable yield of various crops. All the soils were extremely to strongly acidic and it need to reclaim with addition of lime @ 3 to 13 ton/acre with organic manure or FYM before one month of sowing in soil.

1 INTRODUCTION

Soil is a vital natural resource and should be used judiciously according to its potential to meet the increasing demand of ever growing population. To ensure optimum agricultural production, it is imperative to know the basic facts about our soils and their management to achieve sustainable production. The quality of soils needs to be looked into because presently, the natural resources are being over exploited. Soils of Maharashtra State are categorized as poor in fertility and they vary widely in genetic, morphological, physical, chemical and biological characteristics.

The nutrients show prominence in Indian agriculture only after their deficiency. The deficiencies started appearing in different areas due to introduction of intensive production systems after green revolution period. It is due to net removal rates of micronutrients by crops being higher intensive productivity regimes. The situation was further accentuated by discontinuance and diversified use of organic manures and use of high analysis and chemically pure NPK fertilizers.

The incidence of micronutrient deficiencies in crops has increased markedly in recent years due to continuous and intensive multiple cropping and use of high yielding cultivars which may have higher micronutrient demand. Enhanced production of crops on marginal soils that contain low levels of essential nutrients. Increased use of high analysis fertilizers with low amount of micronutrient contamination. Decreased use of animals manure, compost and crop residues. Use of soils that are inherently low in micronutrients reserves.

Involvement of natural and anthropogenic factors that link adequate plant nutrients availability and create element imbalances.

Soil chemical and physical properties vary spatially sometimes dramatically so within a single field. Spatial tools such as the global positioning system (GPS) for storing and analyzing spatial data can help us make better decisions in Agriculture, land development and environmental protection and restoration. In the precision agriculture to apply appropriate quantities of input in different parts of field. Land use planners and developers use GPS and GIS to assess soil protection of ground and surface water and wetlands.

What is GPS and GIS?

The Global Positioning System (GPS) is a location system best on constellation of about 24 satellites orbiting the earth at altitudes of approximately 11,000 miles. GPS was developed by the United States Departments of Defence (DOD) for its tremendous application as military locating utility.

GPS satellites are orbited high enough to avoid the problems associated with land based system, yet can provide accurate positioning 24 hours a day anywhere in the world. Uncorrected positions determine from GPS satellites signals produce accuracy in the range of 50 to 100 meters. When using a technique called differential correction, users can get positions accurate to within 5 meters or less.

As GPS units are becoming smaller and less expensive, there are an expanding numbers of applications for GPS. In transportation application GPS assists pilots and drivers in pointing their location and avoiding collisions. Farmers can use GPS to guide equipments and control accurate distribution of fertilizers and other chemicals.

Many people argue that GPS has found its greatest utility in the field of Geographic Information System (GIS) with some consideration for error. GPS can provide any point on the earth with a unique address (its precise location). A GIS is basically a descriptive database of the earth or a specific part of the earth. GPS tells you that, you are at points X,Y,Z while, GIS tells you that X,Y,Z is an oak tree or a spot in a stream. GPS tells us the "where" and GIS tells us the "what". GPS/GIS is reshaping the way we locate organize analyze and map our resources.

GPS/GIS are advance tool for studying tools for studying on site specific nutrient management which can be efficiently use for monitoring soil fertility changes. The georeferenced nutrient status of soil of Agriculture Research Station, Mahabaleshwar would be useful for ensuring balanced fertilization to crops, this demands the systematic study of different soils with delineation of areas of nutrient deficiency or sufficiency.

In India, the genetic study of the soil is carried out by Bal (1935), Wadia *et al.* (1936) and Vishwanath (1938) were few workers in the field who gave a broad generalized idea of the evaluation of soils. Soils of Maharashtra State have been broadly classified as 1) The coastal saline and coastal alluvium soils. 2) The lateritic soils. 3) Shallow medium and deep black soils from trap. 4) Grey and red soils of mixed parent materials.

5) Saline, saline-alkaline and non-saline-alkali soils (Raychaudhari and Chakravarty 1943).

A pioneer work on the physico-chemical characteristics of Kumbhave-5 soil series of Konkan region of Maharashtra State was carried out by Kale and Chavan (1996). The soils of Maharashtra their kinds, distribution, characterization and interpretation for optimizing land use were given by Challa *et al.* (1995). Prasad *et al.* (2001) Characterized and classified some orange growing soils in Nagpur district of Maharashtra.

Challa *et al.* (1999) reported the detailed soil series with chemical characteristics of soils of Western Konkan Coast, Western Ghat and North Deccan Maharashtra plateau. However, use of heavy doses of fertilizers and chemicals leads to deteriorate the soil health. It is, therefore, necessary for research workers to manage the farm by knowing the soil fertility status in relation to physico-chemical properties of the soils, so as to make efficient use of available resources on the farms and planning the cropping patterns.

The present study was, therefore, undertaken to prepare the detailed soil resource inventory of agriculture research station farm, Mahabaleshwar, dist. Satara which would provide base for conducting research experiment on mapped soil and to develop an improved agro-technology for its effective transfer to other areas having comparable soil site characteristics.

There is no scientific report of any survey work carried out of this agriculture research station Farm, Mahabaleshwar Hence, the present investigation was undertaken with following objectives.

1) To study the GPS based morphological characteristics of pedon.
2) To study the physical and chemical properties of soil based on GPS.
3) To prepare GPS based soil fertility map and delineate the extent of area of soil series on map.
4) To Correlate soil properties with available nutrients.
5) To evaluate fertility index.

2 REVIEW OF LITERATURE

The pertinent literature on soil survey and different soil studies were reviewed and presented under following sub heads :-

2.1 Morphological features

2.2 Physico-chemical properties

2.3 Correlation coefficient

2.4 Taxonomic classification

2.5 Mapping of soils

2.1 Morphological features

Dasog and Hadimani, (1980) studied three Vertisols formed under semi-arid climate on deccan trap. Soil under study were developed under similar set of factors of soil formation except parent rocks. All soils were clay in texture and highly calcareous in nature.

Chakraborty and Sinha (1983) studied the morphology of some Hill soils from North-Eastern India. The profile did not show horizon differentiation and indicate immature nature of soils. Inspite of heavy rainfall, high microbial activity and organic matter status, horizon differentiation could not take place due to steep slope and undulating topography, which do not facilitate infiltration and deep percolation of water into the soils.

Prasad *et al.* (1989) described the morphological characteristics of soils in relation to topography. Morphological characteristics of the soils have been greatly influenced by topographic situation. Soils on the hill top, mid slope and foot-hill uplands are reddish brown (5YR 4/4) to dark reddish brown (5 YR to 2.5 YR 3/4), whereas, soil occurring on toe slopes and depressions have dark brown (10YR 3/3 and 7.5 YR 4/4) to very dark grayish brown (2.5 YR 3/2). The reddish colour in the area might be due to the release of iron oxide as a result of weathering of basalt under well drained conditions and brownish and grayish colour may be due to reduction of iron caused by impended drainage conditions. The soils depth varied from very shallow and shallow on hills and convex erosional slopes through deep on mid slope and fast slope to very deep in the depressions. Texture of the soils on the slopes were gravelly loam on erosional surface, clay loam to clay on mid slopes and clay on the toe slopes. The soil structure was weak to moderately developed.

Nandi and Dasog (1992) studied origin, properties and distribution of carbonate nodules and particle size distribution of carbonate in some Vertisols of Karnatak. White and black nodules were irregular in outline, had rough surface and were more porous. Black nodules were spherical smooth and less porous. White nodules contained slightly more $CaCO_3$ than black ones. A decreasing trend of black nodules initially formed as white starts from the surface downwords carbonate of the sizes of sand and silt predominate over clay size carbonate in these soils.

Singh and Bhargava (1992) studied the different characteristics of some Inceptisols. He observed deep cracks in clay and clay loam soils result into high initial infiltration rate.

Due to different percentage of clay wetting from movement was least in clay soil, highest in sandy loam and intermediate in clay loam soil.

Rudramurty *et al.* (1997) described morphological features of red and black soils developed from Dharwad rock system. Two pairs of mixed red and black soils were excavated at Agriculture College Farm, Dharwad and village Mantrigani of Dharwad district. Red soils were developed in situ. Black soil at Agriculural College Farm, Dharwad is not derived from its red soil counterpart but transported from elsewhere, where as the black soil at Mantrigani has been derived from its red soil counterpart. Surface cracks and pressure faces were observed in Mantrigani red soil. Black soils were calcareous, where red soils were non calcareous.

Gangopadhyay *et al.* (2001) studied morphological characteristics of soils of West Tripura District to develope a model of understanding for a set of precise soil parameters requirements of rubber. The soils were deep to very deep, well drained, dark brown to yellowish red, light in texture, low to medium in organic matter and acidic in reaction. The increase in clay content in depth and development of soil structure indicated development of cambic horizon.

Kumar *et al.* (2001) studied the soils of residual hills denudational hills and pediment exhibit dark brown to dark reddish brown (7.5 YR 3/4 to 5YR 3/4) colour. Moderately buried pediment and valley have very dark grayish brown to yellowish brown colour.

Sarkar *et al.* (2002) observed homogenity in soils of Loktak catchment area in central part of Manipur and have requisite clay enrichments in subsurface horizons showing A-B-C profile development except in pedon 1, whereas the B-horizon shows the properties of cambic diagnostic horizon. They further stated that the soils are well to excessively drained, except the plain land (P_6) which are poorly drained, deep to very deep with fine texture.

Sankpal (2008). The data on physico-chemical properties of lateritic soils of Agricultural Research Station Phondaghat (Sindhudurg district) when studied, revealed that bulk density of surface soil varied from 1.09 to 1.48 Mg m^{-3} with mean value 1.25 Mg m^{-3} and in profile soil ranged between 1.39 to 1.52 Mg m^{-3}.He found no specific trend of bulk density with soil depth.

Dhale and Prasad (2009) characterized sweet orange growing soils of Jalna District of Maharashtra for their physical, chemical properties, nutritional status of soil and concluded that the variability in soil productivity of sweet orange. Inceptisols (underlined by saprolite) exhibited higher productivity. These soils have better drainage than deep Vertisols.

Najar *et al.* (2009) studied morphological characteristics of some apple growing soils of Kashmir. The P_1 and P_2 possessed mollic epipedons were classified under Mollisols, since the area qualifies for Udic soil moisture regime, these soils were placed suborder Udols.

Joshi (2012). The bulk density of lateritic soil 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}. Bulk density did not show any definite trend with soil depth.

2.2 Physio-chemical Properties

Chavan *et al.* (1980) collected the twenty six representative soil profile from 9 agroclimatic zones of Maharashtra. They found that total Mo content in soils were in range from 0.50 to 4.83 ppm. Content of Mo in acid soils were <1.0 ppm. Low availability of Mo in lateritic soils may be due to the bindings of molybdate anions by clay minerals containing high amount of Al and Fe.

Chavan *et al.* (1980) studied the twenty six representative soil profiles from 9 agroclimatic zones of Maharashtra. They found that $CaCO_3$ in zones-I (Ventara and Jalgaon, Ratnagiri) and zone-III (Radhanagari, Kolhapur and Mahabaleshwar, Satara) were nil.

Chavan *et al.* (1980) studied the lateritic soils of basaltic origin contains higher values of zinc the soils from arid to semiarid regions. Zn accumulate in the surface layers and regularly decrease down the profile.

Chavan *et al.* (1980) studied the lateritic soils of basaltic origin. Boron ranged from 0.09 to 0.48 mg kg^{-1}. Preferably in high rainfall zones, boron has a tendency to increase gradually with depth.

Chavan *et al.* (1980) studied the twenty six representative soil profiles from 9 agroclimatic zones of

Maharashtra. They found that high amount of Mn (7.36 to 16.94 ppm) than black soils. High availability of Mn may be due to the reduction of manganese oxides by soil organic matter and low pH.

Srivastava and Srivastava (1991) studied cation exchange capacity in relation to pH in salt affected soil and reported that cation exchange capacity of soil was an important property due to which various plant nutrients were retained on the exchange surface through adsorption on clay and humus fractions of the soil and were protected against leaching losses. Negative charge grown and positive charge decreased due to rise in pH. A increase in soil pH influenced many soil properties. Including charge characteristics of soils he found CEC was highly positively and significantly correlated with soil pH.

Herekurubar *et al.* (1991) studied some physical properties of Vertisols derived from different parent materials of Northern parts of Karnataka. Water holding capacity, available water capacity, plasticity index, specific surface area and total porosity were highest in soils derived from chloride schist and aggregation indices were higher in soils of shale origin. The physical properties were lower in the soils developed from limestone. Bulk density, micro porosity and steady infiltration rate were higher in the soils derived from limestone.

Kolape *et al.* (1991) studied available Sulphur of Konkan region, showed that the available S content of these soils ranged from 3.37 to 10.18, 9.44 to 37.26 and 416.04 to 521.67 ppm with mean of 6.93, 15.92 and 468.85 ppm in lateritic soils, medium black soils and the coastal saline soils, respectively.

Das *et al.* (1992) reported laterite soils of Orissa belonging to Alfisols, Ustisols and Inceptisols had pH dependent acidity varying from 3.1 to 11.8 cmol (p^+) kg^{-1} and were mainly associated with the inorganic fractions of soil such as oxides of Fe, Al and clay. pH dependent acidity at pH 8.0 was 3 to 4 time greater than that at pH 7.0.

Pal and Mukhopadhyay, (1992) studied distribution of different forms of potassium in ten soil series under the order Inceptisol of West Bengal. They concluded subsurface soils contained more total K than the surface soils. The depth wise distribution of K was not systematic and varied with soil texture. Total K showed positive correlation with pH.

Patel *et al.* (1992) studied influence of lime on physical properties of silty loam Vertisols of Saurashtra. The major soil groups of Saurashtra region of Gujrat belongs of Vertisols, which were calcareous, the free $CaCO_3$ of these soils varying from 3 to 50%. Addition of lime from 5 to 35% to a soil containing 2% lime decreased the water transmission parameters greatly. However, information on the acidulation of high lime soil to create different lime levels with regard to physical properties of soil was not available. Thus, high lime soil retained more water which released slowly with decrease in soil water potential in comparison to low lime soil.

Patil and Sonar (1994) analyzed twenty representative soil series of Maharashtra and reported that the EC ranging from 0.05 to 1.39 dSm^{-1}.

Satisha and Badrinath (1994) observed the low status of available P mainly attributed to its higher removal than replenishment and also of high P fixing capacity. The P was ranged from 10-25 kg ha^{-1}. The decreasing trend observed with depth.

Satisha and Badrinath (1994) observed the low status of available nitrogen and potassium ranged from 100-498 to 88-268 kg ha^{-1} respectively.

Satisha ans Badrinath (1994) observed the higher iron content in soils of Western Ghat which ranged from 5.0 to 29.5 mg kg^{-1}. The presence of available iron in higher amount was evident in soils of Midland at Kankanady.

Dhane and Shukla (1995) analyzed twenty five surface soil samples from different soil series of Maharashtra, reported that EC of Vertisols, Inceptisols and Entisols soil series were ranged from 0.3 to 1.5,0.3 to 1.3 and 0.1 to 0.5 dSm^{-1}, respectively.

Dharkanath *et al.* (1995) studied depthwise distribution of different forms of sulphur in major soil series of Vertisols in Maharashtra, India. It was observed that S and organic S decreased and water soluble-S and SO_4-S increased with the increase in depth of soil profile. If 10 mg SO_4-S kg^{-1} is considered as critical limit, the available sulphur was sufficient in all the soil series of Vertisols of Maharashtra.

Tandon (1995) reported status of available boron of Indian soils. They noted that available boron in Indian soils, ranged from traces in acidic soils of Bihar to 68 mg kg^{-1} in saline alkali soils of Punjab. The available B in most of Indian soils ranged in between traces to 8 mg kg^{-1} soil. The solubility of B increased in most cases while, it decreased with salinity and alkalinity.

Pharande *et al.* (1996) reported the soils of Western Maharashtra ranged from 0.20 to 1.06 per cent in organic carbon content.

Kale and Chavan, (1996) studied physiochemical characteristics of Kumbhave-5 soil series of Konkan Region of Maharashtra State. The analytical data showed that these soils were silty clay loam to loam in texture, with an average bulk density of 1.15 Mgm^{-3} and maximum water holding capacity of 58.55%. The soils were slightly acidic (pH 5 to 6), non-calcareous, with EC 0.083 dSm^{-1}, high in organic carbon (2.33%), medium in available N (182.75 ppm) and low in available phosphorous (P_2O_5, 3.94 ppm). The available potassium was low to medium, ranging from 36 to 162 ppm K_2O. Available N and EC showed a significant positive correlation with available K and exchangeable K. A significant positive correlation was also obtained between EC and water soluble – K and free $CaCO_3$ and non-exchangeable –K. However, significant negative relationship was observed between organic carbon and total – K.

Raskar and Pharande (1997) reported different forms of potassium and their distribution in some important soil series of Vertisols and Alfisols of Western Maharashtra. They found that water soluble, exchangeable, non- exchangeable, lattice and total K in Vertisols were positively and significantly correlated with each other. In Alfisols, all forms of K were positively correlated with each other except water soluble K. All soil series were low in all forms of K.

Ram *et al.* (1999) reported that the calcium carbonate content of Bundelkhand (U.P.) soils were ranged in between 0.45 to 37.62 per cent.

Diwale and chavan (1999) studied on distribution of different chemical forms of zinc in twenty soil sample from five profile located at different places in south Konkan, showed wide variation in their content. The available Zn (DTPA extractable) ranged between 0.5 to 4.2 Zn mg kg^{-1} soil with overall mean values of 1.4 mg kg^{-1} soil.

Durgude (1999) studied the salt affected soils of central campus farm, M.P.K.V., Rahuri and revealed that 1.66 per cent soils of potential cultivated area are saline, 5.92 per cent area are saline-sodic and 8.60 per cent are sodic. The pH of sodic soils range from 8.30 to 8.90. ECe from 1.46 to 2.45 dSm^{-1} and ESP varied from 5.0 to 24.8.

Singh *et al.* (1999) studied the sulphur distribution in some soil series of Nagaland and observed that sulphur content was highest in Zukuma soils and least in Tsurang soil series. Sulpher content increased down the padons in all these soil, which may be due to high rainfall in this region.

Pandey *et al.* (2000) studied the availability of phosphorus and sulphur in Inceptisols of Central Uttar Pradesh and showed that the content of available P ranged from 7.07 to 55.4 kg ha^{-1}.

Anantwar *et al.* (2000) investigated six profiles representing shrink swell soils developed on basaltic plateau of Wardha district. Bulk density increased with depth. It showed negative correlation of bulk density and organic matter. Increasing trend of bulk density with decreasing organic matter was observed. Bulk density value ranged from 1.2 to 1.80 Mg m^{-3}.

Bhattacharya *et al.* (2000) studied the boron status of some forest soils were soils are strongly to very strongly acidic with pH value ranged from 4.3 to 5.6.

Sarkar *et al.* (2000) studied the Inceptisols and Entisols of Madhubani District in Bihar and showed that the available Cu ranged from 0.3 to 4.8 ppm.

Manorama and Joe (2000). Observed the electric conductivity of surface samples was low and subsurface layers shows higher values. It may be due to accumulation of salts on lower layers. Evan though the lower layers showed higher values none of the soil subgroup showed a definite pattern for it.

Dhage *et al.* (2000) reported that the available N content of soils from Shevegaon Tehsil of Ahmednagar District ranges in between 59.58 to 228.92 kg ha^{-1} with a mean value of 165.9 kg ha^{-1}.

Chinchmalatpure *et al.* (2000) 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.

Rudramurthi and Dasog (2001) reported that the values of organic carbon ranged from 0.3 to 0.6 per cent for Vertisols of North Karnataka.

Agrawal and Singh (2001) recorded the DTPA Fe, Mn and Cu varied from 2.0 to 127 ppm, 1.4 to 85.5 ppm and 0.6 to 6.8 ppm respectively, in soils of Varanasi division of Eastern U.P.

Kharche *et al.* (2001) recorded the DTPA Zn varied from 0.20 to 6.60 mg kg^{-1} in soils of Nashik District of Maharashtra.

Majumdar *et al.* (2002) examined the available P of some acidic hills soils of Meghalaya ranged from 1.91 to 10.59 mg kg^{-1}.

Mahajan (2001) reported that the status of exchangeable calcium content in surface soil varied between 0.95 to 2.37cmol (p+) kg^{-1} with mean value 27.15cmol kg^{-1} and 0.55 to 3.64cmol kg^{-1}in profile soil exchangeable calcium with mean value 1.61 cmol (p+) kg^{-1} from his study on micronutrients status and distribution in mango orchard of South Konkan region.

Sarkar *et al.* (2002) studied the soils of Loktak catchment area in central part of Manipur and observed that pH ranged from 4.5 to 5.8 and generally decreased with depth. The soils were reach in organic carbon, low to medium in exchange cations with higher clay and low base status in the sub surface horizon. Soils were high in available nitrogen, medium to high in available potassium and low in available phosphorous.

Raut and Mali (2003) analyzed the soils of Latur District of Maharashtra, grouped under Vertisols, Inceptisols and Entisols were low in organic carbon with an average of 0.39, 0.32 and 0.36 per cent, respectively.

Kadao *et al.* (2003) studied eight typical pedons supporting Banana in Wardha district of Maharashtra. The texture of pedons ranged from loamy sand to clay (10.7 to 65.4 per cent clay) in different horizons. The pedons 1 and 6 (Typic Haplusterts) have clay more than 67 per cent throughout the profile with tendency to increase with depth.

Khatik *et al.* (2003) studied the soils of Barne nala watershed at Sehora Tehsil of Jabalpur District and found that the available P ranged from 10.23 to 37.12 kg ha^{-1}.

Padole and Mahajan (2003) studied the status of available K of swell-shrink soils of Vidharbha region (Maharashtra) and reported that the available K content ranged from 118 to 257 kg ha^{-1}.

Patil and Meisheri (2004) studied some representative soils of Konkan region and reported that the available Fe content in soils ranged from 14.98 to 111.95 ppm.

Thangaswami *et al.* (2004) studied chemical characteristics of soils developed from quartzite and granite gneiss in Andhra Pradesh (Alfisols). The data showed that soils having very low amount of soluble salts.

Bhaskar *et al.* (2005) reported the organic carbon content in soils of Brahmaputra valley in Jorhat District, Assam in between 0.04 to 3.0 per cent.

Meenakshi *et al.* (2005) showed significant and positive correlation between all micronutrient cations with organic matter and Fe, Mn and Cu with clay content.

Dhage *et al.* (2005) studied micronutrient status of different district of Maharashtra and concluded that the deficiency of Zn and Fe is very less encountered on the soils of Kolhapur. Majority of soils are acidic to slightly alkaline pH with low $CaCO_3$ in Western Ghat and sub mountain zone of Western Maharashtra. This was because of leaching due to heavy rainfall. Soils were well supplied with available Mn and Cu.

Shamsudan *et al.* (2005) stated that the surface horizones of all the soils exhibited high content of organic carbon that varied from 1.31 to 1.71 per cent in pedon 4 and 1.23 to 3.09 per cent in pedon 2 showed a steady decrease down the profile.

Thangaswamy *et al.*, (2005) stated that the higher content of phosphorous in soil was because of confinement of crop cultivation to surface layer and supplementation of the depleted P_2O_5 through fertilizers.

Das *et al.* (2006) showed that the available sulphur content in selected soil series of Inceptisols in West Bengal varied from 3.0 to 16.0 mg kg^{-1}.

Hundal *et al.* (2006) reported that the available K content of soils of Panjab ranged from 7.22 to 885.34 kg ha^{-1}.

Ratnakumari *et al.* (2006) reported that the available P content in soils of Guntur District ranged from 4.60 to 20.33 mg kg^{-1} with an average of 7.82 mg kg^{1}.

Mathur *et al.* (2006) recorded the pH of irrigated North-West plain soils of Rajasthan ranged from 7.2 to 8.60, EC from 0.20 to 2.60 dSm^{-1} and organic carbon from 0.11 to 0.81 per cent.

Shinde (2006) studied that exchangeable magnesium in lateritic soils were in the range of 0.58 to 1.67 with a mean value of 1.20cmol (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 noticed exchangeable magnesium was decreased with soil depth. However, it showed increasing trend with slope.

Chaudhari and Kadu (2007) analyzed 390 soil samples from Dhule Tehsil of Dhule District and reported that the pH of soil varied from 7.3 to 9.1 i.e. neutral to strongly alkaline in reaction and organic carbon content of soils ranged from 0.12 to 1.09 per cent.

Waghmare and Takankar (2007) analyzed 100 representative soil samples from Ausa and Nilanga Tehsil of Latur District of Maharashtra and noted that available N varied from 100.3 to 366.9 kg ha^{-1} and available P varied from 4.22 to 24.98 kg ha^{-1} and 4.22 to 28.13 kg ha^{-1} respectively.

Chinchamalatpure *et al.* (2008) studied salt affected swell and shrink soils of Gujarat, and they reported that organic carbon ranged from 4 to 6 per cent in surface horizons.

Bidari *et al.* (2008) conducted study on different soil pedons of Dharwad District in North Karnataka and reported that available P ranged from 3.56 to 22.05 kg ha^{-1} which decreased with increasing depth.

Shinde (2008) noticed 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 declined trend with soil depth while no specific trend of available Cu with slope of soil.

Kashiwar *et al.* (2009) observed that $CaCO_3$ content in Entisols and Inceptisols of Nagpur (Maharashtra) ranged from 3 to 24 per cent. All the sub groups of North Eastern India were non-calcarious in nature as $CaCO_3$ varied from 0.2 to 3.9 per cent (Singh and Kundu, 2010).

Ashok kumar and Prasad (2010) studied six pedons of Sugarcane growing soils of Ahmednagar district of Maharashtra. They observed that pedon 1 (Vertic Haplustert) was associated with higher value for hydraulic conductivity (0.80 to 0.99 cm hr^{-1}) than P_3 and P_5 (Sodic Haplustept) even soils with ESP more than 5 had HC more than 0.5 cm hr^{-1}.

Patil and Mukhopadhyay (2010) analyzed the DTPA-Extractable Cu content in acidic soil of West Bengal, which varied from 0.17 to 1.96 mg kg^{-1}.

Debnath and Ghosh (2011) studied critical limit of boron (B) in soils and plants was conducted under a pot culture experiment with 22 acidic soils of *terai* zone of West Bengal.

The hot water soluble B in these soil was found to be positively and significantly correlated with pH, organic carbon, and per cent dry matter yield of rice, B concentration in plant tissues and B uptake by shoots. The critical concentration of soil available B and plant tissues B worked out to be 0.32 and 12.5 mg kg^{-1}, respectively, below which appreciable responses to B application were observed. The average dry matter yield increased with increasing level of B application up to 1.5 mg kg^{-1}. The response to B application in rice on B-deficient soils was found to be 88.4%.

Pati and Mukhopadhyay (2011) studied eleven locations under three series of the order Entisols were surveyed to explore the availability of the cations under varying soil conditions and reflection thereof, if any, on the dominant forms of acidity in soils. The soils were acidic in reaction having wide variations in electrical conductivity (EC 0.01-0.21 dSm^{-1}), cation exchange capacity (CEC 1.7-7.9 [cmol (p+)kg^{-1}]), (Ca^{2+}+Mg^{2+} 0.40-2.75 cmol (p+) kg^{-1}), organic carbon (4.32-17.52 g kg^{-1}), available phosphorus (0.89-59.4 mg kg^{-1}) and nitrogen (21.5-240 kg ha^{-1}).

2.3 Correlation coefficient properties

Chavan *et al.* (1980) studied Zn, B and Mo distribution in soil profiles of Maharashtra and revealed that electric conductivity was positively correlate with Zn and Mn in soil.

Revandkar (1990) observed that available Cu was positively and non- significantly correlated with organic carbon. Similarly, 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.).

Patil and Sonar (1994) reported 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.

Dhane and Shukla (1995) noted 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.

Chinchmalatpure *et al.,* (2000) found 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.

Patil and Meisheri (2004) and Patil *et al.,*(2003) noticed 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.).

Sharma *et al.* (2003) analysed the soils from Nagaur District in semi-arid region of Rajsthan and observed that available Zn, Cu, Fe and Mn were negatively correlated with soil pH.

Indulkar *et al.* (2007) stated that the available p showed positive and non-significant correlation with organic carbon and negative and non-significant correlation with available Cu, Fe, Zn and calcium.

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+}.

Pawar (2012) from his study on micronutrient status of soil from mango orchards of Sindhudurg district and their relationship with soil properties revealed that available Fe was correlated positively and significantly with sand (r=0.429*), electrical conductivity (r=0.554*) organic carbon (r=0.476*), available N (r=0.724*), available phosphorus (r=0.688*), available potassium (r=0.773*), exchangeable calcium (r=0.586*) and exchangeable magnesium (r=0.580*) while, it was correlated negatively and significantly with silt (r=-0.372*), clay (r=-0.213*) and pH (r=-429*).

Joshi (2012) studied the available Mn 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*).

2.4 Taxonomic Classification

Diwakar and Singh (1992) observed Tal land soils of Bihar $^{-1}$. Based on the morphological, physical and chemical properties, that tal land soils of old alluvial region were classified as Typic/Entic characters and tal land soils of young alluvial regions as Vertic/Aquic Ustorthents.

Shrivastava and Prasad, (1992) studied some swell-shrink soils of semi-arid Tropics in India. They classified soils like Otur, Achmalti, Kagalgomb and Hungund series as Typic Chromuster/Pellustert, the properties of mollic epipedon were not due recognition. The properties of mollic epipedon were important for plant growth, soil management and land use planning. Considering the importance of mollic epipedon in Vertisols, a new subgroup, viz., mollic chromustert/pellustert was proposed for meaningful classification of such soils.

Shrikant *et al.* (1993) classified the soils in relation to different parent rocks and land farms. They studied six typical pedons formed on sandstone, basalt and alluvium, representing different land forms in Raisen District of Madhya Pradesh were studied. The soils were classified in order as Vertisols, Inceptisols and Entisols.

Tamgadge, (1997) identified seventeen soil series in Bhandara district of Maharashtra and classified according to soil taxonomy while, conducting the reconnaissance soil survey of the area. The soils were classified as Lithic

Ustorthents, Typic Ustorthents, Lithic Ustochrepts, Typic Haplustert, Chromic Haplusterts and Udic Haplusterts.

Prasad, *et al.* (2001) classified four typical shrink-swell orange supporting soils at Nagpur district. The Setu and Gandkhairi soils were grouped under Typic Ustorthents, whereas, Ninji and Gondkhairi soils were classified as Typic Haplustept and Typic Haplustert respectively. Patil *et. al.* (2008) characterized and classified the soils of agriculture college farm, Pune. The soils were gravelly sandy clay to clayey texture. Soils belonged to lower pediment belonging to clayey texture. These soils were moderately alkaline having low EC, organic carbon and moderately calcarious. These soils are low status of N, P and very high status of K. The five soil series (ACP- I, II, III, IV and V) were present on college farm. The soils were classified into Entisols, Inceptisols and Vertisol soil order.

Sarkar *et al.* (2002) examined the soils of Loktak catchment area in central of Manipur based on morphology and soil properties soils have been classified according to Soil Taxonomy (Soil Survey Staff,1998) into order Inceptisols (pedon 1) with diagnostic combic horizons and Ultisols (Pedon 2, 3, 4, 5 and 6) having argillic subsurface diagnostic horizon with base saturation less than 35 per cent. Pedon 1 is classified as Udept at sub order level due to Udic moisture regime and Dystrudept at great group level due to its base saturation being less than 60 per cent within 25- 27cm depth. Pedon 2 is classified as Humic Hapludults Pedon 3 and 4 as Typic Haplohumults, also pedon 5 as Typic Palehumults while pedon six as Aquic Haplohumults.

2.5 Mapping of soils

Soils mapping and classification system have been used for the purpose of delineation, characterization, problem identification etc.

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.

Purna command area of Maharashtra surveyed by More, *et al.* (1987). They observed that nearly 65% of the soils were affected due to salinity. The percent saline, saline-sodic, sodic and normal soils in the command area was 22.92, 14.58, 33.33 and 29.17 respectively.

Diwan (1982) revealed 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.

Datta *et al.*, (1990) reported a decreasing trend of exchangeable calcium with soil depth while Bandopadhyay *et al.*, (2008) found an increasing trend.

Bhattacharya *et al.* (1992) surveyed Ambegaon tahsil of Pune district representing part of Western Maharashtra to bring out the basic soil information for suitable land use pattern. Four physiographic units covering the 37 per cent hilly area, < 1 per cent plateu and pediment 21per cent area and piedmont plains 25.3 per cent area of Tahsil.

Challa *et al.* (1995) mapped the soils of Maharashtra and reported the area under influence of chemical degradation was to the tune of 1.06 million ha and of 3.4 per cent of total geographical area, out of which 2.9 per cent soils were moderate degree and 0.5 per cent of extreme degree of chemical deterioration.

Bhaskar and Subbaiah (1995) reported very low content of exchangeable magnesium content in lateritic soils of Andhra Pradesh which is because of low weathering of magnesium bearing minerals in soils.

He also observed sufficient Cu content in the soil which was due to high organic matter content present in the soil.

Shweta (2010) Studied the characterization and evaluation of land in Khapri village of Nagpur district. Maharashtra were carried out using IRS -1D, IRS –P6 and LISS-IV PAN sharpened LISS-III data and GIS coupled with field survey. Six major landforms *viz.* Isolated hillocks (3-8 % slope), upland (1-3 % slope) and valley plane (1-3 % slope) were identified.

Muthumanickam (2010) visual interpretation of IRS 1C LISS III FCC of kongeyam track of Erode district, Tamil Nadu was carried out to delineate physiographic units. These physiographic units were further sub-divided based on slope classes. The samples strips were selected in each physiographical physical, chemical and exchangeable property. The soils were classified into Inceptisols, Alfisols and Entisols. The soils in general, are very shallow to deep, poor to moderately well drain with varied colour and texture.

Kashiwar (2009) studied visual interpretation of false colour composites of IRS-1D LISS-III and PAN sharpened LISS-III in conjunction with survey of India (SOI) toposheet (1:50000 scale) followed by ground truth observations helped in establishing physiography-soil-land use/land cover identified were single crop, double crop, scrub land and moderately dense forest. Physiographically, the area has been characterized into three major units viz. Sub died table land, upper valley and isolated mount with pediments. Eight soil series were tentatively identified and mapped as series and association and grouped into five land capabilities sub classes IIIs, IIIes, IVs, and IVes and three land irrigability sub classes 2d, 4s and 4st.

3 MATERIAL AND METHODS

This chapter include the materials and standard methods used in the present investigation. The work was under taken to study the morphological characteristics, physico-chemical properties of soils of Agriculture Research Station, Farm, Mahabaleshwar during year 2012-13.

3.1 Material

3.1.1 Location

Agriculture Research Station, Wheat rust Farm lies between $17^{0}56.401'$ North latitude and $73^{0}40.467'$ East longitudes. Its elevation is 4211 m. above the mean sea level. ARS, wheat rust Farm located near Mahabaleshwar-Pune road and three km away from S.T. stand. The national Agriculture Research project Farm, ARS Mahabaleshwar is lies between $17^{0}57.154'$ North latitude and $73^{0}40.554'$ East longitude and its elevation is 4283 feet above mean sea level. The NARP Farm is located near old Mahabaleshwar road and 15 km away from Mahabaleshwar S.T. stand.

3.1.2 Physiography

General slope of Agriculture Research Station Farm is 3 to 5 per cent. The soil is red in colour, they are locally known as *tambadi mati***.** On account of heavy rainfall in the region, these soils were susceptible to leaching and degree of erosion. The soil is reach in high amount of Iron oxides in the sesqui-oxides. The depth of soil is varies from 26 to 70 cm. As result of this, all the soluble salt get leached out leaving behind sesqui-oxides.

3.1.3 Geology

The soils are developed by intensive and long lasting weathering of the underlying parent rock i.e. igneous rock. Due to laterization processes soil were acidic in nature and rich in iron and aluminium.

3.1.4 Climate

Agro-climatically, Mahabaleshwar comes under high rainfall area and it is situated an elevation of 4211 m above mean sea level. The average annual rainfall of the place was 6126.4 mm, out of which 85 per cent rainfall received in monsoon period, 10 per cent received in post monsoon period and 5 per cent in pre monsoon period. In remaining period, there was abundant sunshine and clear sky but occasional rains received during summer season. The annual average maximum and minimum temperatures were 29^{0}C and 5^{0}C, respectively. The area therefore, comes under cool temperature regime.

3.1.5 Hydrology

The area is comes under a high rainfall area but in other season, the well water is the main source of irrigation for both ARS, Farm, Mahabaleshwar. Total area under irrigation was 12.39 ha.

3.1.6 Land use and natural vegetation

The main agronomical crop grown are wheat, strawberry potato and sweet pea. The vegetabale crop grown is brocoly. The natural vegetation consist of hirda, jambul, neem, sisa etc.

3.2 Experimental details

Intensive detailed soil survey was carried out during March 2013 to characterize the soils of Agriculture Research Station, Farm by following the procedure given in the Handbook No. 436 (Soil Survey Staff, 1975). A cadastral map of the area in the scale of 1:2500 was used as a base map. Soil mapping was done by traversing the area of grid spot at every 20 m. distance with screw auger bore. The samples were evaluated for soil depth, texture and colour etc. For that purpose, grid soil survey method was adopted for collecting soil samples. Plot wise samples of soil were collected from 54 grid spots and analyzed for soil separate, bulk dencity pH, EC, organic carbon, calcium carbonate, available nutrients (*viz*; N, P and K) sulphur, calcium, magnecium, and available micronutrients (viz. Fe, Mn, Zn and Cu Mo & B) of soil.

The representative three soil profiles were selected for study as per soil types.

3.3 Methods

The methods used for analysis of different soils are given in Table 2.

Table 1. Meteorological Data of Agriculture Research Station Farm, Mahabaleshwar. (January to December 2012).

Month	Meteorological Week	Temp. (^{0}C)		Humidity (%)		Wind Velocity	Sun Shine	Rainfall	Rainy days	Evaporation
		Max.	Min.	Mor.	Eve.	(Km hr^{-1})	(Hrs.)	(mm)		
Jan.12	1	24.9	5.5	77	44	5.56	4.60	2.20	0	0.00
	2	25.5	4.1	66	22	2.76	7.99	1.5	0	0.00
	3	28.5	3.3	68	28	6.09	8.14	0.0	0	0.00
	4	31.3	6.0	67	20	4.73	7.60	0.0	0	0.00
Feb.12	5	26.3	5.1	62	23	12.23	7.83	0.0	0	0.00
	6	29.1	3.1	62	23	6.99	7.06	2.8	1	0.00
	7	31.5	7.3	74	27	4.26	8.40	0.0	0	0.00
	8	30.4	9.0	60	31	3.86	8.34	0.0	0	0.00
Mar.12	9	31.3	15.8	66	28	5.66	8.14	0.0	0	0.00
	10	32.7	15.0	60	24	1.64	7.01	0.0	0	0.00
	11	32.3	13.1	53	20	2.21	7.67	4.6	1	0.00
	12	31.5	14.8	42	19	4.84	7.73	0.0	0	0.00
	13	33.2	16.1	41	20	5.86	8.13	0.0	0	0.00
Apr.12	14	34.6	16.2	50	18	7.57	8.10	0.0	0	0.00
	15	37.3	10.2	45	23	5.90	8.93	15.5	3	0.00
	16	37.6	19.1	48	23	2.81	9.91	5.0	2	0.00
	17	36.3	18.0	52	22	3.99	8.86	8.0	2	0.00
May.12	18	38.9	19.9	51	25	4.79	9.59	30.0	4	0.00
	19	38.3	20.8	49	18	4.97	8.44	10.0	3	0.00
	20	39.5	23.5	38	17	5.09	6.86	8.0	1	0.00

	21	37.1	23.7	53	30	5.93	7.80	0.0	0	0.00
	22	37.2	24.7	58	40	6.69	1.43	10.4	1	0.00
June.12	23	28.8	20.8	71	58	6.86	0.47	150.2	3	0.00
	24	31.8	20.8	79	53	9.19	1.49	317.0	2	0.00
	25	32.0	21.1	70	50	11.07	1.39	290.0	0	0.00
	26	33.7	19.6	71	53	9.23	1.69	311.6	0	0.00
July.12	27	32.3	17.5	77	64	4.59	0.39	632.6	7	0.00
	28	29.2	18.4	77	66	7.99	1.89	586.6	7	0.00
	29	34.7	17.4	79	69	8.69	0.79	452.0	7	0.00
	30	31.1	18.3	82	58	15.60	0.44	517.6	7	0.00
Aug.12	31	28.5	21.6	76	60	12.97	0.39	451.8	7	0.00
	32	32.1	20.7	72	58	11.40	0.83	380.0	7	0.00
	33	31.0	20.9	77	64	10.71	0.31	352.8	6	0.00
	34	31.8	21.4	89	71	17.50	0.96	470.8	7	2.91
	35	30.3	20.4	81	75	13.51	1.94	394.8	5	1.64
Sept.12	36	26.6	21.5	80	69	8.70	1.64	201.2	3	3.36
	37	31.3	22.0	78	60	12.59	1.67	158.0	5	5.81
	38	30.3	21.6	81	53	12.94	1.89	190.6	7	6.09
	39	31.0	20.9	82	50	11.19	1.34	88.2	3	5.53
Oct.12	40	29.3	19.2	81	60	10.61	2.41	58.6	3	4.53
	41	30.2	20.7	76	50	11.97	4.50	40.0	1	5.29
	42	28.9	20.3	78	53	8.76	3.87	54.6	2	4.60
	43	31.6	14.6	72	25	5.03	6.02	8.0	1	5.40
Nov.12	44	27.3	12.0	58	29	3.81	5.33	0.0	0	5.60
	45	29.5	14.3	68	28	2.17	8.67	20.0	2	5.41
	46	30.8	13.5	69	27	2.53	7.57	26.0	1	5.83
	47	30.5	11.3	65	28	2.27	7.39	0.0	0	4.43
	48	30.7	16.0	71	36	4.05	7.57	0.0	0	3.95
Dec.12	49	24.0	9.5	65	29	3.30	8.30	0.0	0	8.64
	50	26.0	11.7	69	30	1.13	7.67	0.0	0	3.71
	51	29.9	9.1	75	30	4.23	6.90	5.3	1	3.51
	52	27.1	9.4	62	24	2.11	6.10	0.0	0	3.00
Mean		32.6	17.9	67	39	6.93	7.18	6226.3	124	1.72

Table 2: Standard analytical methods used for chemical analysis of soil.

Sr No.	Parameter	Method used	Reference
Physical properties			
1.	Soil texture	International pipette method	Piper (1966)
2.	Soil colour	Munsell colour chart	Soil Survey Staff, USDA (1975)
Chemical properties			
1.	pH (1:2.5)	Potentiometry	Jackson(1973)
2.	EC (1:2.5)	Conductometry	Jackson(1973)
3.	Organic carbon	Wet oxidation	Nelson and Sommer (1982)
4.	$CaCO_3$	Acid neutralization	Alison and Moodie (1965)
5.	Available nitrogen	Modified alkaline permagnate	Subbiah and Asija (1956)
6.	Available phosphorus	Bray and Kurtz P method (1945)	Bray and Kurtz(1945)
7.	Available potassium	Flame photometer N*N* NH_4 OAC, pH 7.0.	Jackson (1973)
8.	DTPA (Mn, Fe, Cu and Zn)	Atomic Absorption Spectrophotometer (DTPA)	Linsay and Norvell (1978)
9.	Ca^{2+}, Mg^{2+}	Versenate titration (EDTA)	Page, *et. al.* (1982)
10.	Available S	0.01M $CaCl_2$ extractable	Williams and Steinbergs (1969)
11.	Available Mo (kg ha^{-1})	AB–DTPA method	Soltanpur *et al* (1977)
12.	Available Boron (kg ha^{-1})	Hot water soluble	Berger and Truot(1939)

Table 3. Ratings of pH, EC and $CaCO_3$

Ratings	pH (1:2.5)	Ratings	EC (dSm^1) (1:2.5)	Ratings	$CaCO_3$ (g kg^{-1})
Extremely acidic	< 4.5	Normal	0-1	Non calcareous	< 1.0
Strongly acidic	4.6-5.5			Low	1-5

Moderately acidic	5.6-6.5	Poor seed emergence	1-2	Medium	5-10
Slightly acidic	6.6-6.9				
Neutral	7.0	Harmful to some crop eg. Pulses	2-3	High	10-15
Slightly alkaline	7.1-8.0				
Moderately alkaline	8.1-9.0				
Strongly alkaline	9.1-10	Harmful to most of the crops	3 or more	Harmfull	>15
Very strongly alkaline	10.1-11				

Patil and Mali (1999)

Table 4. Six tier ratings of organic carbon and available nutrients

Sr. No.	Ratings	Organic Carbon (%)	Available Nutrients (kg ha^{-1})		
			N	**P**	**K**
1	Very Low	<0.20	<140	<7.0	<100
2	Low	0.21-0.40	141-280	7.1-14	101-150
3	Moderate	0.41-0.60	281-420	14.1-21	151-200
4	Moderately High	0.61-0.80	421-560	21.1-28	201-250
5	High	0.81-1.0	561-700	28.1-35	251-300
6	Very High	>1.0	>700	>35	>300

Bangar and Zende (1967)

Table 5. Six tier ratings of available sulphur and available DTPA micronutrients (mg kg^{-1})

Sr. No.	Ratings	S	Fe	Mn	Zn	Cu	B	Mo
1	Very Low	< 5	< 2.5	< 1	< 0.3	< 0.1	< 0.25	< 0.05
2	Low	5 -10	2.5-4.5	1-2	0.3-0.6	0.1-0.2	0.25-0.5	0.05-0.1
3	Medium	10-15	4.5-9	2-4	0.6-1.2	0.2-0.4	0.5-0.75	0.10-0.2
4	Moderately High	15-20	9-18	4-8	1.2-1.8	0.4-0.8	0.75-1.0	0.20-0.4
5	High	20-40	18-27	8-16	1.8-2.4	0.8-1.2	1.0-1.5	0.40-0.6
6	Very High	> 40	>27	>16	>2.4	>1.2	>1.5	>0.6
	Critical limits	**10**	**4.5**	**2.0**	**0.6**	**0.2**	**0.5**	**0.05**

Katkar and Patil (2010)

3.4 Taxonomic classification and mapping

Taxonomic classification of soils were carried out based on soil morphological characteristics and physico-chemical parameters by using keys to soil taxonomy, Soil Survey Staff (1992). The delineation of different types of soils and their extent of area were calculated by planimeter (Albert instrument no. 5544 made in England) and mapping was carried out by using cartographic techniques.

3.5 parkar soil fertility index

Basic data required for computation of fertility status

$$\text{Parkar soil fertility index} = \frac{(A \times 1) + (B \times 2) + (C \times 3)}{\text{Total number of soil samples}}$$

A= No. of soil samples in low category

B= No. of soil samples in medium category

C= No. of soil samples in high category

3.6 Statistical analysis

The correlation was computed within soil parameters as per the procedure outlined by Panse and Sukhatme (1995).

4 RESULTS AND DISCUSSION

The detailed soil survey was carried out during the year May 2013 with the view to study the fertility status of soil of Agriculture Research Station, Farm, Mahabaleshwar, Dist. Satara. The three representative soil pedons were studied. (Two soil pedon from Wheat rust Farm and one from NARP Farm). The representative soil pedons studied for morphological characteristic. Horizonwise soil sample were collected and analysed for physico-chemical properties. The grid soil survey samples were analysed for chemical and physical properties of soils and results obtained are presented in table (6 to 9).

4.1 Nutrient status of soil

The soil sample collected from Agriculture Research Station, Farm, Mahabaleshwar Dist. Satara and data pertaining to different parameters are categorized as per the six tier rating system. The data pertaining to soil pH, electrical conductivity, calcium carbonate and organic carbon, available N, P and K are presented in Table 6.

4.1.1 Soil Reaction (pH)

The data pertaining to the soil pH are reported in Table No. 6 and depicted on map (Plate No.3). The pH of the soils were ranged from 4.18 to 5.53. Among the soil sample tested, most of the soil were strongly acidic (77.28 per cent) followed by extremely acidic (22.72 per cent). The Extreme alkaline soil pH was 5.53 ($17^0$57.159'N-$73^0$40.561'E) and the strongly alkaline was 4.18

(17^{0}56.401'N-73^{0}40.467,E). It may be because of losses of bases due to leaching in presence of Al^{3+} and Fe^{3+} on exchangeable complexes responsible for low soil pH. The similar results were also recorded by Pati and Mukhopadhyay (2011) in some acid soils of West Bengal.

4.1.2 Electrical Conductivity (EC)

Electrical Conductivity of soils are presented in Table No. 6 and depicted on map (Plate No. 4). The EC of Various soil samples are ranged from 0.02 to 0.28 dSm^{-1}. The EC indicated normal in electrolyte concentration (97 %) and all the soils are more leached condition and acidic in nature and suitable for healthy plant growth. The EC comes under normal category might due to sloppy topography of characterised area where the water table is low. The similar results were reviewed by Sing *et al.* (2011) in red soils of Vindhyan region of Utter Pradesh.

Table 6. Categorization of chemical properties and available nutrient status in soil.

Particular	pH (1:2.5)	EC (dSm^{-1})	Organic Carbon (%)	$CaCO_3$ (%)	Available Nutrients ($kg\ ha^{-1}$)		
					N	P	K
Mean	4.820	0.107	1.071	Nil	224.9	13.55	124.99
Range	4.18-5.53	0.02-0.28	0.82-1.35	Nil	157.9-324.8	7.48-22.46	49.28-217.28
Category	Extremely acidic (22.72)	Normal (100)	High (34.09)	Nil	Low	Low (56.81)	Very low (29.54)
	Strongly acidic (77.28)		Very high			Medium	Low (45.45)
							Moderate (25.01)
SD	0.31	0.65	0.13	Nil	22.13	3.64	36.21

(Total No. of soil samples analysized-44, figures in parenthesis are in per cent)

4.1.3 Organic carbon

The organic carbon content in soils are presented in Table No. 6 and depicted on map (Plate No. 5) which ranged from 0.82 to 1.35 per cent with mean of 1.07 per cent. The highest content of organic carbon was 1.35 per cent ($17^0$56.254'N-$73^0$40.481'E) and the lowest was 0.82 per cent ($17^0$56.243'N-$73^0$40.443'E). Among the soil sample tested, most of the soils of organic carbon content are very high (65.91 %) and high (34.09 %). This might due to slow rate of mineralization due to nature of soil acidity. The similar results were also recorded by Laxminarayana (2011) in acid soils of Meghalaya in relation to its forms and availability.

4.1.4 Calcium carbonate

The data in relation to calcium carbonate status of soils are presented in Table No. 6 and depicted on map (Plate No. 6). The calcium carbonate content in all the soils were non calcarious. All the soil samples were found nil in status. This is due to the area are comes under heavy rainfall region. The calcium may completely leachout from the soils during laterization process. The similar results were recorded by chavan *et al.* (1980) in soils of different agroclimatic zones of Maharashtra.

4.1.5 Available nitrogen

The data in relation to available nitrogen status of soils are presented in Table No. 6 and depicted on map (Plate No 7). The available nitrogen in soils were ranged from 175.61 to 324.78 kg

ha^{-1} with an average of 224.9 kg ha^{-1}. All samples collected were low available nitrogen status. The highest available nitrogen was observed 324.78 kg ha^{-1} (17^{0}56.316'N-73^{0}40.497'E) and lowest 175.61 kg ha^{-1} (17^{0}56.365'N-73^{0}40.476'E). It may be due to the high organic matter content and wide C:N ratio of soil (Sarkar *et. al.* 2002). Tiwari stated the nitrogen deficiencies in Indian soils are almost universal.

4.1.6 Available phosphorus

The data with respect to available phosphorus status of soils are presented in Table No. 6 and depicted on map (Plate No. 8). The available phosphorus in soils were ranged from 7.48 to 22.46 kg ha^{-1} with an average of 13.55 kg ha^{-1}. Among the soil samples collected 56.81 per cent are in low category whereas, 43.19 per cent are in medium category. The higher phosphorus status was 22.46 kg ha^{-1} (17^{0}56.263'N-73^{0}40.474'E) and lowest was 7.48 kg ha^{-1} (17^{0}56.280'N-73^{0}40.483'E). The overall P comes under the category of low to medium. This might due to low status of total P influence by topography, parent material, climatic and physicochemical characteristics of soil. The similar results were also reported by Laxminarayana (2011) in acid soils of Meghalaya in relation to its forms and availability.

4.1.7 Available potassium

The data in relation to available potassium status of soils are presented in Table No. 6 and depicted on map (Plate No. 9). The available potassium in soils ranged from 49.28 to 217.28 kg

ha^{-1} with an average of 124.99 kg ha^{-1}. Among the soil samples collected 45.45 per cent are categorised under low category whereas, 29.54 and 25.01 per cent categorised under very low and moderate category, respectively. This may be due to low clay content. The similar result was recorded by Revandkar (1990) in lateritic soils of soil conservation Research Station, Awashi, Ratnagiri.

Table 7. Status of exchangeable Ca, Mg and available S, B and Mo in soil.

Particulars	Exchangeable nutrients [Cmol (p^+) kg^{-1}]		S (mg kg^{-1})	Available nutrients (mg kg^{-1})	
	Ca	**Mg**		**B**	**Mo**
Mean	0.85	0.52	29.65	0.40	0.26
Range	0.54-0.98	0.37-0.67	20.69-40.58	0.28-0.51	0.15-0.42
Category	Deficient (100)	Deficient (100)	Sufficient (100)	Deficient (100)	Sufficient (100)
SD	1.12	0.82	1.34	0.10	29.79

(Total No. of soil samples analyzed-44, figures in parenthesis are in per cent).

4.1.8 Exchangeable calcium

The data in respect of exchangeable calcium status of soils are presented in Table No. 7 and depicted on map (Plate No 10). The exchangeable calcium in soils ranged from 0.54 to 0.98 [cmol (p^+) kg^{-1}] with an average of 0.51 [cmol (p^+) kg^{-1}]. Out of all soil samples collected, 100 per cent samples are deficient in calcium. This might be due to loss of calcium from exchangeable site during laterization. The highest exchangeable calcium was 0.98 [cmol (p^+) kg^{-1}] in ($17^0 56.291$'N-$73^0 40.481$'E) and lowest was 0.54 [cmol (p^+) kg^{-1}] ($17^0 56.257$'N-$73^0 40.462$'E). The deficiency of calcium might due to high percolating nature and intensive leaching of bases due to high rainfall. The similar results were also reported by Mohapatra and Kibe (1973) in lateritic soil of Maharashtra.

4.1.9 Exchangeable Magnesium

The data in respect of exchangeable magnesium status of soils were presented in Table No. 7 and depicted on map (Plate No. 10). The available magnesium in soils ranged from 0.37 to 0.67 [cmol (p^+) kg^{-1}] with an average of 0.522 [cmol (p^+) kg^{-1}]. Out of all the soil samples collected, all the soil samples are deficient in available magnesium. The higher values of exchangeable magnesium was 0.63 [cmol (p^+) kg^{-1}]. ($17^0 56.252$'N-$73^0 40.450$'E) and lowest 0.37 [cmol (p^+) kg^{-1}]. ($17^0 56.340$'N-$73^0 40.474$'E). The deficiency of Mg in soil might be due to fine coarse to loamy texture under heavy rainfall condition. The similar results were also reported by Basker and Subbaiah (1995) in lateritic and associated soils along the east coast of Andhra Pradesh.

4.1.10 Available sulphur

The data in relation to available sulphur status of soils are presented in Table No. 7 and depicted on map (Plate No. 11). The available sulphur in soils ranged from 20.69 to 40.58 mg kg^{-1} with an average of 29.65 mg kg^{-1}. Out of the soil sample collected, all are sufficient in sulphur status, as the critical limit of available sulphur is 10 mg kg^{-1}. The highest available sulphur recorded 6.35 mg kg^{-1}($17^0$56.365'N-$73^0$40.476'E) and lowest 1.54 mg kg^{-1} ($17^0$56.254'N-$73^0$40.481'E). The total S in soil is present in organic combination therefore, soils which are rich in organic matter will have high level of S. Also the coarse-textured sandy soils generally have low total S content as compared to fine textured soils (Kanwar, 1976). The results indicated that sufficiency of available sulphur is directly proportional to the organic matter content of soil. The similar results were also found by Kolape *et al.* (1991) in Konkan region.

4.1.11 Available Boron

The data in relation to available boron statusof soils are presented in Table No. 7 and depicted on map (Plate No. 12). The available boron in soils were ranged from 0.281 to 0.51 mg kg^{-1} with an average of 0.40 mg kg^{-1}. Out of the soil sample collected, all are deficient in boron, as the critical limit of available boron is 0.5 mg kg^{-1}. The highest available boron was recorded 0.51 mg kg^{-1} ($17^0$56.365'N-$73^0$40.476'E) and lowest 0.281 mg kg^{-1} ($17^0$56.254'N-$73^0$40.481'E). Among, the entire sample collected categorised under low category. The deficiency may be due to high rainfall and topography of soil. The similar results were recorded by Diwale *et al.* (1999).

4.1.12 Available Molybdenum

The data in relation to available molybdenum status of soils are presented in Table No. 7 and depicted on map (Plate No. 11). The available molybdenum in soils were ranged from 0.51 to 0.98 mg kg^{-1} with an average of 0.26 mg kg^{-1}. The entire sample collected were sufficient in available molybdenum. As the critical limit of available molybdenum is 0.05 mg kg^{-1}. The highest available molybdenum was 0.42 mg kg^{-1} ($17^0$56.376'N-$73^0$40.471'E) and the lowest was 0.15 Mg kg^{-1} ($17^0$56.388'N-$73^0$40.467'E). The low availability of Mo in lateritic soils may be due to the binding of molybdate anions by clay minerals containing high amount of Al and Fe. The similar results were also reported by Chavan *et al.* (1980) in soils of different agro-climatic zones of Maharashtra.

Table 8. Status of available micronutrients in soil.

Particulars	**Available DTPA micronutrients (mg kg^{-1})**			
	Fe	**Mn**	**Zn**	**Cu**
Mean	9.74	8.385	1.329	1.051
Range	7.88-10.40	6.152-10.290	0.521-7.747	0.553-1.694
Category	Sufficient (100)	Sufficient (100)	Sufficient (100)	Sufficient (100)
SD	0.64	0.87	0.38	0.29

4.1.13 Available iron

The data in respect of available iron status of soils are presented in Table No. 8 and depicted on map (Plate No. 13). The available iron in soils were ranged from 7.88 to 10.40 mg kg^{-1} with an average of 9.7 mg kg^{-1}. All the samples were sufficient in available iron, as the critical limit of available iron is 4.5 mg kg^{-1} (Takkar *et al.,* 1989*).* The highest available Iron was 10.40 mg kg^{-1} ($17^0$56.243'N-$73^0$40.470'E) and the lowest was recorded 7.88 mg kg^1 ($17^0$56.328'N-$73^0$40.486'E). The higher Fe content might be due to laterization processes in which sesqui-oxide 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. The similar result was also reported by Diwan (1982) in the soils from bench terraced area of the Central Farm, Wakawali.

4.1.14 Available manganese

The data in relation to available Manganese status of soils are presented in Table No. 8 and depicted on map (Plate No. 13). The available manganese in soils were ranged from 6.1 to 10.2 mg kg^{-1} with an average of 8.4 mg kg^{-1}. All the soil samples collected from Agriculture Research Station, Farm, Mahabaleshwar are sufficient in available Manganese as the critical limit of available manganese was 2.0 mg kg^{-1} (Takkar *et al.,* 1989*).* The highest available manganese was 10.2 mg kg^{-1} ($17^0$56.388'N-$73^0$40.467'E) and the lowest 6.1 mg kg^{-1} ($17^0$56.209'N-$73^0$40.453'E). The sufficiency of available Mn might be due to high organic matter content and chelating action of organic compound released during the decomposition of organic manure. The similar results were also reported by Chinchmalatpure (2000) soils on different parent materials and landforms in a micro-watershed of Wunna catchment near Nagpur.

4.1.15 Available Zinc

The data in relation to available Zn status of soils are presented in Table No. 8 and depicted on map (Plate No. 13). The available Zn in soils were ranged from 0.5 to 1.99 mg $kg^{-1}$with an average of 8.3 mg kg^{-1}. The soil samples collected were sufficient in available Zn as the critical limit of available Zn is 0.6 mg kg^{-1} (Katyal, 1985*)*. The highest available Zn was 7.7 mg kg^{-1} ($17^0$56.279'N-$73^0$40.493'E) and the lowest was 0.5 mg kg^{-1} ($17^0$56.304'N-$73^0$40.486'E). The sufficiency of Zn might due to the comparatively low pH of soil and regular turn over through crop residue and complexing with organic matter. The similar result was also reported by Diwale (1999) in lateritic soils of Konkan.

4.1.16 Available Copper

The data in relation to available Cu status of soils are presented in Table No. 8 and depicted on map (Plate No. 13). The available Cu in soils were ranged from 0.5 to 1.6 mg kg^{-1} with an average of 1.051 mg kg^{-1}. The entire soil samples collected were sufficient in available Cu as the critical limit of available Cu is 0.2 mg kg^{-1} (Katyal, 1985*)*. The highest available Cu was 1.6 mg kg^{-1} ($17^0$56.291'N-$73^0$40.481'E) and the lowest was 0.5 mg kg^{-1} ($17^0$56.224'N-$73^0$40.432'E). The sufficiency of available Cu might be due to the higher organic matter content and optimum soil moisture in soil. Similar result was also reported by Shide (2008) in soils of Udgir and Deoni Tehsil of Latur.

4.2 Physical properties of surface soil sample

Table 9 Physical properties of surface soil samples

Plot No.	Bulk Density (Mg m^{-3})	Sand (%)	Silt (%)	Clay (%)	Textural class
19	1.30	43.47	25.65	30.88	Clay Loam
19	1.13	36.6	25.17	38.23	Clay Loam
19	1.12	40	27.5	32.5	Clay Loam
19	1.30	32.72	31.01	36.27	Clay Loam
18	1.26	35	23.44	41.56	Clay Loam
18	1.42	31.35	28.95	39.7	Clay
16	1.24	32.1	22.43	45.56	Clay
15	1.40	33.71	23.06	43.23	Clay
16	1.27	36.71	24.05	38.23	Clay Loam
14	1.20	35.19	25.3	39.51	Clay Loam
17	1.26	39.01	28.71	32.28	Clay Loam
16	1.35	32.03	28.17	39.80	Clay Loam
13	1.26	41.08	23.56	45.39	Clay Loam
17	1.30	33.58	28.05	38.38	Clay Loam
12	1.32	35.02	22.58	38.43	Clay Loam
13	1.37	31.09	29.82	39.09	Clay Loam
11	1.29	30.89	25.32	43.81	Clay
11	1.30	33.41	24.67	41.92	Clay
10	1.32	39.2	23.71	35.09	Clay Loam

10	1.09	29.03	32.14	38.83	Clay Loam
9	1.32	33.49	27.03	39.49	Clay Loam
9	1.22	33.81	37.84	38.38	Clay Loam
8	1.16	38	17.70	44.30	Clay
9	1.29	37.06	28.18	34.76	Clay Loam
9	1.14	32.85	20.15	47.0	Clay
9	1.28	38.83	22.88	38.29	Clay Loam
1	1.16	32.85	27.80	39.35	Clay Loam
2	1.27	34.83	23.88	43.29	Clay
8	1.34	38.28	26.04	37.68	Clay Loam
7	1.35	43.55	21.1	35.35	Clay Loam
3	1.18	32.83	26.07	41.10	Clay
8	1.30	40.60	22.80	36.60	Clay Loam
5	1.33	35.08	25.11	39.81	Clay Loam
4	1.21	35.80	24.17	40.03	Clay Loam
5	1.19	31.79	31.59	36.62	Clay Loam
6 A	1.27	39.77	25.21	35.02	Clay Loam
6 A	1.25	32.98	23.88	43.34	Clay
4 A	1.33	35.9	20.23	43.87	Clay
4 A	1.24	40.39	22.91	36.7	Clay Loam
4 A	1.24	41.43	27.34	37.33	Clay Loam
1	1.34	43.21	22.09	35.70	Clay Loam
1	1.25	37.42	28.49	33.97	Clay Loam
1	1.19	32.83	27.61	39.61	Clay Loam
1	1.19	33.04	25.04	41.95	Clay
Mean	1.26	33.97	22.15	44.14	Clay to clay loam
Range	1.09-1.46	22.7-43.4	14.5-32.14	30.8-56.2	
SD	0.089	3.61	4.20	4.14	

4.2.1 Soil texture

The soil sample collected from Agriculture Research centre, Farm, Mahabaleshwar were analysed for partical size distribution. Soil texture of 73 per cent soils were categorised under clay loam and 27 per cent under clay textural cass. The sand, silt and clay was ranged from 30.89 to 43.47, 17.70 to 32.14 and 30.88 to 41.56 respectively. The soil texture categorised under clay to clay loam. (Poddar *et al.* 2003)

4.2.2 Bulk density

The bulk density of Agriculture Research Station, Farm, Mahabaleshwar ranged from 1.13 to 1.42 Mg m^{-3} with an average of 1.26 Mg m^{-3} which is categorised under normal range to slightly high.

4.3 Correlation of available nutrients with chemical properties

The correlation of available nitrogen, phosphorus, potassium, sulphur, boron, molybdenum, iron, zinc, copper, exchangeable Ca and Mg with pH, EC, organic carbon and $CaCO_3$ are calculated.

The data on correlation coefficient between chemical properties and available nutrients are presented in Table 10.

The pH of the soils showed the positive and non significant correlation with available nitrogen, phosphorus, sulphur, iron and exchangeable magnesium. It is negatively and non-significantly correlate with available potassium, boron, molybdenum, zinc, copper, manganese and exchangeable calcium. The similar results were also recorded by Sharma *et al.* (2003) who analysed the soils from Nagaur District in semi-arid region of Rajsthan and observed that available Zn, Cu, Fe and Mn were negatively correlated with soil pH.

The EC of the soils showed negative and significant correlation with exchangeable magnesium which is evident by 'r' value 0.376**. It is positively and significantly correlated with available manganese and sulphur with evident 'r' value of 0.291* and 0.376** respectively. It is negatively and non- significantly correlated with available nitrogen, potassium, iron, copper, boron and molybdenum. It is positively and non- significantly correlated with available phosphorus, iron zinc, manganese and sulphur. Chavan *et al.* (1980) studied Zn, B and Mo distribution in soil profiles of Maharashtra and revealed that el;ectric conductivity was positively correlated with with Zn and Mn in soil.

Table No. 10 Correlation coefficient between chemical properties and available nutrient of surface soil samples in agriculture research station, farm, Mahabaleshwar.

Chemical properties	Available			Exchangeable		Available			Available			
	N	P	K	Ca	Mg	S	B	Mo	Fe	Zn	Mn	Cu
pH	0.095	0.089	-0.021	-0.078	0.164	0.236	-0.184	-0.199	0.056	0.096	-0.233	-0.045
EC	-0.223	0.028	-0.031	0.014	-0.387**	0.383**	-0.012	-0.15	-0.011	0.019	0.301*	-0.164
Organic carbon	0.003	0.162	0.000	-0.019	0.064	0.196	0.142	-0.167	-0.029	-0.148	-0.097	-0.066
$CaCO_3$	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

* Significant at 5% level: 0.29

** Significant at 1% level: 0.37

The organic carbon showed the positive and non significant correlation with available nitrogen, phosphorus, potassium, sulphur, boron, and exchangeable magnesium. It is negative and nonsignificantly correlate with available calcium, iron, zinc, copper, manganese and molybdenum. Indulkar *et al.* (2007) stated that the available p showed positive and non-significant correlation with organic carbon and negative and non-significant correlation with available Cu, Fe, Zn and calcium.

The calcium carbonate of the soils of Agriculture Research Station, Farm, Mahabaleshwar not showed any correlation with available and exchangeable nutrients.

4.4 Soil fertility index

Table No. 11 Parkar index

According to the Parkar index of soil fertility, available nitrogen, phosphorus and potassium is categorised under medium category.

Particulars	Available N	Available P	Available K
Low (%)	100	56.81	74.99
Medium (%)	0	43.19	25.01
High (%)	0	0	0
Parkar index	1.92	2.75	2.40
Category	Medium	Medium	Medium

4.5 Morphological properties of soil profile study.

Horizone	Depth	Texcture	Structure	Colour	Consistency		
					Dry	Moist	Plasticity
Pedon 1 Fine loamy mixed isohyperthermic family of Lithic Usthorthent (Satara soil series)							
Ap	0-28	Cl	f1sbk	5YR 4/6	dsh	wss	Wps
Pedon 2 Fine loamy mixed isohyperthermic family of Typic Haplustept (Chandgad soil series).							
Ap	0-15	Cl	m1sbk	7.5 YR 6/6	dsh	wss	wps
B1	15-45	Cl	m1sbk	7.5 YR 5/6	dsh	wss	wps
B2	45-70	Cl	m1sbk	7.5 YR 5/6	dsh	wss	wps
B3	70+						
Pedon 3 Fine loamy mixed isohyperthermic family of Udic Rhodustalf (Amba soil series).							
Ap	0-17	Cl	m2 sbk	5 YR 4/4	dsh	wss	Wps
B1	17-42	Cl	m2 sbk	2.5 YR 3/4	dsh	Wss	wps
B2	42-72	Cl	m2 sbk	2.5 YR 3/4	dsh	Wss	wps
B3t	72+	Cl	m2 sbk	2.5 YR 3/4	dsh	Wss	wps
Cr	28+	Hard rock					

Pedon description

Pedon 1 Agriculture Research Station, Mahabaleshwara, plot No. 18.

Typifying pedon: Satara clay loam cultivated.

Taxonomic classification: Fine loamy mixed isohyperthermic family of Lithic Ustorthent.

Horizon	Depth	Descreption
Ap	0-26	Yellowish red (5 YR 4/6) clay loam, fine weak subangular blocky, dry slight hard , slightly sticky and slightly plastic, fine common roots, clear smooth boundary, pH 4.6
Cr	26+	Hard rock

Pedon 2 Agriculture Research Station, Mahabaleshwar, plot No.5.

Typifying pedon : Changad clay loam –cultivated.

Taxonomic classification: Fine loam mixed isohyperthermic family of Typic Haplustept.

Horizon	Depth	Description
Ap	0-15	Reddish yellow (7.5 YR 6/6) clay loam, medium weak subangular blocky, dry slight hard, slight sticky and hard, clear smooth boundary, pH 4.4.
B1t	15-45	Reddish yellow(7.5 YR5/6) clay loam, medium weak subangular blocky structure, gradual smooth boundary, dry slight hard, moist slight sticky and plastic, pH 5.3.
B2	45-70	Strong brown (7.5 YR 5/6) clay loam, medium moderate subangular block structure, dry slight hard, moist slight sticky and plastic, gradual smooth boundary, pH 4.89.
B3	70+	Weathered laterite

Pedon 3 Agriculture Research Station, Mahabaleshwar, plot No. 1.

Typifying pedon : Amba- forest.

Taxonomic classification : Fine loam mixed isohyperthermic family of Udic Rhodustalf.

Horizon	Depth	Description
A	0-17	Reddish yellow (5 YR 4/4 m) clay loam, medium, moderate subangular blocky structure, dry slight hard, moist slight sticky and slight plastic, clear smooth boundary, pH 5.6.
B1	17-42	Dark reddish brown (2.5 YR 3/4 m) clay loam, medium moderate subangular structure, dries slight hard moist slightly sticky and plastic, clear smooth boundary, pH 5.03.
B2	42-72	Dark reddish brown (2.5 YR 3/4 m) clay loam, medium moderate subangular structure, dries slight hard moist sticky and plastic, clear smooth boundary, pH 4.8.
B3t	72+	Dark reddish brown (2.5 YR 3/4 m) clay loam, medium moderate subangular structure, dries slight hard moist sticky and plastic, clear smooth boundary, pH 5.0.

4.6 Physical properties of soil pedon.

4.6.1 Particle size distribution

Partical size distribution of soil pedon 1 to 3 arepresented in Table 12which revealed that, soil texture of pedonwas clay however, pedon 2 qnd 3 were clay loamin texture.

Table 12. Physical properties of soil pedon

Plot No.	Pedon No.	Horizon	Depth (cm)	Partical size distribution (%)			Texture	Bulk density (Mg m-3)
				Sand	Silt	Clay		
Pedon 1 : Lithic Usthorthents (Satara soil series)								
18	P1	Ap	0-28	40.59	21.17	38.17	Cl	1.14
18		Ac	Hard rock					
Pedon 2 : Typic Haplustept (Chandgad soil series)								
5	P2	Ap	0-15	31.91	30.09	38.04	cl	1.22
5		B1	15-45	40.01	22.81	37.19	cl	1.30
5		B2	45-70	41.91	22.87	36.23	cl	1.26
5		B3	70+	39.91	25.87	34.23	cl	1.38
Pedon 3 : Udic Rhodustalf (Amba soil series)								
1	P3	Ap	0-17	42.08	25.09	32.83	cl	1.16
1		B1	17-42	39.91	27.74	32.37	cl	1.16
1		B2	42-72	43.91	22.25	34.55	cl	1.19
1		B3t	72+	35.88	27.03	37.09	cl	1.24

4.6.2 Bulk density

The soils of Agriculture Research Station, Farm, Mahabaleshwar showed low bulk density which ranged from 1.14 to 1.38 Mg m^{-3}. The higher value recorded (1.38 Mg m^{-3}) in Chandgad soil series (P2) and lower value recorded (1.14 Mg m^{-3}) in Satara soil series (P1). There was no wide variation of bulk density in pedon 2 and 3. There is no specific trend of bulk density with soil depth. Similar results were also recorded by Sankpal (2008).

4.7 Chemical properties of soil pedon

4.7.1Soil pH :

The soils of Agriculture Research Station, Farm, Mahabaleshwar are categorised in extremely to strongly acidic in reaction (Table 13). The soil pH was ranged from 4.40 to 5.6. The lowest mean value of soil pH was reported in Amba soil series (P3) and highest was reported in Chandgad soil series (P2). The increase in soil pH in all three soil series with increase in depth, due to leaching of bases. The similar result of soil pH value with increase in depth was also reported by Sarkar and Sahoo (2000).

4.7.2 EC

The EC value of soil ranged from 0.11 to 0.14 dSm^{-1} (Table 13). The minimum variation found in all three soil series. The lowest values (0.04 dSm^{-1}) belonged to the soils on high slope (P1) which may be due to excess drainage condition and presence of sesque-oxide clay minerals. Similar results were also recorded by Manorama *et al.* 2000.

Table 13. Chemical properties of soil pedons.

Plot No.	Pedon No.	Horizon	Depth (cm)	pH (1:2.5)	EC (dSm^{-1})	Organic carbon (%)	$CaCO_3$	Available nutrients kg ha^{-1}		
								N	P	K
Satara soil series (Lithic Ustorthent)										
18	P1	Ac	0-28	4.61	0.04	1.02	nil	189.46	8.04	105
18		Cr	28+	Hard rock						
Chand gad soil series (Typic Haplustept)										
5	P2	Ap	0-15	4.40	0.11	1.18	nil	226.89	16.08	118.72
5		B1t	15-45	5.23	0.13	0.91	nil	224.15	13.31	98.56
5		B2	45-70	5.89	0.14	1.03	nil	225.46	7.48	98.32
5		B3	70+	Weathered laterite						
Amba soil series (udic Rhodustalf)										
1	P3	Ap	0-17	5.6	0.08	1.03	nil	256.12	13.31	154.23
1		B1t	17-42	5.03	0.07	0.98	nil	245.47	12.47	145.25
1		B2t	42-72	4.48	0.08	0.91	nil	244.68	11.92	122.24
1		B3t	72+	5.0	0.09	0.88	nil	238.4	8.03	112.6

4.7.3 Organic carbon

The value of organic carbon content varied from 0.91 to 1.18 per cent. The highest organic carbon content was reported in Chandgad soil series (1.18 %) and lowest was recorded in amba soil series (0.88 %). The maximum variation in range of content was reported in Chandgad and Amba soil series (0.91 to 1.18 %) and (0.88 to 1.03 %) respectively. The horizonwies distribution of organic carbon decreased with increase in depth (P1, P2 and P3). This may be due to the slow microbial activity at sloppy areas (Sarkar *at al.* 2002). In general, with increase in a depth, the organic carbon content of all the soil series were decreased.

4.7.4 Calcium Carbonate

All three soil series are nil in $CaCO_3$. This may be because of heavy rainfall and leaching losses of bases.

4.7.5 Available N

The available nitrogen content in soils ranged from 224.15 to 256.12 kg ha^{-1}. The maximum variation in range of available nitrogen was reported in Amba soil series (237.68 to 256.12 kg ha^{-1}). The value of available nitrogen was higher in surface soils of all the soil series. It may be due to application of organic manure in surface horizon. (Sharma and Bali 2000).

4.7.6 Available P

The low status of available phosphorus was reported in soils with the maximum variation in the range of (7.48 to 16.03 kg ha^{-1}) was observed in Chandgad soil series (P2) and the minimum (8.31 to 13.03 kg ha^{-1}) in Amba soil series (P3). However, surface horizon showed higher phosphorus which decreased with depth. The decline trend of phosphorus may be due to higher fixation of available P by clay (Satisha and Badrinath 1994).

4.7.7 Available K

The soils of Agriculture Research Station, Farm, Mahabaleshwar showed the low potassium status. The available potassium content ranged from 98.32 to 154.25 kg ha^{-1}. The Amba soil series showed the maximum variation (112.23 to 154.25 kg ha^{-1}) and the minimum (98.32 to 118.72 kg ha^{-1}) in Chandgad soil series (P_2). The surface soil had a higher available K content which may be due to more intense weathering of potash bearing minerals generation of leaf litter from different crops in cropping system, release liable K from organic residue (Hirekurabar *et al.* 2000).

Secondary and micronutrient chemical status of soil pedon

4.7.8 Exchangeable Calcium

The soils of Agriculture Research Station, Farm, Mahabaleshwar showed the deficiency of exchangeable calcium which ranged from 0.75 to 0.92 [cmol (P^{+}) kg^{-1}]. The pedons showed the minimum variation (0.73 to 0.89 and 0.75 to 0.89 [cmol (P^{+}) kg^{-1}] in P_2 and P_3 respectively. Similar results were also reported by Mahajan (2001).

4.7.9 Exchangeable Magnesium

The soils of Agriculture Research Station, Farm, Mahabaleshwar showed deficient in exchangeable magnesium which ranged from 0.42 to 0.46 [cmol (P^{+}) kg^{-1}]. There is minimum variation in both Chandgad and Amba soil series (P_2 and P_3). Similar results were also reported by shinde (2008).

Table 14. Secondary and micronutrient chemical status of soil pedons.

Plot No.	Pedon No.	Horizon	Depth	Secondary nutrients			DTPA micronutrient status Mg kg^{-1}					
				Ca	Mg	S	Fe	Zn	Mn	Cu	Mo	B
			(cm)	[cmol(p+)kg^{-1}		(Mg kg^{-1})						
Satara soil series (Lithic Usrtorthent)												
18	P1	Ap	0-28	0.92	0.62	40.58	9.92	1.56	7.89	1.55	0.25	0.45
18		Cr	28+	Hard rock								
Chandgad soil series (Typic Haplustept)												
5	P2	Ap	0-15	0.87	0.42	32.56	9.61	1.92	9.88	1.37	0.41	0.31
5		B1t	15-45	0.78	0.43	28.45	9.27	1.87	9.04	1.19	0.32	0.36
5		B2	45-70	0.89	0.52	30.65	9.31	1.57	8.77	0.96	0.30	0.38
5		B3	70+	Weathered laterite								
Amba soil series (Udic Rhodustalf)												
1	P3	Ap	0-17	0.75	0.43	34.77	9.78	1.39	9.34	1.25	0.37	0.32
1		B1t	17-42	0.87	0.42	34.16	9.58	0.94	9.30	0.94	0.33	0.37
1		B2t	42-72	0.83	0.48	21.42	9.01	0.89	8.31	0.84	0.27	0.38
1		B3t	72+	0.89	0.58	34.11	8.96	0.54	6.51	0.67	0.25	0.39

4.7.10 Available Sulphur

The soils of Agriculture Research Station, Farm, Mahabaleshwar showed higher and sufficient sulphur content soil which ranged from 21.18 to 40.58 mg kg^{-1}. The maximum variation observed (21.11 to 35.77 mg kg^{-1}) in Amba soil series (P3) and minimum variation (28.45 to 32.56 mg kg^{-1}) in Chandgad soil series. It increase down with pedon in all these soils, which may be due to high rainfall in this region (Singh *et al.* 1999).

4.7.11 Available Iron

The soils of Agriculture Research Station, Farm, Mahabaleshwar showed high and sufficient in iron content in soil, which ranged from 8.96 to 9.92 mg kg^{-1}. The maximum variation was observed (8.96-9.78 mg kg^{-1}) in Amba soil series (P3) amd minimum variation (9.27 to 9.61 mg kg^{-1}) in Chandgad soil series (P2). The higher iron content in all three soil pedon may be due to the high organic matter content and presence of sesque-oxide in soil (Satisha and Badrinath 1994)

4.7.12 Available Zinc

The soils of Agriculture Research Station, Farm, Mahabaleshwar showed sufficient zinc status. The available zinc in soil ranged from 0.54 to 1.92 mg kg^{-1}. The maximum variation was observed (0.54-1.39 mg kg^{-1}) in Amba soil series (P3) and minimum (1.57-1.92 mg kg^{-1}) in Chandgad soil series. Laterite soils of basaltic origin contain high amount of zinc than soils from arid to semi arid soils. Zinc accumulates in the surface layer and regularly decreases down in profile (Chavan *et al.* 1998).

4.7.13 Available Manganese

The soils of Agriculture Research Station, Farm, Mahabaleshwar showed sufficient available manganese content in soil. The available Mn was ranged from 6.51 to 9.88 mg kg^{-1}. The maximum variation observed (6.51 to 9.34 mg kg^{-1}) in Amba soil series (P_3) and minimum (8.77 to 9.88 mg kg^{-1}) in Chandgad soil series (P_2). Laterite soils content high amount of available manganese than black soils. High amount of available Mn may be due to reduction of manganese oxides by soil organic matter and low pH (Chavan *et al.* 1998).

4.7.14 Available Copper

The soils of Agriculture Research Station, Farm, Mahabaleshwar showed sufficient available copper content. The available Cu which ranged from 0.67 to 1.37 mg kg^{-1}. The maximum variation observed (0.67 to 1.25 mg kg^{-1}) in Amba soil series (P_3) and minimum (0.96 to 1.37 mg kg^{-1}) in Chandgad soil series (P_2). The available copper was decrease with increase in depth.

4.7.15 Available Mo

The soils of Agriculture Research Station, Farm, Mahabaleshwar showed sufficient available Mo content. The available Mo was ranged from 0.25 to 0.41 mg kg^{-1}. The maximum variation was recorded (0.25 to 0.37 mg kg^{-1}) in Amba soil series (P_3) and minimum (0.30-0.41 mg kg^{-1}) in Chandgad soil series (P_2). Distribution of Mo in soil profile, it has a tendency to accumulate in surface layer and decrease down the profile (Chavan *et al.* 1994).

4.7.16 Available Boron

The soils of Agriculture Research Station, Farm, Mahabaleshwar showed low and deficient available B content. The available B was ranged from 0.31 to 0.49 mg kg^{-1}. The maximum variation observed (0.32 to 0.49 mg kg^{-1}) in Amba soil series (P_3) and minimum (0.31 to 0.38 mg kg^{-1}) in Chandgad soil series (P_2). Preferably in high rainfall zones, it has a tendency to increase gradually with depth may be due to heavy rainfall and leaching losses of boron (Chavan *et al.* 1994).

4.9 Soil fertility maps

The soil fertility maps of pH, EC, organic carbon, calcium carbonate, major, secondary and micronutrients *viz.,* N, P, K, Ca, Mg, S, B, Mo, Fe, Zn, Mn and Cu respectively were prepared and presented in (plate No. 3 to 14). The category in which nutrients were presented in Agriculture Research Station, Farm, Mahabaleshwar were shown in legend.

Table 15 : Lime requirement to soil based on soil pH

(Shomaker, *et al.*, 1961)

Plot No.	Soil pH	Lime requirement (tons/acre)
19	4.41	10.9
19	5.32	6.5
19	4.32	12.7
19	4.4	10.9
18	5.53	8.9
18	4.93	5.3
16	4.98	3.4
15	5.32	12.7
16	4.58	6.6
14	4.18	13.8
17	5.03	3.4
16	4.63	6.6
13	4.9	5.3
17	4.85	5.3
12	4.61	6.6
13	4.95	4.5
11	4.97	3.8
11	5.18	7.2
10	4.28	12.7
10	4.83	5.0
9	4.58	5.2
9	4.67	8.1
8	4.48	9.0
9	4.58	6.6
9	4.82	5.3
9	5.48	6.0
1	4.66	6.6
2	4.8	5.4

8	4.62	6.4
7	5.38	6.5
3	5.01	3.4
8	5.17	3.2
5	4.62	6.6
4	5.03	3.4
5	4.48	8.9
6 A	4.73	5.3
6 A	5.11	3.3
4 A	4.7	5.4
4 A	4.72	5.3
4 A	4.67	5.5
1	5.01	3.4
1	4.87	5.3
1	4.93	5.3
1	4.8	5.3

Lime requirement of soil based on soil pH:

The lime requirement to respective soil for reclamation based on soil pH are given in table 15. All the soils were extremely to strongly acidic and it need to reclaim with addition of lime with organic manure or FYM before one month of sowing in soil, after reclamation of acid soil the nutrient use efficiency, will be increased and structure improvement will be take place.

5 SUMMERY AND CONCLUSIONS

5.1 chemical properties and available soil nutrients.

1. The soils of ARS farm were found strongly to moderately acidic in reaction with pH ranged from 4.15 to 5.89. EC of the soil samples were normal, which ranged from 0.02 to 0.28 dSm^{-1}. The organic carbon content of soil ranged from 0.82 to 1.35 per cent. The calcium carbonate content in soil samples were found nil.
2. The available nitrogen content in the soils ranged from 157.9 to 324.78 kg ha^{-1}. And 100 per cent soils were categorised under low status.
3. The available phosphorus content in soils ranged from 7.48 to 22.46 kg ha^{-1}. The 61.11 per cent of the soil samples were in low category and 38.89 per cent soil samples in medium category.
4. The available potassium content in soils ranged from 49.28 to 217.28 kg ha^{-1}. The 31.48 per cent samples were in very low category and 68.51 per cent in low category.
5. The exchangeable Ca and Mg content in soils ranged from 0.54 to 0.98 cmol (p+) kg^{-1} and 0.37 to .067 cmol (p+) kg^{-1} respectively. All the soil samples of exchangeable Ca and Mg were found in deficient category.
6. The available sulphur content in soils ranged from 20.69 to 40.58 mg kg^{-1}. However, all the soil samples were found in sufficient category.

7. The available boron content in soils ranged from 0.51 to 0.98 mg kg^{-1}. However 61.11 per cent samples were observed to be deficient and 38.88 per cent samples were in sufficient range.
8. The available molybdenum was ranged from 0.15 to 0.42 mg kg^{-1}. All the soil samples were in sufficient ranged.
9. The available iron content in soils ranged from 7.88 to 10.48 mg kg^{-1}. However all the soil samples were in sufficient category.
10. The available manganese content in soils ranged from 6.15 to 10.29 mg kg^{-1}. All the soil samples were found in sufficient category.
11. The available zinc content in soils ranged from 0.52 to 7.74 mg kg^{-1}. However, all the soil samples in sufficient category.
12. The available copper content in soils ranged from 0.55 to 1.69 mg kg^{-1}. All the soil samples were sufficient copper.
13. All the soils were extremely to strongly acidic and it need to reclaim with addition of lime @ 3 to 13 ton/acre with organic manure or FYM before one month of sowing in soil.

5.2 Physical properties of surface soil samples

Soil texture is categorised under clay loam category. The sand, silt and clay ranged from 30.89 to 43.47, 17.70 to 32.14 and 30.88 to 41.56 per cent respectively. Bulk density is normal which ranged from 1.13 to 1.42 Mg m^{-3} with an average of 1.26 Mg m^{-3}.

5.3 Correlation properties

The pH was positively and non-significantly correlated with available N, P, S, Fe and exchangeable Mg. Negatively correlate with available K, B, Mo, Zn, Cu, Mn, and exchangeable calcium. EC was negative and significantly correlate with exchangeable Mg. positive correlate with available Mn and sulphur. Negatively and non-significantly correlate with available N, K, Cu, B and molybdenum. Whereas, positively and non-significantly correlate with available P, Fe, Zn, and Mn.

5.4 Parkar soil fertility index

Parkar soil fertility index showed that the available nitrogen, phosphorus and potassium were categorised as medium in category.

5.5 Morphological properties of soil pedon

All the soil developed on the lateritic parent material and belonged to yellowish red (5 YR 4/6) in (P_1), reddish yellow (7.5 YR 6/6) in (P_2) and reddish yellow (5 YR 4/4) to dark reddish brown (2.5 YR 3/4) in (P_3) soil group. The soil structure ranged from fine weak, medium, subangular blocky throughout the depth in all soil pedons. The dry, slight hard and moist, slightly sticky and slightly plastic consistency of soil series were recorded.

5.6 Physical properties of soil pedons.

All the soil pedons showed minimum variation of sand, silt and clay content. The soils of all three pedons studied were categorised under clay loam texture studied horizons. The bulk density was low in all three soil pedon which were ranged from 1.14 to 1.38 Mg m^{-3}.

5.7 Chemical properties of soil pedons

The data on chemical properties of soil pedons revealed that soils were categorised under extremely acidic to strongly acidic in reaction. The EC value of soil increased with increase in depth of profile. The EC of soils ranged from 0.04 to 0.14 dSm^{-1}. The organic carbon content in all soil series were found to be decreased with increase in depth. The value of organic carbon varied from 0.91 to 1.18 per cent. $CaCO_3$ were found nil in all three soil pedons under study.

The available N, P and K varied from 224.15 to 256.12, 7.48 to 16.03 and 98.32 to 154.25 kg ha^{-1} respectively. The available N, P and K were found low in soils of all three pedons. The available N, P and K showed higher nutrient status in upper layer while, decreased with increase in depth. The available sulphur ranged from 21.18 to 40.58 mg kg^{-1} which were sufficient in status. It showed increasing trend of nutrient status with increasing depth. Boron and Molybdenum ranged from 0.31 to 0.49 mg kg^{-1} and 0.25 to 0.37 mg kg^{-1} respectively. The B content in soils were deficient while, Mo content in soils were sufficient.

The Fe, Zn, Mn and Cu showed sufficient range in all three soil pedons which ranged from 8.96 to 9.92, 0.54 to 1.92, 6.51 to 9.58 and 0.97 to1.37 mg kg^{-1} respectively. These all four micronutrients accumulate in surface soil layer respectively which was decreased with increase in depth of soil pedon.

5.8 Conclusion

It can be concluded that the soils of Agriculture Research Station, Farm, Mahabaleshwar were taxonomically classified as Lithic Ustorthent (Satara soil series), Typic Haplustept (Changed soil series) and Udic Rhodustalf (Amba soil series). All the soils were extremely to strongly acidic in reaction which needs lime application @ 3 to 13 tonn/acre is recommended based on soil pH for improvement of structure and increasing the nutrient use efficiency. The EC was normal and very low which need to apply secondary nutrients source of calcium and magnesium which were deficient in soil. The soil fertility index categorised as medium in available nitrogen, phosphorus and potassium.

All the soils were sufficient in iron, manganese and copper where 39 per cent soils were deficient in available zinc and 100 per cent soils were deficient in available boron which indicat application of Zn and boron through $ZnSO_4$ (30 kg ha^{-1}) and Borax (5 kg ha^{-1}) respectively to the different field crops are necessary for the balance use of nutrients.

5.9 Future implication

Holistic survey and precise use of analytical techniques in this investigation have enabled to come out with soil fertility maps of Agriculture Research Station, Farm, Mahabaleshwar. The use of GPS-GIS based technique for soil sampling in new landmark, which enable the further researcher and university officials to monitor the changes in soil fertility status for year after year. Also used for monitoring fertilizer scheduled on sound scientific footing for improvement the crop yields of the seed production programme of the University. Moreover the timely monitoring the soil health deterioration can also be maintain by following appropriate soil reclamation techniques.

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7. VITA

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A candidate for the degree

Of

MASTER OF SCIENCE (AGRICULTURE)

in

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Chemical properties of surface soil samples of Agriculture Research Station, Farm, Mahabaleshwar

Sample no.	Plot no.	pH (1:2.5)	EC (dSm^{-1})	OC (%)	Av. N ($kg\ ha^{-1}$)	Av. P ($kg\ ha^{-1}$)	Av. K ($kg\ ha^{-1}$)	Ca	Mg	Fe	Zn	Cu	Mn	S	B	Mo
								[cmol (p^+)]		($mg\ kg^{-1}$)						
1	19	4.41	0.04	0.93	187.25	13.58	141.12	0.842	0.583	9.554	1.24	1.141	7.926	23.27	0.33	178
2	19	5.32	0.04	1.03	225.44	9.72	114.24	0.895	0.408	8.965	0.527	0.841	6.152	24.45	0.457	0.206
3	19	4.32	0.06	0.94	212.89	14.69	168	0.874	0.587	8.313	1.099	0.721	8.372	21.73	0.49	0.154
4	19	4.4	0.13	1.00	237.4	15.8	138.88	0.947	0.564	9.846	1.448	0.913	9.026	22.11	0.313	0.316
5	18	5.53	0.09	0.93	200.15	11.92	188.16	0.983	0.532	9.775	1.996	1.38	8.765	34.04	0.457	0.286
6	18	4.93	0.04	0.94	225.14	14.14	100.8	0.842	0.542	9.884	1.825	0.919	8.41	30.65	0.302	0.426
7	16	4.98	0.18	1.12	185.26	19.88	156.8	0.872	0.556	9.768	1.871	1.652	8.197	25.39	0.457	0.196
8	15	5.32	0.08	1.17	187.8	18.02	116.48	0.978	0.521	8.989	1.241	0.718	7.316	24.04	0.412	0.242
9	16	4.58	0.21	1.08	225.44	9.15	129.92	0.843	0.589	9.774	1.527	1.023	8.777	35.96	0.281	0.21
10	14	4.18	0.07	1.04	188.98	13.58	114.24	0.856	0.478	9.233	1.137	1.168	8.813	24.81	0.447	0.176
11	17	5.03	0.14	0.96	200.36	8.04	91.84	0.978	0.673	7.881	1.008	0.973	9.132	33.56	0.491	0.298
12	16	4.63	0.08	0.93	192.54	13.86	118.72	0.753	0.421	9.316	1.062	1.694	8.554	27.45	0.491	0.272
13	13	4.9	0.08	1.06	189.91	10.53	179.2	0.867	0.547	9.325	0.856	0.851	7.124	32.46	0.313	0.258
14	17	4.85	0.04	1.03	231.25	10.53	161.28	0.602	0.378	9.983	1.083	1.239	7.87	22.85	0.358	0.246
15	12	4.61	0.07	1.15	225.4	8.59	145.6	0.632	0.422	7.898	1.026	0.986	7.102	25.96	0.446	0.194
16	13	4.95	0.06	1.01	195.25	12.2	217.28	0.813	0.503	9.768	1.239	0.891	9.233	35.24	0.323	0.266
17	11	4.97	0.18	1.00	237.56	14.14	118.72	0.972	0.663	9.485	1.398	1.638	7.882	20.69	0.425	0.224
18	11	5.18	0.15	1.14	175.61	13.58	87.36	0.942	0.524	9.697	1.258	0.71	8.965	26.96	0.397	0.234
19	10	4.28	0.28	1.02	227.19	9.98	127.68	0.542	0.437	9.848	1.901	0.88	10.29	29.56	0.388	0.176
20	10	4.83	0.11	0.94	247.34	11.36	89.6	0.936	0.644	9.391	1.068	0.863	9.115	30.26	0.413	0.187
21	9	4.58	0.17	1.02	254.24	7.48	132.16	0.847	0.453	8.332	1.038	0.553	6.889	25.77	0.435	0.219
22	9	4.67	0.15	1.05	205.23	11.09	152.32	0.753	0.521	9.869	1.618	1.091	8.006	28.8	0.413	0.407
23	8	4.48	0.05	1.00	236.76	10.81	156.8	0.863	0.543	9.266	1.958	0.93	8.393	31.73	0.48	0.334
24	9	4.58	0.1	0.84	215.48	15.25	145.66	0.945	0.652	9.285	1.237	0.812	9.363	33.65	0.38	0.309
25	9	4.82	0.19	1.03	287.57	22.46	136.64	0.783	0.501	8.789	1.983	0.898	8.115	40.12	0.446	0.276
26	9	5.48	0.21	1.00	324.78	21.96	150.08	0.882	0.489	10.07	1.089	0.978	8.759	35.39	0.383	0.285
27	1	4.66	0.16	1.14	208.95	16.36	147.84	0.942	0.546	9.867	1.113	0.899	8.726	28.62	0.458	0.251
28	2	4.8	0.04	1.05	250.52	14.69	91.84	0.856	4.9	9.7	1.473	1.36	9.338	22.5	0.402	0.272
29	8	4.62	0.21	1.05	200.36	18.3	71.68	0.82	0.387	9.814	1.48	1.149	9.177	32.45	0.424	0.166
30	7	5.38	0.09	1.15	245.46	13.03	51.52	0.892	0.532	10.4	1.762	0.67	7.011	28.45	0.426	0.191
31	3	5.01	0.09	0.93	187.48	11.92	94.68	0.753	0.467	9.801	1.589	0.775	9.957	33.46	0.469	0.225

32	8	5.17	0.06	1.03	233.45	15.8	168	0.864	0.578	8.891	1.357	0.833	7.29	34.2	0.39	0.254
33	5	4.62	0.09	1.02	245.15	20.24	94.08	0.834	0.524	10.21	1.432	1.231	7.173	37.54	0.347	0.315
34	4	5.03	0.06	1.14	250.24	15.52	112.00	0.783	0.523	8.233	1.137	1.091	7.808	32.11	0.402	0.338
35	5	4.48	0.02	0.82	237.98	16.08	49.28	0.765	0.456	10.29	1.985	1.525	8.739	24.51	0.387	0.283
36	6 A	4.73	0.03	1.17	201.56	14.69	76.2	0.876	0.456	9.843	0.939	0.93	8.002	27.26	0.403	0.312
37	6 A	5.11	0.06	1.15	256.54	9.98	98.56	0.967	0.567	9.883	1.23	1.648	9.146	25.69	0.433	0.326
38	4 A	4.7	0.07	0.87	240.53	10.53	118.72	0.768	0.574	9.763	1.782	1.558	8.862	32.14	0.491	0.203
39	4 A	4.72	0.08	1.08	268.54	16.91	123.2	0.932	0.543	9.821	1.546	0.831	7.29	37.5	0.49	0.247
40	4 A	4.67	0.09	1.06	259.63	13.86	161.28	0.934	0.564	8.401	1.564	1.088	8.941	33.48	0.458	0.368
41	1	5.01	0.04	1.17	243.57	14.41	123.2	0.845	0.512	8.967	1.239	1.237	8.115	31.98	0.357	0.314
42	1	4.87	0.14	1.2	202.21	13.58	161.28	0.842	0.435	9.203	1.011	0.851	8.759	23.85	0.369	0.378
43	1	4.93	0.28	1.14	234.12	8.04	78.4	0.834	0.523	8.585	0.521	0.739	8.828	34.51	0.402	0.321
44	1	4.8	0.11	1.06	207.56	10.26	98.56	0.912	0.576	8.494	0.587	1.398	9.24	37.59	0.392	0.255

Chemical properties of soil pedon of agriculture research station, farm, Mahabaleshwar

Sample No.	Plot No.	pH (1:2.5)	EC (dSm^{-1}) (1:2.5)	OC (%)	Av. N (kg ha^{-1})	Av. P (kg ha^{-1})	Av. K (kg ha^{-1})	Ca	Mg	Fe	Zn	Cu	Mn	S	B	Mo
								[cmol(P^+)]		(mg kg^{-1})						
							Profile 1									
1	18	4.61	0.04	1.02	189.46	8.04	105.28	0.929	0.623	9.921	1.561	1.554	7.89	40.58	0.456	0.257
							Profile 2									
2	5	4.40	0.14	1.18	226.89	7.48	118.72	0.879	0.437	9.61	1.92	1.376	9.049	28.45	0.38	0.418
3	5	5.23	0.11	0.91	224.15	16.08	98.56	0.783	0.425	9.272	1.873	1.192	9.881	32.56	0.369	0.322
4	5	5.89	0.13	1.03	225.46	13.31	98.32	0.898	0.524	9.31	1.575	0.963	8.772	30.65	0.346	0.306
							Profile 3									
5	1	5.6	0.08	1.03	256.12	8.31	112.23	0.876	0.435	9.781	1.397	0.678	8.317	35.77	0.49	0.376
6	1	5.03	0.07	0.98	245.47	12.47	154.25	0.894	0.425	9.584	7.747	1.256	9.309	34.16	0.387	0.278
7	1	4.84	0.08	0.91	237.68	11.92	122.24	0.832	0.588	9.017	0.894	0.941	9.347	34.42	0.375	0.254
8	1	5	0.07	0.88	238.4	13.03	145.6	0.753	0.486	8.965	0.544	0.841	6.512	21.11	0.324	0.338

Physical properties of surface soil samples of agriculture research station, farm, Mahabaleshwar

Sample No.	**Plot No.**	**Bulk Density (Mg m^{-3})**	**Sand (%)**	**Clay (%)**	**Silt (%)**	**Textural class**
1	19	1.30	43.47	30.88	25.65	Clay Loam
2	19	1.13	36.6	38.23	25.17	Clay Loam
3	19	1.12	40	32.5	27.5	Clay Loam
4	19	1.30	32.72	36.27	31.01	Clay Loam
5	18	1.26	35	41.56	23.44	Clay Loam
6	18	1.42	31.35	39.7	28.95	Clayey
7	16	1.24	32.1	45.56	22.43	Clay
8	15	1.40	33.71	43.23	23.06	Clay
9	16	1.27	36.71	38.23	24.05	Clay Loam
10	14	1.20	35.19	39.51	25.3	Clay Loam
11	17	1.26	39.01	32.28	28.71	Clay Loam
12	16	1.35	32.03	39.80	28.17	Clay Loam
13	13	1.26	41.08	45.39	23.56	Clay Loam
14	17	1.30	33.58	38.38	28.05	Clay Loam
15	12	1.32	35.02	38.43	22.58	Clay Loam
16	13	1.37	31.09	39.09	29.82	Clay Loam

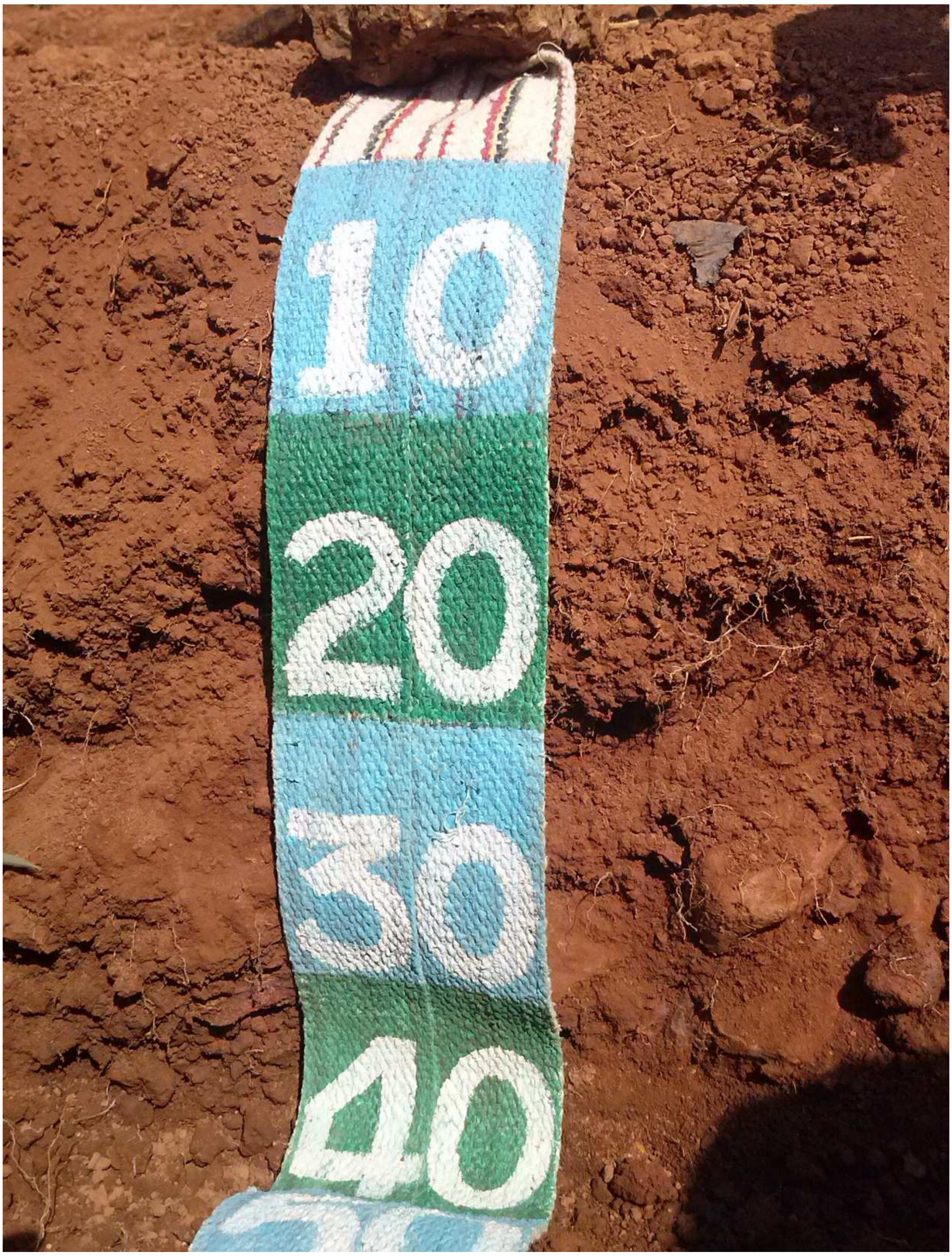
17	11	1.29	30.89	43.81	25.32	Clayey
18	11	1.30	33.41	41.92	24.67	Clayey
19	10	1.32	39.2	35.09	23.71	Clay Loam
20	10	1.09	29.03	38.83	32.14	Clay Loam
21	9	1.32	33.49	39.49	27.03	Clay Loam
22	9	1.22	33.81	38.38	37.84	Clay Loam
23	8	1.16	38	44.30	17.70	Clayey
24	9	1.29	37.06	34.76	28.18	Clay Loam
25	9	1.14	32.85	47.0	20.15	Clayey
26	9	1.28	38.83	38.29	22.88	Clay Loam
27	1	1.16	32.85	39.35	27.80	Clay Loam
28	2	1.27	34.83	43.29	23.88	Clayey
29	8	1.34	38.28	37.68	26.04	Clay Loam
30	7	1.35	43.55	35.35	21.1	Clay Loam
31	3	1.18	32.83	41.10	26.07	Clayey
32	8	1.30	40.60	36.60	22.80	Clay Loam
33	5	1.33	35.08	39.81	25.11	Clay Loam
34	4	1.21	35.80	40.03	24.17	Clay Loam
35	5	1.19	31.79	36.62	31.59	Clay Loam

36	6 A	1.27	39.77	35.02	25.21	Clay Loam
37	6 A	1.25	32.98	43.34	23.88	Clayey
38	4 A	1.33	35.9	43.87	20.23	Clayey
39	4 A	1.24	40.39	36.7	22.91	Clay Loam
40	4 A	1.24	41.43	37.33	27.34	Clay Loam
41	1	1.34	43.21	35.70	22.09	Clay Loam
42	1	1.25	37.42	33.97	28.49	Clay Loam
43	1	1.19	32.83	39.61	27.61	Clay Loam
44	1	1.19	33.04	41.95	25.04	Clayey

Physical properties of soil pedons of Agriculture Research Station, Farm, Mahabaleshwar

Sample No.	**Plot No.**	**Bulk Density (Mg m^{-3})**	**Sand (%)**	**Clay (%)**	**Silt (%)**	**Textural class**
Profile 1						
1	18	1.14	40.59	38.17	21.17	Clay Loam
Profile 2						
2	5	1.22	31.91	38.04	30.09	Clay Loam
3	5	1.38	40.01	37.19	22.81	Clay Loam
4	5	1.26	41.91	36.23	22.87	Clay Loam
Profile 3						
5	1	1.16	42.08	32.83	25.09	Clay Loam
6	1	1.16	39.91	32.37	27.74	Clay Loam
7	1	1.19	43.91	34.55	22.25	Clay Loam
8	1	1.24	35.88	37.09	27.03	Clay Loam

Pedon 1 Satara soil series (Lithic Ustorthent)



Pedon 2 Chandgad soil series (Typic Haplustept)

Pedon 3 Amba soil series (Udic Rhodustalf)