"GPS-GIS BASED SOIL FERTILITY MAPS OF AJRA TEHSIL OF KOLHAPUR DISTRICT (M.S.)"

By

Miss. Apurva Madhusudan Bhagwat

(Reg.No.-K-014/107)

A thesis submitted to the

Mahatma Phule Krishi Vidyapeeth,

Rahuri- 413 722 Dist. Ahmednagar,

Maharashtra (India)

In partial fulfillment of the requirements for the Degree

of

MASTER OF SCIENCE (Agriculture)

in

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

DIVISION OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY,

COLLEGE OF AGRICULTURE, KOLHAPUR - 416 004

MAHARASHTRA (INDIA)

2017

"GPS-GIS BASED SOIL FERTILITY MAPS OF AJRA TEHSIL OF KOLHAPUR DISTRICT (M.S.)"

By

Miss. Apurva Madhusudan Bhagwat

(Reg.No.-K-014/107)

A thesis submitted to the

Mahatma Phule Krishi Vidyapeeth,
Rahuri- 413 722 Dist. Ahmednagar,
Maharashtra (India)

In partial fulfillment of the requirements for the Degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Approved by

Dr. R. B. Pawar
(Chairman and Research Guide)

Dr. D. S. Patil	**Dr. B. S. Kadam**	**Prof.M.R.Shewale**
(Committee member)	**(**Committee member)	**(**Committee member)

DIVISION OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY
COLLEGE OF AGRICULTURE,
KOLHAPUR - 416 004
MAHARASHTRA (INDIA)
2017

CANDIDATE'S DECLARATION

I hereby declare that this thesis or a part

there of has not been submitted

by me or any other person

to any other University or

Institute for award

of a Degree or

Diploma

Place: A.C. Kolhapur

Date: / / 2017 **(Miss. BHAGWAT A.M.)**

Dr. R. B. Pawar
Assistant Professor,
Soil Science and Agril. Chemistry,
College of Agriculture, Kolhapur – 416 004,
Maharashtra State (India).

CERTIFICATE

This is to certify that the thesis entitled, **"GPS-GIS BASED SOIL FERTILITY MAPS OF AJRA TEHSIL OF KOLHAPUR DISTRICT (M.S.)",** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra State) in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (Agriculture)** in **SOIL SCIENCE AND AGRICULTURAL CHEMISTRY**, embodies the result of a piece of *bonafide* research work carried out by **MISS. BHAGWAT A.M.** under my guidance and supervision and that no part of the thesis has been submitted for any other Degree or Diploma in other form.

The assistance and help received during the course of this investigation and sources of reference have been duly acknowledged.

Place: A.C.Kolhapur
Date: / /2017.

(Dr.R.B.PAWAR)
(Research Guide)

Dr. G. G. Khot,
Associate Dean,
College of Agriculture,
Kolhapur – 416 004.
Maharashtra State (India)

CERTIFICATE

This is to certify that the thesis entitled, **"GPS-GIS BASED SOIL FERTILITY MAPS OF AJRA TEHSIL OF KOLHAPUR DISTRICT (M.S.)",** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra State) in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **SOIL SCIENCE AND AGRICULTURAL CHEMISTRY** embodies the results of a piece of *bonafide* research work carried out by **Miss. BHAGWAT A.M.** under the guidance and supervision of **Dr.R.B.PAWAR,** Assistant Professor, Soil Science and Agril. Chemistry, College of Agriculture, Kolhapur and that no part of this thesis has been submitted for any other degree or diploma in other form.

Place: A.C.Kolhapur
Date: / /2017.

(Dr.G.G. Khot)
Associate Dean

ACKNOWLEDGEMENT

I avail this opportunity to acknowledge my sincere, humble indebtedness and deepest sense of gratitude to my honorable guide Dr. R. B. Pawar, Assistant Professor of Soil Science and Agril. Chemistry, College of Agriculture, Kolhapur, whose insight, unfailing interest, constructive critism, inspiring guidance, infinite patience were as asset throughout the course of investigation, providing necessary facilities and valuable help in conducting the studies. The words are inadequate to thank him for the painstaking efforts; he has taken during the research work in the preparation of manuscript and final shaping of the thesis in present form.

I sincerely thanks to Dr. G. G. Khot, Associate Dean, College of Agriculture, Kolhapur for providing necessary facilities for successful completion of research work.

I enroll my esteem and inestimable gratitude with great respect Dr. D. S. Patil professor of SSAC A.C. Kolhapur and member of advisory committee, for the valuable guideline and suggestion during all phases of present investigation, I also thank to Dr. B.S.Kadam Assistant professor of SSAC and members of my advisory committee Prof. M. R. Shewale, Assistant professor of statistics and mathematics, College of Agriculture, Kolhapur for their valuable guideline suggestions during the course of present investigation.

I wish to place on record my heartful thanks to Dr. R. V. Kulkarni, Prof. S. M. Jagtap, and Dr. P. C. Bhosale madam for their valuable support, help and co-operation throughout the course of study.

I owe my heartful gratitude to Shri. Mukund M. Patil, Shri. Randive sir, Sankpal kaka, Nikam Kaka and Devappa Kaka for their timely help and co-operation.

I would like to express my sincere appreciation to my colleagues Usha, Swati, Mukesh, Kiran Taral, and Kiran Gosavi for their help during course of time. My heart is filled with sweet memories of my sweet friends Komal, Harshada, Ashwini and all my friends. I also thank to my juniors Sayali, Shital, Madhuri, Bornali, Hemanth and all other junior friends for their kind co-operation and support.

Everlasting words seem to be inadequate to express my indebtedness to my parents Mr. Madhusudan Sau. Minakshi and my brother Mr. Kaustubh and my sisterinlaw Shilpa and my lovely nephew Kshitijeet special thanks to my sweet Husband Vivek for their exemplary enthusiasm, supreme sacrifice, immense care, moral courage, constant motivation and support through ramifying paths of thick and thin, throughout my career.

Place : Kolhapur

Date : / /2017 *(Miss. Bhagwat A.M.)*

CONTENTS

		Page
CANDIDATE'S DECLARATION		**iii**
CERTIFICATES		
1. Research Guide		**iv**
2. Associate Dean (ACK)		**v**
ACKNOWLEDGEMENTS		**vi**
LIST OF TABLES		**xi**
LIST OF PLATES		**xii**
LIST OF ABBREVATIONS		**xiii**
ABSTRACT		**xv**
1.	**INTRODUCTION**	**1**
2.	**REVIEW OF LITERATURE**	**5-29**
2.1	The introduction of GPS and GIS	5
2.2	Chemical properties of soil	7
2.3	Soil mapping	21
2.4	Correlation between soil properties	26
2.5	Fertility index	28
3.	**MATERIAL AND METHOD**	**30-37**
3.1	Material	30
3.1.1	Location	30
3.1.2	Climate	30
3.1.3	Hydrology	30
3.1.4	Present land use and natural vegetation	30
3.1.5	Soils	31
3.2	Methodology	31

3.2.1	Experimental details	31
3.2.2	Collection and processing of soil samples	32
3.2.3	Observations recorded	33
3.2.4	Methods	34
3.2.5	Statistical Analysis	35
3.2.6	Arc GIS software	35
4.	**RESULT AND DISSCUSSION**	**38-50**
4.1	**Nutrient status in soils of Ajra tehsil**	38
4.1.1	Soil reaction (pH)	38
4.1.2	Electrical conductivity (EC)	39
4.1.3	Organic Carbon	40
4.1.4	Calcium Carbonate	40
4.1.5	Available Nitrogen	41
4.1.6	Available Phosphorus	42
4.1.7	Available Potassium	42
4.1.8	Exchangeable Calcium	43
4.1.9	Exchangeable Magnesium	43
4.1.10	Exchangeable Sodium	44
4.1.11	Available Sulphur	44
4.1.12	DTPA extractable Iron	45
4.1.13	DTPA extractable Manganese	46
4.1.14	DTPA extractable zinc	47
4.1.15	DTPA extractable Copper	47

4.2	**Correlation of available nutrient with soil properties of Ajra tehsil**	48
4.3	**Fertility indices**	50
5.	**SUMMARY AND CONCLUSIONS**	**51-53**
6.	**LITERATURE CITED**	**54-69**
7.	**APPENDIX-I**	**70-82**
8.	**VITA**	**83**

LIST OF TABLES

Table	Title	Page
1.	Standard analytical methods used for Chemical analysis of soil.	34
2.	Rating of pH, EC and $CaCO_3$ of soil	36
3.	Six tier ratings of organic carbon, available nitrogen, phosphorus and potassium of soil.	36
4.	Six tier rating of available sulphur (mg Kg^{-1}) of soil.	37
5.	Critical limits of DTPA extractable micronutrients (mg Kg^{-1}) of soil.	37
6.	pH, EC, Organic carbon and $CaCO_3$ of soils of Ajra tehsil.	39
7.	Status of available nitrogen, phosphorus and potassium of soils of Ajra tehsil.	41
8.	Status of exchangeable calcium, Magnesium and sodium in soils of Ajra tehsil.	43
9.	Status of available sulphur in soils of Ajra tehsil.	45
10.	Status of DTPA extractable micronutrients of soils of Ajra tehsil	46
11.	Correlation coefficient between chemical Properties and available nutrient status in soils of Ajra tehsil.	49
12.	Chemical properties and available nutrient status of soils of Ajra tehsil	70

LIST OF ABBREVIATIONS

%	-	Per cent
^{o}C	-	Degree Celsius
Ca	-	Calcium
$CaCO_3$	-	Calcium carbonate
cm	-	Centimeters
cmol (P^+) Kg^{-1}	-	Centimol per kilogram
Cu	-	Copper
DTPA	-	Diethylene triamine penta acetic acid
dS m^{-1}	-	Deci Siemens per metre
EC	-	Electrical conductivity
et al	-	And other (*et alli*)
Fig.	-	Figure
Fe	-	Iron
g Kg^{-1}	-	Gram per kilogram
ha	-	Hectare
i.e.	-	Id est, that is
K	-	Potassium
Kg	-	Kilogram
Kg ha^{-1}	-	Kilogram per hectare
m	-	Meter
Mn	-	Manganese
Mg	-	Magnesium
mm	-	Millimeter
mg Kg^{-1}	-	Milligram per kilogram
N	-	Nitrogen

Na	- Sodium
OC	- Organic carbon
P	- Phosphorus
pH	- Puissance de hydrogen
ppm	- parts per million
S	- Sulphur
viz.,	- Vide licet, namely
Zn	- Zinc

ABSTRACT

"GPS-GIS BASED SOIL FERTILITY MAPS OF AJRA TEHSIL OF KOLHAPUR DISTRICT (M.S)"

By

Miss. APURVA M BHAGWAT

A candidate for the degree of

MASTER OF SCIENCE (AGRICULTURE)

Research Guide: Dr. R. B. PAWAR

Department : Soil Science and Agricultural chemistry

The study was carried out to know the fertility status of soils of Ajra tehsil, Kolhapur district by using GPS-GIS technology and to correlate soil properties with the available nutrients and to evaluate the fertility index of Ajra tehsil.

The pH of soils of Ajra tehsil varied from 4.71 to 7.52, most of the soils are moderately acidic (51.72%) while EC of the soils varied from 0.06 to 0.60 dS m^{-1}, and the values were normal. The calcium carbonate content of soils of Ajra tehsil varied from 0.26 to 2.8 per cent. Organic carbon content varied from 0.30 to 2.35 per cent and categorized as very high (17.24%), high (36.55%), moderately high (21.38%), moderate (18.62%) and low (6.21%). The available nitrogen, phosphorus and potassium in soils of Ajra tehsil ranged from 175 to 401.4, 7.34 to 34.8 and 78.87 to 236.80 Kg ha^{-1}, respectively. The soils of Ajra tehsil were moderate (64.14%) in available -

nitrogen, high (8.96%) to medium (44.14%) in available phosphorus and low (55.86%) in available potassium. The exchangeable calcium and magnesium ranged from 7.0 to 61.0 and 0.5 to 32.0 cmol (p^+) Kg^{-1}, respectively. The exchangeable sodium ranged from 0.26 to 1.17 cmol (p^+) Kg^{-1}.

The available sulphur varied from 0.78 to 28.75 mg Kg^{-1} respectively, and 68.96 per cent soil samples were in very low category.

The DTPA extractable zinc, iron, manganese and copper were sufficient however iron was deficient in two samples from village Bhairewadi.

The pH was significantly and positively correlated with DTPA extractable Cu. The EC was significantly and positively correlated with DTPA extractable Zn. The organic carbon was significantly and positively correlated with nitrogen, potassium, DTPA extractable Zn and Mn. Calcium carbonate eq. was significantly correlated with DTPA extractable Cu.

The fertility indices of soils of Ajra tehsil for organic carbon, available nitrogen, phosphorus and potassium were medium (1.7), low (1.3), medium (1.54) and low (1.1), respectively.

1. INTRODUCTION

Soil is dynamic natural body on earth crust and differs from the material from which it is derived in many physical, chemical, biological and morphological properties and other characteristics, which supports the plants growth by providing water, nutrient and mechanical support. The life supporting system of a country and socioeconomics development of its people depends on the soils. A renewed attention is being given to soil due to rapidly declining land area for agriculture and declined in soil fertility. If we cannot improve the health and productive capacity of our cultivable soil, we cannot supply the food, fiber and increasing demands of our growing population. Systematic study of morphology and taxonomy of soils provides information on nature and type of soil, their constrains, potential, capabilities and their suitability for various uses (Sehgal, 1996).

Soils of Maharashtra State have been broadly classified as 1) The laterites and lateritic soils 2) The costal saline and costal alluvium soils 3) Shallow medium and deep black soil 4) Gray and red soils of mixed parent material and 5) Saline, Saline-alkali and non-saline–alkali soils (Raychudhari and Chakravarty ,1943). 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 best fact about our soils and their management to achieve sustainable production. Soils of Maharashtra state are categorized as poor in fertility and vary

widely in genetic, morphological, physical, chemical and biological characteristics (Challa et al., 1995). The nutrient 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 under intensive productivity regimes (Kanwar, 2004).The nutrient deficiencies situation was further intensified by the discontinuous and diversified use of organic manures and chemical fertilizers.

The deficiencies of nutrients are now a day's manifested and reported, but it is more area, soil, crop and situation specific. Arnon and Stout (1939) enunciated the deficiency of any nutrient whether macro or micro can be eliminated only by application and provision of that nutrient and not by substitution of other in adequate amount. It holds true even today. It is also relevant to quote Liebig's law which state that the plant growth and development and ultimate economic yield is limited by the nutrient present in least available amount. Thus, the deficient one is decisive in their use to correct that deficiency. There are several reports, indicated that N, P and K nutrients are not giving as much response as before, due to the situation that have been explained to macronutrient deficiency (Kanwar, 2004).Intensification of agriculture aimed at obtaining the highest yields per unit time per unit area. There is increasing concern of yield stagnation owing to the state of fatigue to the soils which have depleted their nutrients status. The emergence of multi-nutrient deficiencies in the crop efficient zones of many soils is the consequences of intensive cropping.

Ray and Dadhwal (2001) used satellite based RS data and GIS tools for estimating seasonal crop evapotranspiration in Mahi Right Bank Canal (MRBC) command area of Gujarat, India.

The recent technologies like GPS and GIS thus have much to offer for preparing soil fertility maps. Global positioning system (GPS) is a space based navigation and positioning system administered by U.S military, which helps to determine the exact position of an object on the earth surface in terms of geographical co-ordinates (French, 1996). Geographic information system (GIS) is a computer system for capturing, storing , querying and displaying geographical data (Chang,2002).Once the soil fertility maps are created, it is possible to transform the information about the fertility status of the area, such maps provide site specific recommendation, validation for soil fertility over the following years.

GPS-GIS are advanced tool for studying on site specific nutrient management which can be efficiently used for monitoring soil fertility status in Ajra tehsil of Kolhapur district (M.S.) and useful for ensuring balanced fertilization to crops. This tool is useful for systematic study of nutrients including assessment of major, secondary and micronutrient status of soil with delineation of areas of nutrient deficiency or sufficiency.

The Department of Soil Science and Agril. Chemistry, MPKV, Rahuri has planned to prepare a GPS-GIS based tehsil wise soil fertility maps through post graduate students, which

will be useful for management of natural resource as well as strategic research planning and monitoring the soil health.

The information on soil fertility status of Ajra tehsil based on GPS-GIS studies is very limited. Therefore, the present investigation was planned with the objectives mentioned below.

i. To assess the soil macro and micro nutrients status of Ajra tehsil of Kolhapur district and delineate the fertility map.
ii. To correlate soil properties with the available nutrients.
iii. To evaluate fertility index of soils of Ajra tehsil.

2. REVIEW OF LITERATURE

The present investigation was carried out to study the fertility status of soils of Ajra tehsil of Kolhapur (M.S.) with the use of GPS-GIS technology and to correlate soil properties with available nutrients and to prepare the fertility maps for the benefit of farmers and planners.

The relevant work carried out by various researchers on the topic is reviewed under the following headings.

2.1. The basics of GPS and GIS.
2.2. Chemical properties of soil.
2.3. Mapping of soil.
2.4. Correlation analysis.
2.5. Fertility index

2.1. The basics of GPS and GIS.

The Relevant literature on the basics of GPS and GIS are collated hereunder.

2.1.1 Global Positioning System (GPS)

Global Positioning System (GPS) is space based navigation and positioning system administered by U.S military which helps to determine the exact position of an object on the earth surface in terms of geographical co-ordinates (French, 1996).

GPS is used extensively for GIS data collection (Pradeep, 2006). Apel *et al.* (2011) identified GPS based techniques are

best for monitoring of river stages which is one of the basic observations required for understanding catchment hydrology and hydraulic systems. GPS technology was utilized for practicing site-specific irrigation that reduced the water loss significantly (Charles *et al.*, 2011).

Palaniswami *et al.* (2011) identified the necessity for a change in farming system of sugarcane to incorporate controlled traffic, wider row spacing and permanent cropping beds with the aid of GPS guidance.

Kaleeswari *et al.* (2012) reported the soil mapping carried by GPS technique by 1:50,000 scale and recorded overall soil fertility status of soil of virudhunagaer district of Tamilnadu, also reported that the thematic map prepared by GIS and GPS technique of Theni District of Andhra Pradesh clearly indicated the available NPK and micronutrient status of soils.

2.1.2. Geographic Information System (GIS)

GIS is a computerized spatial information system for supplying data or information for planning and policy making. According to the type and use of GIS, several definitions of GIS has been coined. GIS is a system of hardware, software, and procedures designed to support the capture, management, manipulation, analysis, modeling and displaying of spatially referenced data for solving complex planning and management problems (Bernhardsen, 1999).

Clarke (2001) described GIS as an automated system for capture, storage, analysis and display of spatial data. Chang (2002) defined GIS as a computer system for capturing, storing, querying and displaying geographic data. Geographic information system is a computer system that can hold and use data describing places on earth's surface (Das, 2004). GIS can be defined as an organized collection of computer hardware and software designed to efficiently capture, store, update, manipulate, analyze and display all forms of geographically referenced information (ISSS, 2007).

GIS is a computerized data base management system for capturing, storing, validating, analyzing, displaying and managing spatially-referenced data sources (Seghal, 2008).

Koshal (2013) had reported that remote sensing and GIS technique can be extremely useful in accurate mapping and quantification of problematic soils.

2.2. Chemical properties of soil

2.2.1. Soil reaction (pH)

Katkar (1994) studied Entisol of Nagpur region and reported the pH range from 6.7 to 7.5. However the depth wise decrease in soil pH was observed.

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 saline sodic and 8.60 per cent are sodic. The pH of sodic soil ranges from 8.30 to 8.90.

Thakur *et al.* (1999) studied the Vertisols of Central India and reported the pH range from 7.2 to 8.8. Anantwar *et al* (2000) studied the basaltic Plateau of Wardha district of Maharashtra and reported the soil pH ranges from 7.6 to 8.0.

Kadao *et al.* (2003) studied eight typical pedons supporting banana were characterized as Vertisols and Inceptisols. The soils were alkaline and pH ranged from 7.9 to 8.4.

Mandal and Sharma (2005) prepared a relational database for salt affected soils using GIS. They also generated the spatial and non- spatial information on salt-affected soils derived from remotely sensed data to manage soil salinity in irrigated agriculture.

Kadu *et al.* (2009) studied soils of Wardha command area and observed that soils are moderately to strongly alkaline in reaction and the pH ranged from 7.5 to 8.8.

Deshmukh (2012) studied the soil fertility status of Sangamner area, Ahmednagar district, (Maharashtra). Total 62 surface soil samples were analysed and reported that, the pH ranged from 8.0 to 9.7 reflecting alkaline nature of soils.

Surbhi *et al* (2014) studied the soil fertility status of Shirol area, Kolhapur district, (Maharashtra).Total 200 surface soil samples were analysed and reported that, the pH ranged from 7.0 to 9.0 reflecting alkaline nature of soils.

2.2.2. Electrical conductivity (EC)

Patil *et al.* (1987) observed that the soils of Konkan region are acidic in region, low in EC, Phosphorus, exchangeable calcium, and magnesium and sufficient in organic carbon and available Fe and Mn.

In general electrical conductivity increase with depth of soil profile of Entisol and Inceptisol of Nagpur district (Katkar, 1994).

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

Dhane and Shukla (1995) analyzed twenty five surface soil samples from different soil series of Maharashtra and reported the of EC of Vertisoils, Inceptisols and Entisols soil series which ranged from 0.3 to 1.5,0.3 to 1.3 and 0.1 to 0.5 dS m^{-1}; respectively.

Anantwar *et al.* (2000) reported that the range of EC value of Wardha district from 0.32 to 0.43 dS m^{-1}.In these soils salts content was found to be increased with depth.

Balpande *et al.* (2007) studied grape growing soils of Nasik District. Soils were developed from basaltic parent material and the EC ranged from 0.08 to 1.22 dS m^{-1} and found to increased down the slope in some pedons viz Haplusterts and Typic Haplusterts owing to leaching of salts.

Singh *et al.* (2009) reported the range of EC value of soils of Hoshangabad district which ranged from 0.057 to 0.717 dS m^{-1}.

Patil *et al.* (2011) reported spatial variability in fertility status of surface soils in Dharwad district and concluded that soils were moderately alkaline in reaction with normal electrical conductivity (EC).

Jadhav (2014) reported that the range of EC value of soils of Kagal tehsil of Kolhapur district from 0.02 to 1.80 dS m^{-1}.In these soils salts content was found to be increased with depth.

2.2.3. Organic carbon

Katkar (1994) reported the range value of organic carbon from 0.07 to 0.93 and 0.12 to 0.63 per cent for Entisols and Inceptisols of Nagpur, respectively. This result showed the higher content of organic carbon in Entisols than Inceptisols soil profiles.

Sohan Lal l. *et al* (1994) reported low content of organic carbon in Entisols and Inceptisols of Maharashtra, which decreased with depth. Ranges of Organic carbon content of soil ranged from 0.1 to 0.4 per cent.

Pharande *et al.* (1996) reported the Organic carbon content of soils of western Maharashtra which ranged from 0.20 to 1.06 per cent.

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

Jagtap (2007) reported that the organic carbon content of soils of Chakur and Shirur –anantpal tehsil ranged from 0.20 to 1.33 and 0.16 to 1.29 percent, respectively.

Chinchmalatpure *et al* (2008) studied the salt affected swell - shrink soils of Gujarat and reported that the organic carbon ranged from 4 to 6 g kg^{-1} in surface horizons.

Singh *et al.* (2009) reported the 0.61 per cent of organic carbon content value in soils of Hoshangabad district.

Kale (2014) reported the organic carbon content of soils of western Maharashtra of Karveer tehsil of Kolhapur district from 0.43 per cent to 1.08 per cent.

2.2.4. Calcium Carbonate

In general the swell - shrink soils are moderate to highly calcareous in nature where as in some Vertisols of soil series of Maharashtra and Madhya Pradesh the range was 1.3 to 11.6 per cent (Subha Rao and Sekhon, 1991).

Deshmukh and Rangacharya (1992) reported the CaCO3 content in Vertisols of Akola (Maharashtra) from 0.6 to 4.5 per cent.

Katkar (1994) studied the Inceptisols of Nagpur district of Maharashtra and reported $CaCO_3$ content from 7.5 to 25 per cent. The content of $CaCO_3$ was found to be increased with depth of soil.

Anantwar *et al.* (2000) reported the $CaCO_3$ content in Vertisols of Wardha district which ranged from 5.2 to 9.8 per cent. In case of Entisols the range was from 2.8 to 4.2 per cent and for Inceptisols it was from 4.3 to 6.4 per cent.

Reddy Kishor (2002) studied the swell and shrink soils of Pathardi tehsil of Ahmednagar and reported the range of $CaCO_3$ from 60g kg^{-1} to 186 g kg^{-1}. It was observed that Vertisols and Inceptisols where more or less similar in $CaCO_3$ content and the $CaCO_3$ content increased with increase in depth of Vertisols.

The salt affected soils of Gujarat showed. The $CaCO_3$ content of salt affected soils of Gujarat ranged from 77.5 to 182.8 g kg^{-1} in different horizon with tendency to increase with depth. (Chinchmalatpure *et al*, 2008)

Gabhane *et al.* (2006) analysed the soils in Vidarbha region of Maharashtra and noticed that the $CaCO_3$ content in the soils ranged from 4.0 to 23.0 per cent.

Singh and Agrawal (2005) studied Alfisols of western Maharashtra and Showed that the $CaCo_3$ is low due to porous nature of soil and rapid leaching.

Kashiwar *et al.* (2009) concluded that $CaCO_3$ content in Entisols and Inceptisols of Nagpur (Maharashtra) ranged from 3.0 to 24 per cent.

All the subgroups of north eastern India was non-calcareous in nature as $CaCO_3$ varied from 0.2 to 3.9 per cent (Singh and Kundu 2010).

Thombare *et al* (2014) reported the $CaCO_3$ content in Hatkanangle tehsil of Kolhapur district from 0.5 to 29.00 per cent.

2.2.5. Macronutrients

Patil *et al.* (1987) reported that the soils of bench terraces in konkan were well supplied with total N and available K_2O, while they were found to be deficient in available P_2O_5. The exchangeable Calcium and Magnesium contents were also low.

Patil and Sonar (1994) studied widely spread swell and shrink soils of Maharashtra for available nutrient and micro-nutrients. These soils were found low in available N, very low to moderate in available P and moderate to high in available K. Available N, P, K ranged from 115 to 225 kg ha^{-1}, 5.08 to 16.38 kg ha^{-1}, 224 kg ha^{-1} to 909 kg ha^{-1}, respectively.

Chinchmalatpure *et al.* (1998) reported that available calcium and magnesium content in soils of North Western part of Nagpur district ranged from 2.8 to 32.8 C mol Kg^{-1} and 0.2 to 12.4 C mol Kg^{-1},respectively.

Challa *et al.* (2000) characterized some problematic Vertisols in Maharashtra Plateau. They reported the calcium is the dominant cations in exchange complex with average value 24 cmol(p+)kg^{-1} ,and showed increasing trend with depth, Magnesium showed irregular trends in distribution with depth and varies from 2.8 to 27.6 cmol(p+)kg^{-1}.

Hasan (2002) reported soil test results for potassium (K) fertility status among India's agricultural soils are categorized as 21 per cent low, 51 per cent of India's agricultural area, representing 266 districts, needs immediate potassium fertilization.

Bhalerao and Pharande (2003) studied potassium behaviour in salt affected swell and shrink soils. They concluded that exchangeable K status was moderate in saline soils and moderately high in saline sodic and sodic soils.

Padole and Mahajan (2003) studied the potassium release behavior in some selected swell-shrink soils of Vidarbha region of Maharashtra. The total-K viz. water soluble, available, exchangeable, non exchangeable and lattice-K were 0.09 to 0.15 per cent, 1.1 to 1.76 per cent, 1.04

to 1.63 per cent, 3.16 to 5.25 per cent and 93.17 to 95.66 per cent, respectively.

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.

Mandal and Sharma (2005) found that the exchangeable calcium and magnesium in soils of Nagpur district ranged from 18.50 to 39.40 cmol (p^+) Kg^{-1} and 8.0 to 21.4 cmol (p^+) Kg^{-1} respectively.

Shrinivasarao *et al.* (2005) reported sulphur status and distribution in different soil group of West Bengal belonging to order Inceptisol. The higher amount of available sulphur was observed in surface layer than underlying horizon. Decreased in sulphur according to depth may be due to leaching of sulphur by percolating water. It varied from 7 to 15 mg kg^{-1} soil.

Binita *et al.* (2008) prepared soil fertility map in Ghataprabha left bank canal command area of North Karnataka by GIS technique to assess the status of major nutrients Viz. primary nutrient N, P, K and secondary nutrients in the soils on different physiographic units are presented as range, mean and standard deviation.

Ravte (2008) analysed the soils of Ause and Nilanga tehsil of Latur district and reported that the calcium,

magnesium and sulphur content in these soils ranged from 11.05 to 50.7 cmol (p^+) Kg^{-1} and 20.6 to 28.9 and 3.62 cmol (p^+) Kg^{-1} to 84.61 mg Kg^{-1} respectively.

Ashokkumar and Prasad (2010) studied typical sugarcane growing soils of Ahamednagar district of Maharashtra. He found that available NPK ranged from 47 to 228.9, 0.6 to 28.6 and 80.3 to 760.3 kg ha^{-1}, respectively.

Patil *et al.* (2011) reported spatial variability in fertility status of surface soils in Dharwad district and concluded that the available nitrogen content was low in 488 ha and medium in 544 ha. Available phosphorus was medium in 622 ha and low in 256 ha and high in the remaining area of 154 ha. The soils in the study area were high in available potassium status.

Survase *et al.* (2011) studied the fertility status of soil and nutrients recommendations in Panchaganga basin (Maharashtra) and found that most of the areas of the study region are fertile in nature. However low and very low fertility of soil was noted in some pockets only. The physiography, climate and agricultural activities have greatly influenced the nutrients status of soil. Specific fertilizers and addition of organic matters were recommended for nutrients deficient areas to keep the balance of nutrients and to restore the fertility of soils.

Pulakeshi *et al.* (2012) conducted a survey to assess available nutrient status of soils of Mantagani village in North Karnataka by GIS technique in black and red soil, the available nitrogen, phosphorus, potassium content ranged from 179-303 kg ha^{-1}, 21-35 kg ha^{-1}, 202 -417 kg ha^{-1}, respectively.

Haribhushan *et al.* (2013) studied on macro and micro nutrient status of Senapati district, Manipur (India). The mean values of available N, P, K and S were 382.04, 38.31, 208.86 and 22.65 kg ha^{-1}, respectively.

Sannappa and Manjunath (2013) reported to know the fertility status of soils in five selected regions (H.D.Kote, Madikeri, Sakaleshpur, Shimoga and Sirsi) of the Western Ghats of Karnataka. The chemical properties of soils were statistically varied among the selected regions of the Western Ghats of Karnataka at 5% level of probability. Available nitrogen contents were significantly more (709.2 kg ha^{-1}) with H.D. Kote region and Sakaleshpur region recorded less content (250.6 kg ha^{-1}). The soils of Madikeri region had higher available phosphorus content (34.34 kg ha^{-1}) and it was lower with Sirsi region (9.450 kg ha^{-1}). Both Madikeri and Sakaleshpur regions recorded highest potassium content of 717.0 kg ha^{-1} with least being in Sirsi region (90.00 kg ha^{-1}).

Singh and Rathore (2013) studied the available nutrient status of Aravalli mountain ranges and Malwa plateau of Pratapgarh, Rajasthan. Total eight pedons were examined in

the field and investigated in the laboratory using standard laboratory procedures. The soils of all pedons were found deficient in available nitrogen and phosphorus while adequate in available potassium. Major nutrients are found relatively higher in soils of Malwa plateau compared to soils of Aravali mountain ranges.

2.2.6. Micronutrients

Mahapatra and Kibe (1973) estimated representative surface soil sample from six agro- climatic zone of Maharashtra state for their manganese fractions. It was found that, the available manganese ranged from 1.5 to 67.0 ppm. In general thesoils of arid to semi arid region and transition zones were richer in their active Mn status in comparison with laterites. The acid soils contained more available manganese than black soils. Higher the pH and CEC lower was the available manganese. Probable deficiency and toxicity of Mn appear to exist respectively in the neutral to alkaline soils and laterite soils of western belt of state.

Pharande *et al.* (1996) studied widespread Vertisol and Alfisol soil series of Western Maharashtra for total and DTPA extractable micronutrient contents. The total Fe, Mn, Zn and Cu contents of Vertisols ranged 6.1 to 14.3 per cent, 870 to 3310, 74 to 311 and 174 to 560 mg kg-1 respectively; While in Alfisols the range was 8.4 to 19.5 per cent, 796 to 3390, 84 to 192 and 212 to 572 mg kg^{-1} respectively.

Surface soil samples from different soils types of konkan region were also studied for DTPA extractable Zinc, copper, manganese and iron and their relationship with some soil properties. The contents of available Zn, Cu, Mn and Fe suggested that deficiency of Zn and Mn might be expected, however the available Cu and Fe was observed to be adequate. (Patil and Meisheri 2004).

Satyavathi and Suryanarayan reddy (2004) studied the distribution of DTPA extractable micro nutrients in soils of Telangana, Andhra Pradesh. There was no definite trend for the distribution of these micronutrients with respect to depth. As per critical limit prescribed for Zn and Fe, 44 and 20 per cent of the soils were rated as deficient in available Zn and Fe respectively, whereas Cu and Mn were found to be adequate.

Dhage *et al.* (2005) studied micronutrient status of different district of Maharashtra and concluded that the deficiency of Zn and Fe was very less in the soil of Kolhapur. Soils were well supplied with available Mn and Cu.

Wajahat *et al.* (2006) studied the micronutrient status of soils of Bhimber district (Jammu and Kashmir). The DTPA extractable Fe, Cu, Zn and Mn ranged from 5.37-23.36, 0.59-4.38, 0.74-2.08 and 4.59-21.08 mg Kg-1. DTPA extractable Fe, Cu and Mn was found high in all sites while Zn was low in 26.66 per cent, medium in 70 per cent and high in 3.34 per cent samples.

Katkar and Patil (2010) studied the soil samples representing the available micronutrient status in soils of Vidarbha. The mean range of extractable Zn, Fe, Cu, Mn, avail B and Mo was 0.65, 4.18, 0.56, 4.23, 0.60 and 0.2 mg kg-1 respectively.

Kumar and Babel (2011) studied the micronutrient status of Jhunjhunu tehsil of Rajasthan. The 90 per cent of analyzed soil samples were found to be deficient in iron and 70 per cent deficient in zinc and their values ranges from 1.22 to 5.87 and 0.12 to 1.30 mg kg-1, respectively. While the remaining micronutrients (Cu, Mn and B) were found to be sufficient and their values ranges between 0.17 to 3.32, 2.03 to 5.67 and 0.37 to 1.51 mg kg-1 ,respectively.

Cholarajan and Vijayakumar (2013) investigated the micronutrient status of rhizosphere soils of Thanjavur district, Tamilnadu was at nine different locations. The Zn, Cu, Fe and Mn ranged from 0.56-0.96, 0.57-0.96, 4.16-5.36 and 2.03-2.65 mg kg^{-1}, respectively.

Thakre *et al.* (2013) reported the micronutrient status of red soils in Wardha region, India. The DTPA extractable Fe ranged from 7.12 to 22.52 ppm, Mn ranged from 8.70 to 26.97 ppm, Zn ranged from 0.41 to 0.65 ppm and Cu ranged from 2.77 to 7.10 ppm in red soils of Wardha region. The results revealed that in red soils, Fe and Mn content was very high, Cu content was found to be sufficient and Zn content was very less.

2.3. Mapping of soil

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

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

Bhattacharya *et al.* (1989) surveyed Junnar tehsil of Pune district, Maharashtra to bring out basic information on soils and the land use pattern. Eighteen soil series were identified, classified, correlated and mapped as soil series associated into 21 units. Nearly 50% of the area was very shallow soils, 15% moderately deep soils and 25% deep to very deep soils.

Prasad *et al.* (1989) mapped the soils of Institute of deciduous forests, Jabalpur. Entisols were the dominate soils of hillocks and convex erosional slopes. Alfisols were the next dominant soils and Mollisols and Vertisols covered 16.7 and 12.5 per cent of the area, respectively. Inceptisols covered only 2.9 per cent of the study area.

Bhattacharya *et al.* (1992) Surveyed Ambegaon tehsil 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 plateau and pediment 21 per cent area and piedmont plains 25.3 per cent area of tehsil.

Verma *et al.* (1994) studied salt affected soils by using remote sensing image interpretation of Etah, Aligarth, Manpuri and Mathura District of Uttar Pradesh in different mapping unit as S_1 (<10%) limited extensive area covered by salt, S_2 (10-30%) moderate extensive, S_3 (30-50%) extensive, S_4 (50-75%) very extensive and S_5 (>75%) extremely extensive area. They observed about 0.21 million ha area under salt affected soils.

Challa *et al.* (1995) mapped the soils of Maharashtra and reported the area under influence of chemical degradation to the tune of 1.06 million ha which was 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.

Tamgadge (1997) identified and mapped twenty soil series in Gadchiroli district of Maharashtra while conducting the reconnaissance soil survey. The geology of the area consisted of granite, granite-genesis and shale. The form land sequence in the area comprised of plateau escarpment, pediment, valley bottom and flood plain. Present land use and climatic makeup of the soil have been interpreted for sustainable land uses. The seventeen soil series in Bhandra district of Maharashtra also mapped into 35 soil association.

Based on properties, climate and experience gained in the area, the land use and productivity potential of these soils was suggested.

Durgude (1999) studied the salt affected soils of central campus FARM, M.P.K.V., Rahuri and reported that 1.66 per cent soils of potential cultivated area was saline, 5.92 per cent area saline – sodic and 8.60 per cent was sodic. The pH of sodic soils was ranged from 8.30 to 8.90. EC was ranged from 0.46 to 2.45 dS m^{-1} and ESP was varied from 5.0 to 24.8.

Vedivelu *et al.* (2001) mapped spatial pattern of available K distribution in the soils of Assam state is important for the studies of K fertilization and to judge the adequacy of soil K. The soil map (1:500,000 scale) with family association as map units for mapping the distribution of available K the mean available K was used.

Sharma *et al.* (2004) studied six typical pedons representing cultivated soils of Neogal watershed in North West Himalayas occurring on river terraces and hill slopes viz., Bau, Talinu, Phata, Gopalpur, Bhatu and Makadrv were studied for their morphological characteristics and physico-chemical properties and suitability for totally preferred crops.

Asadi *et al.* (2008) analysed and mapped soil quality in Khandaleru catchment area using remote sensing and GIS. Result obtained used to create database consisting selected soil quality parameters and computation of soil quality index

to develop spatial distribution maps showing variations in soil quality index. The study indicated that the soil quality is largely controlled by chemical properties viz., organic carbon, exchangeable Ca, Mg, S and pH etc.

Sharma *et al.* (2008) evaluated soils for mapping of micronutrients status and mapped soils of Amritsar district (Punjab). The maps of various nutrient elements clearly indicated the specific locates deficiency of nutrients and their constraints in crop production.

Srikanth *et al.* (2008) studied Soils of Bhanapur micro watershed in Northern Dry Zone of Karnataka, for available nutrient status and mapped by GIS technique. Twenty five surface soil samples from black soils and seventy five surface soil samples from red soils in Bhanapur micro watershed were collected and assessed for the available major nutrient status. The results revealed that, the majority of the area (580.42 ha) in the watershed was low in available nitrogen, medium in available phosphorus was medium in major part of the watershed (555.25 ha), but it was low in 26.71 ha and the available potassium content in major portion of the study area was under medium to high category. Available sulphur status was low (417.32 ha) to medium (164.64 ha).

Singh *et al.* (2009) reported the Soils of characterized, classified and mapped the soils of Churu on 1:50,000 scale. The results showed that the soils of aeolian plains were very deep somewhat excessively drained loamy sand to fine sand,

single grained, moderately alkaline and were mapped as association of normal, moderately and highly hummocky phase of Molasar, Modasar and Dume complex, respectively.

Ardak *et al.* (2010) characterizated and evaluated the land resources in Khapri village of Nagpur district of Maharashtra. Using IRS-P6, LISS-IV and IRS-1 D PAN sharpened LISS-III data and GIS coupled with field survey. Eight soil series were tentatively identified and mapped as series and complex with phases on 1:12,500 scale based on landforms-soil relationship.

Jadhav *et al.* (2012) prepared a soil fertility maps of Babhaleshwar farm, Nasik, Maharashtra. Representative soil samples from each of eighteen plots of Babhaleshwar farm were collected. The soil survey of representative area was completed by plane table survey method. The soil samples were tested in laboratory for determining various soil properties viz., soil pH, soil electrical conductivity, soil colour, soil texture, liquid limit, plastic limit, bulk density and soil nutrients like organic carbon content, gypsum content, soil calcium carbonate, available nitrogen, available potassium and available phosphorus.

2.4. Correlation of soil properties

Jadhav *et al.* (1978) studied the vertical distribution of zinc and iron in some citrus growing soils of Marathwada and found no significant relationship between available zinc and iron with soil pH.

Mishra and Srivastava (1991) studied some red soil profile of Garhwal Himalayas and indicated that water soluble, exchangeable and available soil potassium had positive correlation with organic carbon and EC. Among different potassium forms, water soluble and exchangeable potassium were positively correlated with pH.

Pal and Mukhopadhyay (1992) studied distribution of different forms of potassium in ten soil series under the order Inceptisols 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.

Nipunge *et al.* (1996) studied some Inceptisol soil series of Maharashtra and revealed that the EC recorded significant negative correlation with available Mn and Zn and available Fe and Mn had negative relationship with $CaCo_3$.

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

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

Indulkar *et al.* (2007) stated that the available nitrogen recorded positive significant correlation with pH, EC, O.C and $CaCO_3$ whereas available phosphorus showed negative correlation with $CaCO_3$ and the available potassium showed positive significant correlation with pH.

Vijayakumar *et al.* (2011) studied the micronutrients and their relationship with soil properties of natural disaster proned coastal soils of Tamilnadu and analyzed for the basic soil parameters viz., pH, EC, OC, OM and DTPA extractable micronutrients. The result showed that the available micronutrients, Fe was found to be sufficient by 97% and Mn deficient by 100%, Zn was found to be sufficient by 53% and Cu deficient by 45%, respectively. Further, Fe showed positive correlation with OC but negative correlation with pH. The Mn also followed the same trend as that of Fe with OC, EC and pH. The Cu showed positive correlated with EC and negative correlated with pH and OC. The Zn showed negative correlation with OC and positive correlation with EC and pH.

Chaudhari *et al.* (2013) studied the relationships among electric conductivity, soil properties and available nutrients in the soils of north Maharashtra. Nutrient concentrations and soil properties were compared with electrical conductivity. The

results were analyzed statistically, which showed significant correlation between electrical conductivity and available K, Mg, Cu, Clay and sand content in soil samples. Positive correlation of electrical conductivity with N, P and Ca. No correlation of electrical conductivity was found with Fe, Mn, Zn, OC, CaCO3, pH of soil samples.

Surbhi *et al.* (2014) studied the relationships among soil reaction (pH), soil properties and available nutrients in soil of western Maharashtra. Nutrient concentrations and soil properties were compared with pH. She concluded that the pH of the soils was negatively and non significantly correlated with available N, K and DTPA extractable Cu. and organic carbon showed positive and significant relationship with available nitrogen, exchangeable sodium, available Sulphur but it showed negative and significant relation with DTPA extractable manganese and exchangeable calcium. Negative correlation with potassium, magnesium and zinc.

2.5. Fertility index

Singh *et al.* (2005) prescribed optimum doses of nutrients for targeted yield through soil fertility maps in Andhra Pradesh. District wise soil fertility maps were prepared by using the index values of nitrogen (N), phosphorus (P) and potassium (K).

Panwar *et al.* (2011) examined the impact of land use on soil fertility in an Entisol in the Jalpaiguri district of humid subtropical India. Soil fertility index varied from 13.13 in

areca nut plantation to 18.49 in forest. The evaluation factor ranged from 5.32 in agriculture to 6.56 in forest. Person's correlation matrix revealed strongly significant positive correlation of soil fertility index and soil evaluation factor with soil properties.

Ravikumar and Somashekar (2013) studied the nutrient index using organic carbon, available phosphorus and available potassium concentrations as a measure of soil fertility Varahi river basin were characterized as low-medium-low category based on the nutrient index calculated with respect to available carbon, available phosphorus and available potassium.

3. MATERIALS AND METHODS

The present investigation entitled, "GPS-GIS Based Fertility Maps of Ajra tehsil of Kolhapur District", was carried out during 2015- 2016. Total 145 soil samples from cultivable area of Ajra tehsil were collected by using GPS. The collected soil samples were processed and analyzed for their nutrient status by using standard analytical methods.

The details of present study, materials used and methods adopted are presented in this chapter under following subheads.

3.1. MATERIAL

3.1.1. Location

Ajra is one of the tehsil of Kolhapur district of Maharashtra. The geographical area of tehsil is 54874 ha. It belongs to western Maharashtra region and located between 16º 11' 59" north latitude and 74º 21' 06" east longitude and elevation 660 m from mean sea level. The location map of study area is depicted in plate 2.

3.1.2. Climate

During summer highest day temperature is in between 32ºc to 30ºc. Average temperature is in between 22ºc to 30ºc. Annual rainfall is 2980 mm.

3.1.3. Hydrology

Ajra tehsil is gifted by the presence of natural irrigation potential on account of major river Hiranykeshi. The crops mainly irrigated through river, tube well and tank water.

3.1.4. Present land use and natural vegetation

Out of total geographical area 54874 ha area is under

forest 14795.88 ha and cultivable area 35617.50 ha.

The Soils of Ajra tehsil of Kolhapur are under the cultivation of major crops are cultivated rice, kharif sorghum, wheat, groundnut, sugarcane and cashew nut.

Similarly, a few grasses of ecological importance such as Heteropogon contrortus, Cynodon doctylon, Cleosia argentea, Mimosa pudica etc. are observed including Kardai.

3.1.5. Soils

The red lateritic soils are found in western zone. Some areas which are thickly forested and have minimum biotic interference. The soil depth, soil quality and fertility is medium to good.

The lateritic rocks are soft and show bright colours which freshly cut but becomes very hard and dull on exposure to atmosphere. The soils texture mainly consist of fine silt, sandy and clay which is deposited in the valleys along the course of rivers and are fertile. Rice, sorghum and groundnut is generally grown in these soils and in irrigated areas sugarcane is also being cultivated.

3.2. METHODOLOGY

3.2.1. Experimental Details

Ajra tehsil of Kolhapur district was selected to assess the soil macro and micro nutrient status and delineate the fertility map. The 66 villages were selected randomly in such a way that it should cover whole area of the tehsil. One hundred and forty-five of representative soil samples were collected from sixty six villages of Ajra tehsil along with GPS reading. The village name and GPS reading are listed in table.10.

3.2.2. Collection and Processing of Soil Samples

Ajra tehsil has total 98 villages one of that 66 villages were selected for sampling keeping in mind to avoid overcrowding of sampling site on GPS based soil fertility map. Geo-referenced surface (0-22.5) cm soil samples from each selected villages representing different soils were collected. The latitude and longitude of sampling sites were recorded with the help of differential Global Positioning system and presented in Annexure-1, while sampling from each site, following observations were recorded.

1. Record of surveyed fields, latitude and longitude of sampling spots.

2. Crop data, data on use of fertilizers and manures.

The soil samples were collected with the help of wooden peg. The samples were air dried and ground using wooden mortar and pestle and passed through 2.0 and 0.5 mm sieves. The sieved soil samples were stored in cloth bags with proper labeling for subsequent analysis. The soils were analysed for different parameters.

3.2.3 Observations Recorded Chemical Properties

1. pH
2. EC
3. $CaCO_3$
4. Organic carbon
5. Available N
6. Available P
7. Available K
8. Available S
9. Exchangeable Ca, Mg
10. Exchangeable sodium
11. DTPA extractable micronutrients viz, Fe, Mn, Zn and Cu.

3.2.4. Methods

The methods used for chemical analysis of surveyed soils are given as below (Table.1)

Table.1. Standard analytical methods used for chemical analysis of soil

Sr. No.	Parameters	Methods used	References
1.	pH (1:2.5; Soil : Water)	Potentiometry	Jackson (1973)
2.	EC (1:2.5; Soil : Water)	Conductiometry	Jackson (1973)
3.	Organic carbon	Wet oxidation	Nelson and Sommer (1982)
4.	Available Nitrogen	Alkaline Permanganate	Subbiah and Asija (1956)
5.	Available Phosphorus	Olsen (O .5 *M* Sodium bicarbonate) (pH-8.5)	Watanabe and Olsen (1965)
		Bray I (0.03 *N* Ammonium fluoride) (pH-3.5)	Bray and Kurtz (1945)
6.	Available Potassium	Flame photometry, 1 *N* neutral Ammonium acetate (pH-7.0)	Knudsen and Peterson. (1982)
7.	Calcium carbonate	Rapid Titration	Piper (1966)
8.	DTPA Extractable micronutrients (Fe, Mn and Cu)	Atomic absorption Spectrophotometry	Lindsay and Novel (1978)
9.	Exchangeable Ca & Mg	Versenate	Page (1982)
10.	Exchangeable Sodium	Flame photometry	Page (1982)
11.	Available Sulphur	Turbidimetry (calcium chloride extractable)	Williams and Steinberg (1959)

3.2.5. Statistical Analysis

The analytical data was statistically analysed by using standard methods. The NBSS soil survey manual chart was used for presenting the soil analytical data.

3.2.6. Arc GIS 9.3 Software

Soil fertility maps were prepared by using GPS-GIS reading and fertility maps of soil of Ajra tehsil were prepared by employing Arc GIS 9.3 software. The maps were presented in plates 3 to 17.

Fertility Index

The Parker's nutrient index is used to compare soil conditions within a given region by categorizing the area into low, medium and high.

The Parker's nutrient index of Ajra tehsil was calculated by the formula for organic carbon, available nitrogen, phosphorus and potassium of soil:

$$\text{Parker Index} = \frac{(A \times 0.5) + (B \times 1) + (C \times 1.5) + (D \times 2) + (E \times 2.5) + (F \times 3)}{\text{Total number of sample}}$$

Where,

A = No. of samples in very low category.
B = No. of samples in low category.
C = No. of samples in medium category.
D = No. of samples in moderately high category.
E = No. of samples in high category.
F = No. of samples in very high category.

Table.2. Rating of pH, EC and $CaCO_3$ of soil

pH (1:2.5)	Ratings	EC ($dS\ m^{-1}$) (1:2.5)	Ratings	$CaCO_3$ (%)	Ratings
<4.5	Extremely Acidic	0-1.0	Normal	0-0.5	Non calcareous
4.6-5.5	Strongly Acidic				
5.6-6.5	Moderately Acidic	1.0-2.0	Poor seed Emergence	0.5-1.0	Barely calcareous
6.6-6.9	Slightly Acidic			1.0-2.0	Slightly calcareous
7.0	Neutral	2.0-3.0	Harmful to some Crops eg. Pulses	2.0-5.0	Moderately calcareous
7.1-8.0	Slightly alkaline				
8.1-9.0	Moderately alkaline				
9.1-10.0	Strongly alkaline	>3.0	Harmful to most of the crops	5.0-10	Calcareous
10.1-11.0	Very Strongly Alkaline			>10	Highly Calcareous

Patil and Mali (1999)

Table.3. Six tier ratings of organic carbon, available nitrogen, phosphorus and potassium of soil

Sr.no	Ratings	Organic carbon (%)	Available nutrients ($Kg\ ha^{-1}$)		
			N	P	K
1.	Very low	<0.20	<140	<7	<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.4. Six tier rating of available sulphur content in soil (mg Kg^{-1})

Sr. No	Ratings	Sulphur
1.	Very low	<5
2.	Low	5-10
3.	Medium	10-15
4.	Moderately high	15-20
5.	High	20-40
6.	Very high	>40
	Critical limit	10

Katkar and Patil (2010)

Table.5. Critical limit of DTPA extractable micronutrients (mg Kg^{-1}) of soil

Sr.no	Micronutrient	Critical limit
1.	Fe	4.5
2.	Mn	2.0
3.	Zn	0.6
4.	Cu	0.2

Katkar and Patil (2010)

4. RESULTS AND DISCUSSION

The result of the investigation carried out during the year 2015-2016 with the view to study the GPS-GIS based fertility status of soils in Ajra tehsil are presented and discussed in this chapter under following subheadings.

4.1 Nutrient status of soils of Ajra tehsil.

4.2. Correlation of available nutrient status with soil properties of Ajra tehsil.

4.3. Fertility index

4.1. Nutrient status of soils of Ajra tehsil

The soil samples collected from Ajra tehsil were analyzed and the data pertaining to different parameters is categorized as per the six tier rating. The data pertaining to pH, Electrical conductivity, Calcium carbonate, and Organic carbon, available N, P and K are presented in Table.6 and 7.

4.1.1. Soil reaction (pH)

The data pertaining to the soil pH is presented in Table.6 and depicted in plate 3. The pH of the soils in Ajra tehsil ranged from 4.71 to 7.52. Among the soil samples tested, most of the soils were moderately acidic (51.72 per cent) followed by strongly acidic (31.03%) slightly acidic (9.66%), slightly alkaline (6.21%) and neutral (1.38%). The lowest pH was 4.71 and highest was 7.52. Acidic condition of maximum soil might be due to undulating topography, high rainfall, leaching, erosion and accumulation of iron oxides.

The similar results were recorded by Patil *et al* (1987) in red soils of Konkan region of Maharashtra.

Table.6. pH, EC, OC and $CaCo_3$ content in soils of Ajra tehsil

Particular	pH (1:2.5)	EC ($dS\ m^{-1}$) (1:2.5)	Organic carbon (%)	$CaCO_3$ equivalent (%)
Mean	5.93	0.14	0.85	1.27
Range	4.71-7.52	0.06-0.6	0.30-2.35	0.26 -2.8
Category	Extremely acidic **0(0%)**	-	Low **09 (6.21%)**	-
	Strongly acidic **45(31.03%)**	-	Moderate **27 (18.62 %)**	-
	Moderately acidic **75 (51.72%)**	Normal **145 (100%)**	Moderately high **31 (21.38%)**	Non Calcareous **04 (2.76%)**
	Slightly acidic **14 (9.66%)**	-	High **53 (36.55%)**	Barely Calcareous **40 (27.59%)**
	Neutral **02 (1.38%)**	-	Very high **25 (17.24%)**	Slightly Calcareous **95 (65.52%)**
	Slightly alkaline **09(6.21%)**	-	-	Moderately Calcareous **06 (4.13%)**

Total no. of soil samples -145, figures in parenthesis indicates percentages.

4.1.2. Electrical Conductivity (EC)

The EC of soils is presented in Table.6 and depicted in plate 4. The EC of various soil sample of Ajra tehsil ranged from 0.06 to 0.6 dS m^{-1}. The EC noticed in Ajra tehsil indicated that most of the soils were non saline in nature (100 per cent) and suitable for healthy plant growth. The low

EC was may be due to low temperature, porous structure of soil, heavy rainfall, erosion and leaching down of soluble salts. The similar results were reviewed by Patil *et al.* (1987) in red soils of Konkan region of Maharashtra.

4.1.3. Organic carbon

The organic carbon content in soils of Ajra thesil is presented in Table. 6 and depicted in plate 5. The organic carbon of various soil samples of Ajra tehsil ranged from 0.30 to 2.35 per cent with the mean of 0.85 per cent. The data indicated that 17.24 per cent samples were very high, 21.38 per cent samples were moderately high, 36.55 per cent samples were high, 18.62 per cent samples were moderate and 6.21 per cent were low in organic carbon. This might be due to addition of FYM, low temperature, high rainfall, accumulation and decomposition of leaves and litters Mahapatra and Kibe (1973) reported similar reasons for carbon content of soil.

4.1.4. Calcium Carbonate equivalent

The data in respect of percent $CaCo_3$ eq is presented in Table.6 and depicted in plate 6. The $CaCO_3$ in soils of Ajra tehsil ranged from 0.26 to 2.8 per cent with the mean of 1.27 per cent. The data revealed that most of soils were slightly calcareous (65.52%) followed by barely calcareous (27.59%), moderately calcareous (4.13%) and non calcareous (2.76%).The lower value of $CaCo_3$ equivalent of soils Ajra tehsil might be due to low temperature, high rainfall, rapid leaching and porous nature of soil. The similar trend of

$CaCO_3$ equivalent was reported in Alfisols of western Maharashtra by singh and Agrwal (2005). Non calcareousness nature of Alfisols was reported by Pharande *et al* (1996) for western Maharashtra.

Table.7. Status of available nitrogen, phosphorus and potassium in soils of Ajra tehsil.

Particular	Available nutrients (Kg ha^{-1})		
	N	P	K
Mean	294.84	18.31	142.72
Range	175 - 401.4	7.34 - 34.8	78.87 – 236.80
Very low	-	-	14 (9.66%)
Low	52 (35.86 %)	41 (28.28 %)	81 (55.86 %)
Moderate	93 (64.14 %)	64 (44.14 %)	41 (28.27%)
Moderately high		27(18.62%)	09(6.21%)
High	-	13 (8.96%)	-
Very high	-	-	-

Total no. of soil samples -145, figures in parenthesis indicates percentages.

4.1.5. Available Nitrogen

The data in respect of available nitrogen status of soils of Ajra tehsil is presented in Table. 7 and depicted in plate 7. The available nitrogen ranged from 175.0 to 401.4 Kg ha^{-1} with a mean value of 294.84 Kg ha^{-1}. The soil samples of Ajra tehsil were categorized as low (35.86%) to moderate (64.14%) in available nitrogen. It might be due to the low pH which reduces the degradation of organic matter as compare to vertisols which reflected higher status of available nitrogen. Ajra tehsil is slopy, undulating, due to which most of the nitrogen is leached and eroded with the runoff. The similar

results were reported by Patil *et al* (2011) in different soil series of Kolhapur district.

4.1.6. Available Phosphorus

The data with respect to available phosphorus is presented in Table. 7 and depicted in plate 8. The available phosphorous in soil of Ajra tehsil ranged from 7.34 to 34.8 Kg ha^{-1} with a mean of 18.31 Kg ha^{-1}. Among the soil samples collected 28.28 per cent samples were low, 44.14 per cent soil samples were moderate, 18.62 per cent samples were moderately high and 8.96 per cent samples were high in available phosphorus. High phosphorus content was due to continuous use of phosphatic fertilizers in the intensive cropped area. Similar results were observed by Patil *et al* (2011) in different soil series of Kolhapur district.

4.1.7. Available Potassium

The data in relation to available potassium status of soils of Ajra tehsil is presented in Table. 7 and depicted in plate 9. The available potassium ranged from 78.87 to 236.80 Kg ha^{-1} with a mean value of 142.72 Kg ha^{-1}. The available potassium content were categorized as very low (9.66%), low (55.86%), moderate (28.27%) and moderately high (6.21%).

The low potassium status of soils might be due to shallow depth and coarse texture of soils coupled with lack of recycling of organic matter. The similar results were reported by Patil *et al.*, (1987) in the alfisols of Konkan.

Table.8. Status of exchangeable Calcium, Magnesium and Sodium in soils of Ajra tehsil

Particular	Exchangeable [cmol(p^+)Kg^{-1}]		
	Ca	Mg	Na
Mean	27.41	9.3	0.66
Range	7- 61	0.5-32	0.26-1.17
Sufficient	127 (87.60%)	66(45.52%)	-
Deficient	18 (12.40%)	79(54.48%)	-

Total no. of soil samples -145, figures in parenthesis indicates percentages.

4.1.8. Exchangeable Calcium

The data in respect of exchangeable calcium status is presented in Table. 8 and depicted in plate 10. The exchangeable calcium in soils of Ajra tehsil ranged from 7 to 61 [cmol (p+) Kg^{-1}] with a mean of 27.41 [cmol (p+) Kg^{1}]. Out of all the samples collected from Ajra tehsil 87.60 per cent were in sufficient range and 12.40 per cent samples were in deficient range, as the critical limit of available calcium is 15.0[cmol (p+) Kg^{-1}] (Durgude,1999). Mahapatra and Kibe, (1973) reported similar results of exchangeable calcium content in soils of Konkan region of Maharashtra.

4.1.9. Exchangeable Magnesium

The data with respect of exchangeable magnesium status of soils of Ajra tehsil is presented in Table. 8 and depicted in plate 11. The available magnesium in soils of Ajra tehsil ranged from 0.5 to 32.0[cmol (p+) Kg^{-1}] with a mean of

9.30[cmol (p+) Kg^{-1}]. Out of all soil samples collected 45.52 per cent were in deficient range while 54.48 per cent in sufficient range, as the[cmol (p+) Kg^{-1}] critical limit of exchangeable magnesium is 10 (Durgude,1999). The deficiencies of magnesium might be due to the coarse texture of some soils. The similar trend of results were observed by Mahapatre and Kibe (1973) reported similar results of exchangeable magnesium content in soils of Konkan region of Maharashtra.

4.1.10. Exchangeable Sodium

The data in respect of exchangeable sodium status is presented in Table. 8. The exchangeable sodium in soils of Ajra tehsil ranged from 0.26 to 1.17[cmol (p+) Kg^{-1}] with a mean of 0.66[cmol (p+) Kg^{-1}] which might be due to porous texture of soil, sloppy undulating topography, leaching of salt with rain water. This findings are in accordance with those reported by Mahapatra and Kibe (1973).

4.1.11. Available Sulphur

The data in relation to available Sulphur in soils of Ajra tehsil is presented in Table. 9 and depicted in plate 12. The available Sulphur in soils of Ajra tehsil ranged from 0.78 to 28.75 mg Kg^{-1} with a mean of 5.25 mg Kg^{-1}. The majority soils in the tehsil were very low (68.96%) to low (17.93%), in available sulphur, which might be due to leaching of sulphate due to high rainfall. Similar results was observed by Patil (2011) in different soil series of Kolhapur district.

Table.9. Status of available Sulphur in soils of Ajra tehsil.

Particular	Available nutrient (mg Kg^{-1})
	S
Mean	5.25
Range	0.78 - 28.75
Very low	100 (68.96%)
Low	26 (17.93 %)
Medium	09 (6.21 %)
Moderately High	06 (4.14%)
High	04 (2.76%)
Very high	-

Total no. of soil samples -145, figures in parenthesis indicates percentages.

4.1.12. DTPA extractable iron

The data in relation to DTPA extractable iron status of soils of Ajra tehsil is presented in Table. 10 and depicted in plate 13. The DTPA extractable iron in soils of Ajra tehsil ranged from 0.34 to 57.36 mg Kg^{-1} with a mean of 27.54 mg Kg^{-1}. The deficiency of Fe was found in two samples located in village Bhairewadi. The highest DTPA extractable iron was 57.36 mg kg^{-1} and lowest 0.34 mg kg^{-1} the sufficiency of available iron might be due to high organic matter content where as deficiency might be due to coarse texture of soils located at escarpment region of tehsil. Pharande *et al* (1996)

also reported the similar results in Alfisols of western Maharashtra.

Table.10. Status of DTPA extractable micronutrients content in soils of Ajra tehsil

Particular	Available micronutrients(mg Kg^{-1})			
	Fe	Mn	Zn	Cu
Mean	27.54	24.54	1.43	1.59
Range	0.34-57.36	11.38-31.24	0.74-4.22	0.024-5.16
Critical Limit	**4.5**	**2**	**0.6**	**0.2**
Sufficient	143(98.60%)	145 (100 %)	145(100%)	145 (100 %)
Deficient	02 (1.40 %)	-	-	-

Total no. of soil samples -145, figures in parenthesis indicates percentages.

4.1.13. DTPA extractable Manganese

The data in relation to DTPA extractable Manganese status of soils of Ajra tehsil presented in Table. 10 and depicted in plate 14. The DTPA extractable manganese in soils of Ajra tehsil ranged from 11.38 to 31.24 mg Kg^{-1} with a mean of 24.54 mg Kg^{-1}. All the soil samples collected were sufficient in available manganese. The sufficiency of available Mn might due to higher ferromagnesium content and optimum soil moisture content. These results are akin to those reported by Pharande *et al.* (1996)

4.1.14. DTPA extractable zinc

The data in relation to DTPA extractable zinc status is presented in Table. 8 and depicted in plate 14. The DTPA extractable zinc in soils of Ajra tehsil ranged from 0.74 to 4.22 mg Kg^{-1} with a mean of 1.4 mg Kg^{-1}. All the collected soil samples were sufficient, in DTPA extractable zinc. The highest available zinc was 4.22 mg kg^{-1} and lowest was 0.7 mg kg^{-1}. Similar trends of DTPA extractable zinc were reported critical limit in red soils of Andhra Pradesh by Choudhary, (1994).

4.1.15. DTPA extractable Copper

The data in relation to DTPA extractable copper is presented in Table. 8 and depicted in plate 17. The DTPA extractable copper in soils of Ajra tehsil ranged from 0.24 to 5.16 mg Kg^{-1} with a mean of 1.59. All the soil samples collected from Ajra tehsil were sufficient in available copper. The sufficiency of available copper might be due to the high organic matter content and optimum soil moisture in soil. Pharande *et al* (1996) reported similar trends of DTPA extractable cu status in Alfisols of western Maharashtra. DTPA extractable Cu was above critical limit in red soils of Andhra Pradesh which were reported by Choudhary (1994).

4.2. Correlation studies of available nutrient status with soil properties of Ajra tehsil.

The correlation of available nitrogen, phosphorus, potassium, Sulphur, exchangeable calcium, magnesium, sodium and DTPA extractable zinc, iron, manganese, copper with soil pH, EC, calcium carbonate equivalent and organic carbon are calculated. The correlation coefficients between soil properties and nutrients are presented in Table.11.

The pH values of the soils were significantly and positively correlated with available P, K, exchangeable Ca and Mg and extractable Cu. Similar results were reported by Sharma *et al.* (2003).

The EC of Ajra tehsil showed no significant correlation with available nitrogen, phosphorus, DTPA extractable copper and exchangeable calcium but it showed positive and significant correlation with DTPA extractable Fe. These finding are in accordance with the results reported by Chavan *et al* (1980).

Organic Carbon showed positive and significant corelationship with available N, K and DTPA extractable Fe, and Zn. Indulkar *et al* (2007) stated that the available N showed positive significant correlation with organic carbon.

Calcium carbonate was positively and significantly correlated with available potassium, exchangeable Ca and Mg and DTPA extractable Cu in soils. Similar results were reported by patil (2011) in different soil series of Kolhapur district.

Table 11. Correlation coefficient between chemical properties and available nutrients in soils of Ajra tehsil.

Chemical properties	Available nutrient (Kg ha^{-1})			Exchangeable cations [cmol(p^+)kg^{-1}]			Available nutrients (mg Kg^{-1})				
	N	P	K	Ca	Mg	Na	S	Fe	Mn	Zn	Cu
pH	-0.005	0.345**	0.571**	0.676**	0.308**	0.091	-0.102	0.105	-0.133	-0.316**	0.399**
EC	0.112	0.070	-0.160	0.036	-0.087	-0.171	0.110	0.164*	0.007	-0.026	0.005
Organic Carbon	0.672**	0.136	0.183*	0.022	0.041	-0.140	-0.038	0.206*	0.043	0.197*	0.009
$CaCO_3$	0.069	0.206	0.483**	0.476**	0.338**	0.046	-0.191	0.112	-0.089	-0.034	0.387**

Total no. sample: 145

* Significant at 5% level: 0.164

** Significant at 1% level: 0.214

4.4 Fertility indices

Fertility indices of soils of Ajra tehsil for Organic carbon, available nitrogen, phosphorus and potassium were medium (1.7), low (1.3), medium (1.54) and low (1.1), respectively as per criteria (Rammoorthy and Bajaj, 1969). Singh et al. (2005) prepared district wise soil fertility maps by using the index values of nitrogen (N), phosphorus (P) and potassium (K).

5. SUMMARY AND CONCLUSION

The present study entitled “GPS-GIS based soil fertility maps of Ajra tehsil of Kolhapur district (M.S)” was conducted during the year 2015-16.

The survey was carried out in Ajra tehsil, Kolhapur district, Maharashtra. The latitude and longitude of sampling sites were recorded using Global Positioning System (GPS). One forty five surface soil samples were collected to delineate the sufficiency and deficiency areas of macro and micronutrients. The collected soil samples were analyzed by using standard analytical methods. The maps of available macro and micronutrients were prepared by using Arc GIS software. The results are summarized and the conclusions were drawn are put forth in this chapter.

5.1 Summary:

The soils of Ajra tehsil were found strongly acidic (31.03%), moderately acidic (51.72%), followed by slightly acidic (09.66%) and neutral (1.38%) to slightly alkaline (6.21%) in reaction and pH ranged from 4.71-7.52. The EC values of the soils were normal and range from 0.06-0.60 dS m^{-1}. The organic carbon content of soils were categorized as low (6.21%), moderate (18.62%), moderately high (21.38%), high (36.55%) and very high (17.24%) and ranged from 0.30-2.35 per cent. The soils were categorized as non calcareous (2.76%), barely calcareous (27.60%), slightly calcareous

(65.50%) and moderately calcareous (4.13%) and the percent $CaCo_3$ equivalent ranged from 0.26-2.8 per cent.

The majority of soils in Ajra tehsil were medium (64.14%) in respect of available nitrogen, whereas 35.86 per cent soils were low in available nitrogen and ranged from 175-401.4 Kg ha^{-1}. The available phosphorus content were low (28.28%) followed by medium (44.14%) and moderately high (18.62%) and high (8.96%) and ranged from 7.34-34.8 Kg ha^{-1}. The available potassium values were categorized as very low (9.66%), low (55.86%), moderate (28.27%) and moderately high (6.21%) and ranged from 78.87-236.80 Kg ha^{-1}.

The exchangeable calcium and magnesium were found to vary from 7.0 - 61.0 cmol(p+) Kg^{-1} and 0.50-32.0 cmol(p+) Kg^{-1} , respectively. Out of 145 soil samples 87.60 and 45.52 per cent soils were sufficient and 12.40 and 54.48 per cent soils were deficient in exchangeable calcium and magnesium, respectively.

The available Sulphur varied from 0.78-28.75 mg Kg^{-1}.The majority of soils were very low (68.96%) and low (17.93%) in respect of available sulphur content.

The DTPA extractable micronutrients viz Fe, Mn, Zn and Cu were sufficient howeve, Fe was deficient in two samples of Bhairewadi village.

Conclusion:

The soils of Ajra tehsil were strongly acidic to slightly alkaline in reaction, normal in salt content, low to very high in organic carbon and non calcareous to moderately calcareous in nature. Available nitrogen was low to medium, available phosphorus was low to high and available potassium content was very low to moderately high. Exchangeable calcium (87.58%) and magnesium (45.51%) were sufficient. Available Sulphur contents in soils were very low (68.96%) to low (17.93%). The DTPA extractable iron, zinc, manganese and copper were sufficient, except two samples of village Bhairewadi, where the iron was deficient. The pH was significantly and positively correlated with P, K and exchangeable Ca and Mg. The EC was significantly and positively correlated with DTPA extractable Fe. The organic carbon values were significantly correlated with available nitrogen, potassium and DTPA extractable Fe and Zn. Calcium carbonate was significantly correlated with available potassium, exchangeable Ca and Mg and DTPA extractable Cu.

The fertility indices of soils of Ajra tehsil for organic carbon, available nitrogen, phosphorus and potassium were medium, low, medium and low, respectively. The fertility of the tehsil can be improved with the adoption of proper cropping system, integrated nutrient management and suitable soil and water conservations majors.

6. LITERATURE CITED

Apel, H., Hung, N.G., Thoss, H. and Schone, T. 2011. GPS buoys for stage monitoring of large rivers. *J. Hydrol.* **40**: 182-192.

Anantwar, S.G., Babrekar, P.G., Bhaskar, B.P. and Challa, O. 2000. Variability in swell shrink potentials in two transects on basaltic plateau of Wardha District Maharashtra, *J. Indian Soc. Soil Sci.*, **48** (1):145-151.

Ardak, A.S., Nagaraju, M.S.S., Prasad, J., Srivastava, R. and Barthwal, A.K. 2010. Characterization and evaluation of land resources in Khapri village of Nagpur district, Maharashtra using high resolution satellite data and GIS. *Agropedology*, **20**(1):7-18.

Arnon, D.I., and Stout, P.R. 1939. Soil Fertility and Fertilizer Use.

Asadi, S.S., Azeem, S., Prasad, A.V.S. and Reddy, M.A. 2008. Analysis and mapping of soil quality in Khandaleru catchment area using remote sensing and GIS. *Current Science*, **95**(3):391-396.

Ashokkumar, H.P., and Prasad J.2010.Some typical sugarcane growing soils of Ahamednagar District of Maharashtra, Their Characterization and nutritional status of soil and plant. *J.Indian Soc.Soil Sci.*, **58** (3):257-266.

Balpande, H.S., Challa, O., andJagdish Prasad 2007. Characterization and classification of grape growing

soils of Nashik District Maharashtra. J.Indian Soc.Soil Sci., **55** (1):80-83.

Bangar, A.R. and Zende, G.K. 1978. Evaluation of soil test for Nitrogen. J. Maharashtra. Agric. Univ. 3 (1):58-59.

Bernhardsen, T. 1999. *Geographic Information Systems: An Introduction*. John Wiley and Sons, New York, USA, 614.

Bhalerao, V.P., and Pharande, A.L., 2003.Potassium behavior in salt affected swell-shrink soils; Form, fixation and release of potassium.*J.Maharashtra agric. Univ.*, **28** (1):17-21.

Bhattacharya, T., Deshmukh, S.N. and Roychaudhary, C. (1989). Soils and land use of Junnar tehsil, Pune district, Maharashtra. *J. Maharashtra agric. Univ.,* **14**(1): 1-4.

Bhattacharya, T., Mondal, C. and Deshmukh, S.N. 1992. Soil and land use pattern in part of Western Maharashtra. *J.Indian Soc. Soil Sci.,* **40**(3):513-520.

Binita, N.K., Dasog, G.S. and Patil, P.L. (2008). Soil fertility map in Ghataprabha left bank canal command area of North Karnataka by GIS technique. *Karnataka J. Agric. Sci.,* **22**(1): (73-76).

Bray, R. H. and Kurtz, L. T. 1945, Determination of total, Organic, and available forms of phosphorus in soils. *Soil Science*, **59**: 39-45.

Challa, O., Bhaskar, B.P., Anantwar, S.G. and Gaikwad, M.S. 2000. Characterization and Classification of some

problematic Vertisols in semi-arid ecosystem of Maharashatra plateau. *J. Indian Soc. Soil Sci.*, **48**(1):139 145.

Challa, O., Vadivelu, S. and Sehgal, J.L. 1995. Soils of Maharashtra: Their kinds, distribution, characterization and interpretation for optimizing land use chapter-5; Soil degradation status, NBSS, Publ. No. 54. *Soils of India Series*-**5**:51-52.

Chang, K. 2002. Introduction to Geographic Information Systems. *Tata Mc-Graw Hill Publishing Co.,* New Delhi, India, 348

Charles, V. P., Khalilian, A., Torres, O. and Katzberg, S. 2011. Utilizing space-based GPS Technology to Determine Hydrological Properties of Soils. *Remote Sensing Environ*. 115: 3582-3586.

Chaudhari, P.R., Ahire, D.V. and Vidya. 2013. Relationship among electrical conductivity, soil properties and available nutrients in the soil of north Maharashtra region. *J. Chemical, Biological and Physical Sciences.* **3**(1): 5-8.

Chavan, V.R., Shinde, Y.R., Singh,D.S.1980. Studied Zn,Mn,B and Mo distribution in soil profiles of Maharashtra, revealed that electrical conductivity was positively associated with Zn and Mn in soils.

Chinchmalatpure, A.R., Gowrisankar, D., Challa, O. and Sehgal, J. 1998. Soil site suitability of Micro-watershed

of Wunna catchment near Nagpur, *J. Indian Soc. Soil Sci.* **46** (4): 657-661.

Chinchmalatpure, A.R., Khandewal, M.K.and Rao, G.G. 2008. Characterization and classification of salt affected soils of Samni farm, Bharuch district, Gujarat, Agropedology, **18** (2):71-75.

Cholarajan, A. and Vijayakumar, R. 2013. Status of micronutrients in terrestrial soils of Thanjavur district, Tamilnadu, India. *E3 J. Argic Research and Development.* **3**(4): 59-63.

Choudhary, V.B.1994. Characterization and classification of soils of Andhra Pradesh M.Sc Thesis Agril .Univ. Hyderabad (India).

Clarke, K.C. 2001. Getting Started with Geographic Information Systems. Third edition. Upper Saddle River, NJ: *Prentice Hall,* USA, 512.

Das, D.K. 2004. *Introductory Soil Science*. Kalyani Publishers, Ludhiana, 493.

Deshmukh, K.K. 2012. Evaluation of soil fertility status from Sangamner area, Ahmednagar district, Maharashtra, India. *Rasayan J. Chem.,* **5**(3):398-406.

Deshmukh, V.N. and Rangacharya, R.P., 1992. Potassium supplying Power of soils of Western Vidarbha. Potassium Res., **8** (1):26-30.

Dhage, A.R., Kharche, V.K.and Shinde, P.B. 2005. Micronutrient Research in soil and plants, *MPKV Bulletins no.* **72**:18.

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

Durgude, A.G. 1999. Morphology, Characterization, Classification and Mapping of salt affected soils of central campus, research farms, MPKV. Rahuri. Ph.D. thesis submitted to MPKV. Rahuri (M.S.).India.

French, G. T. 1996. Understanding the GPS. *GeoResearch pub-lishers,* Woodmont Avenue, USA. 255.

Gabhane, V.V.Jadhao, V.O. and Nagdeve, M.B. 2006. Land evaluation for land use planning of micro watershed in Vidarbha region of Maharashtra J. Indian Soc. Soil Sci, 54(3): 307-315.

Haribhushan Athokpam, Shabir Hussain Wani, David Kamei, Herojit Singh Athokpam, Jyotsna Nongmaithem, Deepak kumar. And Lamalakshmi Devi. 2013. Soil macro and micro nutrient status of Senapati district, Manipur. *African.J. agric. Research.* **8**(39): 4932-4936.

Hasan, R. 2002. Potassium status of soils in India. *Better Crops Int.*, **16**(2).

ISSS [Indian Society of Soil Science]. 2007. *Fundamentals of soil science*. Indian Agricultural Research Institute, New Delhi, PP 545.

Indulkar, B.S., Shinde, Y.R. and Patil, S.R. 2007. Status of macro and micronutrients in some soils of Deoni tehsil of Latur district. Paper presented in state level seminar on soil health enhancement for food and environmental security, organized by PCISSS, at Marathwada Agril. Univ. Parbhani. Oct. 12 and 13, 2007:3.

Jackson, M.L. 1973. Soil Chemical Analysis. *Prentice Hall of India Pvt. Ltd.*, New Delhi, 256-260.

Jadhav, N.V., Jadhav, V.D. and Burbade, R.G. 2012. Preparation of soil fertility map of Babhaleshwar farm, Nashik, Maharashtra. *Asian Journal of Soil Science*. **7**: 72-75.

Jadhav, N.S., Malewar, G.V. and Varade, S.B., 1978. Vertical distribution of zinc and iron in some citrus growing soils of Marathwada, *J.of Maharashtra agric Univ*, 3 (2): 85-87.

Jadhav, R.D., 2014. A study of fertility status of soil in Kagal tehsil of Kolhapur district (Maharashtra): And micronutrient analysis. Submitted M.Sc thesis Agril.Univ. Rahuri. (Maharashtra)

Jagtap, V.R. 2007. Physio-chemical characteristics and status of N, P, K and some micronutrients in soils from Chakur and Shirur – anantpal Tehsils of Latur District.

M.Sc. (Agri) Thesis submitted to Marathwada Agriculture University, Parbhani, and (M.S) India.

Kadao, S.H., Prasad, J. and Gajbhiye, K.S., 2003. Characterization and classification of some typical banana growing soils of Wardha district of Maharashtra, Agropedology, **13** (2):28-34.

Kadu, P.P. 2009. A survey of fertility status of soils of Parola Tehsil of Jalgaon District. Paper presented in state level seminar on soil health enhancement for food and environmental security, organized by PCISSS, at Marathwada agril.Univ. Parbhani. Oct. 12&13, 2007 Abst.p.4

Kale, A.R., 2014. A study of fertility status of soil in Karveer tehsil of Kolhapur district (Maharashtra): And micronutrient analysis. Submitted M.Sc thesis Agril.Univ. Rahuri. (Maharashtra)

Kaleeswari, R.K. KAyalvizi and Krishnakumar.S 2012. An appraisal of physio-chemical properties and micronutrient status in Virudhnagar District of Tamilnadu using GIS technique. Madras Agric. Journal, 99(10-12): 689-692

Kanwar, J.S. 2004 in soil fertility- Theory and practical. Indian Council of Agriculture Research, New Delhi, 202.

Kashiwar, D.Y., Nagaraju, M.S.S., Srivastava, R., Prasad, J., Ramamurthy, V.and Barthwal, A.K., 2009. Characterization evaluation and management of Salai

watershed in Nagpur district of Maharashtra using remote sensing and GIS techniques, Agropedology, **19** (1) :15-23.

Katkar, R.N., 1994. Landform-soil relationship and its impact on cotton and sorghum production in Nagpur district. A case study, M.Sc. (Agri.) thesis PDKV, Akola.

Katkar, R.N. and Patil, D.B. 2010. Available micronutrient content in soils of Vidarbha. *Souvenir of state level seminar in Dept. of Soil Science and Agricultural Chemistry, Dr. PDKV, Akola* organized during Jan. 2-3, 2010. 161-166.

Koshal, A.K.2013.Cropping system and soil based analysis of south west Punjab area through remote sensing and GIS, Prog.Agric. 13 (1): 38-41.

Knudsen, D.A. and Peterson, G.A. 1982. Lithium, Sodium and Potassium, 225-246. In A. L. Page (Ed). Method soil analysis Agronomy monogram No. 9. *Am, Soc. Agron Incl. Soil Sci. Soc. Am. Publ.*, Madison, Wisconsin, USA.

Kumar, M. and Babel, A.L. 2011. Available micronutrient status and their relationship with soil properties of Jhunjhunu tehsil, Jhunjhunu district, Rajasthan. *J. Agricultural Science.* **7**(3): 97-106.

Lindsay, W. L. and Norvell, W. A. (1978). Development of DTPA soil test for Zn, Fe, Mn, and Cu. *Soil Science American Journal* – **42**:421-426.

Mahapatra, A.R. and Kibe, M.M., 1973.Effect of rainfall on the physico-chemical properties of the basaltic soils of Maharashtra state*, J.Indian Soc. Soil Sci.*, **60**(3):164-169.

Mandal, A.K. and Sharma, R.C. (2005). Computerized data base of salt-affected soils in peninsular India using geographic information system. *Journal of the Indian Society of Soil Science,* **58***(*1):105-116.

Mandal, A.K. and Sharma, R.C. (2005). Description and Characterization of typical soil monoliths from salt affected areas in Nagpur. *Journal of the Indian Society of Soil Science,* **60***(*1):299-303.

Minakshi, N.S., Tur, Nayyar, V.K., Sharma, P.K. and Sood, A.K. 2005. Spatial Distribution of micro nutrients in soils of Patiala District. A GIS Approach.*J. Indian Soc. Soil Sci.*, **53** (3):324-329.

Mishra, M.K. Srivastava, P.C.1991. Depth wise distribution of potassium in some soil profile of Garwal Himalayas. *J. Potassium Res.,* **7**(2):75-85.

More, S.D., Shinde, J.S. and Malewar, G.U. 1987. Studies on salt affected soils of Purna Command, *J. Maharashtra agric. Univ.,* **12**:145-146.

Nelson, D.W. and Sommer, L.E. (1982). Total carbon and organic matter. In methods of soil analysis, Part – 2, Page, A.L. (Ed.*) Am. Soc. Agron. Inc. Soil Sci. Soc. Am.* Inc. Madison, Wise. USA: 539-577.

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

Padole, V.R. and Mahajan, S.B. 2003. Status and release behavior of potassium in some swell-shrink soils of Vidarbha, Maharashtra. *J. Maharashtra agric. Univ.,* **28**(1): 3-7.

Page, A.L. (Ed). (1982). Methods of soil analysis Agronomy Monograph No-9. Pt.2. *American Soc. of Agron. Inc. Soil Sci Soc. of Amer. Inc. Publ.* Medison, Wisconsin, USA.

Palaniswami, C., Gopalasundaram, P. and Bhaskaran, A. 2011. Application of GPS and GIS in Sugarcane Agriculture. *Sugar Tech.* **13**(4): 360-365.

Pal, S.K. and Mukhopadhyay, A.K. 1992. Potassium status in some Inceptisol of West Bengal, *J. Indian Soc. Soil Sci.,* **40**(3)562-565.

Patil, C.H., Diwan, P.M., Chavan, A.S. and Dongale, J.H. 1987. Some Physical and Chemical Properties and Micronutrient Status of the bench terraced soils of Konkan. *J. Indian Soc. Soil Sci.,* **25**(3): 332-335.

Patil, K.D. and Meisheri, M.B. 2004. Mineralogical studies and DTPA extractable Zn, Cu, Mn and Fe in representative soils of Konkan region. *J. Maharashtra agric. Univ.,* **29**(1): 04-08.

Patil, V.D. and Mali, C.V. 1999. *Fundamental of soil science a text book.* Phoenix publication. Parbhani.109.

Patil, Y.M. and Sonar, K.R., 1994. Status of major and minor micronutrient of swell shrinks soils of Maharashtra. *J. Maharashtra agric. Univ.,* **19** (2):169-172.

Patil, S.S., Patil, V.C. and Al-Gaadi, K.A. (2011). Spatial Variability in Fertility Status of Surface Soils. *World Applied Sciences Journal* **14** (7): 1020-1024.

Panwar. Pal, S and Reza, S.K.2011.Communication in soil Science and plant analysis subtropical India 12/2011., 42 (22):2724-2737.

Pharande, A.L., Rasker, B.N. and Nipunage, M.U. 1996. Micronutrient status of important Vertisols and Alfisols soil series of Western Maharashtra. *J.Maharashtra Agric. Univ.* **21** (2): 182-185.

Piper, C. S.1966. Soil and plant analysis, *Hans publishers* Bombay, 135-136.

Prasad, A., Totey, N.G., Singh, A.K., Kulkarni, R., Khatri, P.K., Bhoumik, J.S., Chouhan and Dahia, V.K. 1989. Profile development in relation to topography. *J. Indian Soc. Soil Sci.,* **37**(4):790-797.

Pulkeshi, H.B.P., Patil, P.L, Dasog, G.S, Bidari, B. I. and Mansur, C.P. (2012). Mapping of nutrient status by geographic information system in Mantagani village under northen transition zone of Karnataka. *Karnataka J. Agric. Sci.,* **25**(3): 332-335.

Rammoorthy, B. and Bajaj, J.C., 1969. Available nitrogen, phosphorus and potassium status of Indian soils. *Fert. News,* **14**:25-36.

Ravikumar, P. and Somashekar, R.K. 2013. Evaluation of nutrient index using organic carbon, available phosphorus and available potassium concentrations as a measure of soil fertility in Varahi river basin, India. International Academy of Ecology and Environmental Sciences, **3**(4): 330-343.

Ravte, S.S.2008. Studied on status of available secondary nutrient and micronutrient anions in Ausa and Nilanga tehsils of Latur district. M.Sc. (Agri). Thesis submitted to Marathwada Agricultural University, Parbhani (MS) India.

Raychoudhari, S.P. and Chakravarty, S. 1943. Studies on Indian red soils. *J. Indian Agric. Sci.* 13: 252-254.

Ray, S. S. and Dadhwal, V. K. 2001. Estimation of crop evapotranspiration of irrigation command area using remote sensing and GIS. *Agricultural-Water-Management*. **49**(3), 239-249.

Reddy Kishor, R.K.G. 2002. Clay minerology of shrink swell soils of Pathardi Tahsil. M.Sc. Thesis. M.P.K.V., Rahuri.

Rudramurthy, H.V. and Dasog, G.S., 2001. Properties and genesis of associated red and black soils of North Karnataka. J. Indian Soc. Soil Sci., 49:301-309.

Sannappa, B. and Manjunath, K.G. 2013. Fertility status of soils in the selected regions of the Western Ghats of Karnataka, India. *Scholars Academic Journal of Bioscience*. **1**(5): 200-208.

Satyavathi, P.L.A. and Suryanarayan Reddy, M. 2004. Distribution of DTPA extractable micronutrients in soils of Telangana, Andhra Pradesh. *Agropedology*. **14**(1): 32-37.

Seghgal, J. 1996. *Pedology :* concept and applications, Kalyani publisher, New Delhi.p: 123-125

Sharma, P.K., Anil Sood, Setia, R.K., Tur, Mehra Deepak and

Harpinder Singh (2008) Mapping of micronutrient in soils of Amritsar District (Punjab) - A GIS approach *Journal of the Indian Society of Soil Science,* **56**(1): 34-41.

Sharma, R.P., Singh, M. and Sharma, J.P. 2003. Correlation studies on micronutrients vis-à-vis soil properties in some soils of Nagpur district in semi-arid region of Rajasthan. *J. Indian Soc. Soil Sci.,* 51(4): 522-527.

Sharma, V.K., Sharma, P.D., Sharma, S.P., Acharya, C.L. and Sood, R.K. 2004. Characterization of cultivated soils of Neogal watershed in North-West Himalayas and their suitability for Major crops. *J. Indian Soc. Soil. Sci.,* **52**(1): 63-68.

Shrinivasrao, C.H., Ganeshmurthy, A.N., Singh, R.N. and Masood Ali., 2005. Status and distribution of sulphur vis-à-vis Taxonomic class wise distribution of sulphur

in selected soil series of Inceptisol in West Bengal. *J. Indian Soc. Soil Sci.,* **54** (3): 368-371.

Singh, I.S. and Agrawal, H.P., 2005. Characterizing, genesis and classification of rice soils of western Maharashtra. Agropedology **15**, 29-38.

Singh, K.N., Abhishek Rathore., Tripathi, A.K., Subba Rao, A. and Salman Khan. 2009. *11th ESRI India user conference.* 1-11.

Singh, K.N., Raju, N.S., Subba Rao, A., Abhishek Rathore, Sanjay Srivastava, R.K., Samanta and Maji, A.K. 2005. Prescribing Optimum Doses of Nutrients for Target Yield through Soil Fertility Maps in Andhra Pradesh. *J. Ind. Soc. Agril. Statist.* **59**(2):131-140.

Singh, D.P. and Rathore, M.S. 2013. Available nutrient status and their relationship with soil properties of Aravalli mountain ranges and Malwa plateau of Pratapgarh, Rajasthan, India. African Journal of Agricultural Research. **8**(41): 5096-5103.

Singh, R. and Kundu, D .K. 2010. Physico-chemical and Hydraulic characteristics of soils of major sub group of Eastern India. J. Indian Soc. Soil Sci., **58** (3):267-278.

Sohan Lal, Deshpande, S.B. and Sehgal, J.L., 1994. Soil handbook 18, US. Govt. Printing office Washington, D.C.:139-140.

Srikanth, K.S., Patil, P.L., Dasog, G.S. and Gali, S.K. 2008. Mapping of available major nutrients of microwater –

shed in northern dry zone of Karnataka. *Karnataka J. Agric. Sci.,* **21**(3):391-395.

Subbiah, B. V. and Asija, G. L. (1956). A rapid procedure for estimation of available Nitrogen in soil. *Current Science* **25**:256-260.

Subha Rao, and Sekhon, G.S., 1991. Exchangeable potassium percentage as a measure of solution K in Vertisols and Vertic Ustocrepts .J. Indian Soc. Soil Sci.,39:432-450.

Surbhi H.K., 2014. A study of fertility status of soil in Shirol tehsil of Kolhapur district (Maharashtra): And micronutrient analysis. Submitted M.Sc thesis Agril.Univ. Rahuri. (Maharashtra)

Survase, M. N., Pore, V. and Pawar, C. T. 2011. A study of fertility status of soil and nutrients recommendations in Panchganga basin (Maharashtra): A micro level analysis. *Geography,* Vol. – I (V).

Tamgadge, D.B. 1997. Soils of Gadchiroli district of Maharashtra. *J.Maharashtra Agric. Univ.* **22**(1):1-4.

Thakre, Y.G., Choudhary, M.D. and Raut, R.D. 2013. Available micronutrient cation status of red soils in Wardha region. *J. Chemical and Pharmaceutical Research.* **5**(8): 64-68.

Thakur, D.S., Bapat, P.N., Dubey, D.D. and Gupta, G.P., 1999. Clay properties, mineral stability and mineralogy of Vertisols of Central India. *J. Indian Soc. Soil Sci.*, **47** (4):781-788.

Thombare, P.C, Surbhi, H.K, Jadhav, R.D., Patil, K.B., Kale, A.R. 2014. A study of fertility status of soil in Hatkanangle tehsil of Kolhapur district (Maharashtra): And micronutrient analysis. Submitted M.Sc thesis Agril.Univ. Rahuri. (Maharashtra).

Vedivelu, S., Sen, T. K., and Bhaskar, B.P.2001. Mapping available potassium in the soils of Assam. *Agropedology,* **12**:29-37.

Vijaya Kumar, R., Arokiaraj, A. and Martin Deva Prasath, P. 2011. Micronutrients and their relationship with soil properties of natural disaster proned coastal soils. *Res. J. Chem. Sci.* **1**(1): 8-12.

Verma, K.S., Saxena, R.K., Barthwal, A.K. and Deshmukh, S.N. 1994.Remote sensing technique for mapping salt affected soils.Int.J.Remote Sensing, 15:1901-1914.

Wajahat, N., Sajida, P. and Iftikhar, S. 2006. Status of micronutrients in soils of district Bhimber, Jammu and Kashmir. *J. Agricultural and Biological Science*.**1**: 35-40.

Watanabe, F.S. and Olsen, S.R. 1965. Test of ascorbic acid methods for phosphorus in water and Sodium bicarbonate extract of soil. Proc. Soil Sci. Am. 21: 677-678.

Williams and Steinberg's. (1959). Soil Sulphur fractions as chemical indices of available Sulphur in Australian soils. *Australian Journal of Agriculture Research* **10**:340-352.

7. APPENDIX - I

Table 10. Chemical properties and available nutrient status of soils of Ajra tehsil

Sample no.	GPS reading	pH (1:2.5)	EC dS m^{-1} (1:2.5)	$CaCO_3$ (%)	O.C (%)	Available nutrients (Kg ha^{-1})			Exchangeable Cations (cmol (p+) Kg^{-1})			Available nutrient (mg Kg^{-1})	DTPA extractable micronutrients (mg Kg^{-1})			
						N	P	K	Ca	Mg	Na	S	Zn	Fe	Mn	Cu
Sulgaon																
1	E 16^0 07' 26.3" N 74^0 12' 50.5"	5.33	0.52	0.91	0.85	313.60	19.19	107.56	35.50	1.50	0.52	18.90	1.80	37.90	26.84	1.36
2	E 16^0 07' 38.8" N 74^0 12' 37.8"	5.94	0.16	0.65	0.93	319.87	15.84	115.45	31.50	0.50	0.30	2.34	1.46	40.66	23.28	1.26
Masuli																
3	E 16^0 06' 51.0" N 74^0 11' 1.3"	5.35	0.24	0.78	0.72	326.14	15.71	109.32	33.50	1.00	0.82	3.28	1.10	11.68	28.30	1.94
4	E 16^0 06' 40.9" N 74^0 10' 48.9"	5.65	0.17	0.52	1.24	401.40	23.44	115.30	35.00	5.00	0.56	22.65	1.36	20.22	27.94	1.96
5	E 16^0 06' 29.2" N 74^0 10' 32.9"	5.85	0.13	0.91	0.69	250.88	11.07	120.09	26.50	11.00	0.91	19.21	1.94	28.62	27.40	2.08
Velwatti																
6	E 16^0 06' 50.3" N 74^0 10' 20.8"	5.83	0.10	1.04	0.88	310.46	13.78	125.67	27.50	14.50	0.39	5.78	1.40	21.94	26.36	2.80
7	E 16^0 07' 2.4" N 74^0 09' 54.7"	5.25	0.20	0.91	0.87	301.05	11.20	106.44	35.50	1.00	0.65	2.65	1.00	18.22	26.02	1.24
Haloli																
8	E 16^0 06' 57.3" N 74^0 09' 23.8"	5.33	0.51	0.65	0.69	260.28	12.36	105.23	20.00	8.50	0.47	5.46	1.50	8.38	18.54	0.60
9	E 16^0 06' 55.3" N 74^0 09' 15.4"	5.60	0.11	0.52	0.66	263.43	12.62	112.45	20.50	6.00	0.79	3.43	1.16	23.62	27.64	1.18

Table 10. Chemical properties and available nutrient status of soils of Ajra tehsil

Sample no.	GPS reading	pH (1:2.5)	EC dS m^{-1} (1:2.5)	$CaCO_3$ (%)	O.C (%)	Available nutrients (Kg ha^{-1})			Exchangeable Cations (cmol (p+) Kg^{-1})			Available nutrient (mg Kg^{-1})	DTPA extractable micronutrients (mg Kg^{-1})			
						N	P	K	Ca	Mg	Na	S	Zn	Fe	Mn	Cu
Devarde																
10	E 16^0 07' 22.8" N 74^0 01' 30.2"	6.33	0.18	0.91	0.84	310.46	34.49	130.00	27.50	3.50	1.00	5.15	1.30	11.30	25.96	1.44
11	E 16^0 07' 32.0" N 74^0 09' 43.3"	5.15	0.14	0.78	0.60	257.15	14.03	100.89	18.50	13.00	0.82	4.53	0.80	10.36	24.72	0.86
Gavase																
12	E 16^0 07' 11.8" N 74^0 08' 49.2"	6.27	0.13	1.04	0.64	266.56	33.86	128.00	41.00	15.50	0.26	15.46	1.32	22.06	25.38	1.96
13	E 16^0 06' 01.4" N 74^0 07' 25.6"	5.62	0.08	0.52	0.48	175.61	19.19	116.00	21.50	13.50	0.73	9.21	1.70	32.56	29.16	1.06
14	E 16^0 05' 44.5" N 74^0 07' 14.6"	5.11	0.13	0.65	0.51	294.78	15.97	90.67	21.00	7.00	1.00	11.56	0.84	18.54	22.44	0.54
Suleran																
15	E 16^0 04' 46.0" N 74^0 05' 58.1"	5.45	0.07	0.78	0.66	250.88	15.71	107.44	14.00	10.50	1.13	6.09	0.96	32.96	22.04	0.76
16	E 16^0 04' 46.6" N 74^0 06' 15.5"	5.56	0.19	0.52	0.60	263.42	17.38	109.89	22.50	7.00	0.30	3.75	1.38	35.18	24.28	1.92
Dhangarmala																
17	E 16^0 04' 13.8" N 74^0 05' 33.9"	5.24	0.10	0.96	0.45	232.06	11.33	106.11	21.50	9.50	0.56	4.37	0.96	19.10	17.52	0.68
18	E 16^0 03' 56.6" N 74^0 05' 13.5"	5.33	0.11	0.65	0.36	203.84	13.78	114.00	13.00	13.50	0.82	22.81	1.10	22.26	25.90	0.50
Ghatkarwadi																
19	E 16^0 03' 15.4" N 74^0 04' 24.2"	4.81	0.60	0.26	0.40	244.60	18.28	78.87	14.00	6.50	0.26	4.21	1.08	32.38	15.04	0.68
20	E 16^0 03'13.2" N 74^0 04' 7.6"	4.88	0.17	0.39	0.37	219.52	13.78	90.76	13.50	11.00	1.04	4.37	1.52	20.66	24.36	0.64

Table 10. Chemical properties and available nutrient status of soils of Ajra tehsil

Sample no.	GPS reading	pH (1:2.5)	EC dS m^{-1} (1:2.5)	$CaCO_3$ (%)	O.C (%)	Available nutrients (Kg ha^{-1})			Exchangeable Cations (cmol (p+) Kg^{-1})			Available nutrient (mg Kg^{-1})	DTPA extractable micronutrients (mg Kg^{-1})			
						N	P	K	Ca	Mg	Na	S	Zn	Fe	Mn	Cu
Kittawade																
21	E 16^0 03' 19.5" N 74^0 04' 1.5"	6.06	0.11	1.04	0.57	263.42	26.96	128.34	15.00	5.50	0.56	7.65	1.04	22.54	25.84	0.64
22	E 16^0 03' 38..0" N 74^0 02' 40.5"	5.35	0.15	0.52	0.54	257.15	12.23	105.34	19.50	9.50	0.82	2.96	1.06	33.80	27.38	0.60
Lingwadi																
23	E 16^0 03' 43.5" N 74^0 03' 38.7"	5.12	0.29	0.65	0.48	175.00	16.61	98.43	16.50	3.50	0.69	15.31	0.88	20.38	28.62	0.56
24	E 16^0 03' 22.2" N 74^0 03' 48.0"	5.34	0.08	0.78	0.51	294.78	15.97	107.43	11.50	12.00	0.65	12.65	1.36	19.84	18.70	0.40
Ambadi																
25	E 16^0 03' 27.5" N 74^0 04' 3.3"	5.09	0.10	0.65	0.30	203.84	10.17	97.67	18.00	3.00	1.00	2.50	0.88	28.10	26.96	1.24
26	E 16^0 03' 45.8" N 74^0 04' 12.4"	5.15	0.09	0.52	0.63	285.36	9.78	136.78	29.00	2.50	0.26	1.25	0.88	27.20	26.40	0.40
27	E 16^0 06' 20.8" N 74^0 07' 11.5"	5.24	0.13	0.96	0.60	272.83	13.00	126.34	13.00	3.00	1.10	14.21	0.86	28.66	24.08	0.52
Shelap																
28	E 16^0 06' 27.8'' N 74^0 06' 39.7''	5.31	0.12	0.78	0.87	323.00	14.16	145.09	14.50	2.50	0.78	6.25	1.08	30.36	23.38	0.86
29	E 16^0 06' 42.3'' N 74^0 06' 15.4''	4.71	0.17	0.26	0.84	313.60	17.38	103.47	15.50	1.00	0.39	1.87	0.90	27.72	28.72	0.98
30	E 16^0 06' 11.5'' N 74^0 06' 7.5''	5.16	0.12	0.65	0.94	329.28	16.22	126.00	20.00	0.50	0.69	21.25	1.14	22.36	25.06	0.76
Khedage																
31	E 16^0 05' 52.8'' N 74^0 06' 4''	5.37	0.10	0.91	0.64	319.87	12.23	120.00	15.00	4.00	0.82	1.25	0.80	32.58	23.98	1.20

Table 10. Chemical properties and available nutrient status of soils of Ajra tehsil

Sample no.	GPS reading	pH (1:2.5)	EC dS m^{-1} (1:2.5)	$CaCO_3$ (%)	O.C (%)	Available nutrients (Kg ha^{-1})			Exchangeable Cations (cmol (p+) Kg^{-1})			Available nutrient (mg Kg^{-1})	DTPA extractable micronutrients (mg Kg^{-1})			
						N	P	K	Ca	Mg	Na	S	Zn	Fe	Mn	Cu
Dabhil																
32	E 16^0 06′ 54.7″ N 74^0 06′ 42.2″	5.00	0.09	0.65	0.67	307.32	13.91	117.54	13.50	3.50	0.95	8.12	0.82	27.60	17.10	0.40
33	E 16^0 07′ 17.7″ N 74^0 06′ 38.6″	5.62	0.10	1.04	0.85	338.68	15.71	124.03	17.50	4.00	0.91	4.53	1.52	20.34	22.22	0.52
34	E 16^0 07′ 31.0″ N 74^0 06′ 20.3″	6.33	0.08	1.43	0.87	307.32	31.67	143.32	29.50	8.50	0.69	2.50	0.74	41.50	25.88	0.44
Medewadi																
35	E 16^0 07′ 16.6″ N 74^0 07′ 8.7″	5.43	0.08	1.17	0.33	203.84	13.78	114.00	19.00	11.00	0.47	1.87	1.22	19.86	26.60	0.38
36	E 16^0 07′ 35.5″ N 74^0 07′ 24.6″	5.08	0.08	0.78	0.87	323.00	14.42	106.11	13.00	7.00	0.26	2.34	0.82	41.20	25.18	0.72
37	E 16^0 07′ 28.1″ N 74^0 07′ 52.0″	5.50	0.12	1.75	0.48	250.88	14.03	100.32	13.50	2.50	0.39	2.65	1.08	35.94	25.60	0.64
Madhyal																
38	E 16^0 07′ 26.1″ N 74^0 08′ 30.3″	5.65	0.10	1.43	0.57	263.42	16.10	104.23	54.00	3.00	0.56	3.12	1.68	36.84	27.28	1.48
Salgaon																
39	E 16^0 08′ 4.0″ N 74^0 11′ 40.9″	5.04	0.39	1.43	0.66	313.60	20.09	99.00	23.50	11.00	0.91	2.81	1.16	28.38	27.42	1.46
40	E 16^0 08′ 26.8″ N 74^0 11′ 17.9″	5.67	0.07	1.75	0.87	319.87	23.31	175.67	29.00	3.00	0.34	4.21	0.98	28.32	26.82	1.66
Pernoli																
41	E 16^0 08′ 50.8″ N 74^0 10′ 49.9″	5.30	0.08	1.56	0.66	326.14	16.35	125.34	30.00	4.50	0.60	2.50	1.08	24.26	25.78	1.80
42	E 16^0 08′ 57.5″ N 74^0 10′ 34.0″	5.60	0.07	1.63	0.60	250.88	17.25	133.76	21.00	15.50	0.39	3.75	1.40	29.54	27.04	1.92
43	E 16^0 08′ 59.5″ N 74^0 10′ 36.0″	5.62	0.14	1.75	0.54	257.15	18.93	165.00	16.50	9.50	0.73	1.09	1.04	33.36	27.38	2.24

Table 10. Chemical properties and available nutrient status of soils of Ajra tehsil

Sample no.	GPS reading	pH (1:2.5)	EC dS m^{-1} (1:2.5)	$CaCO_3$ (%)	O.C (%)	Available nutrients (Kg ha^{-1})			Exchangeable Cations (cmol (p+) Kg^{-1})			Available nutrient (mg Kg^{-1})	DTPA extractable micronutrients (mg Kg^{-1})			
						N	P	K	Ca	Mg	Na	S	Zn	Fe	Mn	Cu
Harpawade																
44	E 16^0 08' 44.4'' N 74^0 09' 29.8''	5.20	0.07	1.17	0.75	260.28	13.49	175.07	18.50	10.00	0.82	0.93	1.32	32.58	27.60	1.54
45	E 16^0 08' 56.3'' N 74^0 09' 20.5''	4.90	0.08	0.26	0.69	213.24	13.26	87.00	17.50	6.50	0.95	0.78	1.68	41.68	27.90	2.34
Koriwade																
46	E 16^0 08' 55.2'' N 74^0 08' 49.6''	6.20	0.06	1.95	0.88	313.60	31.04	155.00	19.00	12.50	0.34	2.18	1.14	38.78	27.78	2.88
47	E 16^0 08' 45.8'' N 74^0 08' 30.4''	5.46	0.10	1.43	0.84	301.05	10.04	109.34	24.00	11.50	0.60	2.81	0.82	31.56	27.36	1.88
Devkandgaon																
48	E 16^0 08' 40.5" N 74^0 08' 12.5"	6.50	0.06	1.56	0.87	326.14	12.54	115.73	17.50	14.00	0.78	2.18	1.20	17.56	15.44	0.92
49	E 16^0 08' 43.5" N 74^0 08' 13.1"	6.25	0.15	1.75	0.33	181.88	31.67	145.00	18.50	6.50	0.91	4.21	0.80	35.54	24.58	2.56
Vajare																
50	E 16^0 09' 34.7" N 74^0 10' 29.7"	6.01	0.07	1.63	0.36	197.56	11.28	100.05	14.00	5.00	0.56	3.12	1.06	6.04	16.62	0.44
51	E 16^0 10' 30.9" N 74^0 10' 52.6"	5.53	0.08	1.17	0.96	219.42	14.29	147.00	16.50	4.50	0.30	2.50	1.22	23.32	29.02	1.44
52	E 16^0 10' 58.9" N 74^0 11' 24.7"	5.63	0.12	1.04	1.18	338.68	14.81	187.00	19.50	7.00	0.69	3.28	1.00	24.66	28.34	1.84
53	E 16^0 11' 8.0" N 74^0 11' 40.8"	5.54	0.07	1.17	0.85	348.09	19.19	176.00	24.00	4.50	0.78	3.12	1.50	26.00	26.52	0.68
Mahagond																
54	E 16^0 11' 35.6" N 74^0 12' 28.7"	5.88	0.14	1.30	0.78	332.40	15.06	165.98	25.00	13.00	0.47	2.96	1.90	33.42	27.38	2.40
55	E 16^0 11' 58.1" N 74^0 12' 52.6"	5.83	0.12	1.43	0.69	304.19	16.35	168.25	17.00	10.50	0.56	28.75	1.86	28.04	29.54	3.28
56	E 16^0 11' 53.9" N 74^0 13' 9"	5.06	0.15	1.17	1.36	344.96	15.97	145.22	19.50	15.50	0.82	6.40	1.68	38.14	30.58	2.18

Table 10. Chemical properties and available nutrient status of soils of Ajra tehsil

Sample no.	GPS reading	pH (1:2.5)	EC dS m^{-1} (1:2.5)	$CaCO_3$ (%)	O.C (%)	Available nutrients (Kg ha^{-1})			Exchangeable Cations (cmol (p+) Kg^{-1})			Available nutrient (mg Kg^{-1})	DTPA extractable micronutrients (mg Kg^{-1})			
						N	P	K	Ca	Mg	Na	S	Zn	Fe	Mn	Cu
Vadakshivalay																
57	E 16^0 11' 41.4" N 74^0 13' 5.6"	6.62	0.10	1.56	1.02	338.68	11.60	201.00	29.50	12.00	1.04	2.18	1.26	38.74	25.32	1.70
58	E 16^0 11' 43.1" N 74^0 13' 13.5"	6.64	0.09	1.56	0.51	257.15	31.98	212.00	22.50	18.50	0.60	1.25	1.42	39.82	25.78	2.56
Halewadi																
59	E 16^0 12' 1.11" N 74^0 13' 41.9"	6.35	0.08	1.43	0.36	188.16	14.42	143.67	32.00	14.50	0.56	4.06	1.16	39.00	26.32	2.12
60	E 16^0 11' 58.5" N 74^0 14' 17.9"	6.81	0.06	2.08	0.57	241.47	33.24	224.65	36.00	14.50	0.82	3.12	1.42	35.24	22.24	1.24
Gajargaon																
61	E 16^0 09' 2.3" N 74^0 18' 59.9"	5.76	0.07	0.91	0.60	272.83	16.22	165.90	19.50	3.00	1.04	4.37	1.80	47.08	25.04	0.48
62	E 16^0 08' 41.3" N 74^0 18' 48.4"	6.13	0.19	0.78	0.66	307.32	34.80	118.04	17.50	20.50	1.17	5.46	1.76	45.08	24.00	1.54
Harur																
63	E 16^0 08' 15.6" N 74^0 18' 45.3"	6.06	0.09	1.17	0.57	238.33	26.65	170.07	8.00	8.00	0.95	6.25	1.32	15.94	20.72	0.18
64	E 16^0 08' 18.6" N 74^0 18' 32.6"	5.20	0.11	1.43	0.49	219.52	14.68	175.57	30.50	6.00	0.86	3.59	1.50	49.02	26.48	1.82
65	E 16^0 08' 17.4" N 74^0 18' 37.5"	5.93	0.06	0.65	0.76	307.32	15.71	167.00	17.00	6.50	0.30	2.96	1.94	30.00	27.32	0.72
Sarbalwadi																
66	E 16^0 07' 53.1" N 74^0 18' 31.7"	6.82	0.24	1.04	1.38	319.87	25.08	209.67	20.50	4.50	0.82	0.93	1.22	22.06	21.52	0.44
67	E 16^0 07' 36.6" N 74^0 18' 31.2"	7.22	0.29	1.56	0.63	266.56	26.96	236.80	46.00	0.50	0.52	2.34	0.82	25.28	17.74	0.96
68	E 16^0 07' 31.2" N 74^0 18' 15.0"	6.61	0.08	1.17	1.21	332.40	24.46	208.65	30.00	13.50	1.13	2.65	2.36	38.12	16.22	0.84
69	E 16^0 07' 7.4" N 74^0 17' 51.3"	6.80	0.23	1.95	1.39	338.68	25.40	226.78	34.00	17.00	0.47	7.96	1.16	26.20	22.98	1.62

Table 10. Chemical properties and available nutrient status of soils of Ajra tehsil

Sample no.	GPS reading	pH (1:2.5)	EC dS m^{-1} (1:2.5)	$CaCO_3$ (%)	O.C (%)	Available nutrients (Kg ha^{-1})			Exchangeable Cations (cmol (p+) Kg^{-1})			Available nutrient (mg Kg^{-1})	DTPA extractable micronutrients (mg Kg^{-1})			
						N	P	K	Ca	Mg	Na	S	Zn	Fe	Mn	Cu
Maligre																
70	E 16^0 07' 4.0" N 74^0 17' 25.9"	6.49	0.12	1.04	1.00	326.14	29.47	178.98	26.00	14.50	0.65	8.75	1.68	30.98	23.02	1.26
71	E 16^0 07' 40.4" N 74^0 17' 07.7"	6.46	0.07	1.69	1.68	335.55	33.24	156.98	32.50	19.00	1.04	10.00	1.60	33.52	26.32	1.70
Kovade																
72	E 16^0 08' 25.8" N 74^0 16' 59.3"	6.65	0.08	2.08	1.03	323.00	27.59	225.34	36.50	19.00	0.30	10.31	1.44	29.78	24.80	1.50
73	E 16^0 08' 45.4" N 74^0 17' 2.9"	5.64	0.07	1.43	0.94	313.60	16.48	187.08	30.50	2.00	0.60	4.06	1.98	25.36	27.50	1.94
74	E 16^0 08' 44.3" N 74^0 17' 4"	5.62	0.12	0.52	0.69	250.88	13.78	115.76	13.50	1.50	0.73	4.68	1.56	30.08	27.66	0.90
75	E 16^0 09' 18.7" N 74^0 16' 32.7"	5.70	0.23	1.04	1.23	319.87	15.45	145.98	27.00	14.50	0.78	6.71	2.16	41.20	24.80	1.30
76	E 16^0 09' 13.2" N 74^0 16' 5.5"	7.37	0.22	1.95	1.14	326.14	26.02	178.98	21.00	11.50	0.91	2.50	1.80	21.38	20.92	0.40
Pedrewadi																
77	E 16^0 09' 2.5" N 74^0 15' 36.4"	5.23	0.08	0.78	0.96	323.00	11.20	165.90	7.00	8.50	0.39	2.81	1.34	51.36	11.44	2.02
78	E 16^0 08' 59.4" N 74^0 15' 20.1"	4.98	0.15	0.65	0.79	335.55	23.44	99.67	9.50	4.50	0.56	5.00	1.40	53.80	25.04	0.50
Hajgdi																
79	E 16^0 08' 43.1" N 74^0 14' 32.8"	5.85	0.07	0.91	0.58	250.88	7.34	165.78	16.00	6.50	0.60	1.71	0.96	19.18	24.96	0.76
Khedge																
80	E 16^0 08' 45.3" N 74^0 14' 10.6"	5.88	0.08	1.17	0.67	288.51	15.71	134.65	19.00	2.00	0.69	2.65	1.08	27.48	22.46	0.24
81	E 16^0 08' 39.7" N 74^0 13' 26.6"	5.21	0.28	0.78	1.06	348.09	17.25	145.87	14.50	10.00	0.34	2.81	1.90	34.32	25.94	0.64
82	E 16^0 08' 55.0" N 74^0 13' 18.6"	5.77	0.14	1.69	1.26	313.60	17.77	134.67	32.00	13.50	0.47	2.18	1.36	44.48	27.76	2.12

Table 10. Chemical properties and available nutrient status of soils of Ajra tehsil

Sample no.	GPS reading	pH (1:2.5)	EC dS m^{-1} (1:2.5)	$CaCO_3$ (%)	O.C (%)	Available nutrients (Kg ha^{-1})			Exchangeable Cations (cmol (p+) Kg^{-1})			Available nutrient (mg Kg^{-1})	DTPA extractable micronutrients (mg Kg^{-1})			
						N	P	K	Ca	Mg	Na	S	Zn	Fe	Mn	Cu
Ajara																
83	E 16^0 06' 41.5" N 74^0 12' 47.9"	6.02	0.18	1.17	0.96	307.32	33.86	145.76	26.00	7.50	0.39	3.75	1.66	35.92	25.10	1.24
84	E 16^0 06' 35.9" N 74^0 12' 53.1"	6.16	0.20	1.43	1.03	319.87	25.08	137.98	25.00	5.50	0.91	6.40	1.18	32.36	27.52	1.92
Burude																
85	E 16^0 06' 26.6" N 74^0 13' 3.5"	5.91	0.13	1.95	0.63	326.14	16.48	134.98	21.50	14.00	1.00	1.09	2.48	29.62	23.12	1.10
86	E 16^0 06' 36.7" N 74^0 13' 42.3"	5.81	0.11	0.78	1.39	351.23	11.20	145.98	29.00	9.00	0.73	15.78	0.96	30.94	28.98	1.98
Hanewadi																
87	E 16^0 07' 5.7" N 74^0 14' 11.11"	5.78	0.25	1.04	0.88	310.46	11.59	123.76	26.00	10.00	0.52	7.96	2.68	10.28	17.24	0.50
Mendholi																
88	E 16^0 07' 1.2" N 74^0 13' 55.2"	5.66	0.11	0.65	1.02	326.14	22.41	143.54	18.50	9.00	0.82	2.50	1.50	32.60	22.64	1.54
89	E 16^0 06' 31.5" N 74^0 14' 11.6"	6.33	0.36	1.43	1.32	332.41	30.73	100.89	29.50	15.50	0.30	2.96	1.22	35.08	25.98	1.54
Murude																
90	E 16^0 06' 9.7" N 74^0 12' 44.6"	5.29	0.44	1.30	1.17	316.73	16.10	143.87	20.00	10.00	0.47	2.34	4.22	21.54	28.24	0.92
Kasar kandgaon																
91	E 16^0 04' 58.2" N 74^0 12' 25.3"	5.21	0.14	1.43	1.24	323.00	21.89	135.87	20.00	10.00	0.52	5.78	1.16	23.64	31.24	2.16
92	E 16^0 04' 58.2" N 74^0 12' 26.8"	4.82	0.12	0.91	0.96	307.00	21.38	125.87	14.00	3.50	0.43	5.15	1.08	14.04	28.00	0.92

Table 10. Chemical properties and available nutrient status of soils of Ajra tehsil

Sample no.	GPS reading	pH (1:2.5)	EC dS m^{-1} (1:2.5)	$CaCO_3$ (%)	O.C (%)	Available nutrients (Kg ha^{-1})			Exchangeable Cations (cmol (p+) Kg^{-1})			Available nutrient (mg Kg^{-1})	DTPA extractable micronutrients (mg Kg^{-1})			
						N	P	K	Ca	Mg	Na	S	Zn	Fe	Mn	Cu
Jeur																
93	E 16^0 03' 21.9" N 74^0 12' 29.0"	4.92	0.26	1.43	1.35	338.68	9.78	134.76	15.50	4.50	0.39	4.37	2.30	21.50	28.06	0.14
Chitale																
94	E 16^0 03' 2.6" N 74^0 12' 42.5"	5.73	0.09	2.08	1.83	344.96	22.15	143.74	21.00	9.00	0.52	4.06	0.94	34.24	27.78	0.60
95	E 16^0 02' 34.0" N 74^0 12' 29.3"	5.63	0.08	1.43	0.94	307.32	22.41	153.76	18.50	4.00	0.82	3.75	1.74	5.14	14.40	0.08
Bahirevadi																
96	E 16^0 02' 20.9" N 74^0 12' 36.3"	5.56	0.27	1.30	2.35	357.50	12.62	125.66	20.00	2.00	0.39	3.28	1.02	31.98	27.14	0.28
97	E 16^0 02' 17.0" N 74^0 12' 20.3"	5.72	0.12	1.56	1.84	323.00	12.88	129.67	16.00	12.00	0.78	2.18	1.04	10.34	23.00	0.32
Kine																
98	E 16^0 04' 33.8" N 74^0 18' 17.1"	6.12	0.09	1.95	1.24	344.96	20.69	165.00	25.50	14.50	0.56	1.87	1.10	16.30	22.54	0.24
99	E 16^0 04' 41.3" N 74^0 17' 53.6"	6.01	0.08	1.30	1.11	326.14	17.87	154.76	31.50	5.50	0.73	2.03	1.54	20.24	24.38	0.32
100	E 16^0 04' 52.1" N 74^0 17' 41.1"	6.19	0.09	1.04	0.96	338.68	25.71	134.87	21.00	16.00	0.82	2.50	2.38	26.96	26.30	0.62
101	E 16^0 05' 14.7" N 74^0 17' 16.1"	5.75	0.16	1.69	1.93	257.15	15.84	128.76	19.00	16.00	0.39	2.89	3.44	21.64	29.56	0.42
Shirsange																
102	E 16^0 05' 24.3" N 74^0 16' 38.6"	5.98	0.13	1.43	1.24	348.09	14.03	126.98	34.50	6.50	0.69	3.12	1.48	30.50	29.10	2.16
103	E 16^0 05' 10.8" N 74^0 16' 33.5"	5.56	0.45	1.17	1.08	326.14	18.67	124.00	36.00	10.00	0.91	2.96	1.48	30.04	29.54	1.18

Table 10. Chemical properties and available nutrient status of soils of Ajra tehsil

Sample no.	GPS reading	pH (1:2.5)	EC dS m^{-1} (1:2.5)	$CaCO_3$ (%)	O.C (%)	Available nutrients (Kg ha^{-1})			Exchangeable Cations (cmol (p+) Kg^{-1})			Available nutrient (mg Kg^{-1})	DTPA extractable micronutrients (mg Kg^{-1})			
						N	P	K	Ca	Mg	Na	S	Zn	Fe	Mn	Cu
Vatangi																
104	E 16^0 04' 56.2" N 74^0 16' 17.3"	5.87	0.11	1.82	1.41	376.32	18.03	135.00	29.00	3.50	0.52	1.71	0.98	21.30	28.18	0.42
105	E 16^0 04' 48.6" N 74^0 16' 7.6"	6.04	0.18	1.04	0.85	341.82	10.66	123.00	13.50	20.00	0.34	2.18	1.20	20.42	23.56	2.14
Kine																
106	E 16^0 05' 18.4" N 74^0 17' 32.2"	5.10	0.13	0.91	0.72	307.32	17.77	176.00	30.50	14.50	0.60	2.65	1.50	28.06	27.56	0.94
Kolindre																
107	E 16^0 05' 19.9" N 74^0 14' 8.9"	5.60	0.09	1.56	1.02	338.68	17.51	137.00	16.00	20.00	0.73	2.03	0.96	42.98	25.80	2.46
108	E 16^0 05' 43.5" N 74^0 18' 56.7"	5.63	0.12	0.78	1.06	357.50	18.54	157.78	20.50	0.50	0.56	2.34	1.96	12.12	22.66	1.00
Sule																
109	E 16^0 06' 19.1" N 74^0 19' 0.05"	6.05	0.08	2.08	0.61	272.83	10.03	123.67	19.00	24.00	0.91	2.65	1.46	20.12	28.48	2.84
110	E 16^0 06' 40.2" N 74^0 19' 7.5"	6.42	0.10	1.95	0.42	247.74	11.91	145.65	37.00	19.00	1.13	2.50	1.98	15.40	22.60	1.42
111	E 16^0 07' 13.7" N 74^0 19' 41.5"	6.36	0.27	1.17	1.09	307.32	15.05	143.65	40.00	28.00	0.78	2.34	1.30	20.60	13.04	2.38
Lakudwadi																
112	E 16^0 06' 55.0" N 74^0 26' 21.3"	6.69	0.06	1.69	0.93	282.24	15.99	176.34	57.50	14.00	0.26	2.18	1.18	15.56	22.58	1.82
113	E 16^0 06' 55.0" N 74^0 26' 29.0"	7.21	0.14	1.82	1.05	307.32	17.56	187.34	61.00	5.50	0.52	1.56	1.16	9.50	11.38	1.70
Bhairewadi																
114	E 16^0 16' 56.2" N 74^0 19' 10.7"	7.06	0.09	2.08	0.93	279.10	13.79	198.03	34.50	32.00	0.69	2.50	1.16	0.82	23.04	2.30
115	E 16^0 16' 23.3" N 74^0 18' 26.1"	7.28	0.10	2.08	0.69	197.56	10.03	175.34	50.00	14.00	0.56	2.89	1.38	0.34	24.14	2.28
116	E 16^0 16' 10.0" N 74^0 17' 47.16"	6.55	0.10	1.95	0.48	247.74	10.97	173.23	56.50	6.50	0.91	3.12	1.74	5.12	18.80	2.18

Table 10. Chemical properties and available nutrient status of soils of Ajra tehsil

Sample no.	GPS reading	pH (1:2.5)	EC dS m^{-1} (1:2.5)	$CaCO_3$ (%)	O.C (%)	Available nutrients (Kg ha^{-1})			Exchangeable Cations (cmol (p+) Kg^{-1})			Available nutrient (mg Kg^{-1})	DTPA extractable micronutrients (mg Kg^{-1})			
						N	P	K	Ca	Mg	Na	S	Zn	Fe	Mn	Cu
Momewadi																
117	E 16^0 15' 22.1" N 74^0 14' 7"	6.81	0.12	1.43	1.17	326.14	11.60	177.50	49.00	6.50	1.04	3.75	1.44	40.22	28.38	5.06
118	E $16^0$15' 6.6" N 74^0 17' 21.0"	7.25	0.28	1.82	0.66	250.88	14.42	167.98	41.50	21.50	0.52	2.65	1.56	24.50	25.64	3.14
Uttur																
119	E 16^0 15' 3.8" N 74^0 16' 28.6"	7.02	0.16	1.04	0.73	288.51	20.38	206.56	54.00	4.50	0.69	3.12	1.14	29.12	16.96	1.46
120	E 16^0 14' 26.8" N 74^0 15' 55.1"	6.01	0.11	1.43	0.93	310.46	21.32	176.96	34.50	30.50	0.82	7.34	1.94	44.06	26.86	1.82
121	E 16^0 14' 2.9" N 74^0 15' 40.7"	6.59	0.14	1.82	1.26	326.14	23.20	200.09	49.00	7.50	0.60	10.62	1.22	19.24	28.10	4.14
Pendharwadi																
122	E 16^0 13' 23.7" N 74^0 15' 43.6"	6.48	0.08	1.17	1.09	307.32	21.95	89.98	43.50	3.00	0.95	10.15	3.24	33.58	25.12	2.10
Ardal																
123	E 16^0 12' 48.5" N 74^0 15' 50.6"	6.80	0.09	1.95	0.93	313.60	18.81	98.98	41.00	5.00	1.17	4.37	1.22	24.66	26.68	3.46
124	E 16^0 12' 32.1" N 74^0 15' 43.6"	7.42	0.18	1.69	0.81	282.24	20.38	115.87	45.00	13.50	0.82	1.71	1.92	36.86	23.52	2.48
125	E 16^0 12' 8.8" N 74^0 15' 26.3"	6.39	0.08	1.43	0.93	310.46	19.44	134.98	56.50	1.10	0.69	2.03	1.32	29.56	26.88	5.16
Halewadi																
126	E 16^0 11' 47.6" N 74^0 14' 0.48.5"	5.64	0.27	1.69	1.05	316.73	10.34	165.56	26.00	11.00	0.26	2.18	2.24	24.56	27.20	2.34
127	E $16^0$11' 22.1" N 74^0 14' 5"	6.18	0.18	1.82	0.72	275.96	18.81	187.45	40.50	4.50	0.52	2.65	1.28	57.36	21.56	1.54
128	E 16^0 11' 42.2" N 74^0 14' 34.1"	6.20	0.28	1.43	0.94	313.60	17.56	154.56	28.00	6.00	0.73	10.15	2.22	33.48	25.60	2.52
129	E 16^0 12' 07.8" N 74^0 13' 51.2"	6.51	0.50	1.82	1.08	319.87	28.22	145.87	36.50	1.00	0.52	15.31	1.44	34.68	27.02	5.08

Table 10. Chemical properties and available nutrient status of soils of Ajra tehsil

Sample no.	GPS reading	pH (1:2.5)	EC dS m^{-1} (1:2.5)	$CaCO_3$ (%)	O.C (%)	Available nutrients (Kg ha^{-1})			Exchangeable Cations (cmol (p+) Kg^{-1})			Available nutrient (mg Kg^{-1})	DTPA extractable micronutrients (mg Kg^{-1})			
						N	P	K	Ca	Mg	Na	S	Zn	Fe	Mn	Cu
Mahagaund																
130	E 16^0 11' 52.4" N 74^0 12' 59.9"	6.31	0.09	1.43	0.81	341.82	19.75	138.98	41.00	2.50	0.73	10.46	1.78	30.98	23.66	3.88
Honyali																
131	E 16^0 12' 31.4" N 74^0 13' 19.0"	6.01	0.12	1.95	0.97	344.96	30.41	128.98	29.00	18.00	0.82	6.40	2.30	44.56	27.46	2.02
132	E 16^0 12' 55.7" N 74^0 13' 45.9"	6.08	0.18	1.69	1.02	351.23	27.91	138.65	39.50	7.00	0.47	2.96	1.50	33.30	29.24	5.10
133	E 16^0 13' 19.4" N 74^0 13' 15.7"	6.07	0.12	1.69	0.93	332.41	12.23	134.33	31.00	11.00	0.69	5.15	1.82	36.58	26.30	2.60
Chimne																
134	E 16^0 13' 19.3" N 74^0 12' 46.7"	6.35	0.27	1.82	0.87	348.09	14.73	143.55	42.00	4.00	0.30	8.43	1.22	25.56	27.02	2.80
135	E 16^0 13' 4.7" N 74^0 11' 57.7"	6.26	0.08	1.30	0.58	275.96	10.03	128.63	35.50	9.00	0.60	11.09	1.42	39.92	21.98	0.88
Zulpewadi																
136	E 16^0 14' 07.4" N 74^0 11' 45.4"	6.90	0.09	1.95	0.36	188.16	11.91	111.64	49.00	14.50	0.34	9.37	1.28	21.06	26.00	4.66
137	E 16^0 14' 26.6" N 74^0 12' 11.6"	7.52	0.14	1.82	0.51	269.69	11.28	167.62	56.50	6.50	0.56	1.71	1.64	7.78	16.08	2.34
138	E 16^0 15' 5.3" N 74^0 13' 30.6"	7.46	0.18	1.69	0.81	341.82	26.96	178.74	58.50	13.00	0.78	2.65	1.30	21.56	18.66	1.30
Belewadi																
139	E 16^0 15' 22.7" N 74^0 13' 7.3"	6.85	0.16	1.43	0.54	279.10	22.57	163.66	53.50	8.00	0.91	1.87	1.66	28.72	19.18	3.08
140	E 16^0 15' 35.6" N 74^0 13' 45.5"	5.94	0.10	1.17	0.96	341.82	25.08	143.66	26.50	13.00	0.52	5.00	1.30	18.30	28.30	4.02

Table 10. Chemical properties and available nutrient status of soils of Ajra tehsil

Sample no.	GPS reading	pH (1:2.5)	EC dS m^{-1} (1:2.5)	$CaCO_3$ (%)	O.C (%)	Available nutrients (Kg ha^{-1})			Exchangeable Cations (cmol (p+) Kg^{-1})			Available nutrient (mg Kg^{-1})	DTPA extractable micronutrients (mg Kg^{-1})			
						N	P	K	Ca	Mg	Na	S	Zn	Fe	Mn	Cu
Pipalgaon																
141	E 16^0 14' 47.9" N 74^0 14' 49.6"	7.31	0.13	1.95	0.61	175.61	24.77	187.43	31.00	18.00	1.00	4.06	1.62	25.44	18.56	2.00
Dhamne																
142	E 16^0 15' 9.9" N 74^0 14' 59.8"	6.33	0.10	1.56	0.52	272.83	20.38	136.76	44.50	11.50	0.73	8.43	1.16	32.78	23.80	1.74
143	E 16^0 15' 37.5" N 74^0 14' 35.4"	6.34	0.08	1.69	0.78	307.32	19.75	146.53	28.00	2.50	0.34	5.15	2.28	13.16	21.12	2.28
144	E 16^0 15' 38.5" N 74^0 15' 36.3"	6.73	0.21	1.82	0.81	341.82	21.32	167.32	32.50	10.50	0.82	6.25	1.48	39.04	21.02	1.80
145	E 16^0 16' 6.9" N 74^0 14' 15.8"	6.81	0.08	1.95	0.51	269.69	21.01	178.45	39.00	13.00	0.43	3.28	1.14	14.64	24.00	2.80
Mean		**5.93**	**0.15**	**1.28**	**0.85**	**294.84**	**18.32**	**142.73**	**27.41**	**9.31**	**0.66**	**5.26**	**1.44**	**27.54**	**24.55**	**1.59**
Range		**4.71 - 7.52**	**0.06 - 0.6**	**0.26 - 2.08**	**0.3 - 2.35**	**175 - 401.4**	**7.34 - 34.8**	**78.87 - 236.8**	**7 - 61**	**0.5 - 32**	**0.26 - 1.17**	**0.78 - 28.75**	**0.74 - 4.22**	**0.34 - 57.36**	**11.38 - 31.24**	**0.08 - 5.16**
SE ±		**0.05**	**0.01**	**0.04**	**0.03**	**3.86**	**0.53**	**2.74**	**1.01**	**0.51**	**0.02**	**0.40**	**0.04**	**0.89**	**0.33**	**0.09**

8. VITA

MISS. BHAGWAT A.M.

A candidate for the degree

Of

MASTER OF SCIENCE (AGRICULTURE)

2016

Thesis title	: GPS-GIS based soil fertility maps of Ajra tehsil of Kolhapur district (M.S.)
Major Field	: Soil Science

Biographical Information : Born at Rahuri, Taluka. Rahuri, District. Ahmednagar on 02nd October, 1990. Daughter of Shri Madhusudan and Sou.Minakshi Bhagwat

Educational : Passed Primary and High School from Vidya Mandir Rahuri, Taluka. Rahuri, District.A.Nagar in 2006 and 2008.

: Received B.Sc. (Agriculture) degree from College of Agriculture, Pune of M.P.K.V Rahuri in 2013 with second class.

Address : At/post- Rahuri, Tal. Rahuri, Dist.A.Nagar 413705.

E-mail **:** apurvabhagwat15@gmail.com

LIST OF PLATES

No.	Title	Between Page number
1	Location map of study area	30-31
2	Crops and Cropping system in Ajra tehsil	30-31
3	The pH of soils of Ajra tehsil	39-40
4	Electrical conductivity (dS m^{-1}) of soils of Ajra tehsil	39-40
5	The per cent Organic carbon content in soils of Ajra tehsil	39-40
6	The per cent Calcium carbonate equivalents in soils of Ajra tehsil	39-40
7	Available Nitrogen (Kg ha^{-1}) in soils of Ajra tehsil	41-42
8	Available Phosphorous (Kg ha^{-1}) in soils of Ajra tehsil	41-42
9	Available Potassium (Kg ha^{-1}) in soils of Ajra tehsil	41-42
10	Exchangeable Calcium in soils of Ajra tehsil	43-44
11	Exchangeable Magnesium content in soils of Ajra tehsil	43-44
12	Available Sulphur (mg Kg^{-1}) in soils of Ajra tehsil	45-46
13	DTPA Extractable Iron (mg Kg^{-1}) in soils of Ajra tehsil	46-47
14	DTPA Extractable Manganese (mg Kg^{-1}) in soils of Ajra tehsil	46-47
15	DTPA Extractable Zinc (mg Kg^{-1}) in soils of Ajra tehsil	46-47
16	DTPA Extractable Copper (mg Kg^{-1}) in soils of Ajra tehsil	46-47