

**Evaluation of Soil Fertility in Soils of Ralyawan Village of
Jhabua District of Western Madhya Pradesh**



THESIS

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**Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya,
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BY

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2015

CERTIFICATE – I

This is to certify that the thesis entitled "**Evaluation of Soil Fertility in Soils of Ralyawan Village of Jhabua District of Western M.P.**", submitted in partial fulfillment of the requirements for the "**DEGREE OF MASTER OF SCIENCE IN AGRILTURE (Soil Science & Agricultural Chemistry)**" of the Rajmata Vijayaraje Scindhiya Krishi Vishwa vidyalaya, Gwalior, is a record of the bonafide research work carried out by **NARENDRA PATIDAR**, I.D.No. RA/IN/826/2009, Under my guidance and supervision. The subject of the thesis has been approved by the student's advisory committee and the Director of Instructions, R.V.S.K.V.V. Gwalior (M.P.).

No part of the thesis has been submitted for any other degree or diploma (certificate awarded etc.) or has been published. All the assistance and help received during the course of investigations have been duly acknowledged by her.

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CERTIFICATE – II

This is to certify that the thesis entitled " **Evaluation of Soil Fertility in Soils of Ralyawan Village of Jhabua District of Western M.P** ",submitted by **NARENDRA PATIDAR**, I.D.No. RA/IN/826/2009, to the Rajmata Vijayaraje Scindhiya Krishi Vishwa vidyalaya, Gwalior, in partial fulfillment of the requirements for the "**DEGREE OF MASTER OF SCIENCE IN AGRICULTURE (Soil Science & Agricultural Chemistry)**" has been, after evaluation, been approved by the external examiner and by the student's advisory committee after an oral examination on the same.

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CHAPTER – I INTRODUCTION

At present, the greatest challenge before Indian agriculture is to boost food production and productivity as well as sustainability of agriculture as a whole. There are problems that impose limits on these objectives or goals which raise serious concerns about national food security. These include deterioration of soil fertility, increase in cost of production, and low diversity of production systems. However, the need for improved crop productivity is more now than ever because of the increasing population and the consequent pressures from competing demands for land over time. With resultant reduction in the land-man ratio and this has drastically reduced the average size of farm land and invariably leads to soil fertility depletion through continuous or intensive cropping along with imbalance fertilization. Soil fertility is one of the major constraints in achieving high productivity goals. In both rain-fed and irrigated systems, nutrient replenishment through fertilizers and manures remains far below the crop removal, thus causing mining of native reserves over the years. Soil nutrient depletion has grave implications in terms of: (1) Wide spread deficiencies of macro and micro nutrients; N, P, K, Cu, Zn, B, Ca and S deficiencies were observed. (2) Declining nutrient use efficiency and returns from money spent on nutrient and other inputs. (3) A weakened foundation for high yielding sustainable farming (4) Escalating remedial costs for rebuilding depleted soils. Site-specific estimates of the nutrient fertility status of the soils are therefore very important to rational fertilizer use. Reliable site-specific information can only be accomplished through an orderly program of soil fertility evaluation.

Intensively cultivated soils are being depleted with available nutrients especially secondary and micronutrients. Therefore, assessment of fertility status of soils that are being intensively cultivated with high yielding crops needs to be carried out. Soil testing is usually followed by collecting composite soil samples in the fields without geographic reference. The results of such soil testing are not useful for site specific recommendations and subsequent monitoring. Soil available nutrients status of an area using Global Positioning System (GPS) will help in formulating site specific balanced fertilizer recommendation and to understand the status of soil fertility spatially and temporally.

Soil test-based fertility management is an effective tool for increasing productivity of agricultural soils that have a high degree of spatial variability. However, major constraints impede wide scale adoption of soil testing in most developing countries. In India, these include the prevalence of small holding systems of farming as well as lack of infrastructural facilities for extensive soil testing. Under this context, GIS-based soil fertility mapping has appeared as a promising alternative. Use of such maps as a decision support tool for nutrient management will not only be helpful for adopting a rational approach compared to farmer practices or blanket use of state recommended fertilization, but will also reduce the necessity for elaborate plot-by-plot soil testing activities. However, information pertaining to such use of GIS-based fertility maps has been meager in India. The current study was carried out to assess the GIS map-based soil fertility evaluation with regard to traditional soil testing in the Ralyawan village of western MP. This study presents the soil spatial variability maps for soil texture, pH, EC, organic carbon, available – N, P, K, S, Zn, Cu, Mn and Fe along with multi nutrient deficiency maps. The information generated will be useful for managing soil resources of the village on sustainable basis. Therefore, the study on “Evaluation of Soil Fertility in Soils of Ralyawan village of Jhabua District of Western Madhya Pradesh” is planned with the following specific objectives:

1. To estimate the major nutrient (N, P and K) and secondary nutrient(S) status of the soils of Ralyawan village of Jhabua district of western MP.
2. To estimate the micronutrient status (Zn, Cu, Fe and Mn) of the soils of Ralyawan village.
3. To determine the textural class of sampled soils of the village.
4. To assess the soil reaction (pH) and electrical conductivity (EC) and organic carbon (OC) in different soil samples of the study area.
5. To prepare the fertility maps of Ralyawan village.

CHAPTER II

REVIEW OF LITERATURE

In this chapter an attempt has been made to present review of research work done in the country on the status of available major and micro nutrients and its relationship with physico- chemical properties.

2.1 Physico- chemical properties of soil:

2.1.1 Available Nitrogen status in soils:

Thakur and Bhandari (1986) reported that available nitrogen content ranged from 120 to 200 kg ha⁻¹ in sandy clay loam soils of Sapruon Valley of Himachal Pradesh.

Singh and Datta (1988) observed that the available nitrogen content fluctuated from 115 to 507 ppm in Inceptisol and Ultisol order of Mizoram soils. They further reported that the status of nitrate in these soils was low, possibly due to the leaching down stemming by high rainfall. A low status of ammonia fraction in the present soils may be due to its assimilation by micro-organisms and reversion in to the organic nitrogen reservoir.

Kanthaliya and Bhatt (1991) estimated available nitrogen content in soils of Wasundhara, Wasundhara variant, Lalmadri and Khumangach, respectively in Rajasthan and values varied from 112 to 431 kg ha⁻¹. Similarly, Mongia and Bandyopahdyay (1994) detected that available content of nitrogen fluctuated from 0.10 to 0.16 g kg⁻¹ in soils of Wimberlygunj forest division of South Andaman.

Ramesh *et al.* (1994) analyzed the soils of Guntur district of Andhra Pradesh for available nitrogen content and found the variation from 85 to 282 kg ha⁻¹. Similarly several other workers also analyzed the soils of different places and reported as 203.8 to 407.2 kg ha⁻¹ in soils of Soan river valley of lower Shiwaliks.

Jain (1997) studied the available macro and micro nutrient status of five hundred twelve surface soil samples representing the Inceptisols, Alfisol and Vertisol orders of Farm of IGKV, Raipur (C.G.), during summer season and analyzed for available N, P, K and DTPA-extractable Zn, Cu, Fe, Mn. and found that the available N varied from 140.2 to 280.7 kg ha⁻¹.

In Karnataka about 10.3 per cent of soils fall under low category, 35.8 per cent under medium and 53.9 per cent under high category of available nitrogen status (Shivaprasad *et al.*, 1998).

Ashok *et al.* (2006) conducted a survey for comprehensive study of soil nutrient status in Auraiya district of Uttar Pradesh, India. A total of 168 soil samples were collected from seven blocks representing important soil groups in wheat growing areas of Auraiya district reported that most of the soils were low in N.

Pradeep *et al.* (2006) studied the chemical properties and nutrient status of seventy-one groundnut soils of Shorapur and Shahpur taluks in Upper Krishna Project, Karnataka, India. Surface soil samples from these two taluks were collected before sowing of rabi/summer groundnut crop during 2003-04 and found that the status of available N was low in Shorapur and Shahpur taluks.

Kumar *et al.* (2009) observed that an available nitrogen content of Dumka and Lachimpur series varied from 125 to 310 kg ha⁻¹ with a mean of 216 kg ha⁻¹ and 210 to 545 kg ha⁻¹ with a mean of 401 kg ha⁻¹ in soils of Santhal Paraganas region of Jharkhand. About 40 to 50 % soil samples in light texture soils of Dumka series were rated as low in available nitrogen.

Rajeswar *et al.* (2009) reported that the available nitrogen content in all the pedons were low ranging from 133 to 188 kg ha⁻¹ throughout the depth. However, available nitrogen content was found to be maximum in surface horizons and distribution of available macronutrients decreased regularly with soil depth in soils of Garikapadu in Krishna District of Andhra Pradesh.

Ravikumar and Somashekar (2013) Spatial distributions for twenty physical and chemical properties were examined in the soil samples of selected agricultural fields in 28 different locations in Varahi River basin. The present study revealed that there is not much variation in soil fertility status of soils developed on various landforms in the area as the soils were having low to medium in available nitrogen (6.27 to 25.09 Kg/ha) content.

Kumar *et al.*, (2014) Grid based (GPS) surface (0-15 cm) soil samples by systematic survey were collected from 4 blocks, 84 selected villages in Kabeerdham district were 297 samples identified from Vertisol. These soil samples were analyzed for N, P and K and Fe, Mn, Cu and Zn and categorized as low medium and high as per criteria followed in the soil testing laboratory. Based upon the coefficient of correlation between macronutrients & micronutrient and soil properties, a significant

and positive correlations observed was between soil pH and available N, P and K. Electrical conductivity exhibited significant and positive relationship with available N, P, K and organic C showed significant and positive correlation with available N and K.

Singh *et al.*(2014) revealed that fertility status of alluvial and medium black soil and ravinous land, and their correlation studies were carried out for Chambal region of Madhya Pradesh. the range of available N were 126 to 361kg ha⁻¹ in alluvial soil ; 178 to 408 Kg ha⁻¹ in medium black soil and 125 to 301 Kg⁻¹ in ravinous land, respectively. Of alluvial soil samples, 97% were low and 3% medium in N. Of medium black soil samples, 90% were low and 10% medium in N. Of ravinous land soil samples, 95% were low and 5% medium in N.

Shivanna and Nagendrappa (2014) Nutrients present in a soil are the most important elements required for the healthy growth of plants and soil fertility is the status of the soil to supply nutrients to plants in adequate amounts and in suitable proportions. Soil fertility may be influenced by the water quality of the tanks used for irrigation. Study was conducted to evaluate the soil fertility status of selected command areas of three lakes-Eachanur, V.Mallenahalli and Halkurke in Tiptur taluk .The variables tested included N. Available nitrogen ranged from 54.825kg/ha to 85.72kg/ha and samples were nitrogen deficient.

2.1.2 Available Phosphorus status in soils:

Singh and Singh (1985) reported that in beel soils of Assam, the available content of phosphorus ranged from 6.2 to 84.0 kg ha⁻¹.

Kumar *et al.* (1995) found that in soils of Soan river valley of Himachal Pradesh the available 'phosphorus' content varied from 2.0 to 29.0 g kg⁻¹ .

Sahoo *et al.* (1995) found that in soils of Sunder bans of West Bengal the available phosphorus content varied from 26 to 76 g kg⁻¹.

Jain (1997) studied the available macro and micro nutrient status of five hundred twelve surface soil samples representing the Inceptisols, Alfisols and Vertisols orders of Farm of IG KV, Raipur (C.G.), during summer season and analyzed for available N, P, K and DTPA–extractable Zn, Cu, Fe, Mn and found that Available P varied from 7.3 to 25.4 kg ha⁻¹.

Sahu and Mishra (1997) reported that available phosphorus content varied between 12.76 to 14.00 kg per ha and was in medium level. While characterizing and classifying soils of an irrigated river flood plain in the eastern coastal region.

Shivaprasad *et al.* (1998) that the data on the available phosphorus status in the soils of Karnataka showed that about 83 per cent of the soils are low in phosphorus and 17 per cent area is under medium category.

Sood *et al.* (2003) studied in the Talwara block of Hoshiarpur district (Punjab), he studied that the available phosphorus content varied from 1.8 to 32.5 kg ha⁻¹ with a mean value of 12.0 kg ha⁻¹ in the surface soils. In the surface soils, 59 per cent samples low in available phosphorus, 22 per cent samples medium in available phosphorus and 19 percent samples high in available phosphorus.

Dwivedi *et al.* (2005) showed in the study area the available phosphorus ranged from 2.35 to 25.66 kg ha⁻¹ in Leh and 2.55 to 137.4 kg ha⁻¹ in Kargil district of Jammu and Kashmir.

Kumari *et al.* (2005) conducted a Survey and analysis of 100 soil samples of nine different mandals in Guntur district to assess an overall picture of physicochemical properties and fertility status of the cotton (*Gossypium*) growing soils of Guntur district, Andhra Pradesh, India. Their results showed that available phosphorus ranged from 4.60-20.33 ppm with average of 7.82 ppm.

Pradeep *et al.* (2006) reported that the status of available P was low in Shorapur and Shahpurtaluks in Upper Krishna Project, Karnataka.

Ved *et al.* (2008) conducted a soil survey of Bajaj Sugar Mill Bhasana, Muzaffarnagar district, Uttar Pradesh, India during the year 2004-05. Six hundred soil samples were collected from 22 circles of sugar factory zone and analysed for the current status of the available macronutrients and other parameters and found that available nutrient index value of the zone for available phosphorus was found 1.20 and showing the deficiency.

Bali *et al.* (2010) characterized the soils of Punjab and presented the data agro-eco-Subregionwise. The descriptive statistics on soil characteristics indicated that the available phosphorus ranged from 1.12 to 238 kg ha⁻¹ with mean value of 42.77 kg ha⁻¹.

Ibiremo *et al.* (2011) evaluated the soil fertility for cocoa production in Southeastern Adamawa State, Nigeria. Analytical results indicated that the soils in the area are sandy loam. The sand content ranged from 665.04-737.67 gKg⁻¹ while the silt and the clay content ranged from 61.13-159.12 and 100.87-233.07 gKg⁻¹ soil respectively. The available P at Ganye (Gurum-Pawo and Jagaba) was 6.98 gkg⁻¹ soil while that of Toungo was 3.93 g/Kg⁻¹ soil. From the results, phosphorus

appear to be the most critical nutrients in the soils of the area and therefore would require an average of 60.60 Kg SSP ha⁻¹ to bring up the phosphorus to levels required for cocoa production. The values of the nutrients obtained from the three sites are below the critical levels for most soil requirements for cocoa production.

Singh *et al.* (2013) analysed the available nutrient status of soil samples collected at two depths (0-30 and 30-60 cm) from the rubber growing areas of Meghalaya. Available phosphorus (P) was very low for all the districts. Majority of the samples from all the districts where rubber is cultivated have shown low available and nutrient index values ranged from 1.00 to 1.02 and the fertility rating for available was low for the entire rubber growing areas of Meghalaya state.

Singh *et al.* (2014) revealed that fertility status of alluvial and medium black soil and ravinous land, and their correlation studies were carried out for Chambal region of Madhya Pradesh. the range of available P were 7.0 to 29.5 kg ha⁻¹ in alluvial soil ; 7.9 to 28.8 Kg ha⁻¹ in medium black soil and, 6.2 to 25.3Kg⁻¹ in ravinous land, respectively. Of alluvial soil samples, 14% low, 68% medium and 18% high in P. Of medium black soil samples 21% low 69% medium and 10% high in P. Of ravinous land soil samples, 68% low and 32% medium in P.

2.1.3 Available Potassium status in soils:

Chibba and Sekhon (1995) obtained that in soils of Punjab, the available potassium content ranged from 0.67 to 57.1 mg kg⁻¹.

Ghosh and Mukhopadhyay (1996) reported that available K content varied from 62 to 262 and 52 to 386 kg ha⁻¹, respectively in soils of Jagannathpur and Barakonda of West Bengal. The higher value of available K in the Barakonda series explained as intensive weathering leading to increased released of K to the exchange site of clay minerals. The higher content of available K is attributed to the prevalence of Illite a potassium rich mineral in these soils. Moreover, as the ground waters of Mansa district have considerable amount of dissolved potassium, irrigation with such waters also results in higher amounts of available K in these soils (Patel *et al.*, 2000).

Muneshwar *et al.* (2001) reported that the use of FYM and green manure increased K availability in soil but a net negative balance in total K was noticed.

Arora and Chahal (2003) reported that the range of available K in soils series varied from 48.5 to 314.0 mg kg⁻¹ in Aridic, 32.0 to 134.0 mg kg⁻¹ in ustic, and 36.0 to 62.5 mg kg⁻¹ in udic moisture regime of Punjab.

Setia and Sharma (2004) noticed that the accumulation of potassium in all the forms was higher in the plots receiving K dressing than those in NP treated plots. The cumulative effect of continuous cropping and fertilizer application markedly influenced K availability in soil.

Sharma (2004) reported that the exchangeable-K is the most important chemical pool contributing to the nutrition of rice and wheat grown in sequence.

Verma *et al.* (2005) reported that the available potassium content of these soils is generally medium to high, and only 3% soil samples tested low in available K. It ranged from 67.2 to 851.2 kg ha⁻¹ with a mean value of 291.15 kg ha⁻¹. About 52 and 45% samples tested medium and high in available K, respectively. The available K content of soils of Sardulgarh, Bhikhi and Budhlada blocks is medium and that of Jhunir and Mansa is high.

Meena *et al.* (2006) reported that status of available potassium (K₂O) in the soils ranged from 105 to 1059 kg ha⁻¹ with an average of 377 kg ha⁻¹.

Talashilkar *et al.* (2006) found that none of the K fraction showed any definite trend with changes in pH.

Sharma *et al.* (2006) found that available K status of Hoshiarpur district of Punjab soils varied from 62 to 476 kg ha⁻¹.

Kumar *et al.* (2009) observed that the content of available K in soils of Dumka series varied from 111 to 145 kg ha⁻¹ with a mean value of 124 kg ha⁻¹ and in Lachimpur series from 110 to 188 kg ha⁻¹ with a mean of 134 kg ha⁻¹. The available K in both the series was medium in status in soils of Santhal Paraganas region of Jharkhand.

Nirawar *et al.* (2009) observed that the content of available K in soils of Takalgaon varied from 208 to 213 kg ha⁻¹ with a mean value of 211 kg ha⁻¹ and in Andori village varied from 353 to 655 kg ha⁻¹ with a mean of 551 kg ha⁻¹ in soils of Ahemedpurtahsil of Latur district.

2.1.4 Available sulphur status in soils:

Balanagoudar (1989) studied 15 soil bodies representing red, black and lateritic soils in north Karnataka for sulphur status and forms of sulphur. The available sulphur content in different soils in surface in decreasing order was red soils > black soils > lateritic soils.

Sharma and Gangwar (1997) observed that the total sulphur content in Inceptisols of Moradabad district in Uttar Pradesh ranged from 167 to 917 mg kg⁻¹ soil and also noticed negative correlation between total sulphur and pH and also between total sulphur and electrical conductivity

Singh *et al.* (2000) observed that the sulphate sulphur content in soils from thirty six soil series under varying physiographies and representing four soil orders *viz.*, Entisols, Inceptisols, Alfisols and Mollisols varied from 9.1 to 54.3 mg per kg with a mean value of 30.1 mg per kg and constituted 2.5 per cent of total sulphur.

Ashoka *et al.* (2001) examined twelve soil series representing black, red and coastal soils from different agro-climatic zones of Karnataka and twelve surface soil samples from each series were analyzed for sulphur status and distribution of different forms of sulphur, relationship between sulphur and various soils properties. The CaCl₂ extracted sulphur content in black, red and coastal soils ranged between 5.08 to 59.95 ppm, 8.66 to 27.15 ppm and 7.26 to 20.32 ppm, respectively.

Mali and Syed (2002) reported the status of sulphur in soil of 240 districts of India including Maharashtra. Results revealed that near about 50 per cent of soil samples were found to be deficient in sulphur whereas, extent of sulphur deficiency was 54 per cent.

Bhatnagar *et al.* (2003) studied on the distribution of sulphur in some soil of Shivepuri districts, Madhya Pradesh. The total sulphur in surface soil of Vertisols varied from 798 to 987 mg kg⁻¹ with mean value of 892 mg kg⁻¹. Total sulphur showed highly significant correlation with organic carbon. It also showed negative relationship with pH, calcium carbonate and clay content.

Huda *et al.* (2004) evaluated suitable extractants for available sulphur and critical limit of sulphur for wetland rice soil of Bangladesh, The critical level of MCP, 0.15 per cent CaCl₂, NaHCO₃ and NH₄OA_C extractable S were 9.3, 9.7, 15.8 and 17.8 mg per kg. The critical limit for plant sulphur was found to be 0.12 per cent at 56 days of crop growth.

Basavaraju *et al.* (2005) while characterizing and classification of soils of Chandragirimandal of Chittoor district in Andhra Pradesh found that soils were deficient in sulphur.

Kundu *et al.* (2005) reported that the available sulphur content ranged from 5.5 to 18.5 ppm with the average value of 12.61 ppm and the sulfur status was medium considering 7.5 to 15.0 ppm as the medium range in soil samples were collected from the rice growing plots of 4 villages (Uttar Duttapara, Kurumbelia, Mollabelia and Dasdia) of Haringhata block under Nadia district of West Bengal.

Malik *et al.* (2005) AB In order to study the plant available sulfur (S) status, 500 surface sample (0-15 cm) depth were collected from three villages under paddy-wheat rotation from Sirsa district of Haryana, India. The soils are neutral in reaction, non-saline and medium to high in organic carbon content. Approximately 11.67, 1.73 and 11.23% of the samples were below the critical level in available sulfur at Titukhera, DhaniGurusar and Ottu village of the district. In total, 8.18% of the soils were deficient in available sulfur in the study area.

Thangasamy *et al.* (2005) reported that soils in sivagiri micro-watershed of Chittoor district in Andhra Pradesh, were high in sulphur.

Ghosh *et al.* (2006) Available sulfur was determined on 5077 soils from the tea growing areas of Dooars, North Bengal, India, received for routine soil testing between 2000-03. Over 43% of the soils had more than the critical limit of 40 ppm available sulfur. A distinct geographical trend in sulfur availability was observed, with the four western sub-districts showing a greater frequency of high available sulfur than the three eastern sub-districts.

Jat and Yadav (2006) noticed that the sulphate sulphur content in mustard growing Entisols of Jaipur district in Rajasthan ranged from 4.10 to 39.95 mg per kg with a mean value of 14.52 mg per kg. The percentage contribution of sulphate sulphur to total sulphur was 9.41.

Singh and Bansal (2007) reported that the current available S status (0.15 per cent CaCl_2 -extractable) of the soils of Nabha series ranged from 3.75 to 43.5 mg kg^{-1} with mean value of 19.6 mg kg^{-1} . They also found that out 100 farmer's field, 26 were found to be deficient in available sulphur.

Singh *et al.* (2009) observed that the status of available sulphur Five hundred surface soil samples of Udham Singh Nagar district, Uttarakhand varied from 4.6 to 118.4 mg kg^{-1} . The soil samples testing for low, medium and high in available sulphur were 22, 31 and 47 per cent, respectively.

Bacchewar and Gajbhiye (2011) studied the status of secondary nutrients and effect of soil properties on their status in some soils from Latur district (Maharashtra). Available sulphur contents ranged from 2.98 to 85.53 mg kg⁻¹ with mean values of 22.88 mg kg⁻¹.

Chouhan *et al.* (2012) studied the sulfur and micronutrient contents in medium black cotton soils and 202 medium black soil samples (0-15 cm) were collected from cultivated fields in Dewas district, Madhya Pradesh, India, The available S content ranged from 0.9-50.2 mg/kg, and approximately 38.6% of the samples were deficient in available S.

Ghosh *et al.* (2012) reported that the sulphur content of surface soils of four districts Birbhum, Burdwan, Purulia and Brigham (West Bengal). Under this experiment sixty seven each of surface and sub-surface soil samples found that the lowest mean available sulphur content was recorded in the surface soils of Birbhum district, and in the sub-surface soils of Burdwan district, whereas the highest was recorded in the surface and sub-surface soils of Purulia district. Brigham district recorded to be the most deficient as 87 per cent of the surface soil samples and 67 per cent sub-surface soils of Burdwan district fall under low sulphur range. Correlation studies revealed an intimate association of organic carbon and pH with SO₄ –S and SAI.

Isitekhal *et al.* (2013) evaluated sulphur status of some soils in Edo Central, Nigeria. Surface soil samples (0-15 cm) collected from the five localities was found that inorganic sulphur content of all the locations was generally below the critical level of 8.50 mg per kg and therefore generally deficient in inorganic sulphur. Inorganic sulphur correlated significantly with available phosphorus but was negative and non-significant with organic carbon, pH, nitrogen, CEC, clay and silt contents. Application sulphur fertilizer is recommended for adequate crop yield in the agro-ecological zone.

2.1.4 pH:

Kher and Khajuria (2005) found that the range of pH 6.2 to 8.2, with the mean values 7.2 in Kandi belt of Jammu Region. Tripathi *et al.* (2006) characterized and classified the soils of Kiar-Nagali micro watershed. The soils were neutral to slightly alkaline (pH 7.2 – 7.6), mixed in mineralogy, shallow to very deep and have thermic temperature and udic moisture regimes.

Verma *et al.* (2005) reported that the soils of the Sardulgarh and Bhikai blocks of Punjab are alkaline in reaction (pH >7.0). The distribution of samples in various pH ranges indicates that only 26% of total soil samples fall in the pH range from 8.00 to 8.75. The maximum number of soil samples (51%) fall in 8.75 to 9.00 pH range. However, it is startling to observe that a significant number of samples, i.e., 23% have pH values ranging from 9.00 to 9.75.

Mondal *et al.* (2006) showed that the soil reaction was acidic (pH <5.0) to alkaline (pH 7.5 to 8.5) in orchard soils of temperate Jammu. Lathwal (2006) showed that the soil pH of the district Kurukshetra (Haryana) ranged between 7.3 and 9.5.

Nazif *et al.* (2006) observed that majority of the soil sites were alkaline in nature. The soil pH ranged from 6.88 to 8.06 (average 7.56) in the micronutrient status of soils of district Bimber (Azad Jammu and Kashmir) at 30 different locations.

Najar *et al.* (2007) reported that the pH of Karewa apple orchards soils of Kashmir, varied from 6.7 to 7.2. The soils were slightly acidic to neutral in reaction and exhibited a significant variation in pH.

Ved *et al.* (2008) found that pH of the study area varied from 7.25 to 8.26 with an average of 7.79 in the Bajaj sugar mill Bhasana, Muzaffarnagar district, Uttar Pradesh.

Singh *et al.* (2009) reported that the surface and subsurface soils were normal to slightly alkaline with pH ranging between 7.1 to 8.6 in the soils of District Ghazipur, Uttar Pradesh.

Rajeswar *et al.* (2009) reported that all the pedons were neutral (7.4) to moderately alkaline (8.7) in reaction (pH) in soils of Garikapadu of Krishna District of Andhra Pradesh. Lower pH values were recorded in the surface as compared to subsurface horizons.

Kumar *et al.* (2009) reported that soils of Dumka series were characterized by low pH ranging from 3.80 to 6.40 and the Lachimpur series showed wide variation in pH (4.60 to 7.70) in soils of Santhal Paraganas region of Jharkhand.

Nirawar *et al.* (2009) AB Laboratory experiment was conducted to know the status of available N, P and K in relation to physico-chemical properties of soils from Ahemadpurtahsil of Latur district, Maharashtra, India. A total of 100 surface soil

samples were collected from 20 villages (5 samples from each village). The analyzed samples showed that these soils were neutral to moderately alkaline in reaction.

Jatav (2010) reported that the pH (soil reaction) varied from 4.7 to 7.50 with the mean value 5.89 in Inceptisols of Baloda block of Janjgir-Champa district of Chhattisgarh undertaken during 2009-10 covering 87 villages.

Shukla (2011) found that the pH of the soils varied from 4.5 to 8.1 (mean- 6.12) in Inceptisols, Alfisols and Vertisols orders of Pamgarh block in Janjgir-Champa district (C.G.)

Deshmukh (2012) evaluate the soil fertility status from Sangamner area, Ahmednagar district, Maharashtra. 62 surface soil samples were analyzed for various soil fertility parameters pH. pH ranged from 8 to 9.7 reflecting alkaline nature of soil

Mahla *et al.* (2014) conducted a study to evaluate the fertility status of Navagarh block, Janjgir-Champa district, Chhattisgarh. The statistical description of soil characteristics indicated that the pH of the soils varied from 4.5 to 7.2 (mean- 5.73). A positive significant correlation was found between pH and EC.

Tsanglao *et al* (2014) studied the fertility status and soil acidity under different land use systems in Wokha district of Nagaland. Ninety surface of soil samples (0-20 cm), representing cultivated and forest land use systems (45 from each land use systems) were collected from 15 villages of the Wokha district, Nagaland. Processed soil samples were analysed for pH Various forms of soil acidity. The pH of soils under cultivated and forest land use systems varied from 4.46 to 4.85 and 4.53 to 5.10 with an average of 4.65 and 4.77 respectively, indicating that soils are acidic in reaction.

2.1.5 Electrical conductivity (EC):

Pillai and Natarajan (2004) reported the electrical conductivity of the soils of Garakahalli watershed ranged from 0.02 to 0.20 dS m⁻¹ indicating non-saline nature of the soil. However, these soils did not show any relationship with depth. This may be due to the undulating nature of the terrain coupled with free drainage conditions, which favoured the removal of released bases by the percolating and drainage water.

Thangasamy *et al.*(2005) reported that the soils in Sivagiri micro-watershed of Chittoor district in Andhra Pradesh showed very low electrical conductivity values

ranging from 0.02 to 0.36 dS m⁻¹, suggesting the presence of very low amount of soluble salts .

Shamsudheen *et al.*(2005)The forest soils of North Karnataka were non-saline with EC values ranging from 0.01 to 0.07 dS m⁻¹.

Kher and Khajuria (2005) observed that the range of EC 0.03 to 0.13 dSm⁻¹, with the mean values 0.72 dSm⁻¹ in the Kandi belt of Jammu Region.

Lathwal (2006) showed that the EC of soils in the district was below 0.8 dS m⁻¹ in the district Kurukshetra (Haryana).

Ved *et al.* (2008) found that EC of the study area varied from 0.14 to 0.54 dSm⁻¹ with an average of 0.32 dSm⁻¹, respectively in the Bajaj Sugar Mill Bhasana, Muzaffarnagar District, Uttar Pradesh.

Rajeswar *et al.* (2009) reported that the EC values varied from 0.10 to 0.32 dSm⁻¹ in the soils of Garikapadu of Krishna District of Andhra-Pradesh.

Singh *et al.* (2009)reported that electrical conductivity varied between 0.10 and 0.38 dSm⁻¹ in the soils of District Ghazipur, Uttar-Pradesh.

Bali *et al.* (2010) reported that the EC of soil solution ranged from 0.14 to 1.37 dSm⁻¹ with a mean value of 0.46 dSm⁻¹ in the state of Punjab.

Deshmukh (2012) evaluated the soil fertility status from Sangamner area, Ahmednagar district, Maharashtra. 62 surface soil samples were analyzed for various soil fertility parameters EC. Higher EC in the downstream part reflecting low flushing rate and sluggish ground water movement in the area.

Shivanna and Nagendrappa (2014) Conducted a study to evaluate the soil fertility status of selected command areas of three lakes-Eachanur, V.Mallenahalli and Halkurke in Tiptur taluk .The variables tested included EC. EC values ranged from 0.26 dSm⁻¹ to 0.485 dSm⁻¹ and were within the limit of 0.8 dSm⁻¹ indicating low salinity status of the soils.

2.1.6 Organic Carbon:

Basava *et al.*(2005) reported the organic carbon content in soils of Chandragirimandal of Chittoor district, Andhra Pradesh varied from 0.6 to 6.3 g kg⁻¹ (plains), 0.8 to 4.1 g kg⁻¹ (uplands) and 3.7 to 6.6 g kg⁻¹ (hill slope). Irrespective of landforms, the organic carbon decreased with depth.

Sanjeev *et al.* (2005) reported that the organic carbon content invariably high in surface horizons and exhibited a declining trend with depth in forest soils as compared to cultivated soils.

Meena *et al.* (2006) observed that the organic carbon (OC) content was low (< 0.50 %) in 63% soil samples, medium (0.50 to 0.75 %) in 21 % and high (>0.75 %) in 16 % soil samples in light texture soils of Tonk District of Rajasthan.

Ashok *et al.* (2006) observed that soils of Auraiya district of Uttar Pradesh, India have medium to high organic carbon.

Chatterjee *et al.* (2006) categorized soil organic carbon on the basis of organic carbon content in soil *viz*, low ,medium and high following the rating scale used in West Bengal and found that organic carbon content indices of soils within seven block were low (less than 1.67) except Haripa (block) Hooghly district, was medium (1.78). In this percent assessment a nutrient index less than 1.65 denotes low category and that falling between 1.65 and 2.33 represents the medium fertility class. Value of 2.34 and above (maxi 3.00) signifies a high fertility class in respect of the particular nutrient (Ghosh and Hasan , 1976).

Nazif *et al.* (2006) showed that majority of the soil sites were medium in organic matter content. The OC content ranged from 0.65 to 2.07 % (average 1.18 %) in the soils of District Bhimber (Azad Jammu and Kashmir) at 30 different locations.

Lathwal (2006) organized Soil testing campaigns during 2005 and 2006 to assess the soil fertility status in district Kurukshetra, Haryana, India. Two blocks with different cropping patterns were selected: rice-potato-sunflower and rice-wheat-sugarcane in Shahbad block and rice-wheat in Thanesar block. One hundred forty-four and 104 soil samples were collected from the village Dangali (Shahbad block) and Adhon (Thanesar block) showed that the OC status of village Dangali (Shahbad block) ranged between 0.05 to 0.80% and Adhon (Thanesar block) 0.05 to 0.50%.

Sharma and Chaudhary (2007) found that the OC content ranged from 1.5 to 15.9 g kg⁻¹ showed a considerable variation with depth in different soil type (Entisol, Alfisoland Inceptisol), lower Shiwaliks of Solan District in North – West Himalayas.

Sharma *et al.* (2008) reported that the majority of the soils of Amritsar District are medium in their Organic carbon status. Organic carbon (OC) in these soils ranged between 0.16 to 0.97% with an average value of 0.61%. Considering

the soils having <0.4 as low , 0.4 -0.75 % as medium and > 0.75 % as high in OC status , the distribution of soil samples under these categories was 6.8 ,73.5 and 19.7%, respectively.

Kumar *et al.* (2009) reported that soils of Dumka series were characterized by OC ranging from 2.53 to 7.80 g kg⁻¹. The results showed that 77% soils were rated as low, 18% as medium and 5% as high in the OC status and the Lachimpur series of organic carbon ranging from 3.80 to 9.50 g kg⁻¹ and the percentage of soils low, medium and high in organic carbon status was 13, 66 and 21, respectively in soils of SanthalParaganas region of Jharkhand.

[Bama \(2009\)](#) conducted a study to delineate the organic carbon content in the major soil series of Coimbatore and Erode districts. Surface soil samples were collected from different places and analyzed. The analytical results showed that the average organic carbon content was 0.4 per cent and 69 per cent of soils comes under low status and 27 per cent comes under medium status of organic carbon content in the Coimbatore district.

Bali *et al.* (2010) characterized the soils of Punjab and presented the data agro-eco-Sub region wise. The descriptive statistics on soil characteristics indicated that the available OC ranged from 0.11 to 1.55 %.

Jatav (2010) noted that variation in organic carbon content in sampled soils was from 0.23 to 0.83 with the mean value of 0.44 per cent Inceptisols of Baloda block of Janjgir-Champa district of Chhattisgarh during 2009-10 covering 87 villages.

Vaisnow (2010) observed that the organic carbon content of *Vertisols* of Dhamtari block in C.G. varied from 0.15 to 0.91 per cent.

Shukla (2011) reported that the variation in organic carbon of the soils varied from 0.09 to 1.1 per cent (mean-0.57 per cent). In *Inceptisol*, *Alfisols* and *Vertisols* orders of Pamgarh block in Janjgir-Champa district (C.G.).

Tsanglao *et al.*(2014) studied the fertility status and soil acidity under different land use systems in Wokha district of Nagaland. Ninety surface of soil samples (0-20 cm), representing cultivated and forest land use systems (45 from each land use systems) were collected from 15 villages of the Wokha district, Nagaland. Processed soil samples were analysed organic carbon (OC), The soil organic carbon (SOC) content of the soils varied from 9.7 to 23.7 g Kg⁻¹ indicating high SOC.

2.1.6. Status of macronutrients in soils:

Ramamoorthy and Bajaj (1964) assessed the soil fertility status of Indian soils. They observed that soils of majority of the states were low in available nitrogen, medium in available phosphorus and medium to high in potassium status.

Divakar *et al.* (1989) assessed soil fertility status of five blocks of hilly region representing the horticultural area in Nainital region of Uttar Pradesh and found that all soils were slightly acidic to alkaline. Available nitrogen was high but available phosphorus and potassium was low in all the soils tested.

Vedavyasa (1989) reported that available plant nutrients such as nitrogen, phosphorus, potassium and sulphur increased significantly with the application of FYM or NPK fertilizers while the contents were highest under combination of both FYM and NPK fertilizers in agricultural system.

Monem *et al.* (1990) assessed the soil fertility status of Chaouia village by collecting soil samples from 25 mapped sites and a site in phosphate mining area. They observed that most of the samples were deficient in N and only a small percentage was deficient in P and K.

Chavan *et al.* (1995) observed that the available nitrogen, phosphorus and potassium increased very markedly in the surface layers. The changes of these nutrients were due to decomposition of organic matter added through the leaf litters. Gurumurthy *et al.* (1996) reported that the red, black and associated soils of Giddalurmandal of Andhra Pradesh were low in available nitrogen (42 to 105 mg kg⁻¹) and phosphorus (1.40 to 11.50 mg kg⁻¹) while potassium (73 to 210 mg kg⁻¹) was medium to high and the available sulphur content was sufficient (5.00 to 21.20 mg kg⁻¹) in surface soils.

Ashoka (1998) reported that forest tree species recorded higher available nutrients such as nitrogen, phosphorus, potassium and sulphur both at surface and subsurface soils, respectively. Whereas soils of agricultural lands recorded lower values of available nutrients such as nitrogen, phosphorus, potassium and sulphur both at surface and subsurface soils. Changes in nutrient status were due to decomposition of organic matter added through the leaf litter.

Sreerangappa (1998) and Dhananjaya (2000) found that available nutrients like nitrogen, phosphorus, potassium and sulphur contents were increased in both surface and subsurface soils of agriculture lands followed by agri-hort system.

Mukhopadhyay *et al.*(1998) conducted a detailed soil survey in Punjab Agricultural University Nucleus Seed Farm, Naraingarh (District-Fatehgarh Sahib), India. The surface soils were low in N, low to medium in P, medium in K, sufficient in Zn, Cu and Mn and deficient in Fe.

Ndakidemi, and Semoka (2006) Soil samples from thirty sites representing four agro-ecological zones in the Western Usambara Mountains (WUM) of the Lushoto District in northern Tanzania were collected and analyzed for different nutrients. The results suggested that the major soil fertility constraint was P deficiency. On the basis of critical levels established in other areas, 90% of the soils were ranked as P deficient. This was followed by N, which was ranked as inadequate in 73% of the sites.

Sahrawat *et al.*(2007) characterize the fertility status of soils under dryland agriculture in the semi-arid regions of India, they collected 3622 soil samples from farmers' fields in watersheds, spread in several districts of Andhra Pradesh (AP; 5 districts), Karnataka (5 districts), Tamil Nadu (TN; 5 districts), Rajasthan (3 districts), Madhya Pradesh (MP; 2 districts), and Junagad, District, Gujarat. Results of the analysis of soil samples showed that almost all farmers' fields sampled were low in organic carbon and low-to-moderate in extractable phosphorus, but generally adequate in extractable potassium. They also observed widespread deficiencies of sulphur (S).

Singh *et al.*(2009) carried out an investigation to evaluate the some soil properties in paddy soils of Saharanpur district (UP), values of available N was found to be (43 to 174 mgkg⁻¹) while, available P and K was in low to medium range (7.5 to 19.6 and 50 to 380 mgkg⁻¹, respectively).

2.2 RELATIONSHIP BETWEEN SOIL CHARACTERISTICS AND AVAILABLE MACRONUTRIENTS:

2.2.1 Relationship between Available Nitrogen and pH:

Meena *et al.* (2006) reported that available N was negatively correlated ($r = -0.292^{**}$) with pH. This might be due to increased rate of denitrification at lower pH values (Tisdale, 1997).

Sharma *et al.* (2008) reported that available nitrogen was positive and nonsignificant correlation ($r = 0.105$) with pH, in soils of Amritsar district (Punjab).

Kumar *et al.* (2009) showed that the negative and non-significant relationship ($r = -0.03$ and $r = -0.019$) between available nitrogen content and pH in soils of Dumka and Lachimpur series in Santhal Paraganas region of Jharkhand.

Wagmare *et al.* (2009) reported that the available nitrogen was positive and significant correlation with pH in soils of Aushatahsil of Latur District.

2.2.2 Relationship between Available Nitrogen and Electrical Conductivity:

Sharma *et al.* (2008) showed that the positive and non significant correlation ($r = 0.131$) between available nitrogen and electrical conductivity in soils of Amritsar District of Punjab.

2.2.3 Relationship between Available Nitrogen and Organic Carbon:

Sharma *et al.* (2008) reported that available N was positively and significantly correlated with organic C ($r = 0.436^*$) and available K showed a significant and positive relationship with EC ($r = 0.584^*$) and organic C ($r = 0.351^*$) in soils of Amritsar district.

Kumar *et al.* (2009) showed that relationship between available N content was a highly significant and positive correlation with organic carbon ($r = 0.838^{**}$) in Lachimpur series in soils of SanthalParaganas region of Jharkhand.

2.2.4 Relationship between Available Phosphorus and pH:

Meena *et al.* (2006) reported that available phosphorus was significant and negatively correlated with pH ($r = -0.575^{**}$) because at higher pH, calcium can precipitate with phosphorus as Ca- phosphate and reduce phosphorus availability in light texture soils of Tonk District of Rajasthan.

2.2.5 Relationship between Available Phosphorus and Electrical Conductivity:

Sharma *et al.* (2008) showed that the positive and non significant correlation ($r = 0.148$) between available phosphorus and electrical conductivity in soils of Amritsar District of Punjab.

2.2.6 Relationship between Available Phosphorus and Organic Carbon:

Meena *et al.* (2006) reported that a significant positive correlation ($r = 0.797^{**}$) was observed between organic carbon and available Phosphorus. This

relationship might be due to the presence of more than 50 % of phosphorus in organic forms and after the decomposition of organic matter as humus is formed which forms complex with Al and Fe that a protective cover for P fixation adsorption / phosphate fixation (Tisdale *et al.* ,1997).

2.2.7 Relationship between Available Potassium and pH:

Meena *et al.* (2006) studied in soils of Tonk district of Rajasthan to evaluate the macro and micro nutrients status and concluded that available P was significant and negatively correlated with pH ($r = -0.575^{**}$) and organic C ($r = 0.797^{**}$). This relationship might be due to the presence of more than 50 % of phosphorus in organic forms and after the decomposition of organic matter as humus is formed which forms complex with Al and Fe and that is a protective cover for P fixation with Al and Fe thus reduce P adsorption / phosphate fixation (Tisdale *et al.* 1997). Available N was negatively correlated ($r = -0.292^{**}$) with pH and significant positive correlation ($r = 0.639^{**}$) with organic carbon.

2.2.8 Relationship between Available Potassium and Electrical Conductivity:

Yadav and Meena (2009) showed that relationship between available potassium content was a significant and positive correlation with electrical conductivity in light texture soils of Degana soils series of Rajasthan.

2.2.9 Relationship between Available Potassium and Organic Carbon:

Sharma *et al.* (2006) reported that a significant positive correlation of available K was observed with organic C ($r = 0.466^*$) in soils of Kargil district of cold arid region of Ladakh. Wagmare *et al.* (2009) showed that the available potassium was positive and significant correlation with organic carbon in soils of Aushatahsil of Latur District.

2.2.10 Relationship between Organic Carbon and Electrical Conductivity:

Sharma *et al.* (2008) showed that the positive and non significant correlation between organic carbon and electrical conductivity in soils of Amritsar District of Punjab.

2.2.11 Relationship between Available Sulphur and pH:

Ghosh *et al.* (2006) Available sulfur was determined on 5077 soils from the tea growing areas of Dooars, North Bengal, India, . Surprisingly, a negative linear relationship could be observed between soil pH and available sulfur.

2.2.12 Relationship between Available sulphur and Organic Carbon:

Ghosh *et al.* (2006) Available sulfur was determined on 5077 soils from the tea growing areas of Dooars, North Bengal, India, . Surprisingly, a negative linear relationship could be observed between soil OC and available sulfur.

Singh *et al.* (1993) Misra *et al.* (1990) and Sharma and Gangwar (1997) reported that for some Indian soils. The content of total S showed highly significant and positive correlation with OC ($r = 0.527^{**}$).

2.2.13 Relationship between Available sulphur and Electrical Conductivity:

Singh *et al.* (1993), Misra *et al.* (1990) and Sharma and Gangwar (1997) reported that for some Indian soils. The content of total S showed highly significant and positive correlation with EC ($r = 0.370^{**}$).

2.2.14 Relationship between Available Nitrogen and Clay:

Bipul *et al.* (2012) reported that a positive and non-significant correlation ($r = 0.236$) existed between Available Nitrogen and Clay in soils of Assam.

Singh and Mishra (2012) reported that a positive and significant correlation ($r = 0.763^{**}$) existed between Available Nitrogen and Clay in soils of varanasi (U.P).

2.2.15 Relationship between Available Nitrogen and Silt:

Bipul *et al.* (2012) reported that a positive and non-significant correlation ($r = 0.051$) existed between Available Iron and sand in soils of Assam.

2.2.16 Relationship between Available Nitrogen and sand :

Bipul *et al.* (2012) reported that a negative and non-significant correlation ($r = -0.116$) existed between available Nitrogen and sand in soils of Assam.

2.2.17 Relationship between Available Phosphorus and Clay:

Bipul *et al.* (2012) reported that a positive and significant correlation ($r = 0.410$) existed between available Phosphorus and Clay in soils of Assam.

R.P.singh and S.K Mishra (2012) reported that a positive and significant correlation ($r= 0.316^{**}$) existed between Available phosphorus and Clay in soils of varanasi (U.P).

2.2.18 Relationship between Available Phosphorus and Silt:

Bipul *et al.* (2012) reported that a positive and non- significant correlation ($r=0.174$) existed between available Phosphorus and silt in soils of Assam.

2.2.19 Relationship between Available Phosphorus and sand :

Bipul *et al.* (2012) reported that a negative and significant correlation ($r=-0.448$) existed between available Phosphorus and sand in soils of Assam.

2.2.20 Relationship between Available Potassium and Clay:

Bipul *et al.* (2012) reported that a positive and significant correlation ($r= 0.361$) existed between available Potassium and clay in soils of Assam.

Singh and Mishra (2012) reported that a positive and significant correlation ($r= 0.746^{**}$) existed between available potassium and clay in soils of varanasi (U.P).

2.2.21 Relationship between Available Potassium and Silt:

Bipul *et al.* (2012) reported that positive and non significant correlation ($r=0.206$) existed between available Potassium and silt in soils of Assam.

2.2.22 Relationship between Available Potassium and sand :

Bipul *et al.* (2012) reported that a negative and non significant correlation ($r=-0.531$) existed between available Potassium and sand in soils of Assam.

2.2.23 Relationship between Available Sulphur and Clay:

Bipul *et al.* (2012) reported that a positive and significant correlation ($r= 0.353^*$) existed between available Potassium and Clay in soils of Assam.

Singh and Mishran (2012) reported that a positive and significant correlation ($r= 0.290^{**}$) existed between available sulphur and clay in soils of varanasi (U.P).

2.2.24 Relationship between Available Sulphur and Silt:

Bipul *et al.* (2012) reported that positive and non significant correlation ($r=0.246$) existed between Available Sulphur and Silt in soils of Assam.

2.2.25 Relationship between Available Sulphur and sand :

Bipu *et al.* (2012) reported that a negative and non significant correlation ($r=-0.267$) existed between Available sulphur and sand in soils of Assam.

2.3 Status of available micronutrients in soils:

Singh *et al.* (1993) found that the highest DTPA extractable Zn and Mn in forest and agricultural soils but did not show marked differences with waste lands. Rainfed agricultural lands were poorer in micronutrients than irrigated agricultural lands.

Talukdar *et al.* (2009) investigated the DTPA extractable cationic micronutrient relationship with some important soil physicochemical properties in two agro-ecosystems of Golaghat district of Assam. Considering the critical limits of soil micronutrients, all the soil associations were adequately supplied with DTPA-extractable micronutrients.

Venkatesh Bhardwaj *et al.* (1994) indicated that FYM when applied along with 100 per cent dosage of NPK increased the DTPA extractable micronutrients. Ashoka (1998) reported that DTPA extractable iron, manganese, zinc and copper content of surface and subsurface soils were higher in the lands of forest trees as compared to agricultural lands. soils of Silvi-pasture system as compared to natural system.

Sreerangappa (1998) observed that DTPA extractable micronutrients like iron, manganese, zinc and copper were higher in surface and subsurface.

Satyavathi and Suryanarayana Reddy (2004) studied fifty four soil samples from ten pedons of Telangana region. Andhra Pradesh for vertical distribution of DTPA- extractable Zn, Cu, Fe and Mn and their relationship with some soil properties. Soil pH, calcium carbonate, organic carbon and particle size fractions had strong influence on the distribution of these micronutrients. The content of micronutrient increased with the increase in organic carbon and decreased with increase in pH and CaCO₃. There was no definite trend for the distribution of these micronutrients with respect to depth. 44 and 20 per cent of the soils were rated as deficient in available zinc and iron respectively. Copper and manganese were found to be adequate.

Hirey and Takankhar (2013) carried out a study to determine the status of secondary and micronutrients of Tuljapur tehsil of Osmanabad District, Maharashtra, India. Based on the analysed data, all the soils were of high nutrient range Among the various soil order, Vertisols and Inceptisols showed considerably higher DTPA-Fe, Mn, Zn and Cu followed by Entisols.

2.3.1 Available Copper status in soils:

Rathore *et al.* (1995) found the available copper content in soils of Hissar and Sirsa district of Haryana ranged from 0.2 to 3.8 mg kg⁻¹.

Singh and Raj (1996) reported that the available copper ranged from 0.2 to 0.4 mg kg⁻¹ in hill soils, 0.3 to 0.7 mg kg⁻¹ in piedmont plains and 0.1 to 0.2 mg kg⁻¹ in flood plains of Himachal Pradesh respectively.

Sharma *et al.* (2001) reported that DTPA-Copper content in soils varied from 0.24 to 6.20 (mean 1.42) ppm in Rajgarh, 0.22 to 5.44 (mean 1.21) ppm in Biaora, 0.28 to 4.32 (mean 2.10) ppm in Sarangpur, 0.30 to 6.20 (mean 1.98) ppm in Narsinghgarh, 0.18 to 1.54 (mean 0.63) ppm in Khilchipur, and 0.22 to 0.12 (mean 0.57) ppm in Jirapur Tehsil. Copper content in the districts as such ranged from 0.18 to 6.20 with an average of 1.52 ppm. Practically deficiency of available copper was not observed in soil of Rajgarh district taking 0.22 ppm as the critical limits of its deficiency.

Kher and Khajuria (2005) observed that the range of Cu, 0.26 ppm to 1.00 ppm, with the mean values 0.63 ppm in the Kandi belt of Jammu region.

Dwiwedi *et al.* (2005) conducted field research laboratory (DRDO), Leh during the year 1998-2001, surface soil samples was collected each from in Leh (96) and Kargil (50) from five cultivated fields, in Ladakh region and found that in Leh soils the DTPA extractable Cu ranged from 0.43 to 3.52 mg kg⁻¹ and 0.51 to 3.41 mg kg⁻¹ in Kargil district of Jammu and Kashmir.

Nazif *et al.* (2006) reported that the AB-DTPA extractable Copper ranged from 0.59-4.38 mg kg⁻¹. AB-DTPA extractable Copper was found high in all sites. The micronutrient status of soils of district Bhimber (Azad Jammu and Kashmir) was made at 30 different locations.

Talukdar *et al.* (2009) investigated the DTPA extractable cationic micronutrient relationship with some important soil physicochemical properties in two agro- ecosystems of Golaghat district of Assam. Considering the critical limits of soil micronutrients, all the soil associations were adequately supplied with DTPA - extractable micronutrients.

Hirey, and Takankhar (2013) carried out a study to determine the status of secondary and micronutrients of Tuljapur tehsil of Osmanabad District, Maharashtra, India. Based on the analysed data the DTPA-Cu content of soil series

of Vertisols and Alfisols of western Maharashtra ranged from 1.30 to 6.30 and 0.4 to 6.7 mgkg⁻¹, respectively.

2.3.2 Available Zinc status in soils:

Dube *et al.* (2001) AB Pigeonpea (*Cajanuscajan*) when raised in pot-culture on an adequately fertilized loamy sand Gangetic upland semiarid alluvial soil (Ustifluent) of Putti village, Bulandshahar district in western Uttar Pradesh, India showed positive responses to graded (1 to 25 mg kg⁻¹soil) Zn amendment. The increase in height, branching, production of pods and harvest index of pigeonpea was highest at 5 mg kg⁻¹ Zn added soil which raised DTPA extractable soil Zn from 0.41 to 1.23 mg kg⁻¹.

Kher and Khajuria (2005) observed that the range of Zn, 0.46 ppm to 1.0 ppm, with the mean values 0.73 ppm in the Kandi belt of Jammu Region.

Sharma and Chaudhary (2007) reported that available Zn in the studied profiles varied from 0.31 to 4.7 mg kg⁻¹ in lower Shiwaliks of Solan district in North – West Himalayas.

Andrabi and Shah (2010) studied the micronutrient status in relation to physico-chemical properties in the soils of three different agro-climatic zones of Jammu and Kashmir at 12 different locations, (four samples from each zone). The results revealed that by and large there is a decrease in micronutrient content with depth. Available Zn status in all the soil profiles was in deficient range.

Bali *et al.* (2010) studied the GIS-aided thematic maps and indicated that 10% of the total geographical area of Punjab was affected by the Zn deficiency based on critical limit and result showed that the DTPA- Zn ranged from 0.07 to 3.06 mg kg⁻¹ with mean value of 1.10 mg kg⁻¹.

2.3.3 Available Iron status in soils:

Gajbhiye *et al.* (1993) found that available iron content varied from 3.26 to 11.04 ppm in Vertisols of Saongi watershed of Maharashtra.

Dhane and Shukla (1995) revealed that available iron content showed a variation from 2.6 to 8.3 mg/kg in Entisols, Inceptisols and Vertisols of Maharashtra.

Sharma *et al.* (2001) reported that DTPA-extractable Iron ranged 4.2 to 26.4 (mean 11.7) ppm, 3.8 to 24.8 (mean 9 ppm) ppm, 1.8 to 15.8 (mean 7.7) ppm, 2.8 to 22.8 (mean 7.2) ppm, 2.8 to 19.4 (mean 9.5 ppm), and 3.4 to 17.6 (mean 8.0) ppm in Rajgarh, Biora, Sarangpur, Narsingharh, Khilchipur and JirapurTahsils,

respectively in Rajgarh district of Madhya Pradesh. The deficiency of available iron was of the order of 1.7 % in Rajgarh, 7.5% in Biaora, 18.7% in Saranpur, 16.1 % in Narsingharh, 13.5% in Khilchipur and 20.5% in Jirapur Tehsil. The available iron content for the district as such ranged from 1.8 to 26.4 ppm with a mean value of 8.5 ppm and 13.3% samples tested low in available iron

Sharma *et al.* (2006) reported that mapping of DTPA-extractable micronutrients were carried out by randomly collecting georeferenced surface (0–0.15 m) soil samples representing different soils (as per soil map prepared on 1:50,000 scale) from 645 sites in Amritsar district (Northwest Punjab, India) using Global Positioning System (GPS) at flag leaf stage of wheat (*Triticum aestivum L.*). These soil and plant samples were analyzed for micro nutrients (Fe, Mn, Zn and Cu). The DTPA-Zn in soils varied from 0.18 to 3.91 mg kg⁻¹.

Yadav and Meena (2009) reported that available Fe in soil samples of Degana soil series of Rajasthan varied from 0.20 to 18.73 mg kg⁻¹.

Rajeswar *et al.* (2009) reported that the DTPA – Extractable iron content varied from 0.4 to 40.2 mg kg⁻¹ soil. All the surface soils were sufficient in available iron content. Vertical distribution of iron exhibited little variation with depth in soils of Garikapadu in Krishna District of Andhra Pradesh.

2.3.4 Available Manganese Status in soils:-

Rawat and Mathapal (1981) reported that the available content of manganese 3.6 to 26.0 ppm in clay to loamy sand soils of Uttar Pradesh hills. Other workers have also reported the similar trends 5.1 to 51.5 ppm in alkaline soils of Punjab (Arora and Sekhon, 1981), 3.1 to 22.5 ppm in arid soils of Kangra district of Punjab (Chibba and Sekhon, 1985), 6.3 to 37.6 ppm sandy clay loam soils of Saproon Valley of Himachal Pradesh (Thakur and Bhandari, 1986). Singh and Raj (1996) reported that DTPA- extractable Mn content in the range from 1.7 to 14.9 mg kg⁻¹ in soils of Hisar and Sirsa districts of Haryana

Datta and Ram (1993) reported that available manganese content ranged from 18.1 to 33.6 ppm in soils of Tripura. Maji *et al.* (1993) reported that an available manganese content, 14.3 to 59.3 mg kg⁻¹ of Basanti, 6.1 to 51.7 mg kg⁻¹ of Sundeshkhali, 16.0 to 75.1 mg kg⁻¹ of Kakdwip and 10.5 to 44.4 mg kg⁻¹ of Mathurapur, in soils of West Bengal.

Sharma *et al.* (2001) reported that DTPA - Mn the soil ranged from 1.8 to 38.4 ppm (mean 16.8 ppm) in Rajgarh, 1.8 to 50.4 ppm (mean 12.1 ppm) in Biaora, 1.4 to 42.8 ppm (mean 13.2 ppm) in Sarangpur, 2.4 to 44.2 ppm (mean 12.2 ppm) in Narsinghgarh, 1.8 to 31.8 ppm (mean 10.6 ppm) in Khilchipur, and 1.4 to 26.2 ppm (mean 9.8 ppm) in Jirapur tehsil. The available Mn in the district ranged from 1.4 to 50.4 ppm with a mean value of 12.6 ppm and none of the soil was found to be deficient in available Mn.

Sharma and Chaudhary (2007) reported that available Mn in the studied profiles varied from 2.7 to 56.7 mg kg⁻¹, respectively. All the soils had amounts of available Mn in lower Shiwaliks of Solan district in North – West Himalayas. Considering 1.0 mg kg⁻¹ for Mn as critical limits suggested by Lindsay and Norvell (1978).

Kumar *et al.* (2009) observed that an available Mn content of Dumka and Lachimpurseries varied from 26.20 to 180.00 mg kg⁻¹ with a mean of 94.44 mg kg⁻¹ and 15.60 to 189.00 mg kg⁻¹ with a mean of 95.99 mg kg⁻¹, respectively in soils of SanthalParaganas region of Jharkhand.

Rajeswar *et al.* (2009) reported that the available DTPA -Extractable manganese content in these soils varied from 2.6 to 19.7 mg kg⁻¹. It was high in the surface horizons and gradually decreased with depth of soil. Vertical distribution of available manganese micronutrient was also observed in soils of Garikapadu of Krishna District of Andhra Pradesh..

Singh *et al.* (2009) reported that the DTPA-Extractable Mn content in the soils varied between 3.2 to 8.5 mg kg⁻¹ in surface and subsurface soils. Sixteen percent of the samples contained DTPA-Mn between 3.3 and 4.0 mg kg⁻¹ and 84% had more than 4 mg kg⁻¹ DTPA-Mn micronutrients in the soils of District Ghazipur, Uttar Pradesh.

2.4 Relationship between soil parameters and micronutrient

2.4.1 Relationship between Available Copper and pH:

Maji *et al.* (1993) reported that the available Cu correlated significantly and negative with pH ($r = -0.37^{**}$) in coastal soils of Sundarbans, West Bengal in relation to soil characteristics

Sood *et al.* (1995) reported that a significant negative correlation between available Cu and pH ($r = -0.54^{**}$) in soils of Malwa plateau Rajasthan.

Meena *et al.* (2006) reported that a significant negative correlation ($r = -0.195^{**}$) was observed between soil pH and available copper Tonk district of Rajasthan.

Jena *et al.* (2008) observed that available Cu was negatively correlated with pH and positively with Organic Carbon.

Kumar *et al.* (2009) showed that positive significant correlation of available Cu with pH ($r = 0.494^{**}$) in Lachimpur series, whereas no such relationship was found in Dumka series in soils of SanthalParaganas region of Jharkhand.

Yadav and Meena (2009) reported that available Cu were positively correlated ($r = -0.537^{**}$) with pH content in Degana soil series of Rajasthan.

2.4.2 Relationship between Available Copper and Electrical Conductivity:

Maji *et al.* (1993) reported that a positive and significant correlation existed between DTPA–extractable copper and electrical conductivity in soils of sunderbans, West Bangal.

2.4.3 Relationship between Available Copper and Organic Carbon:

Meena *et al.* (2006) reported that available Cu were positively correlated ($r=0.268^{**}$) with Organic Carbon content. Kumar *et al.* (2009) showed that positive significant correlation of available Cu with OC ($r = 0.526^{**}$) in Lachimpur series, whereas no such relationship was found in Dumka series in soils of SanthalParaganas Region of Jharkhand.

Mahesh Kumar *et al.* (2011) A comprehensive study was undertaken in Churu District, Rajasthan, India to determine The significant and positive correlation of Cu with organic carbon content.

2.4.4 Relationship between Available Zinc and pH

Gupta (1995) reported that the significant and negative correlation between extractable zinc with pH in soils of Delhi.

Nazif *et al.* (2006) reported that the correlation value obtained between Zinc and soil pH was 0.086. It means there was positive non-significant correlation between zinc and soil pH in the micronutrient status of soils of district Bhimber (Azad Jammu and Kashmir) at 30 different locations.

Jena *et al.* (2008) showed that Zn was correlated negatively with pH and positively correlated with organic carbon. There was antagonistic effect of available Zn with Cu in deltaic alluvium (Ustipsamment) in coastal Orissa.

Ajay *et al.* (2009) reported that the significantly negative correlation ($r = -0.38$) between available zinc and pH in soils of South- Western Plain Zone of Uttar Pradesh.

2.4.5 Relationship between Available Zinc and Electrical Conductivity

Maji *et al.* (1993) reported that a significant positive correlation between available zinc and electrical conductivity in coastal soils of Sunderbans, West Bengal.

2.4.6 Relationship between Available Zinc and Organic Carbon:

Sharma *et al.* (2003) reported that the positive and significant correlation observed between available zinc with organic carbon in soils of Nagaur district in Semi Arid region of Rajasthan.

Nazif *et al.* (2006) reported that the correlation coefficient (r) obtained between Zn and organic matter was 0.623. It concluded that Zn was positive significant correlated with organic matter in the micronutrient status of soils of district Bhimber (Azad Jammu and Kashmir) was made at 30 different locations. The positive correlation may be due to the formation of organic complexes between organic matters.

Kumar *et al.* (2009) showed that positive significant correlation of available Cu with pH ($r = 0.494^{**}$) in Lachimpur series, whereas no such relationship was found in Dumka series in soils of SanthalParaganas region of Jharkhand.

2.4.7 Relationship between Available Iron and pH:

Verma *et al.* (2007) reported that the negative and significant correlation between available iron with pH ($r = -0.822^*$) in the soils of Semi-Arid Region of Punjab.

Jena *et al.* (2008) studied soil samples from intensive rice-groundnut growing area of deltaic alluvium (Ustipsamment) in coastal Orissa, India, were analyzed for available S, Zn, Cu, Fe, Mn and B and some important soil properties

such as textural class, pH, EC, and organic carbon. Results showed that Fe, were negatively correlated with pH in deltaic alluvium (Ustipsamment) in coastal Orissa.

Kumar *et al.* (2009) reported that the soil pH was non significant correlated with iron content in Dumka ($r = 0.101$) and Lachimpur ($r = 0.058$) series in soils of SanthalParaganas region of Jharkhand.

Andrabi and Shah (2010) reported that DTPA extractable Fe gave negative significant correlation with soil pH soil in three different agro-climatic zones of Jammu and Kashmir.

2.4.8 Relationship between Available Iron and Electrical Conductivity:

Sharma and Chaudhary (2007) reported that in multiple regression studies of available Fe showed significant and positive regression coefficient with EC ($b_7 = 70.366^{**}$) profiles of different series representing in lower Shiwaliks of Solan district in North – West Himalayas.

2.4.9 Relationship between Available Iron and organic carbon:

Meena *et al.* (2006) reported that available iron were positively correlated ($r = 0.226^{**}$) with organic carbon content in light texture soils of Tonk district of Rajasthan.

Mahesh Kumar *et al.* (2011) A comprehensive study was undertaken in Churu district, Rajasthan, India to determine the significant and positive correlation of Fe with organic carbon content.

2.4.10 Relationship between Available Manganese and pH

Sahoo *et al.* (1995) reported that the significant correlation of manganese with pH in Vertisol, Entisol and Inceptisol of soils Rajasthan and formation of insoluble high manganese oxides at high pH. These results were in agreement with Chattotadhyay *et al.* (1996), Patiram *et al.* (2000); and Chinchmalatpure *et al.* (2000).

Nazif *et al.* (2006) reported that the correlation value (r) between Manganese and Soil pH was ($r = -0.392$). Manganese had negative significant correlation with soil pH in the micronutrient status of soils of district Bhimber (Azad Jammu and Kashmir) was made at 30 different locations. It showed that as pH increases availability of Manganese decreases.

Kumar *et al.* (2009) showed that negative significant correlation of available Mn with pH ($r = -0.374^{**}$) in Lachimpur series, whereas no such relationship was found in Dumka series in soils of Santhal Paraganas Region of Jharkhand.

Andrabi and Shah (2010) reported that DTPA extractable Mn gave negative significant correlation with soil pH in soils of three different agro-climatic zones of Jammu and Kashmir.

2.4.11 Relationship between Available Manganese and Electrical Conductivity

Murthy and Shrivastava (1994) found a low degree correlation between DTPA extractable manganese and electrical conductivity in acidic soil of Majera form of Uttar Pradesh.

2.4.12 Relationship between Available Manganese and Organic Carbon:

Nazif *et al.* (2006) reported that the correlation result (r) between manganese and organic carbon was 0.246. The result was positive non-significant in the micronutrient status of soils of District Bhimber (Azad Jammu and Kashmir).

Kumar *et al.* (2009) showed that negative significant correlation of available Mn with OC ($r = -0.289^{**}$) in Lachimpur series, whereas no such relationship was found in Dumka series in soils of Santhal Paraganas Region of Jharkhand.

Mahesh Kumar *et al.* (2011) A comprehensive study was undertaken in Churu district, Rajasthan, India to determine the significant and positive correlation of Mn with organic carbon content.

2.4.13 Relationship between Available Zinc and Clay:

Bipul *et al.* (2012) reported that a positive and significant correlation ($r = 0.333^*$) existed between Available Zinc and Clay in soils of Assam.

Khan *et al.* (1996) reported that a positive correlation existed between Available Zinc and Clay in soils of Bangladesh.

2.4.14 Relationship between Available Zinc and Silt:

Bipul *et al.* (2012) reported that a positive and non significant correlation ($r = 0.024$) existed between Available Zinc and Silt in soils of Assam.

2.4.15 Relationship between Available Zinc and sand:

Bipul *et al.* (2012) reported that a negative and non significant correlation ($r = -0.129$) existed between Available Zinc and sand in soils of Assam.

2.4.16 Relationship between Available Iron and Clay:

Bipul *et al.* (2012) reported that a positive and significant correlation ($r=0.641^{**}$) existed between Available Iron and Clay in soils of Assam.

Khan *et al.* (1996) reported that a positive correlation existed between Available iron and Clay in soils of Bangladesh.

2.4.17 Relationship between Available Iron and Silt:

Bipul *et al.* (2012) reported that a positive and significant correlation ($r=0.504^*$) existed between Available Iron and Silt in soils of Assam.

2.4.18 Relationship between Available Iron and sand:

Bipul *et al.* (2012) reported that a negative and non significant correlation ($r=-0.536$) existed between Available Iron and sand in soils of Assam.

2.4.19 Relationship between Available manganese and Clay:

Bipul *et al.* (2012) reported that a positive and non significant correlation ($r=0.656$) existed between Available manganese and Clay in soils of Assam.

Khan *et al.* (1996) reported that a positive correlation existed between Available manganese and Clay in soils of Bangladesh.

2.4.20 Relationship between Available manganese and Silt:

Bipul *et al.* (2012) reported that a positive and significant correlation ($r=0.481^*$) existed between Available manganese and Silt in soils of Assam.

2.4.21 Relationship between Available manganese and sand:

Bipul *et al.* (2012) reported that a negative and non significant correlation ($r=-0.508$) existed between Available manganese and sand in soils of Assam.

2.4.22 Relationship between Available copper and Clay:

Bipul *et al.* (2012) reported that a positive and non significant correlation ($r=0.110$) existed between Available copper and Clay in soils of Assam.

Khan *et al.* (1996) reported that a positive and significant correlation ($r=0.539^*$) existed between Available copper and Clay in soils of Bangladesh.

2.4.23 Relationship between Available copper and Silt:

Bipul *et al.* (2012) reported that a positive and non significant correlation ($r=0.010$) existed between Available copper and Silt in soils of Assam

2.4.24 Relationship between Available copper and sand:

Bipul *et al.* (2012) reported that a negative and non significant correlation ($r=-0.209$) existed between Available copper and sand in soils of Assam

2.5 Soil particle size distribution :

Parvathappa (1981) reported that clay content increased with depth mainly because of illuviation in the irrigated soils of Karnataka. Marked change in the particle size distribution of soils in different horizons of soil profile due to irrigation has been reported (Kenchana Gowda, 1977). The process of eluviation and illuviation were the main factors responsible for bringing out the alterations in the physical and chemical makeup of the soil profile and its development.

Sahu and Mishra (1997) while studying the irrigated soils of Orissa reported that texture of soil ranging from loamy sand to loam in the surface and clay loam downwards (74.4 to 44.4%), where as clay content gradually increased with the depth (9.3 to 35.3%) indicating pedogenic soil development.

Sreerangappa (1998) reported that the texture of soils were sandy clay loam to sandy clay under agriculture, agro forestry and agri-horti systems. The clay content increased with soil depth, this was attributed to high rain fall resulting in vertical movement of clay down the soil profile, through the voids created by plant roots and decomposed organic matters. While studying comparative assessment of resource degradation under identified land use system in selected agro climatic zones of Karnataka,

Dhananjaya (2000) observed that soil texture was coarse at surface and finer at bottom this was attributed to illuviation of clay. While studying the physico-chemical properties of soils under different land use systems in central dry zone of Karnataka.

Verma *et al.* (2001) reported the soils in different landscapes showed that the sand and silt constitute major portion in mechanical composition. Particle size distribution in Alfisols of some benchmark soils of West Bengal indicated that a distinct increase in clay content in sub-surface (Bt) horizons (Nayak *et al.*, 2002).

Patil and Jagdish Prasad (2004) reported the clay content ranged from 44.5 to 50.7 per cent and increased with depth in sal growing soils of Dindori district in Madhya Pradesh. Further, these soils were developed over basalt or partly laterised basalt and hence produced higher amount of clay.

Gabhane *et al.* (2006) reported that clay content ranging from 34.4 to 73.4 per cent and it increased with depth. The silt content ranged from 12.8 to 40.0 per cent and sand content was less than 10.0 per cent in soils of micro-watershed in Vidarbha region of Maharashtra .

Tripathi *et al.* (2006) characterized and classified the soils of Kiar-Nagali micro watershed texture ranged from silty loam to loam.

[Shilpa Babar](#) *et al.* (2007) investigated in forty-five soil samples representing fourteen profiles from five districts (TypicHaplusterts) of Central and WesternVidarbha region of Maharashtra. Central Vidarbhasoils are clay in texture having high CEC and organic carbon content. Where as the soils of Eastern Vidarbha is clay loam, sandy clay loam.

Niranjana *et al.* (2009) AB Twenty pedons were studied in the Central Coffee Research Institute farm, near Balehonnur in Chikmagalur district of Karnataka and characterized for their morphological, physical and chemical properties. The texture of the soils varied from sandy clay loam to clay loam.

Kitutu *et al.* (2009) One factor that was common to all soils sampled in the western side was the same soil texture of clay down the profile and the subsequent absence of landslides in the surroundings of the profiles.

Sharma *et al.* (2009) AB An investigation was undertaken to evaluate the somesoil properties in paddy soils of Saharanpur district (UP). Soils were found to the content of sand, silt and clay resulted loam texture.

Surya and Singh (2012) AB Soils from the Indo-Gangetic alluvial plains of Sirsivillage, Karnal, Haryana, India, were characterized and classified. Six soil series (Sirsi A, Sirsi, B, Sirsi, C, Sirsi D, Sirsi E and Sirsi F, corresponding to SA, SB, SC, SD, SE, SE and SF) were tentatively identified and mapped into 18 plates of soil series. SA and SB had a clay loam texture, whereas SC and SD had a sandy loam texture. The textures of SF and SE varied from loam to silty clay loam. The organic carbon and clay contents decreased with depth.

2.6 preparation of soil fertility maps using GIS:

Byju (1996) reviewed the importance of soil classification and land evaluation in effective transfer of agro-technology. Proper soil fertility evaluation and interpretation of results are required for agro technology transfer. Emphasis should be given to the concept such as Geographic Information System (GIS) and Soil Information System (SIS).

Das *et al.* (1999) Detailed soil resource inventories need to be readily available through a standardized and computerized database. This is pre-requisite for determining appropriate conservation activities in monitoring our natural

resource base. With the advances in information technology the data on soils, weather and other data can be integrated in making such decisions.

Sharma *et al.* (2004) The advent of information technology have provided tools like Global Positioning System (GPS), Geographical Information System (GIS), which help in collecting a systematic set of geo-referenced samples and generating the spatial data about the distribution of nutrients

Sood *et al.* (2004). The maps generated through remote sensing helps in delineating the homogenous units to decide the sampling size and thereby saving a lot of time. This will also helps to monitor the changes in Macro and micronutrients status over a period of time as sampling sites can be revisited with help of GPS which is otherwise difficult in the random sampling.

2.7 Spatial variability of soil physio –chemical properties:

Guo Xi Guo Xiao Min Tan Xue Ming Chen Fang (2003) reported that the data collected from soil sampled from 120 hm₂ field in Suxi Mirror Village, Taihe County, Jiangxi Province, were analysed using 3 methods: (1) inverse distance weight interpolation; (2) field average value; and (3) spatial variability interpolation model of field nutrients. Results showed that the spatial variability interpolation model of field nutrients properly fitted the spatial distribution of soil nutrients.

Sen and Majumdar (2006) reported that the spatial variations of soil pH, organic carbon, N, P₂O₅, K₂O, S, Fe, Cu, Mn, Zn and B were evaluated in Sripurdanga village (TypicUstifluent) of Murshidabad district in the new alluvial zone of West Bengal, India, in a rice field with no standing summer rice crop. Global positioning system (GPS) guided surface soil sampling (0-15 cm) were done over an area of about 40 hectares in a 100 m x 100 m grid in April 2006. Wide ranges of variation were noted for different soil physico-chemical properties as well as nutrient status in the study area. The organic-C (%) varied from 0.20 to 1.08, total nitrogen (%) from 0.017 to 0.093, P₂O₅ content varied from 50 to 366 kg/ha, K₂O varied between 87 to 448 kg/ha, while Zn and S content varied from 0.24 to 3.82 mg/litre and 7.75 to 82.5 mg/litre, respectively. The variation of soil nutrient contents across the study area was found to be related to variability of cropping sequences adopted and fertilizer use pattern among farmers. The evaluated physico-chemical and nutrient status data of the area were used to develop variability maps with the aim of generating site-specific nutrient management strategies.

GaoYiMin Tong YanAn (2007) presented a paper on spatial variability and distribution of 5 soil micro-element contents (available B, Fe, Mn, Zn, and Cu) in farmland of Guanzhong Plain. Total 364 top-layer (0-20 cm) soil samples were taken by grid from 219 hm² farmland in Xinji village of Shaanxi Province and analyzed by Geostatistics method. Results indicated that the variogram of 5 micro-element nutrients showed a linear model (B), exponential model (Fe), spherical model (Mn), exponential model (Zn) and linear model (Cu). B and Mn had intermediate spatial correlation ranges, while Cu, Fe and Zn had sharp spatial correlation ranges. The order of longest correlation range in 5 micro-elements was B, Cu>Zn>Mn>Fe (from 648 m to 1855.1 m). By using kriging method, the spatial distributions of 5 soil micro-element took on piece and speckle shape in study area, the spatial distributions of Fe, Mn, Zn, and Cu were connected with the moisture level, while available B was connected with the soil pH.

Darwish *et al.* (2008) Collected Soil samples to determine properties of soil such as salt (EC), pH, available N-P-K, and onion yield. The main objective of this study was to determine spatial variability in a dry onion field in EL-Saff agricultural farming village, Giza Governorate, and to produce a management strategy which is based on spatial variability of yield and soil components. The onion field properties Longitudinal slope was also measured. Results were used to produce maps. The greatest percentage of the field soils was determined as sand to sandy loam textured soils and loamy sand in lower depth. Their surface is covered with a lot of fine and medium gravel. Yield of dry onion increased with decreasing level of total soluble salts. Available nitrogen, phosphorus and potassium in the field reflected good nutrient power supply of the studied soil as well as onion dry bulbs according to the related maps.

Wang GuoWei Yan Li Chen GuiFen (2009) reported that In 3rd field of 13th village in Gongpeng Town of YuShu city, Jilin Province, China, comprehensive comparison of the soil nutrients of the field with no variable rate fertilizer application, with continuous variable fertilizer application for two years or five years was conducted. Result showed that the soil nutrients spatial difference was significantly reduced after continuous variable rate fertilizer application.

Nouri *et al.* (2010) conducted a study to determine spatial variability of sugar beet leaf N content affected by distribution pattern of urea fertigation. This study was conducted in Fesaran village, Isfahan Province of Iran and limited to sugar beet

(monogerm seed) which is the fourth commercial crop in Isfahan Province. Urea applied through sprinkler irrigation (solid set system-removable sprinklers). Soil and sugar beet leaves samples were obtained to specify soil total N as well leaf N content. Results of soil and crop analysis were used to produce spatial variability maps through GS⁺ and ArcGIS 9.2 software. Semivariogram results were used to perform an ordinary kriging to obtain interpolated values of selected variables from the sample points through and across the study area. It was found that there was a low variability of soil total N 4 days after fertigation as well as low variability in sugar beet leaf N content which indicates that the soil has a homogenous total N through and across the field and urea fertigated uniformly on sugar beet leaves. The results of urea fertigation through sprinklers indicate uniform fertigation makes low spatial variability of sugar beet leaf N content.

Patil *et al.* (2011) reported that the knowledge of spatial variability in soil fertility is important for site specific nutrient management. In their study, spatial variability in properties that influence soil fertility such as soil organic carbon (OC), available N, available P₂O₅ and available K₂O in surface soils of 154 farmers' fields of Karlawad village in Navalgund taluk of Dharwad district of Karnataka (India) were quantified and the respective thematic maps were prepared on the basis of ratings of nutrients. Soils sampled (0-20 cm depth) at 154 locations in an area of 1032.15 ha were analyzed for their composition. Arc Map 9.0 with spatial analyst function of Arc GIS software was used to prepare soil fertility maps. Interpolation method employed was spline. Soils were moderately alkaline in reaction with normal Electrical Conductivity (EC). The coefficient of variation (CV) values for soil OC, available N and available P₂O₅ were 0.35, 0.32 and 0.30 respectively, in the study area and it was lower (0.16) in case of available K₂O. Organic carbon content in the soils was low in majority of the area (683 ha) while it was medium in the remaining area (350 ha). 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. The observed spatial variability in various soil properties that influence soil fertility will help farmers in making crop management decisions.

Tekin *et al.*(2011) reported that improved nutrient management in precision agriculture is important for achieving high yield and protecting environmental quality. The objectives of this study were to explore the spatial distribution of soil-available

microelements and investigate the spatial relationship between corn yield and soil properties. The topsoil was sampled according to a nested sampling pattern (20*20 m), to describe the spatial variability by geo statistical techniques from 0 to 220 m. The mean plant-available Cu, Zn, Fe, and Mn contents were 1.91, 0.63, 16.88, and 11.93 mg kg⁻¹, respectively, being at medium or at high levels. The results indicated that coefficient of variation for soil properties varied from 1.28 (pH) to 47.51% (EC). Within the field studied, moderate spatial dependence was found for many of the variables, but at different spatial scales. The semi-variance analysis showed that available Zn and Mn were spatially correlated at the greater distances of 155.8 m and 379.8 m, hence requiring the largest sampling interval, and available Cu and Fe were at shorter distances of 95.3 and 57.1 m, respectively. The results revealed that available macro and micronutrient status showed wide variations across the study area which was mainly associated with the variation in soil texture, organic matter and calcium carbonate contents of the field. The spatial variation in soil characteristics within the field has clearly been reflected in the yield of corn.

Jahknwa *et al.* (2014) .Conducted a study to assess the heterogeneity of pH, Electrical Conductivity (EC_{1:2}) and Exchangeable Sodium Potential (ESP) of Vertisols of a 0.5hectares farmland in Kerau village located in Guyuk Area of Adamawa state, Nigeria. The objective was to examine the soil salinity status and variability at the study site. The grid sampling technique was used to collect 50 soil samples at each of 0-15 cm and 15-30 cm depths of the study site. Accordingly, descriptive statistics were used to examine the physical and chemical properties of the soil. Semivariogram analysis was used to assess the spatial variation of soil properties while ordinary kriging interpolation technique was used to map the spatial distribution of soil properties. The findings showed that vertisols of the study area are alkaline in nature evident by the high pH values recorded. They however, exhibited very low EC and ESP values indicating the absence of salinity or sodicity problems in the soil of the study area. The study recommends periodic assessment of soil salinity parameter in the study area in order to avoid its effects on crops.

2.8 Evaluation of fertility status of soils to asses multi-nutrient status:

Akbari *et al.* (2003). One hundred seven red loam soil samples (84 and 23 from Udaipur and Chittogarh district, respectively) collected from Mewar region of Rajasthan, India, were analysed for basic properties (pH, electrical conductivity

(EC), CaCO₃, organic C and available phosphorus and potassium). Results indicated that most of the soils were light to moderately alkaline (pH 7.0 to 8.4) in reaction, non-saline (EC 0.1 to 1.1 dS/m), non-calcareous (0.12 to 3.50% CaCO₂), low to high in organic C (0.03 to 1.44%), marginal to high in available phosphorus (13.44 to 132.96 kg P₂O₅/ha) and medium to high in available potassium content (104.08 to 953.68 kg K₂O/ha). The available content was negatively related with pH and CaCO₃ and positively with organic C content of soil. Organic C played the most important role for variation in available phosphorus. No significant relation ship was observed between potassium and any of the soil properties studied.

Rajkumar *et al.* (2009) Assessed soil fertility status of Faridkot district of Punjab based by analysing 1706 soil samples. ArcGIS 9.2 software was used to extrapolate the information for preparing six thematic maps and overall soil fertility status map of the district. Soils are predominantly coarse textured. Soil fertility status based on per cent samples have been compared with per cent area based on Arc GIS mapping for all the parameters. The results of pH, EC and available K by the two methods are almost comparable. The results indicated that 73 per cent samples are low, 26 per cent are medium and one per cent samples are high in OC content. The actual area calculations based on the Arc GIS showed that 86 per cent of the area is low, 13.8 per cent is medium and only 0.2 per cent of the area is high in OC content. Similarly, results based on per cent samples collected, indicated that 48, 30, 18 and 4 per cent samples are low, medium, high and very high in available P, respectively. The actual area calculations based on GIS software indicated that 21, 53, 22 and 4 per cent is low, medium, high and very high in available P, respectively. Most of the villages are low in organic carbon, low to medium in available P and high in available K.

Kamaraj *et al.* (2010) A field experiment was conducted to find out the effect of organic manure fortified with micronutrients *viz.*, ZnSO₄ and FeSO₄ on the growth and yield of rice in coastal saline soil. The experiment was conducted in farmers field at Sillankuppam village in Cuddalore district, Tamil Nadu during October-January 2009. The initial fertility status of experimental soil was pH - 8.88, EC - 2.16 dS m⁻¹ and OC - 0.22 g kg⁻¹ and represented low status of micronutrients.

Reddy *et al.* (2012) conducted a study during 2011-12 to characterize soils in Musi project command area in Nalognda district, Andhra Pradesh. About 95

surface (0-15 cm) soil samples were collected during June, 2011 from a study area of 24,906 ha by making a 3x3 km² grid. Majority of the soils were sandy clay loam (70%) in texture followed by sandy loam (14%), sandy clay (7%), loamy (4%), clayey (3%) and clay loam (2%). The soil reaction ranged from pH of 6.78 to 9.15 and majority were moderately alkaline in reaction (55%), followed by slightly alkaline (29%), strongly alkaline (12%) and neutral (4%). The EC ranged 0.112-3.53 dS m⁻¹ and majority of samples (99%) were non saline and only one percent soils were found to be moderate. All the soils were found to be high in their organic carbon status (12 to 31 g kg⁻¹), low in available N (53-205 kg N ha⁻¹), very high in available K (460-1298 kg K ha⁻¹). The available P was medium (4%) to very high (96%) (18.9-209.8 kg P ha⁻¹). The thematic maps on spatial variability of soil fertility maps (pH, EC, available N, P and K) were generated by ordinary krigging method available in the sub mode of interpolation in the spatial analyst tools of Arc map 9.3 GIS software.

Singh *et al* .(2012) reported that the spatial distribution of nitrogen, phosphorus and potassium was studied by collecting random geo-referenced surface (0-15 cm) soil samples from 332 sites representing Kurhani block in the Muzaffarpur district of Bihar. These soil samples were analyzed for pH, EC, organic carbon, nitrogen, phosphorus and potassium and categorized as low, medium and high as per standard procedures. The pH of soil samples varied from 7.80 to 8.42, EC of soil samples varied from 0.05 to 0.16 dS/m and organic carbon varied from 0.41 to 0.54%. The available nitrogen, phosphorus and potassium content of surface soil samples varied from 163.37 to 190.66 kg N/ha, 11.90 to 15.69 kg P/ha and 121.15 to 153.40 kg K/ha.

Shankar *et al*. (2013) To identify the best combinations of micronutrient-based fertilization treatments in terms of crop yield and nutrient uptake, three field experiments with greengram - finger millet as the test sequence with 12 treatments on micronutrient-based fertilization [with recommended nitrogen (N) - phosphorus (P) - potassium (K) fertilizer] were conducted during 2005 to 2007 in a semi-arid Alfisol at Bangalore. The effects of treatments on available soil and plant uptake of nutrients [N, P, K, sulfur (S), iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), boron (B), and molybdenum (Mo)] and yield of crops were assessed based on standard analysis of variance procedure. Using the relationships of yield with soil and plant nutrient variables, regression models of yield through soil and plant

variables were calibrated and effects of variables on crop yields were assessed. The models gave high and significant yield predictability in the range of 0.87 to 0.98 through different variables. The model of plant uptake through soil nutrients indicated that soil S, Fe, and Zn had significant positive effects, whereas soil N, K, B, and Mo had negative effects on plant nutrient status in greengram. Similarly, soil P, Mn, and Zn had significant positive effects, whereas soil N, K, and Fe had negative effects on plant uptake of nutrients in finger millet. Based on a relative efficiency index (REI) criteria, T2 for plant uptake and T12 for maintaining soil nutrients were found to be superior in greengram, whereas T2 for plant uptake and T8 for maintaining soil nutrients were found to be superior in finger millet over years based on REI. The combined REI over soil and plant nutrients for both crops indicated that application of T8 for greengram and T2 for finger millet could be prescribed for attaining maximum plant uptake of nutrients and productivity of crops in sequence, apart from maintaining maximum soil fertility of nutrients under semi-arid Alfisols.

Rani and Jayasree (2012) A study was undertaken to map the nutrient status of Nalgonda district of Andhra Pradesh. The soil analysis showed the deficiency of N, P, K and organic carbon in the study area. From the soil fertility maps it was observed that all rice growing soils in the district are low in organic carbon content and available nitrogen. An area of 9462 ha (6.4 per cent) was in the low category and 138390 ha (93.6%) was in the medium category in available phosphorus. An area of 14046 ha (9.5%) was in low category and 133806 ha (90.5%) was in medium category in available potassium.

Pramod *et al.* (2013) Surface and subsurface soil samples of Muzaffarnagar district were collected to characterize their chemical properties and accordingly to develop optimum land use plan to realize maximum agricultural productivity. The pH value of study area varied from 6.02 to 8.39 and 6.35 to 8.50 for surface and sub surface, respectively, electrical conductivity from 0.069 to 0.390 and 0.073 to 1.10 dSm^{-1} , organic matter content 7.241 to 15.221 and 3.695 to 10.179 g kg^{-1} , available nitrogen (N) 131.53 to 348.97 and 99.32 to 217.44 kg ha^{-1} , Phosphorus (P) 15.67 to 52.61 and 11.17 to 45.40 $\text{P}_2\text{O}_5 \text{ kg ha}^{-1}$, potassium (K) 79.16 to 436.8 and 47.04 to 399.84 $\text{K}_2\text{O kg ha}^{-1}$ for surface (0-15 cm) and subsurface soil (15-30 cm). Cationic micronutrients Zn, Cu, Fe and Mn varied from 1.636 to 6.164, 1.024 to 4.282, 0.672 to 5.802 and 0.332 to 2.652, and 113.13 to 11.232, 10.33 to 79.326, 10.272 to

38.572 and 29.578 to 77.882 mg kg⁻¹ in surface (0 -15 cm) and subsurface soil (15-30 cm) respectively. As per soil nutrient index (SNI), the soils of study area were found in low fertility category for nitrogen and medium with respect to phosphorus and potassium. A positive and significant correlation of NPK and micronutrients was found with organic matter content while significant and negative correlations exist between micronutrients and soil pH.

Prabhavathi *et al.* (2013) Assessment of the soil fertility status in a watershed was carried out for efficient soil management and cropping systems for sustainable yields. Composite soil samples in surface soil (0-15 cm) from 253 locations were collected from the watershed by considering their physiographic units. Samples were analyzed for pH, electrical conductivity, organic carbon, available N, P₂ O₅ and K₂ O and micronutrients *i.e.* Zn, Cu, Fe and Mn. Results revealed that Nutrient Index of organic carbon (g kg⁻¹), available N (kg ha⁻¹) and zinc (mg kg⁻¹) were very low and nutrient index was medium for available P₂ O₅ and K₂ O in the watershed. The extent of deficiency of organic carbon, nitrogen and zinc was 63%, 86% and 58%, respectively. The study indicated that the low organic carbon and nitrogen in soils were attributed to low application rates of organic material, high temperature and low rate of application of N fertilizers, especially in the rainfed areas. To build up organic matter and native nitrogen and maintain nutrient balance in the soil, farmers are advised to adopt FYM and ZnSO₄ application, crop rotation of groundnut with bajra, intercropping of groundnut with redgram in the rainfed areas, whereas in irrigated areas, crop rotation along with application of farm yard manure, SSP and ZnSO₄ can enhance crop production and soil fertility.

Patil *et al.* (2013) have attempted to evaluate soil fertility status from the soils from dapoli tahsil, Ratnagiri District Maharashtra. The 110 soil samples were collected and analyzed for the various basic parameters like pH, Electrical Conductivity (EC), Organic Carbon (OC), and macronutrients like N (Nitrogen), P (Phosphorous), and K (Potassium). The pH of the soil ranges from 5.77 to 7.95 reflecting slightly alkaline nature of the soil. The EC ranging from 0.09-0.19 dS/m. EC of the soil samples indicates the salt free nature of the soil in all samples. The values of the OC range from 0.57 to 2.06% in the soils of tahsil. Majority of the villages 72.72% have low proportion of the N and 54.54% villages having medium proportion of P. The proportion of K is high in 72.72% villages and medium in 27.27%. This means that the soils in the tahsil lack in N. Low status of Nitrogen and

organic carbon indicates the need of adequate Nitrogen fertilization with bio-fertilizers.

Baruah *et al* .(2014) reported that the increasing land use intensity without adequate and balanced use of chemical fertilizers and with little or no use of organic manure have caused severe fertility deterioration of our soils resulting in stagnating or even declining of crop productivity in Assam. The need of the hour is to achieve substantially higher crop yield than the present yield levels from our limited land resources on a sustainable basis. A study was carried out in the paddy fields of tea garden belts namely, Rungagora, Balijan, Banwaripur, Khomtai, Rungajaun, Lattakoojan, Borjan, Behora, Negheriting, and Borsapori of Golaghat district of Assam to investigate the fertility status of soil during 2008-2010. Results of the present study showed that soil solutions were acidic in nature in all seasons. Medium-to-high BD, medium SOM, medium-to-high available N and available phosphorous, and low availability of potash showed that soils were not sufficiently fertile for crop production. Depending on the SOM, available N, available P, and exchangeable K in soil, the study areas were grouped in to six fertility classes as MMML, MMHL, MMMM, MHHL, MHHM, and MMHM. Student *t*-test values of all the parameters with control sample showed statistically significant results for SOM, available N, and available P in both seasons (dry and wet) and EC in wet seasons and bulk density in dry season only.

CHAPTER – III

MATERIALS AND METHODS

The materials used and methods employed during the course of the investigation are presented in the following sections. The present investigation entitled “Evaluation of Soil Fertility in Vertisols and Associated Soils of Ralyawan Village of Jhabua district of Western M.P.” was carried out in Kharif season during the year 2014 under All India Coordinated Research Project for Dryland Agriculture, College of Agriculture, Indore. The details of material used and methodology adopted are given in this chapter.

1. Characterization of the soils of Ralyawan Village:

1. 1: Location and climate:

The village Ralyawan is about 25 km, towards north of Jhabua, which is surrounded by Mohankheda in South, Dhanpura North, Soliya, in East and Jhawliya on the Western side. The village is under the administration of – *Gram Panchayat*. Jhawalia, which comes under the block Petlawad. This block is under the Jhabua district of Madhya Pradesh state.

Jhabua is situated at an altitude of 428 meters above the mean sea level with latitude of 21⁰30'-22⁰55'N and longitude of 73⁰30'-75⁰01'E and Ralyawan is located in Jhabua district lying between 21⁰30N latitude and 73⁰30'E longitude. This village comes under the western zone of Madhya Pradesh. The region generally experiences hot, sub tropical climate, having average rainfall of 800 mm, with erratic pattern of distribution, mostly concentrated in the month of June to September, with very little amount from October to February. The hottest and coolest months are May and December, respectively. The maximum temperature during the summer may exceeds even 45⁰C and the minimum temperature often falls below 5⁰C during winter season.

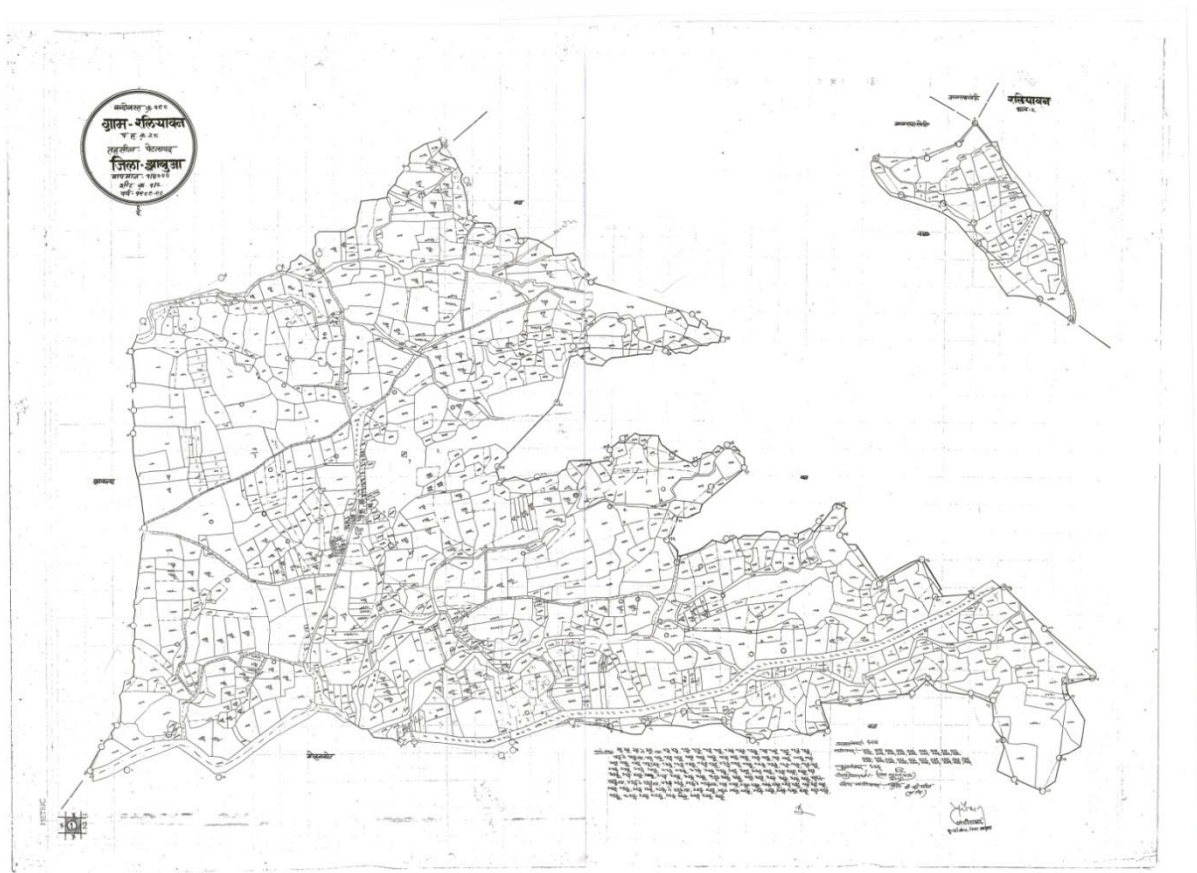
1.2 Agricultural Scenario:

i. Crop husbandry:

During rainy season major crop of the village are Soybean which is grown in 50% area and Maize is grown in 35% area of the village, other kharif crops are Cotton , Redgram and fodder. wheat and gram are the main crops grown by the

farmers in rabi season. In summer season, field crops like Greengram & Blackgram and horticultural crops like Coriander, Tomato, Chilli and Brinjal are Cultivated. Ground and surface water are used for irrigation purpose. Major part of the village is rainfed and partially irrigated.

1.3: CADASTRAL MAP OF RALYAWAN VILLAGE:

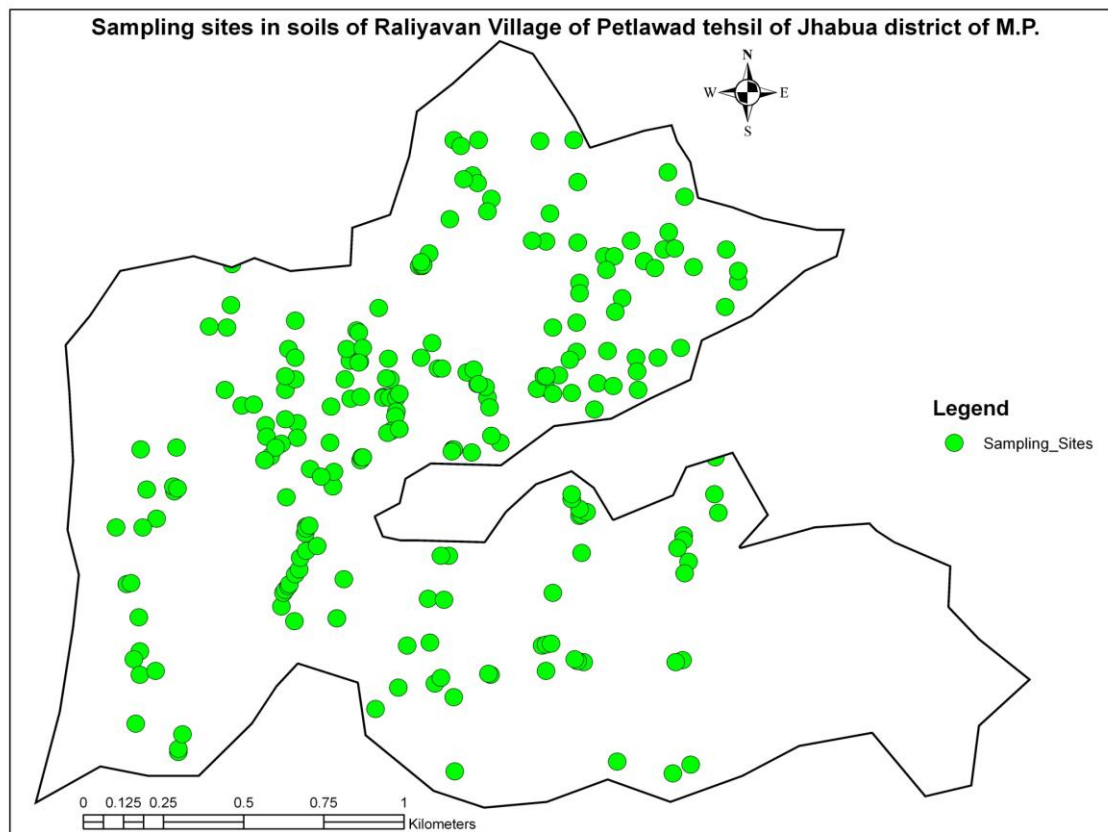


Map 1: Cadastral Map Of Ralyawan Village

1.4 Soil Characterization and preparation of soil fertility maps of Ralyawan village:

Looking to the crop production and soil related constraints in Ralyawan village we found it important to characterize the soils of the region at village levels. We got an opportunity to assess the soil fertility status of the TSP (Tribal Sub Plan) village adopted by the All India Co-ordinated Research Project for Dryland Agriculture, Indore. Surface(0-15 cm) soil samples were collected from 250 locations in

Ralyawan village (sampling points are depicted in Map 2). The GPS points were also collected for preparing the spatial distribution maps of various analysed soil parameters (textural class, pH, EC, OC, Available-N, P, K, S). These spatial distribution maps are depicted in Map 2. For soil analysis standard methods were adopted. The nutrient index figures were worked out and the soil were categorized to different fertility units. DTPA- extractable content of Zn, Fe, Cu and Mn elements determined the micronutrient status of soils.



Map 2: Sampling points at village Ralyawan

2.Methods of analysis for Assessment of soil fertility:

2.1:Collection of samples

Soil samples (0-15 cm) at random were collected during May 2014 in the help of soil auger . The exact sample location was recorded using a GPS. Processed soil samples were analysed for nutrient availability by following standard analytical techniques.

(1) Chemical properties

(a) Determination of soil pH

Soil pH was determined in a 1: 2 soil: water suspension by glass electrode Beckman pH meter (Jackson, 1967).

(b) Determination of electrical conductivity

The soil suspension used for pH determination was allowed to settle down and conductivity of supernatant liquid was determined by using conductivity meter (Jackson, 1967). The results are expressed in dSm^{-1} at 25°C .

(c) Determination of organic carbon

Organic carbon content in soil was determined by Walkley and Black's rapid titration method (1934).

Five gram of soil sample was taken to which 10 ml potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) and 20 ml commercial sulphuric acid (H_2SO_4) were mixed. The mixture was kept as such for about $\frac{1}{2}$ an hour. Then 200 ml tap water, 10 ml phosphoric acid and 2 ml diphenylamine indicator was added. The colour of the solution turned into ink blue. Now this solution was titrated against 0.5 N ferrous ammonium sulphate till the solution became green in colour indicating the end point of the titration. The value at end point was noted down from the burette and organic carbon content was estimated by using the formulae.

$$\text{O.C.(\%)} = \frac{X - Y}{2} \times 0.003 \times 100$$

Where X = Blank reading Y = Titrated value

(2) Available Nitrogen

It was determine by alkaline permanganate method (Subbiah and Asija, 1956). Twenty gram of soil samples were taken in one litre flask and to it added 100 ml of 0.32% KMnO_4 and 2.5% NaOH each. The flask was immediately connected to distillation assembly and heated. The distilled ammonia was collected in 2% Boric acid using methyl red indicator. The distillate was titrated against 0.1N H_2SO_4 . Results have been expressed in N kg/ha.

(3) Available phosphorus

Available phosphorus was determined by using Olsen's extractant (0.5 N sodium bicarbonate solution of pH 8.5, Olsen *et al.*, 1954).

I. Preparation of standard curve

Standard solution was prepared by dissolving 0.2195 g of pure dry KH_2PO_4 in one litre of distilled water. This solution contained 50 microgram (0.05 mg) per

milliliter. This was prepared as a stock standard solution of phosphate, 100 ml of this solution was diluted to 1000 ml with distilled water. This solution contained 5 microgram (0.005 mg) of P per milliliter. Then 1, 2, 3, 4, 6 and 10 ml of this solution were taken in separate 25 ml volumetric flasks and 5 ml of the extractant solution and 5 ml of molybdate reagent were added and diluted with distilled water to about 20 ml. After the addition of 1 ml of SnCl_2 solution, it was diluted to 25 ml mark and then contents were shaken vigorously. After two minutes the transmittance per cent of the solution was read on spectrophotometer at 660 m μ . The transmittance per cent was plotted against microgram of P and standard curve was prepared accordingly.

II. Extraction

One gram of soil sample was taken with 20 ml of 0.5 N NaHCO_3 of pH 8.5 as an extractant (Olsen *et al.*, 1954) together with 0.5 g of Darco G-60 (free from phosphorus). The contents were shaken for 30 minutes in 100 ml conical flask and then filtered through Whatman filter paper No.40.

III. Development of colour

Five ml of the colourless filtrate was taken in 25 ml of volumetric flask for determination and then 5 ml of ammonium molybdate hydrochloric acid solution was added. The contents were diluted to about 22 ml, now 1 ml of working solution of stannous chloride was added to each flask to develop blue colour. The contents of flasks were shaken well and diluted to the mark. Colour intensity was measured in spectrophotometer within 10 minutes after setting the instrument to 100 reading of transmittance with blank prepared. The amount of phosphorus was calculated as P in kg/ha.

(4) Available potassium

One gram of soil was shaken with 100 ml of neutral normal ammonium acetate solution as an extractant in 200 ml conical flask for 30 minutes and then filtered through Whatman number 40 filter paper. The amount of potassium present in extract was determined by flame photometer as described by Jackson (1967). The results were calculated as K kg/ha.

(5) Available sulphur

Available sulphur was determined the method given by Chesnin, L and Yien, C.H. (1951)

I. Preparation of standard curve

Dissolved 0.5434 g of oven dried K_2SO_4 (A.R.) in one litre of distilled water. This solution contained 100 ppm of sulphur concentration. A series of different concentrations 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50 ppm S solution were prepared. 10 ml of standard solution of varying concentrations were taken in 25 ml volumetric flasks, 1 ml of 6N HCl (seed solution) and 1 ml of 0.25 per cent gum acacia solution were added in each flask and shaken. Final volume was made up to the mark with distilled water. Contents of the flasks were transferred to a beaker, 0.5 g of barium chloride crystals (30 mesh) added and swirled gently for two minutes. Turbidity produced was measured as transmittance per cent on spectrophotometer at 420 m μ . The transmittance per cent was plotted against concentration of sulphur (ppm) in solution and standard curve was prepared accordingly.

II. Extraction

Ten gram of soil sample was taken with 50 ml of extractant ($CH_3COONH_4 + CH_3COOH$) and 0.5 g of sulphur free activated charcoal, shaken thoroughly for about 30 minutes and filtered through Whatman number 40 filter paper.

III. Development of turbidity

Ten ml of the above extract was shaken in a 25 ml volumetric flask. 1 ml of 6 N HCl (seed solution) and 1 ml of 0.25 per cent gum acacia solution were added to it and shaken. Final volume was made up to the mark with distilled water. Contents of the flask were transferred to a beaker 0.25 g of barium chloride crystals (30 mesh) added and swirled gently for two minutes. Turbidity produced was measured as transmittance per cent on spectrophotometer at 420 m μ . After setting the instrument to 100 reading of transmittance per cent with blank prepared. The amount of sulphur was calculated as S kg/ha.

6 .Available micronutrients

The micronutrients Zn, Cu, Fe and Mn were extracted by using 0.005 M diethylenetriaminepenta acetic acid, 0.01 M calcium chloride dehydrate and 0.1 M triethanol amine buffered at pH 7.3 (Lindsay and Norvell, 1978) and concentrations were analysed by atomic absorption spectrophotometer .

7. Particle size analysis(mechanical analysis of Soil)

Particle size distribution of soil samples was determined by hydrometer method as described by Buoyoucos (1962) using 5% sodium hexameta phosphate as dispersing agent.

8.Theoretical considerations for preparing spatial pattern maps of soil nutrients:

In nature the soil properties are highly variable spatially and for accurate estimation of soil properties these continuous variability should be considered. In recent years a new technique called kriging and its variants were widely recognized as an important spatial interpolation technique in land resource inventories (Hengl et al., 2004). The traditional method of soil analysis and interpretation are laborious, time consuming, hence becoming expensive. With the advancement of GIS and remote sensing technology, predictive soil mapping techniques are introduced. Using inexpensive and readily available ancillary data and indicators that reveal a close relationship to specific soil quantities are being used recently for spatial interpolation.

It is fact that soil properties vary from place to place even within the same field. As a result, the spatial structure can vary at scales that differ by several orders of magnitude from a few meters to hundred kilometers. Such variation with distance can be described well with the help of geo-statistics (Carr and Meyers 1984, woodcock et. al., 1981, Collin sand woodcock 1999). The above phenomena is the best accomplished by the studying the semivariogram (Warrick et. al., 1986) which is a plot of semi-variance that characterizes the rate of change of a mapped variable with respect to distance. Semi-variogram $\hat{\gamma}(h)$ is computed as half the average squared difference between the soil properties of data pairs. The structure of spatial variability was analyzed through semivariograms. Spatial distribution was analyzed through kriging interpolation using ARCGIS 9.3.1 software. A semivariogram from the set of sample data is calculated using the following equation (Chile` s and Delfiner 1999):

$$\hat{\gamma}(h) = \frac{1}{2N(h)} \sum_{\alpha=1}^{N(h)} [(z(\mu_{\alpha}) - z(\mu_{\alpha} + h))]^2$$

where $N(h)$ is the number of data pairs separated by lag distance h ; $z(u\alpha)$ is measured value of the variable at point a ; and $z(u\alpha+h)$ is measured sample value at point $u\alpha+h$.

Parameters defining semivariogram models are nugget (variability at a smaller scale than the sampling interval and/or sampling and analytical error), sill and range. The range of the semivariogram is defined as the distance at which the variogram stabilizes around a limiting value, the sill, which can be approximated by the total variance of $Z(x)$. The sill expresses the distance (range) beyond which samples are not correlated.

Kriging of geo-statistics is an optimum interpolation technique for making unbiased estimates of regionalized variables at unsampled locations in which the structural properties of the semivariogram and the initial set of samples are used. The spatial prediction of the values of a soil variable Z at an unsampled point X_0 is estimated by the formula (Chile` s and Delfiner 1999):

$$Z(x_0) = \sum_{i=1}^n \lambda_i Z(x_i)$$

where X denotes the set of spatial coordinates $\{ X_1, X_2 \}$, n is the number of neighboring samples and λ_i are the weights associated with the sampling points X_i . The predicted value $Z(X_0)$ at point X_0 is a weighted average of the values Z at n surrounding points.

In the present study the collected cadastral maps were geo-referenced and identified the sites for sampling. Soil samples were collected from 250 sites and their location are recorded through global position system during post-harvest period considering the variations. Spatial variability maps of soil properties was created using the latitude and longitude, the point shape files showing the location of the observation were generated by using ARC Map 9.3.1.

The other parameters like range, mean Standard deviation and coefficient of variation are calculated by classical statistical approach.

9. Methodology for macronutrients status evaluation:

The categorization of the soils of the individual blocks as a whole in to the three fertility classes was done according to the nutrient index values calculated from

the soil test summaries giving their percentage distribution into low, medium and high categories.

The nutrient index (Muhr *et al.*, 1965) was given by-

Nutrient index = [% in high category × 3 + % in medium

Category × 2 + % in low category × 1] / 100

In this percent assessment a nutrient index less than 1.65 denotes low category and that falling between 1.65 and 2.33 represents the medium fertility class. Value of 2.34 and above (maxi 3.00) signifies a high fertility class in respect of the particular nutrient (Ghosh and Hasan , 1976).

The rating of the individual soil test values in to the three classes was performed according to the following limits (Ramamoarhy and Bajaj, 1969) which have been adopted by most of the soil testing laboratories in the country:

10.Statistical Analysis:

- Geo-statistical analysis was carried-out using GIS software.
- Multiple correlation was carried-out using SPS software.
- General statistics was calculated by Microsoft Excel.

CHAPTER-IV

RESULTS

The results achieved from the present investigation are presented in this chapter. The soil samples were analyzed for the physico-chemical properties i.e. pH, electrical conductivity, organic carbon and available nutrient (N, P, K,S, Fe, Cu, Zn and Mn) content and textural classes of soil. Soil fertility maps using GIS software were prepared using geostatistical analysis. The spatial variability maps of pH, EC, major nutrients, micro nutrients, sand, silt and clay and multinutritional status are prepared and presented in this chapter. Brief description of results obtained are presented below.

4.1 Available macronutrients status of soils of Ralyawan village:

4.1.1 Available N status of the soils of Ralyawan village:

Considering the soil test rating for available N (<250 as low, 250-400 as medium and >400 as high in the status of N) the soils of Ralyawan fall under low status (<250 kg ha⁻¹) in available N content. In general out of 250 samples, 55.2% fall under low status and 44.8% samples were categorized under medium N status. The general statistics calculated from 250 soil samples revealed that the available N content ranged from 152–298 kg ha⁻¹ (Table 1) with a mean value of 236 kg ha⁻¹, standard deviation 31.02 kg ha⁻¹ and Coefficient of Variation (CV) 13.14 %.

Table 1 : Distribution of available nitrogen status in the soils of Ralyawan village

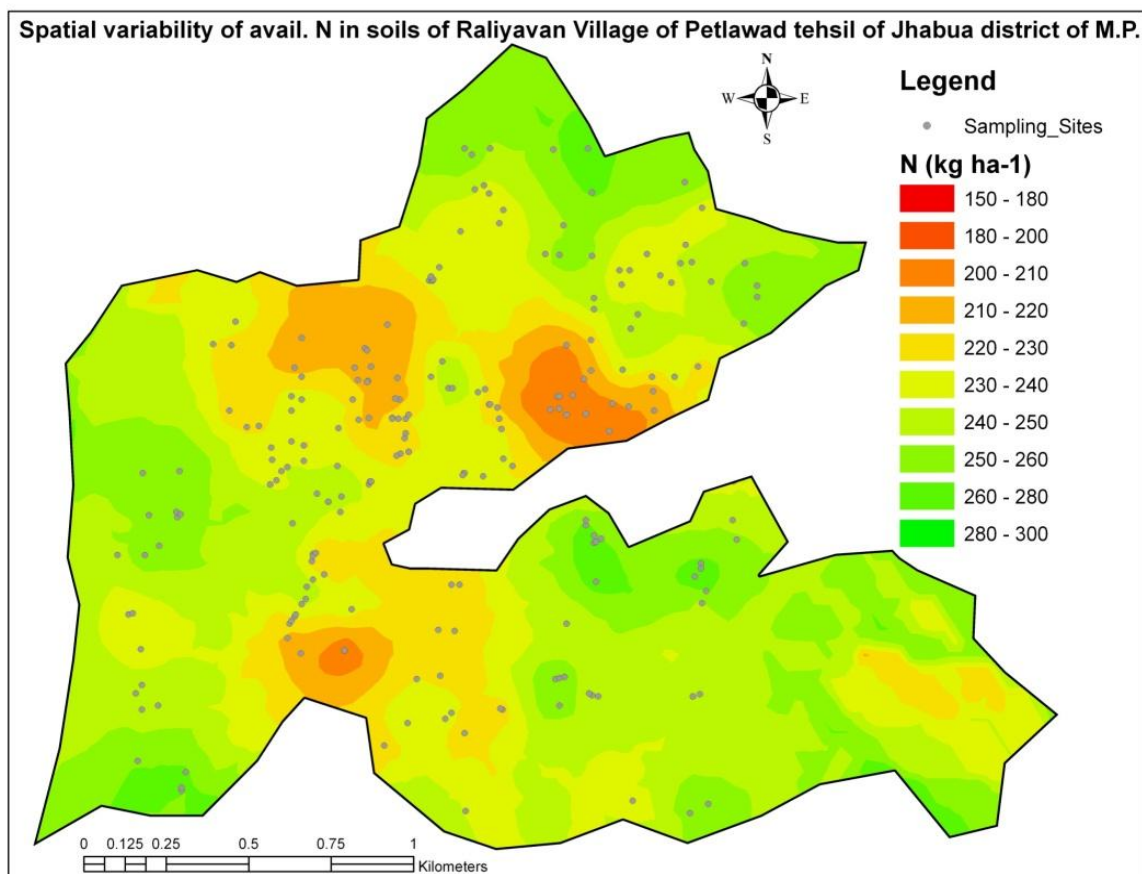
Available -N (kg ha ⁻¹)	No. of Samples	% Samples
Low(<250)	138	55.2
Medium(250-400)	112	44.8
High (>400)	NIL	
General statistics:		
Range (kg ha ⁻¹)	152-298	
Mean (kg ha ⁻¹)	236	
Standard deviation (kg ha ⁻¹)	31.02	
Coefficient of Variation (%)	13.14	

4.2 Spatial distribution of available –N in the village soils:

Spatial variability map of Avail-N of the village soils is presented in map 1. To prepare the N variability map soils were divided in to ten categories (table 2) The spatial variability map of available-N of Ralyawan village (map 1) showed that in whole village the Av-N content varies from < 150 to > 310 kg ha⁻¹. This kind of map will help the farmers for site specific nutrient management on the basis of soil test values.

Table 2: Different N availability classes of the soils of Ralyawan village.

N- availability Class	Available-N , kgha⁻¹
I	<180
II	>= 180 to <200
III	>=200 to <210
IV	>=210 to <220
V	>=220 to <230
VI	>=230 to <240
VII	>=240 to <250
VIII	>=250 to <280
IX	>=280 to <300
X	>=300



Map1:Spatial distribution of Av.-N in village Ralyawan

4.3. Available P status of the soils of Ralyawan village:

The available P content (Table 3) of the soils of Ralyawan village ranged from 7.15 to 38.8 kg ha⁻¹ with an average value of 16.4 kg ha⁻¹. Considering the soil test rating for available P (< 12.5 kg ha⁻¹ as low, 12.5 – 25.0 kg ha⁻¹ as medium and >25.0 kg ha⁻¹ as high in the status of P) the soils of Ralyawan fall under low, medium and high status in available P content. In general out of 250 samples, 12 % samples fall under low status, 67.2% samples under medium P status and 20.8% samples were high in P status. The general statistics calculated from 250 soil samples revealed that the available – P content ranged from 7.5– 38.80 kg ha⁻¹ with a mean value of 16.4 kg ha⁻¹, standard deviation 6.29 kg ha⁻¹ and Coefficient of Variation (CV) 38.44%. The variation in available – P is quite large which might be due to variation in soil properties viz., pH, organic matter content, texture and various soil management and agronomic practices adopted by the farmers of the region.

Table 3 : Distribution of available phosphorus status in the soils of Ralyawan village

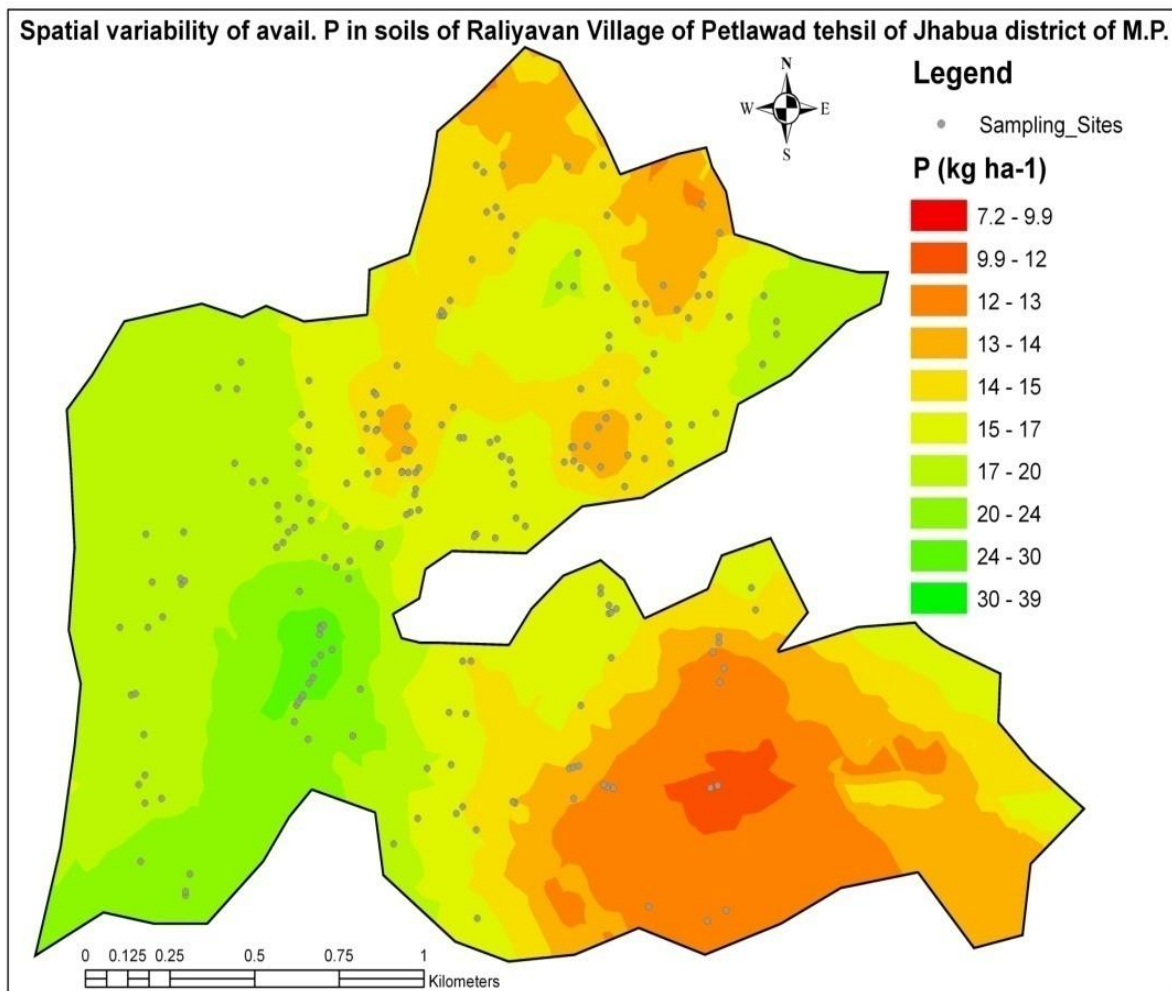
Available-P (kg ha ⁻¹)	No. of Samples	% Samples
Low(<12.5)	30	12
Medium (12.5-25)	168	67.2
High (>25)	52	20.8
General statistics:		
Range (kg ha ⁻¹)	7.15-38.8	
Mean (kg ha ⁻¹)	16.4	
Standard deviation (kg ha ⁻¹)	6.29	
Coefficient of variation (%)	38.44	

4.4 Spatial distribution of available–P in the village soils:

Spatial variability map of Av-P of the village soils is presented in map 2. To prepare the P variability map soils were divided in to ten categories (Table 4) The spatial variability map of available-P of Ralyawan village (Map 2) showed that in the whole village the Av-P content varies from < 7.2 to 39 kg ha⁻¹.

Table 4: Different P availability classes of the soils of Ralyawan village.

P- availability Class	Available-P , kg ha ⁻¹
I	7.2 to 9.9
II	>=9.9 to <12
III	>=12 to <13
IV	>=13 to <14
V	>=14 to <15
VI	>=15 to <17
VII	>=17 to <20
VIII	>= 20 to <24
IX	>= 24 to < 30
X	>=30 to 39



Map 2: Spatial distribution of Av.-P in village Ralyawan

4.5 Available K status of the soils of Ralyawan village:

The available K content (Table 5) of the soils of Ralyawan village ranged from 179 to 826 kg ha⁻¹ with an average value of 418 kg ha⁻¹. Considering the soil test rating for available K (< 135 kg ha⁻¹ as low, 135 – 335 kg ha⁻¹ as medium and >335 kg ha⁻¹ as high in the status of K) the soils of Ralyawan fall under medium and high status in available K content. In general out of 250 samples, 6.4% samples fall under medium status and 93.6 % samples were high in K status. The general statistics calculated from 250 soil samples revealed that the available – K content ranged from 179 to 826 kg ha⁻¹ with a mean value of 418 kg ha⁻¹, standard deviation 66.25 kg ha⁻¹ and Coefficient of Variation (CV) 15.84%.

Table 5: Distribution of available potassium status in the soils of Ralyawan village

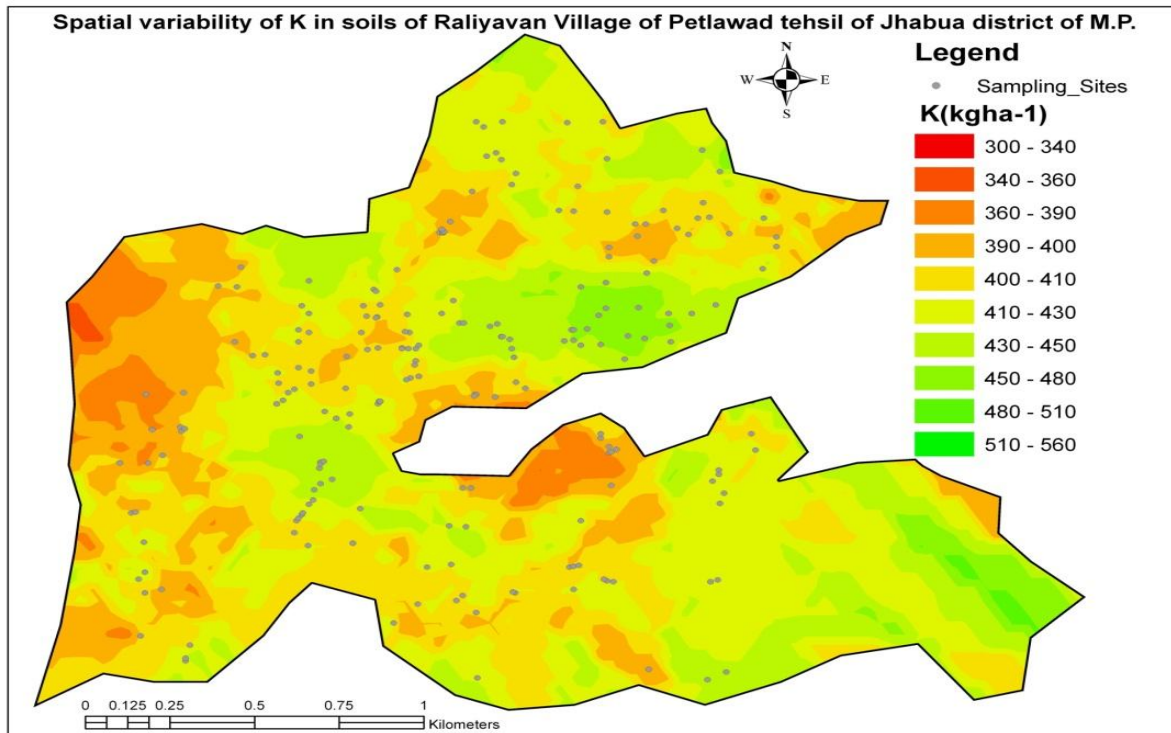
Available-K (kg ha ⁻¹)	No. of Samples	% Samples
Low (<135)	-	-
Medium (135-335)	16	6.4
High (>335)	234	93.6
General statistics:		
Range (kg ha ⁻¹)	179-826	
Mean (kg ha ⁻¹)	418	
Standard deviation (kg ha ⁻¹)	66.25	
Coefficient of variation (%)	15.84	

4.6.1 Spatial distribution of available-K in the village soils:

Spatial variability map of Av-K of the village soils is presented in map 3. To prepare the K variability map soils were divided in to ten categories (table 6) The spatial variability map of available-K of Ralyawan village (map 3) showed that in the whole village the Av-K content varies from < 300 to >=560 kg ha⁻¹.

Table 6: Different K availability classes of the soils of Ralyawan village.

K- availability Class	Available-K , kg ha ⁻¹
I	300 to 340
II	>=340 to <360
III	>=360 to <390
IV	>=390 to <400
V	>=400 to <410
VI	>=410 to <430
VII	>=430 to < 450
VIII	>=450 to < 480
IX	>= 480 to <510
X	>= 510 to 560



Map3: Spatial distribution of Av.-K in village Ralyawan

4.7 Available S status of the soils of Ralyawan village:

The available S content (Table 7) of the soils of Ralyawan village ranged from 8.77 to 29.7 kg ha⁻¹ with an average value of 18.3 kg ha⁻¹. Considering the soil test rating for available S (< 20 kgha⁻¹ as low, 20-40 kgha⁻¹ as medium and >40 kgha⁻¹ as high in the status of S) the soils of Ralyawan fall under low and medium status in available S content. In general out of 250 samples, 75.2 % samples fall under low status and 24.8% samples were medium in S status. The general statistics calculated from 250 soil samples revealed that the available – S content ranged from 8.77 to 29.7 kg ha⁻¹ with a mean value of 18.3 kg ha⁻¹, standard deviation 3.33kgha-1 and Coefficient of Variation (CV) 18.21%.

Table 7: Distribution of available sulphur status in the soils of Ralyawan village

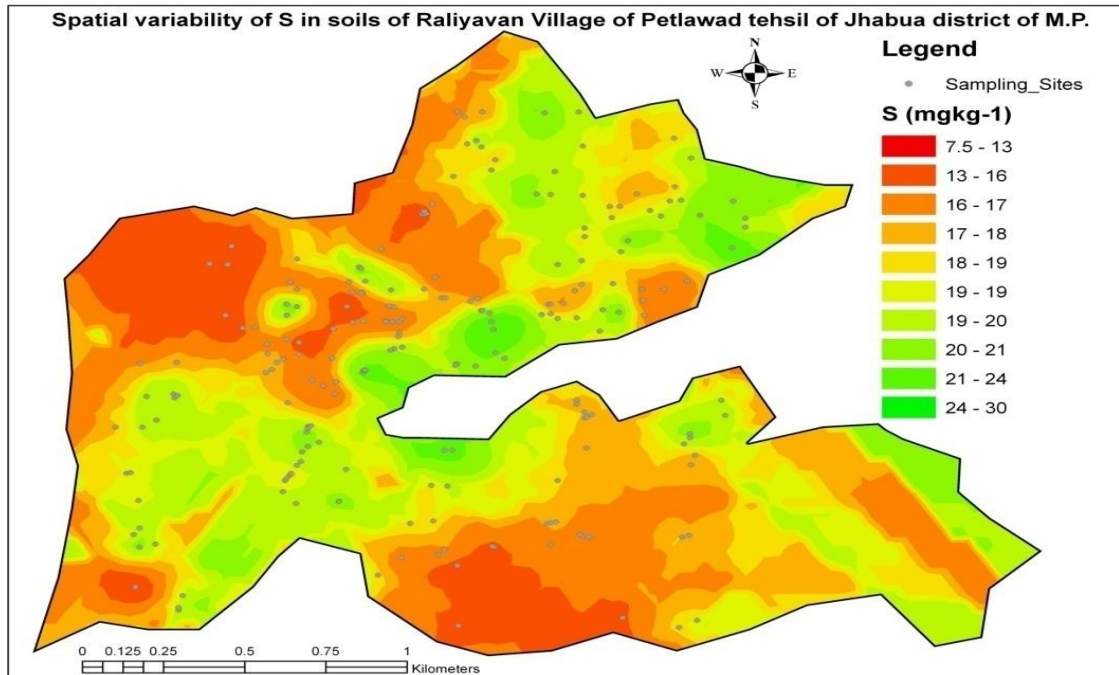
Available-S (kg ha ⁻¹)	No. of Samples	% Samples
Low(<20)	188	75.2
Medium (20-40)	62	24.8
High (>40)	NIL	NIL
General statistics:		
Range (kg ha ⁻¹)	8.77-29.7	
Mean (kg ha ⁻¹)	18.3	
Standard deviation (kg ha ⁻¹)	3.33	
Coefficient of variation (%)	18.21	

4.7.1 Spatial distribution of available-S in the village soils:

Spatial variability map of Av-S of the village soils is presented in map 4. To prepare the S variability map soils were divided in to ten categories (table 8).The spatial variability map of available-S of Ralyawan village (map 10) show that in the whole village the Av-S content varies from < 12 - 28 kg ha⁻¹.

Table 8: Different S availability classes of the soils of Ralyawan village.

S- availability Class	Available-S , kg ha ⁻¹
I	7.5 to 13
II	>=13 to <16
III	>=16 to <17
IV	>=17 to <18
V	>=18 to <19
VI	>=19 to <20
VII	>=20 to < 21
VIII	>= 21 to >24
IX	>= 24 to >28
X	>= 28 to 30



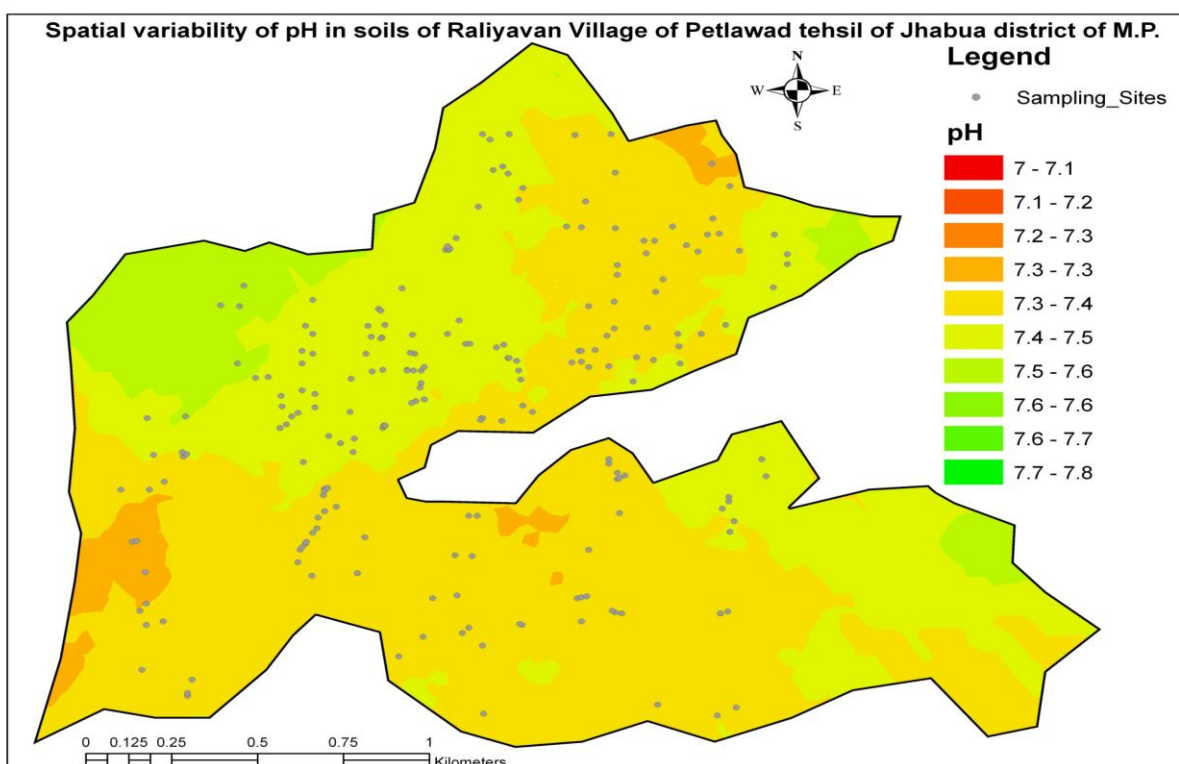
Map 4: Spatial distribution of Av.-S in village Ralyawan

4.1 Soil Reaction of soils of Ralyawan village:

The pH of soils of Ralyawan village ranges from 7-8 with a mean value of 7.5, standard deviation 0.32 and coefficient of variation 4.39% (Table 9). Out of 250 soil samples 163 soil samples were neutral in pH and 87 samples were slightly alkaline. The extent of spatial distribution of soil pH is shown in Map 5 .

Table 9: Soil reaction (pH) of soils of Ralyawan village:

Soil pH class	No. of Samples	% Samples
Strongly acid (<5.0)	Nil	Nil
Moderately acid (5-6.0)	Nil	Nil
Slightly acid (6.1-6.5)	Nil	Nil
Neutral (6.6-7.5)	163	65.2
Slightly alkaline (7.6-8.5)	87	34.8
General statistics		
Range	7-8	
Mean	7.5	
Standard deviation	0.32	
CV%	4.39	



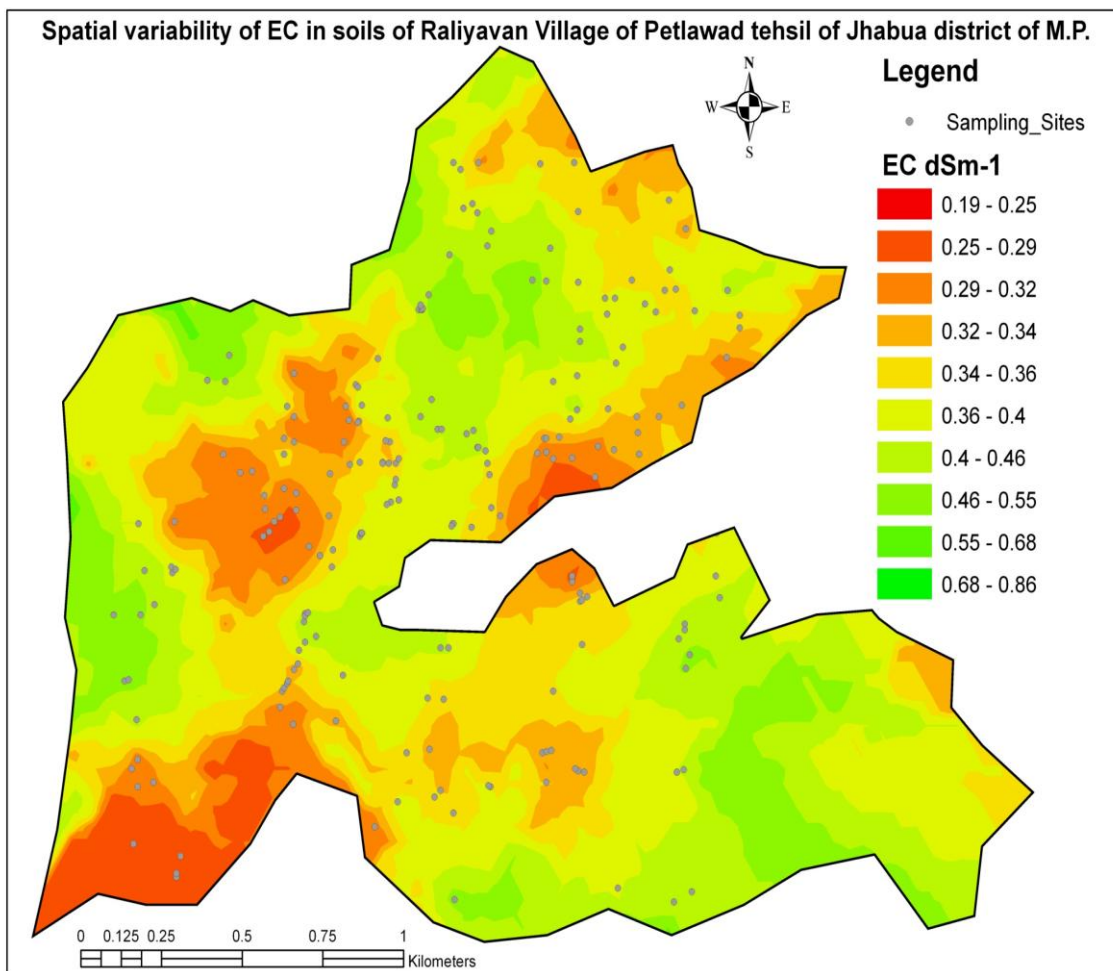
Map5: Spatial distribution of soil pH in village Ralyawan

4.2 Electrical Conductivity of surface soils of Ralyawan village:

Electrical Conductivity of soil ranges from 0.17-0.86 dsm^{-1} with a mean value of 0.37 dsm^{-1} , standard deviation 0.12 and CV 32.79 (Table 10). Most of the soil samples were normal for total salt concentration. The extent of spatial distribution of soil Electrical conductivity is shown in Map 4.

Table10:Electrical Conductivity of surface soils of Ralyawan village:

EC dSm^{-1}	No. of Samples	% Samples
<0.1	Nil	Nil
0.1-0.2	4	1.6
0.2-0.3	108	43.2
>0.3	138	55.2
General statistics		
Range	0.17-0.86	
Mean	0.37	
Standard deviation	0.12	
CV%	32.79	



Map6: Spatial distribution Of EC In Village Ralyawan

4.3 Available Organic Carbon (Av- OC) status of the soils of Ralyawan village:

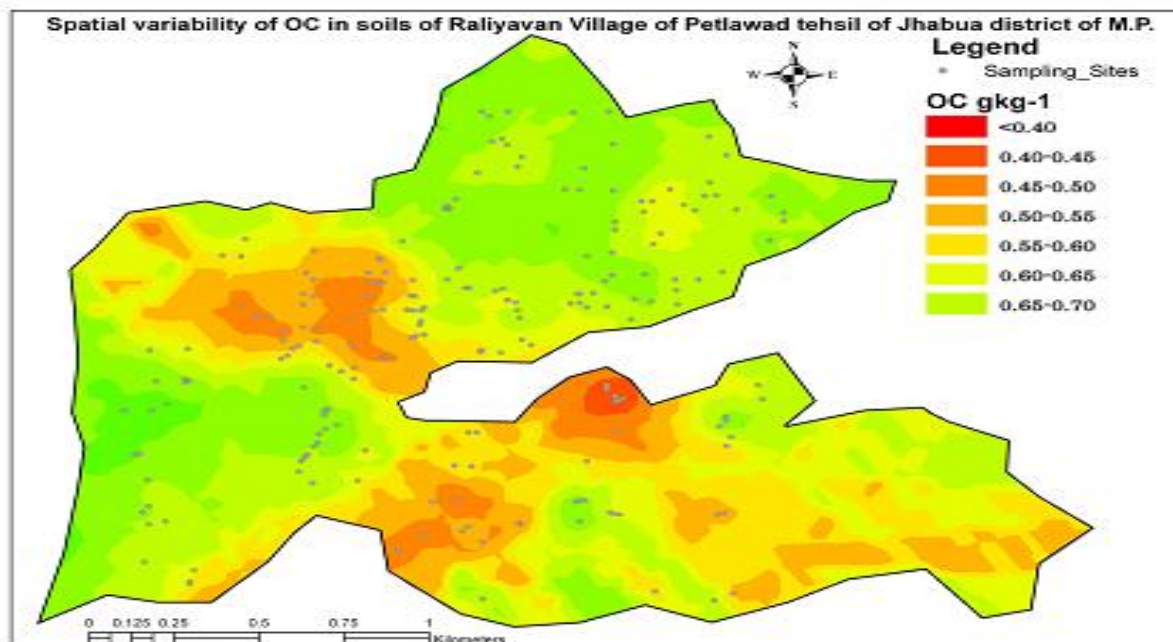
The available organic carbon content (Table 11) of the soils of Ralyawan village ranged from 0.29-0.85 %with an average value of 0.59%. Considering the soil test rating for available - OC (<0.25 as very low, 0.25 – 0.50 as low; 0.50 – 0.75 as medium and >0.75 as high in the status of organic carbon) the soils of Ralyawan fall under all the four rating classes of available OC content. In general out of 250 samples, 9.6% samples were categorized under low OC status, 72% samples under medium OC status and 18.4 % samples were under high OC status. In this way, about 81.6% soil samples were low to medium in av-OC status. The general statistics calculated from 250 soil samples revealed that the available – OC content ranged from 0.29-0.85 % with a mean value of 0.59%, standard deviation 0.10%and Coefficient of Variation (CV) 17.5%.

Table 11 : Distribution of available -OC status in the soils of Ralyawan village

Available-OC (%)	No. of Samples	% Samples
Very Low (<0.25)	NIL	NIL
Low (0.25-0.50)	24	9.6
Medium (0.50-0.75)	180	72
High(>0.75)	46	18.4
General statistics:		
Range (%)	0.29-0.85	
Mean (%)	0.59	
Standard deviation (%)	0.10	
Coefficient of variation (%)	17.52	

4.3.1 Spatial distribution of available –OC in the Ralyawan village soils:

Spatial variability map of Av-OC of the Ralyawan village soils is presented in map 6. To prepare the OC variability map soils were divided in to eight categories (table 12) The spatial variability map of available-OC of Ralyawan village (Map 6) showed that in whole village the Av-OC content varies from < 0.40 to > 0.70%.



Map10: Spatial distribution of OC (%) in village Ralyawan

Table 12: Different organic Carbon availability classes of the soils of Ralyawan village.

OC- availability Class	Available-OC%
I	<0.40
II	>=0.40 to < 0.45
III	>=0.45 to < 0.50
IV	>=0.50 to < 0.55
V	>=0.55 to <0.60
VI	>=0.60 to < 0.65
VII	>=0.65 to <0.70
VIII	>=0.70

4.4 Available micronutrients status of soils of Ralyawan village:

4.4.1 Available Zn status of the soils of Ralyawan village:

The available Zn content (Table 14) of the soils of Ralyawan village ranged from 0.2 – 1.94 mgkg⁻¹ with an average value of 0.58 mgkg⁻¹. Considering the soil test rating for available Zn (< 0.6 mgkg⁻¹ as deficient, 0.6- 1.2 mgkg⁻¹ as sufficient and >1.2 mgkg⁻¹ as high in the status of Zn) the soils of Ralyawan fall under deficient,

sufficient and high status in available Zn content. In general out of 250 samples, 51.87% samples fall under deficient status, 44.95% samples were sufficient in Zn status and 3.17% samples were high in Zn status. The general statistics calculated from 250 soil samples revealed that the available – Zn content ranged from 0.2-1.94 mgkg⁻¹ with a mean value of 0.58 mgkg⁻¹, standard deviation 0.22 mgkg⁻¹ and Coefficient of Variation (CV) 37.28%.

Table 15 : Distribution of available Zinc status in the soils of Ralyawan village

Available-Zn (mg kg ⁻¹)	No. of Samples	% Samples
Deficient (<0.6)	130	51.87
Sufficient (0.6 – 1.2)	112	44.96
High level (> 1.2)	8	3.17
General statistics:		
Range (mg kg ⁻¹)	0.2-1.94	
Mean (mg kg ⁻¹)	0.58	
Standard deviation (mg kg ⁻¹)	0.22	
Coefficient of variation (%)	37.28	

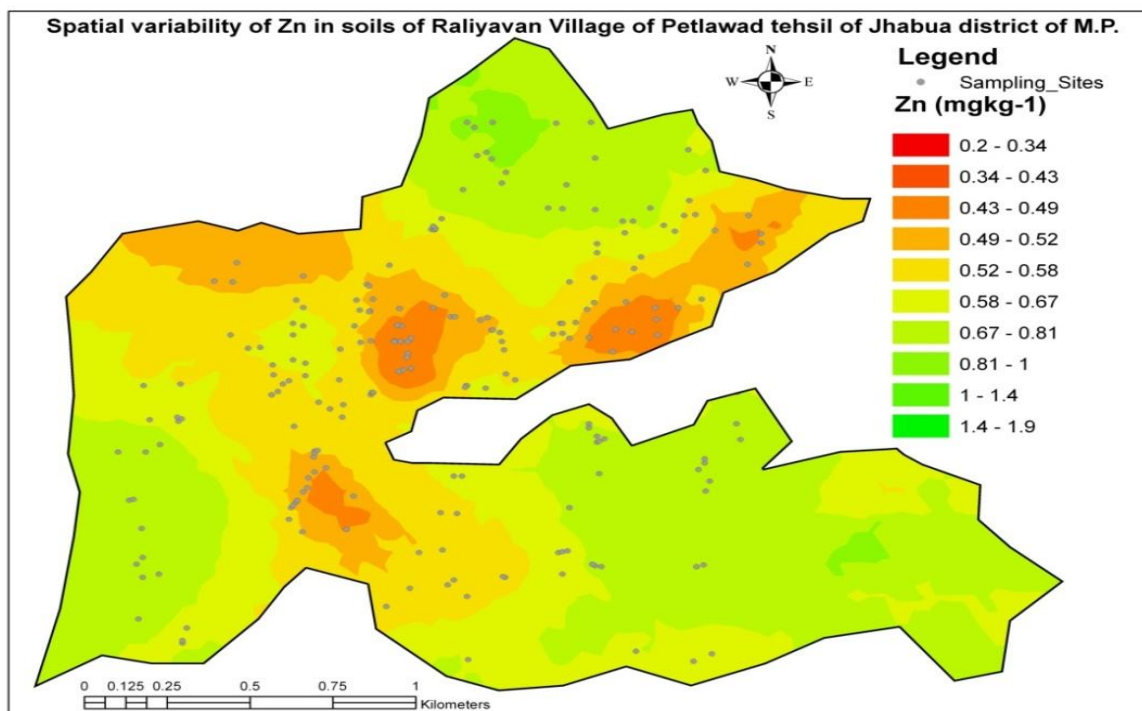
4.4.2 Spatial distribution of available–Zn in the village soils:

Spatial variability map of Av-Zn of the village soils is presented in map 11. To prepare the Zn variability map soils were divided in to eight categories (table 15) The spatial variability map of available-Zn of Ralyawan village (map 11) showed that in the whole village the Av-Zn content varies from 0.2-1.94 mgkg⁻¹.

Table 16: Different Zn availability classes of the soils of Ralyawan village.

Zn- availability Class	Available-Zn , kg ha ⁻¹
I	0.2 to 0.34
II	>=0.34 to <0.43
III	>=0.43 to <0.49
IV	>=0.49 to <0.52

V	≥ 0.52 to < 0.58
VI	≥ 0.58 to < 0.67
VII	≥ 0.67 to < 0.81
VIII	≥ 0.81 to 1
Ix	1 to 1.4
X	1.4 to 1.9



Map 11: Spatial distribution of Av.-Zn in village Ralyawan

4.5 Available Fe status of the soils of Ralyawan village:

The available Fe content (Table 16) of the soils of Ralyawan village ranged from 2.36– 10.94 mgkg^{-1} with an average value of 5.91 mgkg^{-1} . Considering the soil test rating for available Fe ($< 4.5 \text{ mgkg}^{-1}$ as deficient, $4.5 - 9.0 \text{ mgkg}^{-1}$ as sufficient and $>9 \text{ mgkg}^{-1}$ as high in the status of Fe) the soils of Ralyawan fall under deficient, sufficient and high status in available Fe content. In general out of 250 samples, 8.35% samples fall under deficient status, 84.72% samples were sufficient in Fe status and 6.91% samples were high in Fe status. The general statistics calculated

from 250 soil samples revealed that the available – Fe content ranged from 2.36 – 10.90 mgkg⁻¹ with a mean value of 5.91 mgkg⁻¹, standard deviation 1.27 mgkg⁻¹ and Coefficient of Variation (CV) 21.46%.

Table 17 :.Distribution of available iron status in the soils of Ralyawan village

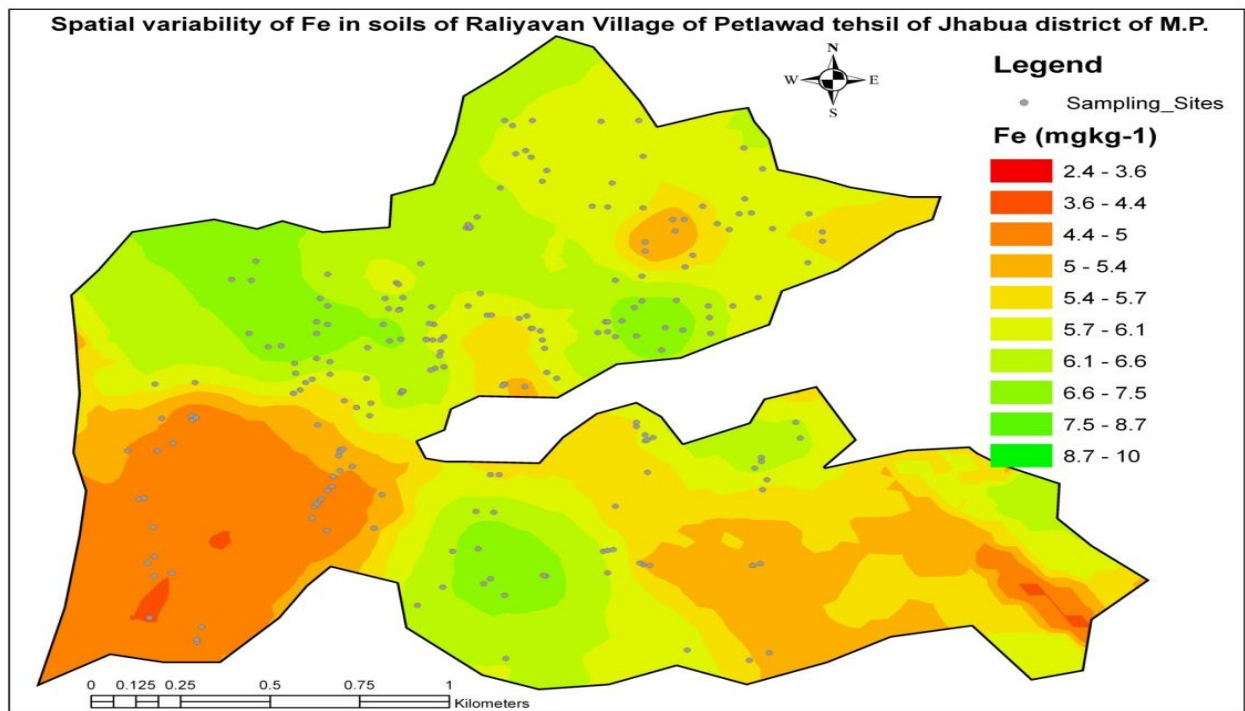
Available-Fe (mg kg ⁻¹)	No. of Samples	% Samples
Deficient <4.5	21	8.35
Sufficient 4.5-9	211	84.72
High level >9	18	6.91
General statistics:		
Range (mg kg ⁻¹)	2.36-10.9	
Mean (mg kg ⁻¹)	5.91	
Standard deviation (mg kg ⁻¹)	1.27	
Coefficient of variation (%)	21.46	

4.5.1 Spatial distribution of available–Fe in the village soils:

Spatial variability map of Av-Fe of the village soils is presented in map13 . To prepare the Fe variability map soils were divided in to eightt categories (table 16) The spatial variability map of available-Fe of Ralyawan village (map 13) showed that in the whole village the Av-Fe content varies from 2.5-10 mgkg⁻¹.

Table 18: Different Fe availability classes of the soils of Ralyawan village.

Fe- availability Class	Available-Fe , kgha ⁻¹
I	2.4- 3.6
II	>3.6 to 4.4
III	>4.4 to < 5.0
IV	>=5.0 to <5.4
V	>=5.4 to <5.7
VI	>=5.7 to <6.1
VII	>=6.1 to <6.6
VIII	>=6.6 – 7.5
IX	>= 7.5 – 8.7
X	>= 8.7 – 10



4.6 Available Mn status of the soils of Ralyawan village:

The available Mn content (Table 18) of the soils of Ralyawan village ranged from 1.34-4.02 mgkg⁻¹ with an average value of 2.7 mgkg⁻¹. Considering the soil test rating for available Mn (< 3.5 mgkg⁻¹ as deficient, 3.5 – 7.0 mgkg⁻¹ as sufficient and >7 mgkg⁻¹ as high in the status of Mn) the soils of Ralyawan fall under deficient and sufficient status in available Mn content. In general out of 250 samples, 83.28% samples fall under deficient status and 16.71% samples were sufficient in Mn status. The general statistics calculated from 250 soil samples revealed that the available – Mn content ranged from 1.34-4.02 mgkg⁻¹ with a mean value of 2.7 mgkg⁻¹, standard deviation 0.43 mgkg⁻¹ and Coefficient of Variation (CV) 15.83%.

Table 18 :Distribution of available manganese status in the soils of Ralyawan village.

Available-Mn (mg kg ⁻¹)	No. of Samples	% Samples
Deficient <3.5	208	83.28
Sufficient 3.5-7.0	42-	16.71
High level >7.0	-	-

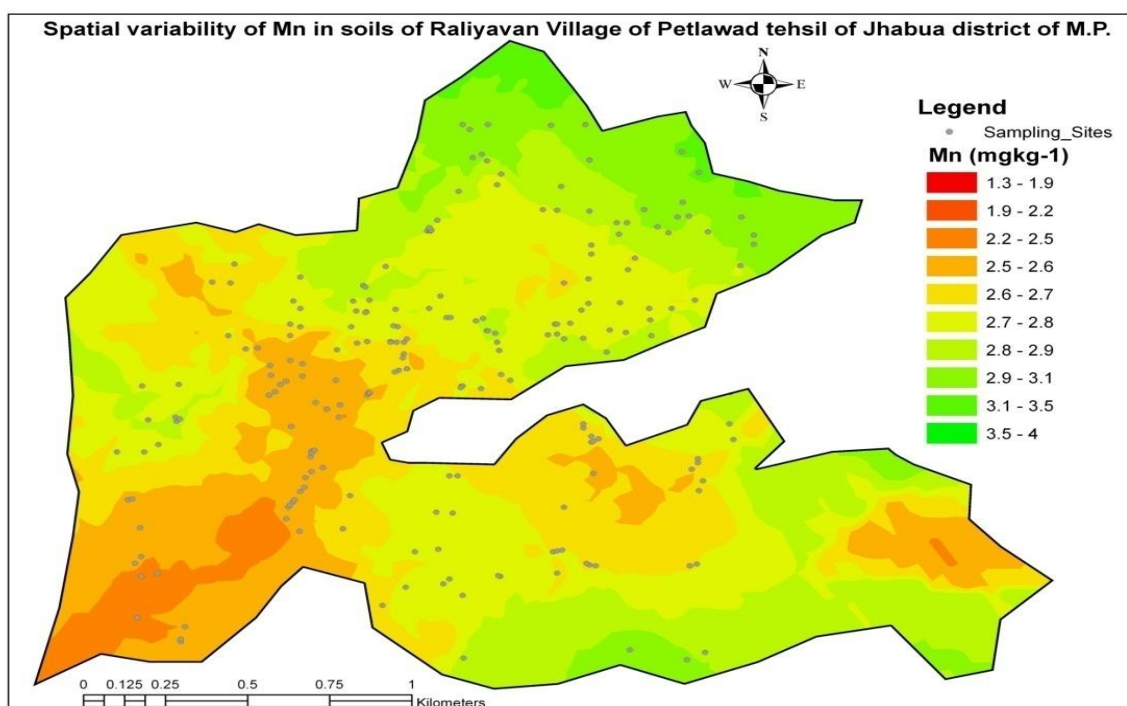
General statistics:	
Range (mg kg ⁻¹)	1.34-4.02
Mean (mg kg ⁻¹)	2.7
Standard deviation (mg kg ⁻¹)	0.43
Coefficient of variation (%)	15.83

4.6.1 Spatial distribution of available-Mn in the village soils:

Spatial variability map of Av-Mn of the village soils is presented in map 14. To prepare the Mn variability map soils were divided in to six categories (Table 19) The spatial variability map of available-Mn of Ralyawan village (map 14) showed that in the whole village the Av-Mn content varies from 1.34-4.02 mgkg⁻¹

Table 19: Different Mn availability classes of the soils of Ralyawan village.

Mn- availability Class	Available-Mn , kgha⁻¹
I	1.3 – 1.9
II	>=1.9 to 2.2
III	>=2.2 to <2.5
IV	>=2.5 to <2.6
V	>=2.6 to <2.7
VI	>=2.7 to < 2.8
VII	>=2.8 to 2.9
VIII	>= 2.9 to 3.1
IX	>= 3.1 to 3.5
X	>= 3.5 to 4.0



Map 13: Spatial distribution of Av.-Mn in village Raliyavan

4.7 Available Cu status of the soils of Raliyavan village:

The available Cu content (Table 20) of the soils of Raliyavan village ranged from 0.08-0.89 mgkg⁻¹ with an average value of 0.37 mgkg⁻¹. Considering the soil test rating for available Cu (< 0.20 mgkg⁻¹ as deficient, 0.20-0.40 mgkg⁻¹ as sufficient and >0.40 mgkg⁻¹ as high in the status of Cu) the soils of Raliyavan fall under deficient, sufficient and high status in available Cu content. In general out of 250 samples, 1.15% samples fall under deficient status, 56.77% samples were sufficient in Cu status and 42.07% samples were high in Cu status.. The general statistics calculated from 250 soil samples revealed that the available – Cu content ranged from 0.08-0.89 mgkg⁻¹ with a mean value of 0.407 mgkg⁻¹, standard deviation 0.12mgkg⁻¹ and Coefficient of Variation (CV) 31.71%.

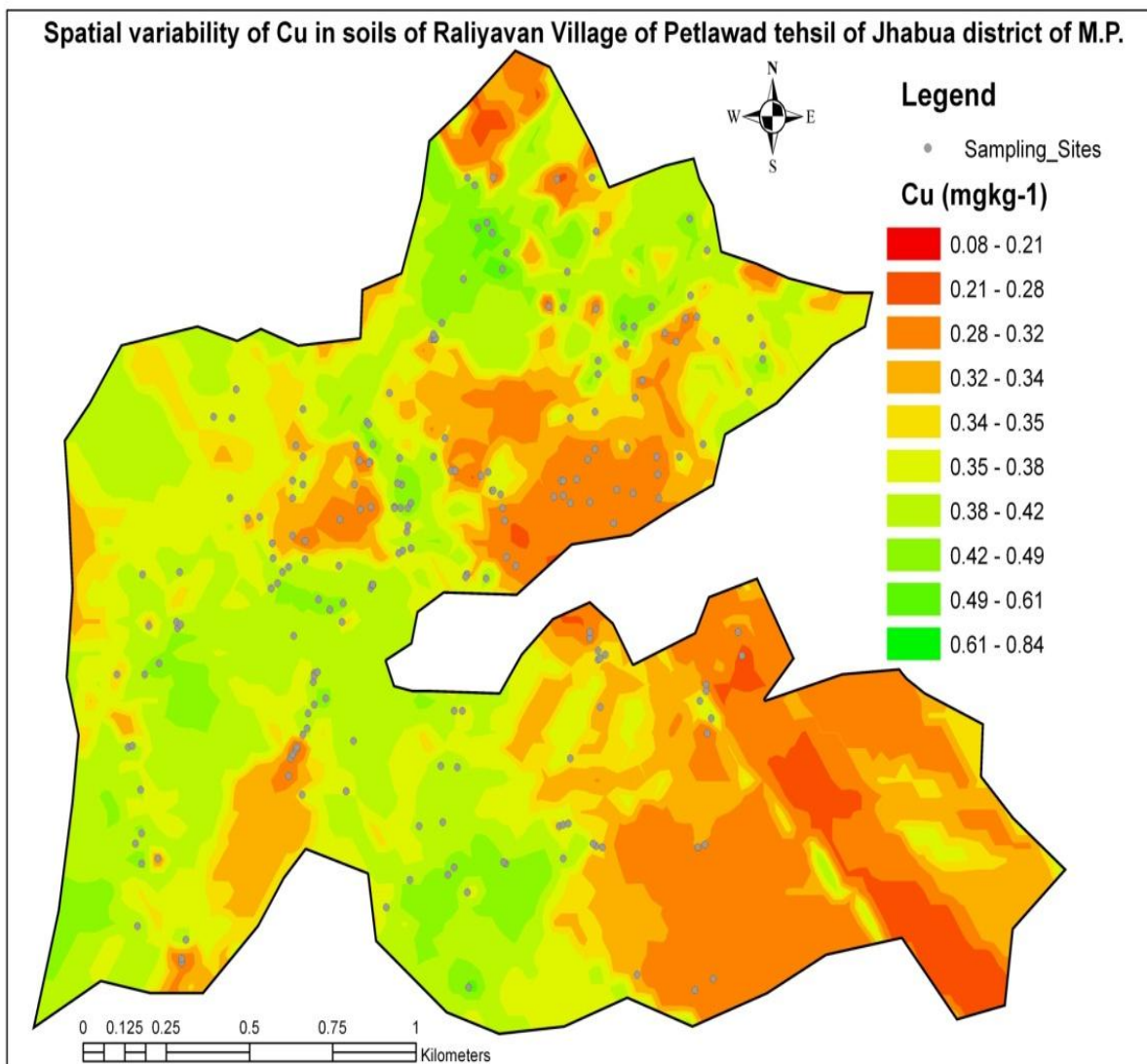
Table 20 : Distribution of available Copper status in the soils of Raliyavan village.

Available-Cu (mg kg ⁻¹)	No. of Samples	% Sam ples
Deficient <0.20	3	1.15
Sufficient 0.2- 0.4	142	56.77

High level > 0.40	105	42.07
General statistics:		
Range (mg kg ⁻¹)	0.08-0.89	
Mean (mg kg ⁻¹)	0.37	
Standard deviation (mg kg ⁻¹)	0.12	
Coefficient of variation (%)	31.71	

4.7.1 Spatial distribution of available-Cu in the village soils:

Spatial variability map of Av-Cu of the village soils is presented in map12. To prepare the Cu variability map soils were divided into eight categories (table 21) The spatial variability map of available-Cu of Ralyawan village (map 12) showed that in the whole village the Av-Cu content varies from < 0.20 – 0.50 mgkg⁻¹.



Map 14: Spatial distribution of Av.-Cu in village Ralyawan

Table 21: Different copper availability classes of the soils of Ralyawan village.

Cu- availability Class	Available-Cu , kgha ⁻¹
I	0.08 to 0.21
II	>=0.21 to < 0.28
III	>=0.28 to < 0.32
IV	>=0.32 to <0.34
V	>=0.34 to <0.35
VI	>=0.35 to <0.38
VII	>=0.38 to 0.42
VIII	>=0.42 to 0.49
IX	>= 0.49 to 0.61
X	>=0.61 to 0.84

4.8 Particle size distribution in the soils of Ralyawan Village:

Soil textural analysis was carried out by Bouyoucos Hydrometer method to determine the relative percentage of sand silt and clay in 250 surface soil samples collected from village Ralyawan . On the basis of textural analysis and spatial distribution map it is found that all the soils of Ralyawan village are clayey in nature having lot of variability in the relative percentage of sand , silt and clay. The data presented in table 23 revealed that the clay content in 250 soil samples ranged from 38.20-62.60 percent, with a mean value of 50.18 percent having standard deviation 5.47 percent with 10.90 percent coefficient of variation. The silt percent ranges from 18.0 - 44.0 with a mean of 30.57 %, standard deviation 5.59 and CV% 18.27. The sand particle range was 13.40 – 29.80 percent with a mean of 19.25 %, standard deviation 3.44 % and CV 17.85 %. Among these three soil particles silt content showed highest variability followed by sand and minimum in case of clay content.

The spatial distribution of sand silt and clay particles in Ralyawan village has been predicted and is presented in map 17 to 19. The extent of spatial distribution of soil particles is presented in table 23.

Table 23: Distribution of particle size status in surface soils of Ralyawan village

Soil Separate	Range	Mean	S.D	CV(%)
Clay %	38.20-62.60	50.18	5.47	10.90
Silt %	18.0-44.0	30.57	5.59	18.27
Sand %	13.40 – 29.80	19.25	3.44	17.85

Table 24 : Extent of spatial distribution of percent Sand, Silt and Clay in the soils of Ralyawan village

Category	Clay (%)	Silt %	Sand %
I	<43.99	<27.67	<18.70
II	>=43.99 to <46.06	>=27.67 to <29.55	>=18.70 to <19.77
III	>=46.06 to <47.72	>=29.55 to <31	>=19.77 to <20.62
IV	>=47.72 to <49.06	>=31 to <32.44	>=20.62 to <21.69
V	>=49.06 to <50.72	>=32.44 to 34.32	>=21.69 to <23.05
VI	>=50.72 to < 52.79	>=34.32	>= 23.05
VII	>=52.79	-	

Table 25: Correlation coefficient (r) village between physico-chemical properties and available N, P ,K and S and micronutrient in vertisols and associated soils of Ralyawan .

	pH	EC	OC	N	P	K	S	Zn	Fe	Mn	Cu	Clay	Silt	Sand
pH	1													
EC	-0.025	1												
OC	0.019	0.21**	1											
N	-0.095	0.020	0.16**	1										
P	0.133*	0.096	0.030	0.101	1									
K	-0.090	-0.84	0.042	-0.105	0.007	1								
S	0.030	-0.001	0.10**	-0.007	0.088	0.030	1							
Zn	-0.069	0.036	-0.022	0.068	-0.12**	0.032	-0.013	1						
Fe	0.035	-0.010	-0.078	-0.206**	-0.131*	0.038	-0.036	-0.110	1					
Mn	0.002	-0.020	0.12**	0.004	-0.129*	-0.076	0.111	-0.136*	0.045	1				
Cu	-0.16**	0.091	-0.015	0.024	-0.022	0.014	0.046	0.088	-0.054	-0.096	1			
clay	-0.036	-0.071	-0.03	0.017	0.124*	-0.083	0.05	-0.144*	0.084	-0.037	-0.03	1		
Silt	0.065	0.175*	0.023	-0.012	0.015	-0.009	-0.039	0.154*	-0.036	0.096	0.26**	-0.80**	1	
sand	-0.049	-0.17**	0.009	-0.009	-0.22**	0.14*	-0.018	-0.021	-0.076	-0.097	0.006	-0.28**	0.34**	1

***Significant at 5 level **Significant at 1%level**

4.9 Correlation study :

a. Soil reaction (pH):

Soil pH showed positive correlation with available - OC($r=0.019$), P($r=0.033$), S($r=0.030$), Fe ($r=0.035$), Mn($r=0.002$) while it showed negative correlation with available N($r=-0.095$), EC($r=-0.025$) , K($r=-0.090$) and Zn ($r=-0.069$), Cu ($r=-0.063$) .(Table 25).

b. Electrical conductivity:

Electrical conductivity of these soils showed positive correlation with, available N($r=0.305$), P($r=0.309$), S($r=0.052$), Zn($r=0.333$), Fe($r=0.144$), Mn($r=0.303$) and Cu ($r=0.201$) and negative correlation with available potassium ($r=-0.231$) in soils of Ralyawan village.(Table 25)

c. Organic Carbon (OC):

Organic carbon showed positive correlation with available N($r=0.020$), P($r=0.096$), Zn($r=0.036$), OC($r=0.217$), EC($r=0.217$) and Cu($r=0.091$) and negative correlation with K($r=-0.084$) and S($r=-0.001$) in study area soils. (Table 25)

d. Clay content:

Clay content showed positive correlation with available N($r=0.017$), P($r=0.124$), S($r=0.05$)) and Fe($r=0.084$) and negative correlation with available K($r=-0.083$), Zn($r=-0.144$) and Mn($r=-0.037$) in study area soils. (Table 25)

e. Silt content:

Silt content showed positive correlation p with available P($r=0.015$), Zn($r=0.154$), Mn ($r=0.096$) and Cu($r=0.026$) and negative correlation with available N($r=-0.012$), K($r=-0.009$), S($r=-0.039$) and Fe($r=-0.036$). (Table 25)

f. Sand content:

Sand content showed positive correlation with available K($r=0.146$) and Cu($r=0.006$) and negative correlation with available N($r=-0.009$), P($r=-0.221$), S($r=-0.018$), Zn($r=-0.021$), Mn($r=-0.097$) and Fe($r=-0.076$). (Table 25)

Table 26: Mean value of soil fertility index and per cent distribution of soil fertility classes in soils of Ralyawan village

Available Nutrients	No. of farmer's samples	Mean value of soil fertility index	Per cent distribution of soil fertility class		
			Low	Medium	High
N	250	1.02	97.11%	2.88%	0%
P	250	2.28	22.47%	64.84%	12.68%
K	250	5.90	0%	2.30%	97.69%
S	250	1.23	76.36%	23.63%	0%

4.10 Soil fertility index and soil fertility class

The data pertaining to soil fertility index and soil fertility classes of status of available nitrogen, phosphorus potassium and sulphur are presented and summarized in table 26.

4.10.1 Available nitrogen status

The status of available N in Ralyawan village under present investigation ranged from 152 to 298 kg ha⁻¹ with a mean value of 236 kg ha⁻¹ (Table 1).

Using the criteria of Ramamoorthy and Bajaj (1969) the 100 per cent of the villages in the present study were found under the low fertility class (Table 28). The reason for low content of available nitrogen might be due to the fact that N is lost through various mechanism like NH₃ volatilization, nitrification, denitrification, chemical and microbial fixation, leaching and runoff (De Datta and Buresh, 1989) which resulted in low amount of available N in soil. Using the model class of Ramamoorthy and Bajaj (1969), 97.11% per cent soils sample in the present study were classified as low fertility class (Table 26). Considering the soils having the nutrient index values <1.67 for low, 1.67 to 2.33 for medium and >2.33 for high

fertility class, the nutrient index mean value of nitrogen was 1.02 (Table 26). The soils of Ralyawan village was found in category of low fertility class of nitrogen.

4.10.2 Available phosphorus status

The status of available P content in soils under present investigation varied from 7.15 to 38.8 kg ha⁻¹ with a mean value of 16.4 kg ha⁻¹ (Table 7). Almost similar ranges of available P were found by Kumar *et al.* (2009) in Lachchampur series of SanthalParaganas region of Jharkhand.

Using the criteria of model class of Ramamurthy and Bajaj (1969), 64.84 % samples in the present study were classified as medium fertility class (Table 26). Considering the soils having the nutrient index values <1.67 for low, 1.67 to 2.33 for medium and >2.33 for high fertility class, the nutrient index mean value of phosphorus was 2.28 (Table 26). The soil of Ralyawan village was found in category of Medium fertility class of phosphorus.

4.10.3 Available potassium status

The status of available potassium content of different soil samples collected from Ralyawan villages of Jhabua district. The results showed that the available potassium content ranged from 179 to 826 kg ha⁻¹ with an average value of 134.1 kg ha⁻¹.

Using the model class of Ramamoorthy and Bajaj (1969), nearly 23.63% per cent samples under the study were classified as medium fertility class, 97.69% per cent as high fertility class of potassium to be found (Table 28) of the study area. the nutrient index mean value of potassium was 5.90 (Table 26) The soil of Ralyawan village was found in category of high fertility class of potassium.

4.10.4 Available Sulphur status

The status of available Sulphur content of different soil samples collected from Ralyawan villages of indore district given in table 12. The results showed that the available Sulphur content ranged from 5.02 to 35.66 kg ha⁻¹ with an average value of 16.58 kg ha⁻¹.

Using the model class of Ramamoorthy and Bajaj (1969), nearly 2.30% per cent samples under the study were classified as medium fertility class, 76.36% per cent as low fertility class of sulphur to be found (Table 28) of the study area. the

nutrient index mean value of sulphur was 1.23 (Table 26) The soil of Ralyawan village was found in category of low fertility class of Sulphur.

It is evident (Table 26) that considering the concept of "Soil Nutrient Index", the *Vertisol* of the study area were found in low fertility class of nitrogen and sulphur, medium fertility class of phosphorus and high fertility class with respect to potassium. The mean values worked out from nutrient index for nitrogen, phosphorus, potassium and sulphur were 1.02, 2.28, 5.90 and 1.23 respectively against the nutrient index values <1.67 for low, 1.67 to 2.33 for medium and >2.33 for high fertility status of study area., nitrogen was low, sulphur and phosphorus were low to medium and potassium was high in the entire study area .

CHAPTER V

DISCUSSION

Rational utilization of our 'finite' soil resources for sustained productivity needs information on nature and extent of distribution of different kinds of soils of an area, problems, potentials, capabilities and their suitability for various uses. All the above information could be available through systematic characterization and classification of soils of an area. Hence, in the present study, 250 samples were studied in Ralyawan village of Jhabua district in western Madhya Pradesh. These samples are examined systematically for morphological features in the field and horizon wise samples were analysed in the laboratory for physical, physico-chemical properties. Based on these characters, the soils were classified high medium and low category. Further, the suitability of these soils were evaluated for growing different crops. The results obtained in the present study are discussed below.

5.1 Physical properties

5.1.1 Textura1 classes (Particle size distribution):

Data present in (appendix I and table 23 & 24) in Ralyawan village Soils were clay, silt loam and silt clay loam in texture and clay content was high in the sub-soil. Morphogenetic expression of most of the soils showed considerable homogeneity. The cracks were noticed in all the pedons. These findings are in conformity with the work of Murthy *et al.* (1972) and Anon (1969). This variation in texture was mainly because of deposition of finer fractions. Similar findings were reported by Arun Kumar *et al.* (2005). The texture was clay loam, because of lesser mobilization and translocation of finer fractions. The variation in texture is mainly due to differences in physiography. These results are in confirmation with the findings of Nayak *et al.* (2002).

A perusal of the data on particle size distribution in soils revealed that all the soil samples are clayey in texture according to the USDA textural triangle. The clay and silt content varied with depth in most of the soils. In black soil pedons, the increase in clay content through the soil depth observed in the study could be attributed to several processes like illuviation of the finer fraction to the lower depth (Dasog, 1975 and Krishnamurthy and Govindarajan, 1977). Similar trend was also noticed by Parvatappa (1981) and Doddamani *et al.* (1994) in Vertisols of the Upper

Krishna Command Area of Karnataka and Balpande *et al.* (1996) in the degraded Vertisols of the Purna valley of Maharashtra. Generally, sand content was low compared to silt in all the samples. High clay and silt content in some of the samples of study area may be due to their formation on the transported parent material, whereas sub-surface horizons exhibited higher clay content as compared to surface horizons due to the illuviation process occurring during soil development. Similarly, the illuviation process also affected the vertical distribution of silt and sand content. Similar observations were also made by Sharma *et al.* (2004a).

5.2 Chemical properties

5.2.1 Soil reaction (pH):

In Ralyawan village soils, pH ranged from neutral to slightly alkaline. High pH in study samples due to their calcareous nature and the accumulation of bases in the solum as they were poorly leached (Satyanarayana and Biswas, 1970). In case in soil, pH with depth was evident in some of the samples which may be ascribed to increasing content of exchangeable and soluble sodium and calcium (Gundlur, 1991). The pH was high at surface and then showed decreasing trend with depths. This may be attributed to high base status of these horizons resulting from the recycling of bases. Similar observations were made by Singh *et al.* (2009) in surface and sub surface soils of district Gajipur Uttar Pradesh. Higher pH values were also recorded by Balpande *et al.* (1996) in degraded Vertisols in Purnavalley. pH increased with depth.. This increase in soil reaction down the slope could be due to leaching of bases from higher topography and getting deposited at lower elevations (Sitanggang *et al.*, 2006). Whereas in C horizon had higher pH which attributed to the accumulation of bases. Similar type of results are reported by Tripathi and Najif *et al.* (2006). Shilpa *et al.* (2007) and Singh *et al.* (2009) also reported the similar type of results in soils of U.P. and Maharashtra.

5.2.2 Electrical conductivity:

Electrical conductivity was safe range in Ralyawan village., which indicated the soil pedons were less leached. In Ralyawan soils the EC values of the soils ranged from 0.17-0.86 In the soils studied, the electrical conductivity generally increased with depths. The upper solum was relatively low in salts than in the lower solum.. This might be due to leaching of salts from the soil surface to lower depths due to irrigation and their accumulation in lower depths. Even at the time when irrigation was introduced the distribution of salts showed a concentration of salts in the lower

solum (Dasog and Hadimani, 1980) in Malaprabha project area. Similar type of results are reported by Bali *et al.* (2006) and Ved *et al.* (2008) in soils of Panjab and U.P states. The normal EC may be ascribed to leaching of salts to lower horizons due to the light textured nature of the soils. The average value of EC of the soil was found minimum i.e. 0.17 dS m⁻¹ in the village and maximum 0.86 dS m⁻¹ in village (Appendix II). All the soil samples have safe range of electrical conductivity with respect to crop growth and development.

5.3 Organic carbon

Organic carbon content of Ralyawan soils ranged from 0.29 to 0.85 percent respectively, which in general accumulated in surface layers. The lower contents of organic carbon apparently resulted because of high temperature which induced rapid rate of organic matter oxidation, while the declining trend towards to accumulation of crop residues every year, without substantial downward movement. Observations in the line with the present findings have been reported in Nazif *et al.* (2006) showed that majority of the soil sites were medium amount of organic matter. The OC content ranged from 0.65 to 2.07 % (average 1.18 %) in the soils of District Bhimber (Azad Jammu and Kashmir) at 30 different locations. The organic carbon content of surface soil was greater than the sub-surface soils in most of the pedons due to high amount of litter and the crop residues at the surface. Organic carbon content of the soils followed by decreasing trend with depth in all the pedons. Its effects the rapid rate of organic matter mineralization in these soils. Out of 180.57 ha area about 180 ha area falls under low to medium (34.29% samples Low and 61.95% medium) status of available OC. Similar findings were reported by Lathwal (2006) in district Kurukshetra, Haryana and Sharma *et al.* (2008) in soils of Amritsar District.

The major proportion of the study area was low to medium in organic carbon (180 ha) (fig 5.) Low organic carbon in the soil is due to low input of FYM and crop residues as well as rapid rate of decomposition due to high temperature. The organic matter degradation and removal taken place at faster rate coupled with low vegetation cover thereby leaving less changes of accumulation of organic matter in the soil. High temperature and good aeration in the soil increased the rate of oxidation of organic matter resulting reduction of organic carbon content. The high temperature prevailing in the area is responsible for the rapid burning of organic matter, thus resulting in medium organic carbon content of these soils. Similar results were also noted by Sharma *et al.* (2008) in soil of Amritsar district and

Lathwal (2006) in soil of Shahbad & Thaneshwar block. An average value of OC of the soil was found minimum i.e. 0.23%, in the village and maximum i.e. 0.80% in village (Appendix II) of Ralyawan village.

5.4 Fertility status

The data pertaining to the fertility status of Ralyawan village are presented in Appendix II. The available nitrogen content varied between 152 to 298 kg per ha. Available phosphorus ranged from 7.15 to 38.8 kg per ha. Available potassium ranged from 179 to 826 kg per ha, respectively. Rajeshwar *et al.* (2009), Kumar *et al.* (2009) and Sharma *et al.* (2008), observed a similar trend of nutrient status in study area soils. Fertility status of N, P, K and S are interpreted as low, medium and high and that of zinc, iron, copper and manganese interpreted as efficient, sufficient and excess by following the criteria given below.

5.4.1 Available nitrogen:

The available Nitrogen content was low in major portion of the study area 97.11% samples which might be due to low organic matter content in these soils. The reason for low content of available nitrogen might be due to the fact that N is lost through various mechanism like NH_3 volatilization, nitrification, denitrification, chemical and microbial fixation, leaching and runoff (De Datta and Buresh, 1989) which resulted in low amount of available N in soil. Only in about 2.88% samples available nitrogen was medium. The variation in N content may be related to soil management, application of FYM and fertilizer to previous crop *etc.* (Ashok Kumar, 2001). The total nitrogen content in the soils is dependent on temperature, rainfall and altitude. Another possible reason may also be due to low organic matter content in these areas due to low rainfall and low vegetation facilitate faster degradation and removal of organic matter leading to nitrogen deficiency. The medium nitrogen status was noticed in some area may be due to application of N fertilizer coupled with high vegetative cover. Kumar *et al.* (2009) in Dumka and Lachimpur series, Ashok *et al.* (2006) in Auraiya district of Uttar Pradesh observed a similar trend of nutrient status in study area soils.

5.4.2 Available phosphorus:

The available phosphorus content was medium (64.84% samples) in major parts of the village (172 ha), but it was low (22.47% samples) in 77.61 ha out of 185

ha total area of the village. Phosphorus is present in soil as solid phase with varying degree of solubility. When water soluble P is added to the soil, it is converted very quickly to insoluble solid phase by reacting with soil constituents. These may include calcium Cate (Olsen, 1953), Fe and Al oxides (Dean and Rubins, 1947) and partly organic matter. These reactions affect the availability of P and as a result of these reactions, a very small amount of total P is present in soil solution at any time reflected by soil testing. However, a low to medium range of soil available P under study area may be mostly affected by past fertilization, pH, organic matter content, texture various soil management and agronomic practices (Verma *et al.*2005). The present findings are in line with those of Mostara (2002) who reported that majority of soils in Karnataka and more so in Malprabha command were medium in phosphorus content. Nirawar *et al.* (2009) and Kumar *et al.* (2009) in Dumka and Lachimpur series of Jharkhand were medium in phosphorus content.

5.4.3 Available potassium:

The available potassium content in major portion of the study area was under high category (180 ha)out of 181.57 ha total area of the village respectively. In general out of 250 samples, 97.69 % fall under high status were categorized under Ralyawan soils .show higher values due to predominance of K rich micaceous and feldspars minerals in parent material. Similar results were observed by Verma *et al.*(2005) in soils of Sardulgarh, Bhikhi and Budhlada blocksand Nirawar *et al.*(2009) in soils of Ahemedpurtahsil of Latur district. Major portion of area under high (180 ha) were seen in studysoils, because these soils have less finer fractions in their soil. In addition Kaolinite type of clay mineralogy are the causes for their medium and low rating. Adequate (medium or high) available K in these soils may be attributed to the prevalence of potassium-rich minerals like Illite and Feldspars (Sharma *et al.*, 2008). The highest and lowest mean values of available potassium were recorded 826 and 197 kg ha⁻¹ K in village respectively, of Ralyawan (Appendix II).

5.4.4 Available sulphur:

The area under medium and low category for sulphur was 175ha and 17 .81 ha out of 180.57 ha total area of the village, respectively. In general out of 250 samples, 76.36 % fall under low status and 23 .63% samples were categorized under medium S status. In this way, almost all the soil samples tested were found to be deficient in S. Low and medium level of available sulphur was recorded due to

lack of sulphur addition and continuous removal of S by crops. Black soils have gypsum ferrous nature of sulphur which is non-available (Balanagoudar, 1989). Similar results were also reported by Chouhan *et al.* (2012) in the soils of Dewas District in Madhya Pradesh and Singh *et al.* (2013) in Garhwal region of western Himalayas. It is a fact that the available S analyzed by turbidity meter method as suggested by Chesnin and Yein (1951).

5.5 Available micronutrients:

5.5.1 Available zinc:

In Ralyawan soils the available zinc was to be deficient in the entire study area except in about 51% samples (229 ha) out of 361.26 ha total area of the village was deficient. (Fig. 11 table 14). Since, the soils are alkaline and rich in CaCO₃, zinc may be precipitated as hydroxides and carbonates under alkali pH range. Therefore, their solubility and mobility may be decreased. In well drained aerated calcareous soils zinc exists in oxidized state and their availability becomes low. The results are in conformity with the finding of Sharma and Chaudhari (2007) in soils of Solan district in North-West Himalayas and also similar findings by Rajeswar *et al.* (2009) in soils of Garikapadu of Krishna district of Andhra Pradesh and similar result were also reported by Singh *et al.* (2009) in the soils of Ghazipur district of Uttar Pradesh. The highest and lowest mean values of available Zn for *Vertisols* were 0.2 and 1.94 mg kg⁻¹ in villages, respectively, (Appendix II).

5.5.2 Available iron:

Ralyawan village soils fall under deficient 8.35 % (12.44 ha) out of 168 ha total area of the village and sufficient category 84.72% (1 ha) from the Fe status (table 16, Fig. 12). In study soils, Majority of the soils were not deficient in Fe as the amount of iron required by crops is being released by iron bearing minerals in these soils. The soil pH had reverse effect on the availability of Fe content in soil. The highest and lowest mean values of DTPA-extractable Fe were recorded 10.9 and 2.36 mg kg⁻¹ Fe in village respectively (Appendix II) of village Ralyawan village of Jhabua district. Low Fe content may be due to precipitation of Fe²⁺ by CaCO₃ and decrease the availability. Similar results were also observed by Sharma *et al.* (2001) in Rajgarh and Narsingharh tehsil of M.P. The available iron in surface soils has no regular pattern of distribution as reported by Nayak *et al.* (2002). This type of

variation may be due to the soil management practices and cropping pattern adopted by different farmers.

5.5.3 Available copper:

Major portion of the study area 56% (31.33 ha) out of 180.57 ha total area of the village was under sufficient rating for available copper status and some area was under deficient for available copper (3 ha) (table 20, Fig. 14) Singh *et al.* (2001) reported that available copper content in Madhya Pradesh soils ranged from 0.08 to 1.18 ppm. Similar results were also observed by Singh and Raj (1996) in flood plains of Himachal Pradesh

5.5.4 Available manganese:

In Ralyawan village soil samples the available manganese was found to be deficient in almost more than 146 ha out of 180.57 ha total area of the village (83 per cent) of study area and sufficient in remaining fields (table 18, Fig. 13), which may be due to neutral to low pH and nature of the parent material as reported by Prasad and Sahi (1989). Arora and Shekon (1981) reported that high pH calcareous black soils coupled with semi-arid conditions decreases the availability of Mn by converting into unavailable forms (Mn^{++} converted Mn^{+++}). Sufficient content of manganese due to high organic matter content was observed in Upper Krishna Command Area by Yeresheemi *et al.* (1997). Similar findings were also reported by Singh *et al.* (2009) in the soils of District Ghazipur, Uttar Pradesh.

5.5.5 Soil map :

A soil map is designed to show the distribution of soil types or other soil mapping units in relation to other prominent physical and cultural feature of the earth's surface. Under the study area, two different types of soil series were identified (Anon, 1969) based on presence or absence of mottles and brown layer at lower solum and were mapped into 16 mapping units as different phases of soil series with the help of Arc View 3.2a GIS software. Maps of one or more soil future may be made directly from field observations or by selection and generalization from a soil map. The first step of soil survey is the establishment of units of classification to be shown on the maps (Murthy *et al.*, 1977), Dent and Young (1981), NBSS and LUP (1984) and Shankaranarayan and Hirekerur (1982). The legend design or the kinds of mapping units for any given kind is determined by nature, procedure and kind of survey (Rourke, 1981).

Correlation studies:

a. Soil reaction (pH):

Soil pH showed positive correlation with available - OC ($r=0.019$), P($r=0.033$), S ($r=0.030$), Fe ($r=0.035$), Mn ($r=0.002$) while it showed negative correlation with available N($r=0.095$) K ($r=-0.090$), Ec($r=-0.025$) and Cu ($r=-0.063$) .(table 25). Similar findings were also reported by Sharma *et al.*(2008),wagmareet *al.*(2009) Ghosh *et al.*(2006) and Meena*et al.* .(2006)in soils of Amritsar district ,Latur district , North Bengal and Rajasthan and Similar findings were also reported by Sood*et al.* (1995) in soils of Malwa plateau Rajasthan, Jena *et al.* (2008) in soils of Orrisa,Meena*et al.* (2006) in soils ottonk district of Rajasthan,Najif*et al.* (2006) in soils of district Bhimber ,Kumar *et al.* (2009) in soils of Jharkhand and Sahoo*et al.*(1995) in soils of Rajasthan.

b. Electrical conductivity:

Electrical conductivity of these soils showed positive correlation with, available N ($r=0.020$), P ($r=0.096$), S ($r=0.052$), Zn ($r=0.336$) and Cu ($r=0.090$) and negative correlation with available potassium ($r=-0.084$) Fe($r=-0.010$) Mn($r=-0.020$) in soils of Ralyawan villege.(table 25) Similar findings were also reported by Sharma *et al.*(2008),Yadav and Meena *et al.*(2009) and Mishra *et al.* (1990) in soils of Amritsar district ,Rajasthan and some indian soils . Similar results were also reported by Sharma and Chaudhary (2007) in lower Shiwaliks of Solan district in North – West Himalayas. Maji *et al.* (1993) in coastal soils of Sunderbans, West Bangal.

c. Organic Carbon (OC):

Data in table 25 Organic carbon showed positive correlation with available N($r=0.165$), P ($r=0.030$) ,K($r=0.042$),Mn ($r=0.128$) and S($r=0.101$) and negative correlation with Zn($r=-0.022$),Fe($r=-0.078$) and Cu($r=-0.015$) in study area soils. Similar findings were also reported by Sharma *et al.*(2008), Meena *et al.*(2006) and Kumar *et al.* .(2009) in soils of Amritsar district ,Rajasthan and Jharkhand . Similar results were also reported by Meena *et al.* (2006) ,Kumar *et al.* (2009) in Dumka series in soils of Santhal Paraganas Region of Jharkhand. Mahesh Kumar *et al.* (2011), Sharma *et al.* (2003),Nazif *et al.* (2006) in soils of Rajasthan, Nagpur and J&K .

d. Clay content:

Data in table 25 clay content showed positive correlation with available N($r=0.017$),P($r=0.124$),S($r=0.05$)) and Fe($r=0.084$) and negative correlation with available K($r=-0.083$), Zn ($r=-0.144$) and Mn ($r=-0.037$) in study area soils. Similar

results were reported by Khan *et al.*(1996), Bipul *et al.* (2012) and Singh R.P . and Mishra S.K(2012) in soils of Bangladesh, Assam and Varanasi.

e. Silt content:

Data in table 25 Silt content showed positive correlation with available P($r=0.015$),Zn($r=0.154$),Mn (0.096) and Cu(0.026) and negative correlation with available N($r=-0.012$),K($r=-0.009$),S($r=-0.039$)and Fe($r=-0.036$). Similar results were reported by Khan *et al.*(1996), Bipul *et al.* (2012) and Singh R.P. and Mishra S.K (2012) in soils of Bangladesh, Assam and Varanasi.

f. Sand content:

Data in table 25 Sand content showed positive correlation with available K($r=0.146$) and Cu($r=0.006$) and negative correlation with available N($r= -0.009$),P($r=-0.221$),S($r=-0.018$),Zn($r=-0.021$),Mn($r=-0.097$) and Fe($r=-0.076$). Similar results were reported by Khan *et al* (1996), Bipul *et al.* (2012) and Singh R.P .and Mishra S.K(2012) in soils of Bangladesh, Assam and Varanasi.

CHAPTER-VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FUTURE RESEARCH WORK

The present investigation was undertaken with a view to evaluate the fertility status of *Vertisols and associated soils* of Ralyawan village in Jhabua district of Madhya Pradesh and its relationship with important physico chemical characteristics for identifying the location specific conditions promoting nutrient deficiencies and realistic assessment of need for nutrients. The highlights of the investigation are summarized and concluded with following objective.

1. To estimate the major nutrient status (N, P and K) and secondary nutrient(S) of the sampled soil.
2. To assess the soil reaction (pH) and electrical conductivity (EC) and organic carbon in different soil samples of the study area.
3. To study the micronutrients (Fe, Zn, Mn and Cu) status in sampled soil.
4. To determine the textural class of sampled soils of the village.
5. To prepare the fertility maps of Ralyawan village.
6. To quantify the relationship between organic carbon and available N content in soil through correlation. Correlation study is also occurred of macro & micro nutrients N,P ,K,S Zn, Mn,Cu and Fe with physio- chemical properties pH,EC ,OC, Sand,Silt and Clay
- 7.To assess the overall fertility status of the village under study area.

Summary

Surface (0-15 cm) soil samples by systematic survey were collected using global position system from Ralyawan village in Jhdbua district . Total 250 soil samples covering all soil types. These samples were analyzed for pH, EC, OC, available N, P, K,S and DTPA-extractable Zn, Cu, Fe and Mn and textural classes of soil .The results are summarized in the following heads.

Physico-chemical properties

The pH of Soils of Ralyawan village varied from 7 to 8 with the mean value of 7.5. The electrical conductivity of soil water suspension ranged from 0.17 to 0.86 ds m⁻¹ with a mean value of 0.37 dS m⁻¹. The variation in organic carbon content in this

soil was from 0.23% to 0.80% with a mean value of 0.53%. In general, the organic carbon status of Ralyawan village soils was low to medium.

The clay content in 250 soil samples ranged from 38.20-62.60 percent, with a mean value of 50.18 percent. The silt percent ranges from 18.0 - 44.0 with a mean of 30.57 %. The sand particle range was 13.40 – 29.80 percent with a mean of 19 .25 %. Among these three soil particles silt content showed highest variability followed by sand and minimum in case of clay content.

Status of available N, P, K,S Zn, Cu, Fe, and Mn in soils

Available N content in soils of Ralyawan village ranged from 152 to 298 kg ha⁻¹ with an average of 236 kg ha⁻¹. Nutrient index values was in low fertility class in soil of village. Thus, the overall poor and or low status of available nitrogen was observed in this soil.

The status of available phosphorous varied from 7.15 to 38.8 kg ha⁻¹ with a mean value of 16.4 kg ha⁻¹. The 22.47% village soil samples from the study area can be classified as low fertility class and 64.84 % in medium fertility class. The nutrient index value for P was in medium fertility class of village.

The status of available potassium varied from 179 to 826 kg ha⁻¹ with a mean value of 418 kg ha⁻¹. The 0% village soil samples under the study were classified as low fertility class, 2.30% as medium and 97.69% as high fertility class.

The status of available sulphur varied from 8.77 to 29.7 kg ha⁻¹ with a mean value of 18.3 kg ha⁻¹. The 76.36% village soil samples under the study were classified as low fertility class, 23.63% as medium fertility class.

The status of available iron varied from 2.36 to 10.9 mg kg⁻¹ with a mean value of 5.91 mg kg⁻¹. The status of available manganese and Copper varied from 1.34 to 4.02 mg kg⁻¹ and 0.08 to 0.89 mg kg⁻¹ with a mean value of 2.7 and 0.37 mg kg⁻¹, respectively. Similarly, the status of available zinc varied from 0.2 to 1.94 mg kg⁻¹ with a mean value of 0.645 mg kg⁻¹.

Correlation studies:

A Positive non significant correlation was found between pH and EC in study soils . A positive significant correlation was found between pH and EC with N in study soils. Further the correlation studies of pH and OC with available N resulted significant positive correlation in all soils ,where as ,pH with available phosphorus had positive non significant correlation in all soils of Ralyawan. The negatively non

significant correlation was found between pH and available K in village. However, OC showed significantly negative correlation with K in Ralyawan village. Soil pH showed positive correlation with available - N ,P, Zn, Fe ,Mn while it showed negative correlation with available K,S and Cu.

A pH had positively non significant correlation with available Fe in *vertisols* of study area and the same was noted with available Mn and Zn in study area .

Electrical conductivity of these soils showed positive correlation with, available N,P,S,Zn,Fe,Mn and Cu and negative correlation with available potassium in soils of Ralyawan village.

Organic carbon showed positive correlation with available N,P,Zn,Mn,Fe and Cu and negative correlation with K and S in study area soils

Clay content showed positive correlation with available N,P ,S and Fe and negative correlation with available K ,Zn and Mn in study area soils. Sand content showed positive correlation with available K and Cu and negative correlation with available N,P,S,Zn,Mn ,and Fe .Silt content showed positive correlation with available P,Zn,Mn and Cu and negative correlation with available N,K,S and Fe. Correlation studies amongst available major nutrients revealed that only available N and K had negatively significant correlation was observed amongst them in *vertisols* soils of Ralyawan .Again the available N had positively significant correlation with P in study soils.. All the remaining correlations have been found non significant either positive or negative in all soil of Ralyawan village.

Conclusion:

It can be concluded from the above results that the Soils of Ralyawan village in Indore district of Madhya Pradesh were low in available N , low to medium available P and S, medium to high level in available K and characterized under neutral to alkaline in soil reaction (pH) and less than one d Sm^{-1} soluble salt content (EC) comes under safe limit for all soils. Out of total soil samples were tested high level DTPA-extractable Cu,medium level Fe. Whereas, Zn & Mn deficiency was observed in study area. The organic carbon level exhibited low to medium and positively significant correlation was exhibited amongst OC and available N. Most of the soils of Ralyawan village were characterized by Low, Medium and High categories. Hence, the soils require attention regarding nutrient management practices and regular monitoring of soil health for better crop production, in future.

From the study, it can be concluded that, soils of Ralyawan village in Malwa Plateau Agro climatic zone of western Madhya Pradesh are low in soil available organic matter content, available nitrogen, available sulphur, low to medium in available phosphorus high in available potassium. Regarding available micronutrients, zinc , Manganese, copper and iron were deficient to sufficient in these soils. Soil organic carbon, available N, P, Zn,, Mn, Cu, and Fe are important soil fertility constraints indicating their immediate attention for sustained crop production. The deficient micronutrient may be replenished to avoid the crops suffering from their deficiency and for optimum utilization of other nutrients. Integrated nutrient management holds the key for sustainable soil fertility management.

Needs Future Research Works:

- The soil test results so obtained under study must be translated into digital map at village level as well as block level for balanced fertilizer application guide. These guidelines will help to the farmers to obtain the balanced fertilizer doses prescribed for different crops and soils.
- Refinement of general recommendations based on soil fertility index of an area as an intermediate approach is to be under taken.
- The available soil fertility map should be utilized for advisory work.
- Soil-test crop response correlation studies are needed for nitrogen, phosphorous and potassium and other nutrients for rain fed/dry land crops. Correlation of crop responses to applied nutrients with varying moisture regime is required.
- Investigation should be carried out to identify location specific conditions i.e. physic-chemical characteristics of soils that modify or promote the nutrients deficiencies.

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Soil Sample Analysis Report of Farmers Field

Village – Ralyawan P.O –

Jhawalia Dist. Jhabua

Appendix I

S.no.	Farmer name	Area	Identification of Field	Longitude & Latitude	Clay	Silt	Sand
1	Ramchandra	4	Road Wala Khet	N 21°48'01.2" E 73°59'43.4"	42.2	34	23.8
2	Ramchandra	3	Mota Khet	N 21°48'05.5" E 73°59'43.0"	48.2	32	19.8
3	Kalu Bhuria	3.2	Patti Wala Khet	N 21°48'05.4" E 73°59'39.6"	44.2	32	23.8
4	Kalu Bhuria	5	Khankra Wala Khet	N 21°48'01.9" E 73°59'32.8"	46.2	38	15.8
5	Vijaysingh/Lunda	3.6	Higoriya Wala Khet	N 21°48'01.1" E 73°59'33.3"	50.2	24	25.8
6	Hirka/Galiya	4	Higoriya Wala Khet	N 21°47'59.5" E 73°59'34.7"	42.2	32	25.8
7	Hirka/Galiya	2	Mota Khet	N 21°48'05.5" E 73°59'33.4"	40.2	38	21.8
8	Bhima/Galiya	1.5	Mota Khet	N 21°48'05.5" E 73°59'30.9"	40.2	34	25.8
9	Bhima/Galiya	5	Aam Wala Khet	N 21°48'04.9" E 73°59'31.6"	42.2	28	29.8
10	Bhima/Galiya	5	Khaad Wala Khet	N 21°48'01.5" E 73°59'31.9"	38.2	36	25.8

11	Tersiya/Nandan	2.5	Khaad Wala Khet	N 21°47'57.4" E 73°59'30.5"	40.2	36	23.8
12	Hadiya/Galiya	5	Thakur Wala khet	N 21°47'53.9" E 73°59'28.4"	42.2	42	15.8
13	Ganesh/Ramchandra	9	Tapra Wala Khet	N 21°47'52.6" E 73°59'27.7"	48.2	30	21.8
14	Ganesh/Ramchandra	9	Tapra Wala Khet	N 21°47'58.2" E 73°59'34.3"	44.2	30	25.8
15	Dalji/Nanji,	1		N 21°47'55.0" E 73°59'43.4"	46.2	34	19.8
16	Dhulia Vajja	3		N 21°47'55.1" E 73°59'40.2"	42.2	34	23.8
17	Omkarji/Lunda	2.5		N 21°47'58.0" E 73°59'40.6"	48.2	32	19.8
18	Omkarji/Lunda	5		N 21°47'55.2" E 73°59'38.8"	42.2	38	19.8
19	Surtan/Lunda	3		N 21°47'53.6" E 73°59'46.1"	42.2	36	21.8
20	Ramesh/valid Katara	3		N 21°47'53.6" E 73°59'47.1"	44.2	36	19.8
21	Ramesh/valid Katara	4		N 21°47'55.2" E 73°59'48.8"	46.2	32	21.8
22	Ramesh/valid Katara	3		N 21°47'53.1" E 73°59'50.1"	48.6	30	21.4
23	Narayan	3	Nichala Hissa	N	46.6	30	23.4

	hurji			21°47'56.1" E 73°59'52.6"			
24	Narayan hurji	2. 3	Upperi Hissa	N 21°47'54.3" E 73°59'52.1"	38.6	34	27.4
25	Vijaysingh Luna	4		N 21°47'54.4" E 73°59'53.2"	44.6	30	25.4
26	Radhapati hemraj	1		N 21°47'54.3" E 73°59'58.4"	42.6	34	23.4
27	Unsingh joshaf	2		N 21°47'00.6" E 73°59'53.0"	48.6	30	21.4
28	Mangu ditya	2		N 21°47'01.8" E 73°59'47.4"	42.6	34	23.4
29	Majiya makna	6		N 21°47'03.1" E 73°59'55.5"	38.6	42	19.4
30	Johan	9		N 21°48'02.2" E 73°59'52.5"	42.6	32	25.4
31	Balu viriya	5. 5		N 21°47'00.8" E 73°59'31.0"	44.6	32	23.4
32	Babu dhhana	4		N 21°47'52.2" E 73°59'46.3"	48.6	30	21.4
33	Rantna hawaji	2		N 21°47'51.0" E 73°59'59.6"	46.6	28	25.4
34	magan fatiya	1. 5		N 21°47'52.1" E 73°59'46.0"	40.6	32	27.4
35	kaliya fatiya	5		N 21°47'46.0"	60.6	22	17.4

				E 73°59'21.1"			
36	shankara fatiy	8		N 21°47'52.4" E 73°59'51.2"	58.6	22	19.4
37	Thavriya	1. 5	Khajarana Field	N 21°47'48.4" E 73°59'58.3"	58.6	20	21.4
38	Toliya kaliya	2		N 21°47'52.5" E 73°59'55.1"	52.6	28	19.4
39	Ramesh bhima	1		N 21°47'49.3" E 73°59'47.9"	58.6	28	13.4
40	Unsingh vesta	2		N 21°47'50.9" E 73°59'43.6"	60.6	26	13.4
41	Bijala badiya	2	Talab Wala Khet	N 21°47'46.8" E 73°59'43.3"	62.6	22	15.4
42	Ramesh Hukiya	2. 5		N 21°47'47.9" E 73°59'47.2"	52.6	30	17.4
43	Johan anhon	1		N 21°47'01.5" E 73°59'54.8"	54.6	28	17.4
44	Bhagirath Manji	5	Talab Wala Khet	N 21°47'38.2" E 73°59'18.5"	50.6	30	19.4
45	Varsingh badiya	3		N 21°47'36.5" E 73°59'15.1"	44.6	28	27.4
46	Premchand jithara	3	Mota Khet	N 21°47'39.9" E 73°59'13.9"	50.6	28	21.4

47	Unsingh joshaf	7		N 21°47'36.3" E 73°59'11.9"	50.6	32	17.4
48	Kailash bheru	1	Moudi Wala Khet	N 21°47'39.9" E 73°59'7.8"	56.6	24	19.4
49	Kaniram punaji	5	Talab Wala Khet	N 21°47'38.3" E 73°59'9.5"	56.6	28	15.4
50	Suresh Totaram	6	Mota Khet	N 21°47'41.0" E 73°59'14.9"	50.6	26	23.4
51	Munnalal punaji	7		N 21°47'38.4" E 73°59'10.7"	48.6	30	21.4
52	Ramnath vagenath	1	Paal Wala Khet	N 21°47'41.0" E 73°59'19.9"	56.6	26	17.4
53	Dhanaji pratap	2	Moudi Wala Khet	N 21°47'39.0" E 73°59'20.5"	54.6	28	17.4
54	Vinod kaniram	5	Talab Wala Khet		56.6	26	17.4
55	Chogalal ranchod	5	Mota Khet	N 21°47'35.1" E 73°59'12.0"	60.6	20	19.4
56	Totaram pujaji	3	Tukadi Wala Khet	N 21°47'44.1" E 73°59'14.2"	56.6	26	17.4
57	Sardar tolaram	4	Kota Wala khet	N 21°47'43.2" E 73°59'14.9"	60.6	20	19.4
58	Shantilal Gendal	1	Vajotiya Wala Khet	N 21°47'42.9" E 73°59'20.4"	58.6	26	15.4
59	Kailash bheru	5	Talab Wala Khet	N 21°47'33.1" E 73°59'12.4"	58.6	18	23.4
60	Mangu	6	Mota Khet	N	58.6	24	17.4

	parmar			21°47'44.1" E 73°59'20.1"			
61	Kailash sarel	7		N 21°47'36.9" E 73°59'13.9"	56.6	28	15.4
62	Rumal menda	1	Vajotiya Wala Khet	N 21°47'41.3" E 73°59'13.9"	52.6	28	19.4
63	Mehaji bhuniya	1	Banjar Wala Khet	N 21°47'35.0" E 73°59'15.1"	54.6	24	21.4
64	Bhura sigad	9.5	56 Wala Khet		52.6	28	19.4
65	Kunsingh hurji	1	Parvat Singh Wala Khet		56.6	26	17.4
66	Khuman Singh	1	Vajotiya Wala Khet		58.6	26	15.4
67	Mohan Singh	1	Vajotiya Wala Khet		56.6	26	17.4
68	Rajendra	3	Bad Wala Khet	N 21°47'43.1" E 73°59'24.3"	52.6	28	19.4
69	Ranjan Singh	1.5	Khale k Pass Wala Khet		50.6	26	23.4
70	Maziya bilawal	1.5	Hole Wala khet	N 21°47'37.9" E 73°59'45.1"	48.6	26	25.4
71	Maziya bilawal	4	Nalle K pass Wala khat	N 21°47'39.2" E 73°59'21.5"	48.6	26	25.4
72	Maziya bilawal	4	Nalle K pass Wala khat	N 21°47'40.1" E 71°59'40.2"	47	28	25
73	Shyama bhaber	4	Bad Wala Khet	N 21°47'40.0" E 73°59'39.3"	51	26	23
74	Shyama bhaber	2	Adaan Wala Khet	N 21°47'46.3" E 73°59'44.9"	57	22	21

75	Shyama bhaber	1	Adaan Wala Khet	N 21°47'43.8" E 73°59'43.3"	57	24	19
76	Bhura sigad	1	Adaan Wala Khet	N 21°47'43.9" E 73°59'46.4"	53	30	17
77	Bhura sigad	2	Talab Wala Khet		57	26	17
78	Lalji hurji	1	Hole Wala Khet	N 21°47'43.0" E 73°59'42.6"	51	32	17
79	Ramchandra vesta	1	Talab Wala Khet		49	32	19
80	Unkar vesta	1	Talab Wala Khet	N 21°47'41.4" E 73°59'41.5"	51	32	17
81	Rumal babu	2	Talab Wala Khet	N 21°47'41.3" E 73°59'40.0"	53	30	17
82	Rumal babu	1	Talab Wala Khet	N 21°47'39.6" E 73°59'42.8"	54.6	28	17.4
83	Shyama uketiya	1	Talab Wala Khet	N 21°47'59.7" E 73°59'54.2"	54.6	28	17.4
84	Bhura hadiya	2	Talab Wala Khet	N 21°47'44.2" E 73°59'53.8"	52.6	32	15.4
85	kaliya ramal	2	Tubewell Wala Khet	N 21°47'43.2" E 73°59'51.5"	48.6	32	19.4
86	kaliya ramal	1	Talab Wala Khet	N 21°47'41.3" E 73°59'40.2"	44.6	40	15.4
87	kaliya ramal	2	Talab Wala Khet	N 21°47'43.2" E 73°59'49.3"	46.6	34	19.4

88	Amsingh gobriya	2	Talab Wala Khet	N 21°47'41.8" E 73°59'49.4"	48.6	32	19.4
89	Shambu badiya	1	Talab Wala Khet	N 21°47'39.9" E 73°59'49.5"	48.6	34	17.4
90	Mansingh luna		Talab Wala Khet	N 21°47'39.5" E 73°59'40.9"	40.6	40	19.4
91	Bhadur Bhaliya	1	Talab Wala Khet	N 21°47'40.6" E 73°59'45.4"	42.6	34	23.4
92	Jogadiya luna	1	Talab Wala Khet		44.6	34	21.4
93	Narayan hurji	1	Talab Wala Khet	N 21°47'48.3" E 73°59'23.3"	42.6	34	23.4
94	Vijaysingh Luna	2	Talab Wala Khet	N 21°47'42.8" E 73°59'21.4"	46.6	32	21.4
95	Radhapati hemraj	2	Talab Wala Khet	N 21°47'40.3" E 73°59'47.0"	48.6	28	23.4
96	Komal Somal Meda	3. 5	Hole wala Khet	N 21°47'52.6" E 73°59'27.7"	44.6	34	21.4
97	Komal Somal Meda	2. 07	Remja wala Khet	N 21°47'52.6" E 73°59'27.7"	42.6	34	23.4
98	Mukesh Somal Meda	2. 07	Babul wala khet	N 21°47'52.6" E 73°59'27.7"	50.6	30	19.4
99	Vijay Singh Luna Kharadi	1. 02	Talab wala Khet	N 21°47'52.6" E 73°59'27.7"	49.4	30	20.6

100	Mahesh SEmala Meda	5. 12	Hole wala Khet	N 21°47'52.7" E 73°59'27.8"	47.4	30	22.6
101	Rakesh Somal Meda	3. 5	Khajur wala Khet	N 21°47'53.0" E 73°59'27.6"	47.4	30	22.6
102	Rakesh Somal Meda	9	Moudi wala Khet	N 21°47'52.6" E 73°59'27.7"	47.4	32	20.6
103	Khuman Singh Vijay singh	1. 5	Khajur wala Khet	N 21°47'52.6" E 73°59'27.7"	45	36	19
104	Satyanaraya n	2. 5	Babul wala khet	N 21°47'52.6" E 73°59'27.7"	47	32	21
105	Bhamar Rupa Solanki	5	Babul wala khet	N 21°47'52.6" E 73°59'27.7"	49	32	19
106	Bhamar Rupa Solanki	5	Hole wala Khet	N 21°47'52.7" E 73°59'27.8"	47	34	19
107	Rajesh mangilal	11	Remja wala Khet	N 21°47'53.0" E 73°59'27.6"	45	34	21
108	Ranjan mangilal	3	Bant Wala Khet	N 21°47'52.8" E 73°59'8.5"	51	30	19
109	Narayan Vijay Singh karadi	9. 5	Chappan wala Khet	N 21°47'48.6" E 73°59'8.4"	53	28	19
110	Narayan Vijay Singh karadi	11	Kunda Wala Khet	N 21°47'46.3" E 73°59'8.0"	49	34	17
111	Roopchan d Sigad Hadia	10	Chappan wala Khet	N 21°47'46.4" E 73°59'6.2"	49	34	17
112	Roopchan d Sigad Hadia	3. 5	Kankad Wala Khet	N 21°47'47.0" E 73°59'14.9"	51	32	17
113	Nanda	10		N	49	30	21

	Megala Munia			21°47'45.8" E 73°59'21.3"			
114	Rukaman bai	10	Sonjad Wala Khet	N 21°47'44.2" E 73°59'21.7"	48.6	28	23.4
115	Bheru Nanji Damar	4		N 21°47'42.7" E 73°59'21.3"	38.6	36	25.4
116	Bheru Naraji Sigad	10	Kankad Wala Khet	N 21°47'41.0" E 73°59'24.5"	50.6	32	17.4
117	Puna Nanji Hatila	12	Patti Wala Khet	N 21°47'41.1" E 73°59'24.8"	44.6	40	15.4
118	Dalji nanji Hatila	2	Talab Wala Khet	N 21°44'40.9" E73°59'24.3"	50.6	34	15.4
119	Ramesh Somala Meda	1. 5	Talab Wala Khet	N 21°47'39.2" E 73°59'23.8"	60.6	22	17.4
120	Lalsingh Rupa Solanki	3	Talab Wala Khet	N 21°47'39.1" E 73°59'23.8"	44.6	40	15.4
121	Kaloo Mangu Bhuria	0. 5	Talab Wala Khet	N 21°47'39.1" E 73°59'24.4"	58.6	24	17.4
122	Kaloo Mangu Bhuria	1. 5	Talab Wala Khet	N 21°47'39.1" E73°59'25.1"	40.6	40	19.4
123	Gulab singh	0. 5	Talab Wala Khet	N 21°47'39.5" E 73°59'25.4"	56.6	24	19.4
124	Soman meda	0. 18	Talab Wala Khet	N 21°47'37.7" E73° 59'25.1"	60.6	20	19.4
125	Khuman singh	0. 75	Talab Wala Khet	N 21°47'37.2" E73° 59'25.0"	58.6	26	15.4

126	Jhind Veshta Khaida	1	Talab Wala Khet	N 21°47'35.7" E73° 59'24.6"	52.6	34	13.4
127	Babu Limji Katara	0. 5	Talab Wala Khet	N 21°47'35.5" E73° 59'24.2"	56.6	28	15.4
128	Balu Ganji Munia	0. 5	Talab Wala Khet	N 21°47'35.9" E73° 59'25.4"	50.6	30	19.4
129	Balu Ganji Munia	0. 5	Talab Wala Khet	N 21°47'35.9" E73° 59'25.4"	50.6	28	21.4
130	Ramesh Khji Katara	0. 5	Talab Wala Khet	N 21°47'43.2" E73° 59'27.6"	48.6	28	23.4
131	Hudtan Galla Katara	0. 5	Talab Wala Khet	N 22°47'43.3" E 73° 59'27.6"	44.6	38	17.4
132	Devchand Jitra Katara	1. 5	Talab Wala Khet	N 21°47'44.7" E73° 59'28.7"	58.6	26	15.4
133	Devchand Jitra Katara	1. 5	Talab Wala Khet	N 21°47'42.1" E73° 59'29.3"	60.6	24	15.4
134	Hardar Jaimal Munia	1. 5	Talab Wala Khet	N 21°47'42.1" E73° 59'29.7"	50.6	30	19.4
135	Metab Tieya Bilwal	1. 5	Talab Wala Khet	N 21°47'40.5" E73° 59'33.3"	51	26	23
136	Jhind Veshta Khaida	2. 6		N 21°47'39.1" E73° 59'34.3"	45	32	23
137	Babu Limji Katara	1. 5		N 21°47'38.1" E73° 59'34.5"	43	34	23
138	Ditia Kaliya	0.		N	45	38	17

	Singad	5		21°47'34.5" E73° 59'35.6"			
139	Balu Ganji Munia	0. 5			57	26	17
140	Ditia Kaliya Singad	1. 5		N 21°47'40.2" E73° 59'34.1"	55	26	19
141	Hudtan Galla Katara	1. 5	Khaida Wala Khet	N 21°47'35.2" E73° 59'34.7"	53	28	19
142	Dhumsing h Jogaliya Katara	0. 74		N 21°47'33.5" E73° 59'32.7"	53	24	23
143	Devchand Jitra Katara	1		N 21°47'33.8" E73° 59'30.8"	51	28	21
144	Jhind Veshta Khaida	1. 25		N 21°47'33.8" E73° 59'30.9"	47	28	25
145	Jhind Veshta Khaida	2		N 21°47'22.9" E73° 59'30.4"	51	30	19
146	Dhumsing h Jogaliya Katara	0. 5		N 21°47'22.9" E73° 59'29.6"	57.8	18	24.2
147	Dhumsing h Jogaliya Katara	1		N 21°47'41.7" E73° 59'32.2"	59.8	20	20.2
148	Ramesh Khji Katara	6	Beed wala Khet	N 21°47'42.0" E73° 59'32.9"	49.8	34	16.2
149	Omprakash	4	Bhot Maharaj wala Khet	N 21°47'40.5" E73° 59'33.4"	45.8	38	16.2
150	Omprakash	10	Tubewell Wala Khet	N 21°47'13.7" E73° 59'26.2"	57.8	24	18.2

151	Nanda manna Meda	10	Jhirri Wala Khet	N 21°47'14.0" E73° 59'28.5"	55.8	24	20.2
152	Nanda manna Meda	10	Bada Wala khet	N 21°47'07.2" E73° 59'23.0"	57.8	20	22.2
153	Sama Ukedia Bhamar	10	Wakil wala Khet	N 21°47'09.8" E73° 59'29.0"	45.8	34	20.2
154	Sama Ukedia Bhamar	10	Aam Wala Khet	N 21°47'10.4" E73° 59'29.6"	57.8	26	16.2
155	Sama Ukedia Bhamar	10	Khajur Wala khet	N 21°47'09.4" E73° 59'25.3"	45.8	32	22.2
156	Gulab Singh Dhavar Meda	8	Tokra Wala Khet		42.6	38	19.4
157	Lala Dita Meda	4	Talai Wala Khet	N 21°47'32.7" E73° 59'21.5"	54.6	32	13.4
158	Gobaria Galia Katara	6	Gundi Wala khet	N 22°47'33.0" E75° 59'21.7"	50.6	26	23.4
159	Bhila Malla Kharadi	5	Talai Wala Khet		46.6	28	25.4
160	Gabbu Dalla Kharadi	7	Khakra Wala Khet	N 21°47'18.5" E73° 59'28.3"	46.6	28	25.4
161	Ter singh nanda Meda	4	Beed Wala Khet	N 21°47'18.4" E73° 59'29.9"	58.6	22	19.4
162	Ter singh nanda Meda	12	Ghanshyam Wala Khet	N 21°47'08.4" E73° 59'30.9"	54.6	30	15.4
163	Nandoo Mala katar	20	Bada Wala khet	N 21°47'10.7" E7° 59'34.6"	56.6	22	21.4

164	Nandoo Mala katar	9	Shiv Singh Wala Khet	N 21°47'10.8" E73° 59'34.4"	56.6	28	15.4
165	Raju kaloo Bhamar	20	Nipaniya Wala Khet	N 21°47'30.0" E73° 59'18.7"	58.6	22	19.4
166	Raju kaloo Bhamar	20	Nipaniya wala khet	N 21°47'31.5" E73° 59'18.8"	53	24	23
167	Nathu Singh	2	Tubewell Wala Khet	N 21°47'33.0" E73° 59'21.7"	49	34	17
168	Nathu Singh	3	Tubewell Wala Khet	N 21°47'33.0" E73° 59'21.6"	51	24	25
169	Vijay singh	2	Makan wala Khet	N 21°47'33.0" E73° 59'21.7"	51	32	17
170	Pyaar Singh	3	Kua Wala Khet	N 21°47'33.0" E73° 59'21.7"	55	28	17
171	Vijay singh	2		N 21°47'33.0" E73° 59'21.7"	49	32	19
172	Pyari bai	4		N 21°47'34.4" E73° 59'13.5"	45	38	17
173	Pyari bai	2		N 21°47'34.5" E73° 59'18.4"	47	30	23
174	Gyan Singh	2		N 21°47'31.8" E73° 59'16.4"	45	30	25
175	Ramesh Sukhia Munia	3		N 21°47'31.0" E73° 59'17.5"	41	40	19
176	Ramesh	2		N	45	40	15

	Sukhia Munia			21°47'31.0" E73° 59'17.5"			
177	Vajing Viriya Munia	2. 5		N 21°47'28.9" E73° 59'14.0"	43	40	17
178	Vajing Viriya Munia	3		N 21°47'34.0" E73° 59'12.9"	53	26	21
179	Humji Jithra Vasuniya	8	Tubewell Wala Khet	N 21°47'34.0" E73° 59'2.9"	43	38	19
180	Humji Jithra Vasuniya			N 21°47'32.7" E73° 59'11.8"	55	24	21
181	Ratna Toliya Bilwal	5		N 21°47'32.7" E73° 59'11.8"	57	20	23
182	Mangu Dita Parmar	7		N 21°47'29.4" E73° 59'08.2"	53	26	21
183	Mangu Dita Parmar	2. 5		N 21°47'29.5" E73° 59'02.7"	61	20	19
184	Mangu Dita Parmar	3		N 21°47'30.0" E73° 59'02.6"	57	26	17
185	Ramesh Sukhia Munia	8	Amba Wala Khet	N 21°47'29.7" E73° 58'59.9"	55	24	21
186	Balu Viriya Munia	8		N 21°47'33.8" E73° 58'59.3"	45	38	17
187	Balu Viriya Munia	10	Tubewell Wala Khet	N 21°47'29.8" E73° 59'03.0"	43	42	15

188	Roopsingh Dalla Vasuniya	3		N 21°47'26.7" E73° 59'00.9"	41	44	15
189	Roopsingh Dalla Vasuniya	8		N 21°47'25.8" E73° 58'59.5"	57	26	17
190	Paru Balchand Bilwal	5		N 21°47'25.8" E73° 58'56.8"	59	24	17
191	Paru Balchand Bilwal	10	Road Wala Khet	N 21°47'20.0" E73° 58'57.9"	57	22	21
192	Shravan Singh	16	Road Se Touch wala Khet	N 21°47'20.1" E73° 58'58.3"	47	34	19
193	BhagwatBhagirath	2		N 21°47'16.6" E73° 58'59.1"	45	32	23
194	Khuman Vesta Munia	6	Beesan Kheda Wala Khet	N 21°47'13.1" E73° 58'59.2"	49	34	17
195	Khuman Vesta Munia	7	Beesan Kheda Wala Khet	N 21°47'12.3" E73° 58'58.6"	47	32	21
S	Ramesh Sukhia Munia	5	Road Se Touch wala Khet	N 21°47'10.7" E73° 58'59.2"	52.6	30	17.4
197	Ramesh Sukhia Munia	10		N 21.47'11.1" E73° 59'00.8"	50.6	30	19.4
198	Rama dhura	5		N 21°47'05.7" E73° 58'58.8"	38.6	36	25.4
199	Chandan Singh	7	Road Wala Khet	N 21°47'02.8" E73° 59'03.1"	50.6	30	19.4
200	Chandan	10	Aam Wala Khet	N	44.6	40	15.4

	Singh			21°47'03.1" E73° 59'03.1"			
201	Punna Nathu Khadiya	7	Road Ke Pass Wala Khet	N 21°47'04.6" E73° 59'03.5"	50.6	34	15.4
202	Punna Nathu Khadiya	2	Hole wala Khet	N 21°47'33.0" E73° 59'57.3"	42.6	40	17.4
203	Babu Ketiya Munia	2	Remja wala Khet	N 21°47'29.2" E73° 59'57.2"	44.6	40	15.4
204	Lalu Pangla Munia	2	Babul wala khet	N 21°47'27.3" E73° 59'57.6"	46.6	36	17.4
205	Habji Wagji Sarel	2	Talab wala Khet	N 21°47'25.0" E73° 59'54.1"	44.6	40	15.4
206	Talu Bhura Parmar T	2	Hole wala Khet	N 21°47'24.5" E73° 59'54.1"	40.6	44	15.4
207	Talu Bhura Parmar	2	Khajur wala Khet	N 21°47'23.7" E73° 59'53.5"	48.6	34	17.4
208	Prakash Lal Parmar	2	Moudi wala Khet	N 21°47'22.3" E73° 59'54.6"	54.6	28	17.4
209	Dalla Dhanna Parmar	4	Khajur wala Khet	N 21°47'21.1" E73° 59'54.2"	48.6	26	25.4
210	Kalia Babu Parmar	2	Babul wala khet	N 21°47'12.0" E73° 59'53.3"	44.6	40	15.4
211	Amru Ikiya Munia	2	Babul wala khet	N 21°47'12.2" E73° 59'54.0"	42.6	42	15.4
212	Amru Ikiya Munia	2		N 21°47'12.0"	50.6	30	19.4

				E73` 59'53.3"			
213	Ramchand ra Irka Tad	3	Road vala Khet	N 21`47'12.0" E73` 59'44.0"	40.6	42	17.4
214	Ramchand ra Irka Tad	3	Gav vala Khet	N 21`47'12.1" E73` 59'43.4"	38.6	42	19.4
215	Badda Varda	3		N 21`47'12.3" E73` 59'43.1"	54.6	22	23.4
216	Hari Singh			N 21`47'13.7" E73` 59'39.8"	54.6	26	19.4
217	Kalyan Singh			N 21`47'13.8" E73` 59'40.2"	44.6	36	19.4
218	Ayodhyasin gh	7		N 21`47'13.9" E73` 59'40.7"	46.6	32	21.4
219	Kamal singh	2	Khankra Wala Khet	N 21`47'11.1" E73` 59'40.2"	54.6	26	19.4
220	Leelam Singh	2		N 21`47'19.1" E73` 59'40.9"	54.6	24	21.4
221	Malkan Singh	2. 5		N 21`47'23.2" E73` 59'43.8"	48.6	26	25.4
222	Badri Singh	2		N 21`47'27.0" E73` 59'43.6"	52.6	26	21.4
223	Antar Singh	4. 5		N 21`47'27.1" E73` 59'43.8"	52.6	30	17.4

224	Sandal Singh	2		N 21°47'27.4" E73° 59'44.3"	52.6	32	15.4
225	Lakhan Singh	1.5		N 21°47'27.7" E73° 59'43.6"	54.6	22	23.4
226	Udhya Singh	1.5		N 21°47'28.7" E73° 59'42.8"	48.6	36	15.4
227	Rajendra Singh	1.5		N 21°47'29.2" E73° 59'42.8"	50.6	34	15.4
228	Vamaan/Ram Singh	1.5	Dungar vala khet	N 21°47'33.6" E73° 59'30.7"	40.6	42	17.4
229	Raghunath/Pratap		Modi vala Khet	N 21°47'20.6" E73° 59'19.8"	54.6	28	17.4
230	Jugraj/Chattar meda	10	Kakad vala Khet	N 21°47'20.5" E73° 59'19.8"	48.6	28	23.4
231	Lakhan/Premdas	7		N 21°47'16.5" E73° 59'19.1"	50.6	24	25.4
232	Pop/Pratap	3	Pakka kua vala	N 21°47'16.5" E73° 59'19.1"	48.6	26	25.4
233	Raghunath/Pratap	2	Mota Khet	N 21°47'16.2" E73° 59'14.8"	44.6	32	23.4
234	Pop/Pratap	2		N 21°47'17.7" E73° 59'13.5"	42.6	40	17.4
235	Jeet/Bhimaji	10		N 21°47'19.1" E73° 59'13.7"	56.6	20	23.4
236	Mohan/Prat			N	57.8	28	14.2

	ap			21°47'19.4" E 73° 59'13.9"			
237	Pop/Pratap	1		N 21°47'19.8" E73°59'14.2"	55.8	22	22.2
238	Kalu/Madhav Singh	1.5		N 21°47'20.0" E73° 59'14.3"	49.8	26	24.2
239	Abhay/Babu Singh			N 21°47'21.0" E73° 59'14.9"	45.8	30	24.2
240	Kunsinghurji		Dada vala Khet	N 21°47'21.5" E73° 59'15.3"	47.8	30	22.2
241	Khuman Singh	10	Aam vala Khet	N 21°47'22.7" E73° 59'15.4"	43.8	40	16.2
242	Mohan Singh	3	Gav Vala Khet	N 21°47'23.4" E73° 59'16.0"	41.8	40	18.2
243	Rajendra	3	Sadak vala Khet	N 21°47'25.2" E73° 59'15.9"	57.8	28	14.2
244	Ranjan Singh	4	Nichala khet	N 21°47'25.9" E73° 59'16.0"	53.8	24	22.2
245	Maziya bilawal	1	Upar Vala Khet	N 21°47'25.7" E73° 59'16.0"	55.8	22	22.2
246	Nathuramlal	1		N 21°47'26.0" E73° 59'16.3"	50.6	36	13.4
247	Maziya bilawal	1	Patti Wala Khet	N 21°47'23.9" E73° 59'17.1"	50.6	34	15.4

248	Shyama bhaber	1	Kua Wala Khet	N 21°42'14.2" E73° 53'52.9"	56.6	22	21.4
249	Bhima galiya	1	Magra Wala Khet	N 21°42'14.1" E73° 53'52.9"	56.6	24	19.4
250	Harika galiya		Hole wala Khet	N 21°47'49.8" E73° 59'43.6"	50.6	30	19.4

Soil Sample Analysis Report of Farmers Field

Village – Ralyawan P.O – Pannod Halka No - 41

Appendix II

No	Farmer name	pH	EC dsm-1	OC%	N Kg ha-1	PKg ha-1	K Kg ha-1	S Kg ha-1	Zn mg ha-1	Fe mg ha-1	Mn mg ha-1	Cu mg ha-1
1	Ramchandra	7.3	0.28	0.75	281	11.92	385	18.88	0.72	4.98	3.48	0.28
2	Ramchandra	7.4	0.29	0.71	289	11.12	375	17.85	0.88	5.42	2.84	0.46
3	Kalu Bhuria	7.6	0.36	0.57	265	9.45	334	24.24	0.66	6.48	3.28	0.14
4	Kalu Bhuria	7.7	0.32	0.60	225	9.96	355	24.24	0.8	5.76	3.16	0.62
5	Vijaysingh/Lunda	7.3	0.54	0.55	224	33.30	490	17.44	0.94	6.46	2.3	0.54
6	Hirka/Galiya	7.2	0.36	0.53	249	10.65	466	16.86	0.98	4.68	1.86	0.38
7	Hirka/Galiya	7.5	0.23	0.62	233	12.98	495	16.21	1.02	6.18	3.54	0.08
8	Bhima/Galiya	7.4	0.33	0.77	269	13.02	450	17.44	0.84	6.76	4.02	0.24
9	Bhima/Galiya	7.2	0.38	0.71	274	13.42	437	16.54	0.92	5.46	3.14	0.68
10	Bhima/Galiya	7.6	0.30	0.69	261	12.23	423	15.98	0.52	4.64	2.94	0.54
11	Tersiya/Nandan	7.4	0.58	0.60	225	10.12	372	19.20	0.84	6.38	2.86	0.28
12	Hadiya/Galiya	7.5	0.49	0.81	269	8.86	380	18.18	0.96	7.12	2.5	0.44
13	Ganesh/Ramchandra	7.0	0.22	0.67	251	8.02	425	22.98	0.34	5.9	3.24	0.72
14	Ganesh/Ramchandra	7.4	0.42	0.50	200	8.82	375	19.84	0.74	4.96	3.14	0.84
15	Dalji/Nanji,	7.2	0.25	0.70	263	7.80	395	19.00	0.68	6.28	3.4	0.14
16	Dhulia Vajja	7.5	0.34	0.75	281	19.62	450	18.76	0.76	7.48	1.68	0.46
17	Omkarji/Lunda	7.3	0.63	0.71	238	33.44	438	19.87	0.28	7.16	2.96	0.38
18	Omkarji/Lunda	7.4	0.71	0.65	244	37.40	445	21.20	1.18	4.98	2.54	0.14
19	Surtan/Lunda	7.8	0.36	0.57	214	12.22	420	19.24	0.76	3.88	3.44	0.7
20	Ramesh/valid Katara	7.2	0.36	0.53	249	10.65	366	16.86	0.94	5.48	2.72	0.54
21	Ramesh/valid Katara	7.0	0.31	0.50	200	9.22	490	17.56	1.3	5.48	2.4	0.54
22	Ramesh/valid Katara	7.4	0.58	0.60	225	10.12	372	19.20	0.88	6.02	1.88	0.28
23	Narayan hurji	7.1	0.41	0.58	215	11.22	470	16.56	0.28	5.9	2.88	0.34
24	Narayan hurji	7.2	0.25	0.70	263	7.80	395	19.00	0.46	6.42	3.62	0.22

25	Vijaysingh Luna	7.5	0.34	0.75	281	19.62	315	18.76	0.42	5.8	3.52	0.46
26	Radhapati hemraj	7.4	0.62	0.65	241	19.40	425	21.25	0.76	6.54	3.42	0.34
27	Unsingh joshaf	7.3	0.57	0.69	259	8.4	394	19	0.26	5.9	3.88	0.28
28	Mangu ditya	7.6	0.38	0.60	225	10.8	441	14.21	0.94	5.98	3.48	0.3
29	Majiya makna	7.2	0.42	0.58	276	13.6	529	17.50	0.7	6.14	2.82	0.54
30	Johan	7.4	0.86	0.67	251	18.6	469	13.3	0.82	5.98	3.14	0.68
31	Balu viriya	7.4	0.34	0.57	214	17.51	420	17.92	0.42	5.01	2.71	0.25
32	Babu dhhana	7.6	0.27	0.55	296	24.76	391	15.6	0.4	4.81	2.62	0.53
33	Rantna hawaji	7.8	0.36	0.72	270	17.07	353	20.86	0.32	4.21	2.85	0.26
34	magan fatiya	7.3	0.23	0.54	224	15.93	509	21.12	0.5	5.03	2.54	0.32
35	kaliya fatiya	7.5	0.28	0.57	214	19.82	358	18.8	0.49	5.42	2.66	0.25
36	shankara fatiy	7.6	0.25	0.66	248	19.79	391	27.58	0.45	6.92	2.96	0.36
37	Thavriya	7.3	0.37	0.56	245	15.48	470	22.904	0.39	5.18	3.24	0.4
38	Toliya kaliya	7.3	0.38	0.53	255	17.72	388	22.94	0.55	5.57	3.25	0.25
39	Ramesh bhima	7.4	0.41	0.65	265	16.19	347	20.76	0.52	3.29	3.18	0.36
40	Unsingh vesta	7.5	0.3	0.61	229	12.14	447	18.7	0.49	4.84	2.57	0.36
41	Bijala badiya	7.2	0.39	0.54	265	18.10	394	18.08	0.45	5.21	2.41	0.35
42	Ramesh Hukiya	7.3	0.45	0.45	280	19.32	447	19.46	0.51	4.24	3.22	0.25
43	Johan anhon	7.5	0.39	0.43	245	15.65	470	15.25	0.52	5.15	3.28	0.24
44	Bhagirath Manji	7.3	0.32	0.34	210	19.41	376	2.54	0.6	5.45	2.29	0.25
45	Varsingh badiya	7.5	0.45	0.69	236	17.94	329	20.12	0.79	10.37	2.42	0.36
46	Premchand jithara	7.3	0.38	0.39	258	21.98	456	13.51	0.49	6.71	2.14	0.35
47	Unsingh joshaf	7.5	0.23	0.42	214	16.25	412	12.47	0.61	5.82	2.41	0.35
48	Kailash bheru	7.4	0.24	0.41	235	16.1	458	12.78	0.6	8.25	2.56	0.26
49	Kaniram punaji	7.5	0.27	0.40	254	14.05	369	23.16	0.5	6.83	2.17	0.42
50	Suresh Totaram	7.6	0.29	0.58	218	18.05	387	19.85	0.49	8.18	2.28	0.41
51	Munnalal punaji	7.3	0.27	0.38	260	20.98	369	11.4	0.41	7.67	2.89	0.37
52	Ramnath vagenath	7.6	0.23	0.52	208	15.5	424	16.52	0.46	8.34	2.54	0.28
53	Dhanaji pratap	7.5	0.27	0.55	224	20.06	369	15.91	0.5	7.24	2.45	0.25

54	Vinod kaniram	7.6	0.31	0.44	210	17.98	421	20.37	0.53	6.96	2.76	0.34
55	Chogalal ranchod	7.3	0.42	0.51	204	15.94	412	14.77	0.6	6.57	2.55	0.28
56	Totaram pujaji	7.4	0.28	0.48	217	13.14	458	15.89	0.61	7.12	3.12	0.35
57	Sardar tolaram	7.3	0.25	0.47	248	16.88	369	14.49	0.57	5.82	2.92	0.25
58	Shantilal Gendal	7.6	0.27	0.53	212	18.26	512	17.21	0.52	5.91	3.13	0.48
59	Kailash bheru	7.6	0.24	0.57	214	19.49	515	16.47	0.59	6.05	2.15	0.31
60	Mangu parmar	7.5	0.28	0.66	248	11.16	432	20.24	0.63	6.14	3.05	0.29
61	Kailash sarel	7.4	0.32	0.66	248	13.86	496	23.04	0.62	6.7	3.35	0.35
62	Rumal menda	7.6	0.23	0.62	233	12.28	378	18.05	0.52	7.1	2.04	0.35
63	Mehaji bhuniya	7.6	0.22	0.52	208	10.02	452	18.89	0.64	5.99	2.24	0.36
64	Bhura sigad	7.3	0.34	0.55	224	14.73	397	17.84	0.67	7.28	2.02	0.42
65	Kunsingh hurji	7.2	0.27	0.44	198	14.44	512	14.98	0.45	8.15	2.03	0.35
66	Khuman Singh	7.4	0.23	0.53	200	13.91	573	25.4	0.38	10.8	3.18	0.29
67	Mohan Singh	7.6	0.46	0.55	224	13.91	332	22.65	0.49	7.54	3.12	0.39
68	Rajendra	7.6	0.22	0.52	208	11.17	479	19.89	0.54	7.6	2.02	0.28
69	Ranjan Singh	7.7	0.27	0.65	152	09.93	547	18.69	0.61	7.28	3.12	0.24
70	Maziya bilawal	7.4	0.53	0.70	198	13.79	369	17.01	0.71	7.57	2.41	0.25
71	Maziya bilawal	7.6	0.25	0.63	166	12.22	440	17.39	0.51	6.65	2.62	0.26
72	Maziya bilawal	7.1	0.31	0.56	192	13.02	369	20.02	0.76	6.59	3.05	0.34
73	Shyama bhaber	7.2	0.29	0.68	184	11.87	498	23.04	0.59	7.47	2.4	0.35
74	Shyama bhaber	7.7	0.78	0.71	204	9.4	498	17.23	0.58	7.87	2.3	0.28
75	Shyama bhaber	7.2	0.29	0.75	270	11.5	532	19.2	0.69	7.54	2.84	0.41
76	Bhura sigad	7.6	0.28	0.48	176	12.82	544	18.69	0.6	5.8	2.91	0.26
77	Bhura sigad	7.2	0.32	0.55	224	09.88	501	16.15	0.63	6.54	2.69	0.31
78	Lalji hurji	7.5	0.28	0.62	233	11.76	415	16.35	0.51	5.35	3.28	0.52
79	Ramchandra vesta	7.6	0.35	0.72	208	13.26	456	17.55	0.54	7.28	2.77	0.24
80	Unkar vesta	7.4	0.29	0.69	152	10.36	497	16.43	0.61	7.2	2.89	0.32
81	Rumal babu	7.5	0.24	0.58	218	12.45	179	19.88	0.2	7.67	3.18	0.42
82	Rumal babu	7.6	0.25	0.58	218	13.11	396	21.27	0.84	6.24	3.52	0.26

83	Shyama uketiya	7.4	0.36	0.54	212	12.12	512	15.76	0.71	6.36	2.58	0.35
84	Bhura hadiya	7.3	0.32	0.72	270	14.78	496	13.9	0.34	5.48	2.23	0.39
85	kaliya ramal	7.2	0.37	0.45	180	11.60	398	15.02	0.61	5.84	2.12	0.28
86	kaliya ramal	7.4	0.28	0.55	224	13.37	389	16.75	0.72	5.96	2.13	0.24
87	kaliya ramal	7.4	0.32	0.56	188	11.16	485	15.31	0.2	7.05	3.05	0.26
88	Amsingh gobriya	7.5	0.35	0.56	200	15.48	356	14.38	0.52	5.25	2.44	0.36
89	Shambu badiya	7.3	0.28	0.59	212	12.47	458	19.96	0.56	5.58	2.5	0.25
90	Mansingh luna	7.3	0.23	0.62	196	12.65	652	16.66	0.22	6.82	3.12	0.29
91	Bhadur Bhaliya	7.6	0.24	0.55	224	15.16	452	17	0.61	6.52	2.62	0.37
92	Jogadiya luna	7.4	0.27	0.70	185	13.01	412	13.65	0.6	6.41	3.21	0.28
93	Narayan hurji	7.6	0.45	0.52	208	20	353	21.08	0.27	7.45	3.25	0.26
94	Vijaysingh Luna	7.3	0.37	0.72	225	18.93	385	28.26	0.3	8.05	3.54	0.25
95	Radhapati hemraj	7.4	0.27	0.63	236	15.03	438	14.05	0.58	7.14	2.67	0.23
96	Komal Somal Meda	7.7	0.46	0.59	212	17.23	320	16.3	0.31	6.35	2.58	0.36
97	Komal Somal Meda	7.6	0.65	0.70	236	09.49	441	12.92	0.32	5.94	2.26	0.51
98	Mukesh Somal Meda	7.6	0.53	0.64	240	15.44	473	14.52	0.54	5.89	2.17	0.48
99	Vijay Singh Luna Kharadi	7.7	0.37	0.62	233	32.33	356	14.32	0.46	6.9	3.54	0.36
100	Mahesh SEmala Meda	7.3	0.56	0.70	263	14.36	341	8.77	0.59	7.15	2.51	0.28
101	Rakesh Somal Meda	7.2	0.39	0.62	233	12.51	435	13.42	0.48	5.95	2.48	0.29
102	Rakesh Somal Meda	7.6	0.42	0.65	244	15.8	370	13.78	0.52	5.84	3.17	0.35
103	Khuman Singh Vijay singh	7.4	0.45	0.53	212	13.63	400	12.78	0.53	7.15	3.28	0.4
104	Satyanarayan	7.3	0.38	0.69	245	11.27	364	15.03	0.56	6.26	3.65	0.25
105	Bhamar Rupa Solanki	7.4	0.56	0.59	221	9.9	388	18.33	0.34	6.84	3.27	0.26
106	Bhamar Rupa Solanki	7.7	0.72	0.68	215	19.16	338	14.65	0.34	6.91	2.56	0.51
107	Rajesh mangilal	7.5	0.69	0.73	245	17.79	447	17.53	0.54	7.15	2.69	0.35

108	Ranjan mangilal	7.5	0.65	0.56	258	18.87	394	11.33	0.33	8	3.24	0.36
109	Narayan Vijay Singh karadi	7.6	0.54	0.59	208	26.86	379	12.69	0.41	6.95	2.31	0.38
110	Narayan Vijay Singh karadi	7.6	0.43	0.60	245	14.46	341	13.29	0.56	6.75	2.23	0.42
111	Roopchand Sigad Hadia	7.6	0.19	0.51	204	16.55	412	20.69	0.3	5.28	3.18	0.43
112	Roopchand Sigad Hadia	7.7	0.56	0.4	180	8.25	435	23.81	0.42	5.54	2.18	0.56
113	Nanda Megala Munia	7.4	0.61	0.54	216	8.64	326	20.18	0.52	6.17	2.47	0.51
114	Rukaman bai	7.3	0.21	0.46	184	7.15	411	13.51	0.85	5.06	3.18	0.26
115	Bheru Nanji Damar	7.6	0.23	0.44	198	10.24	435	17.67	0.65	5.65	2.32	0.68
116	Bheru Naraji Sigad	7.5	0.28	0.58	218	10.9	332	15.44	0.25	7.15	2.49	0.35
117	Puna Nanji Hatila	7.4	0.25	0.58	218	12.41	342	14.39	0.69	8.62	3.17	0.58
118	Dalji nanji Hatila	7.2	0.32	0.54	214	10.74	547	12.3	0.48	5.61	2.66	0.46
119	Ramesh Somala Meda	7.4	0.36	0.65	244	13.85	303	17.54	0.5	5.33	2.75	0.26
120	Lalsingh Rupa Solanki	7.5	0.32	0.51	256	11.68	356	16.66	0.33	4.87	2.94	0.35
121	Kaloo Mangu Bhuria	7.4	0.25	0.63	236	11.74	826	14.61	0.45	4.95	2.15	0.54
122	Kaloo Mangu Bhuria	7.3	0.39	0.63	225	23.97	429	16.43	0.46	5.14	2.25	0.46
123	Gulab singh	7.5	0.32	0.61	229	16.73	332	15.26	0.36	6.75	3.18	0.23
124	Soman meda	7.3	0.54	0.63	225	13.62	450	21.41	0.39	6.32	2.19	0.58
125	Khuman singh	7.5	0.33	0.58	218	9.72	414	15.84	0.4	6.71	2.54	0.26
126	Jhind Veshta Khaida	7.4	0.32	0.47	213	11.5	467	22.98	0.22	7.53	3.08	0.35
127	Babu Limji Katara	7.7	0.42	0.54	216	14.24	429	23.68	0.25	5.81	2.55	0.39
128	Balu Ganji Munia	7.6	0.36	0.72	270	25.56	338	15.74	0.35	5.96	2.42	0.27
129	Balu Ganji Munia	7.6	0.56	0.61	229	16.06	520	21.11	0.33	5.04	3.18	0.42
130	Ramesh Khji Katara	7.5	0.51	0.66	248	33.76	512	25.98	0.53	6.06	2.29	0.53
131	Hudtan Galla Katara	7.6	0.42	0.70	263	10.54	320	12.8	0.56	6.21	2.17	0.23
132	Devchand Jitra	7.5	0.47	0.62	274	15.53	497	15.24	0.41	5.42	3.05	0.32

	Katara											
133	Devchand Jitra Katara	7.6	0.29	0.65	244	18.64	526	19.95	0.61	5.73	3.18	0.25
134	Hardar Jaimal Munia	7.6	0.36	0.55	224	17.93	344	22.12	0.71	5.48	3.27	0.46
135	Metab Tieya Bilwal	7.5	0.31	0.53	212	22.91	464	23.88	0.3	6.47	3.2	0.32
136	Jhind Veshta Khaida	7.5	0.28	0.71	266	19.76	450	29.66	0.5	6	3.25	0.25
137	Babu Limji Katara	7.3	0.23	0.58	218	20.47	385	16.55	0.54	7.12	2.19	0.29
138	Ditia Kaliya Singad	7.4	0.50	0.69	256	10.25	329	22.45	0.31	4.33	3.18	0.38
139	Balu Ganji Munia	7.5	0.51	0.70	218	19.22	441	23.43	0.4	5.04	2.55	0.24
140	Ditia Kaliya Singad	7.4	0.42	0.58	245	9.96	423	24.55	0.5	5.56	2.64	0.25
141	Hudtan Galla Katara	7.3	0.34	0.6	225	11.73	344	20.33	0.89	3.66	2.97	0.53
142	Dhumsingh Jogaliya Katara	7.7	0.36	0.65	244	12.6	424	18.91	0.7	4.91	2.52	0.29
143	Devchand Jitra Katara	7.2	0.39	0.60	225	16.08	382	19.33	0.61	4.84	2.41	0.3
144	Jhind Veshta Khaida	7.3	0.42	0.54	216	9.76	435	24.1	0.61	4.93	3.12	0.31
145	Jhind Veshta Khaida	7.6	0.48	0.58	218	11.89	323	23.95	0.52	5.61	2.16	0.42
146	Dhumsingh Jogaliya Katara	7.2	0.58	0.54	230	16.4	485	21.09	0.54	5.05	2.24	0.24
147	Dhumsingh Jogaliya Katara	7.4	0.36	0.65	244	14.18	369	11.84	0.37	6.81	2.88	0.35
148	Ramesh Khji Katara	7.5	0.46	0.45	225	9.38	491	13.22	0.52	5.25	2.39	0.54
149	Omprakash	7.5	0.41	0.63	236	21.8	391	19.13	0.57	6	2.54	0.4
150	Omprakash	7.3	0.29	0.3	223	31.78	488	18.91	0.48	9	3.12	0.25
151	Nanda manna Meda	7.3	0.27	0.47	214	21.99	409	18.84	0.43	6.81	2.71	0.39
152	Nanda manna Meda	7.6	0.35	0.56	245	13.19	368	16.09	0.65	7.12	2.56	0.41
153	Sama Ukedia Bhamar	7.5	0.26	0.64	240	10.73	388	18.94	0.39	6.32	3.06	0.52
154	Sama Ukedia Bhamar	7.6	0.37	0.34	278	9.89	388	15.31	0.5	6.58	2.65	0.35
155	Sama Ukedia	7.5	0.27	0.59	221	15.05	456	19.65	0.74	5.5	2.75	0.39

	Bhamar											
156	Gulab Singh Dhavaria Meda	7.6	0.48	0.54	216	13.07	406	28.72	1.2	7.81	2.78	0.43
157	Lala Dita Meda	7.4	0.38	0.54	200	12.99	412	18.69	0.65	6.79	2.85	0.42
158	Gobaria Galia Katara	7.2	0.49	0.63	236	12.38	426	14.76	0.7	6.91	2.26	0.32
159	Bhila Malla Kharadi	7.1	0.37	0.62	225	14.31	412	16.75	0.54	6.73	3.51	0.42
160	Gabbu Dalla Kharadi	7.3	0.28	0.55	224	11.98	556	19.68	0.59	7.05	2.15	0.41
161	Ter singh nanda Meda	7.1	0.29	0.51	204	14.87	429	13.86	0.6	7.25	2.26	0.25
162	Ter singh nanda Meda	7.7	0.38	0.56	210	12.54	323	16.78	0.38	7.06	3.18	0.36
163	Nandoo Mala katar	7.2	0.35	0.3	236	8.36	364	13.81	0.54	7.58	2.92	0.47
164	Nandoo Mala katar	7.0	0.35	0.58	223	15.09	420	12.61	0.56	6.81	2.88	0.24
165	Raju kaloo Bhamar	7.3	0.37	0.44	258	16.2	420	17.63	0.52	6.29	2.3	0.48
166	Raju kaloo Bhamar	7.6	0.45	0.61	229	19.32	306	18.82	0.4	5.97	2.43	0.52
167	Nathu Singh	7.6	0.29	0.36	269	19.08	397	20.82	0.39	6.04	2.54	0.42
168	Nathu Singh	7.5	0.28	0.51	286	21.52	409	19.28	0.63	3.6	2.91	0.57
169	Vijay singh	7.3	0.53	0.62	233	16.43	470	24.86	0.54	7	2.6	0.58
170	Pyaar Singh	7.5	0.31	0.39	258	21.33	464	22.8	0.65	4.95	2.52	0.49
171	Vijay singh	7.3	0.23	0.58	289	19.66	329	17.2	0.85	4.22	1.34	0.39
172	Pyari bai	7.6	0.29	0.45	246	21.23	367	16.74	0.52	5.18	2.35	0.38
173	Pyari bai	7.7	0.25	0.62	245	18.09	423	14.42	0.54	5.29	2.41	0.47
174	Gyan Singh	7.4	0.45	0.63	236	18.5	415	15.48	0.74	4.54	2.78	0.42
175	Ramesh Sukhia Munia	7.6	0.22	0.66	280	16.88	497	17.28	0.54	4.91	2.27	0.52
176	Ramesh Sukhia Munia	7.2	0.23	0.78	273	14.84	432	18.46	0.42	5.26	2.36	0.35
177	Vajing Viriya Munia	7.3	0.33	0.56	210	13.16	391	18.38	0.31	5.37	3.32	0.41
178	Vajing Viriya Munia	7.7	0.22	0.57	288	17.3	364	18.54	0.54	5.68	2.52	0.42
179	Humji Jithra Vasuniya	7.4	0.21	0.64	298	19.6	470	19.58	0.5	5.79	2.62	0.23

180	Humji Jithra Vasuniya	7.5	0.29	0.56	210	18.21	370	16.82	0.44	5.51	2.75	0.47
181	Ratna Toliya Bilwal	7.6	0.17	0.51	204	18.14	497	21.78	0.56	5.94	3.18	0.42
182	Mangu Dita Parmar	7.5	0.36	0.69	276	20.24	367	20.68	0.57	4.56	3.27	0.52
183	Mangu Dita Parmar	7.2	0.39	0.67	288	16.23	420	24.56	0.46	3.54	2.65	0.36
184	Mangu Dita Parmar	7.3	0.48	0.66	238	19.34	311	19.48	0.57	5.61	3.15	0.25
185	Ramesh Sukhia Munia	7.6	0.41	0.56	274	17.36	423	16.96	0.54	6.5	2.91	0.38
186	Balu Viriya Munia	7.4	0.39	0.58	218	18.26	382	16.6	0.82	3.02	2.94	0.42
187	Balu Viriya Munia	7.4	0.37	0.76	266	09.84	453	19.5	0.72	4.52	2.74	0.51
188	Roopsingh Dalla Vasuniya	7.5	0.56	0.72	276	18.63	338	19.84	0.83	4.91	2.65	0.45
189	Roopsingh Dalla Vasuniya	7.2	0.58	0.73	234	22.14	420	17.12	0.73	4.63	3.25	0.25
190	Paru Balchand Bilwal	7.3	0.57	0.85	248	10.88	520	17.4	0.79	5.2	2.47	0.35
191	Paru Balchand Bilwal	7.12	0.53	0.56	210	18.94	320	19.53	0.69	5.34	2.28	0.42
192	ShravanPatidar	7.2	0.54	0.62	224	13.87	344	18.74	0.92	3.41	2.34	0.41
193	BhagwatBhagirath	7.3	0.22	0.56	268	19.28	476	19.79	0.82	5.2	2.19	0.52
194	Khuman Vesta Munia	7.4	0.27	0.74	236	15.82	450	17.74	0.62	5.69	2.57	0.35
195	Khuman Vesta Munia	7.3	0.31	0.64	232	13.42	353	24.4	1.13	3.8	2.28	0.52
196	Ramesh Sukhia Munia	7.5	0.31	0.56	247	14.48	438	18.08	0.57	3.97	2.64	0.25
197	Ramesh Sukhia Munia	7.4	0.29	0.66	267	24.61	326	2.67	0.54	4.05	2.8	0.42
198	Rama dhura	7.2	0.21	0.53	268	35.49	491	20.86	0.79	3.73	2.41	0.25
199	Chandan Singh	7.4	0.23	0.65	289	21.32	473	20.54	0.65	5	2.19	0.25
200	Chandan Singh	7.5	0.27	0.50	273	20.77	391	19.23	0.56	5.61	2.37	0.42
201	Punna Nathu Khadiya	7.6	0.37	0.66	248	17.07	491	17.56	0.88	3.32	3.26	0.39

202	Punna Nathu Khadiya	7.3	0.29	0.63	225	15.51	347	19.74	0.7	7.08	2.82	0.28
203	Babu Ketiya Munia	7.3	0.50	0.56	267	17.24	435	19.33	0.73	6.2	2.91	0.21
204	Lalu Pangla Munia	7.2	0.36	0.69	257	13.65	376	22.38	0.67	7.05	2.52	0.25
205	Habji Wagji Sarel	7.6	0.45	0.74	288	11.52	447	21.15	0.69	6.75	2.55	0.26
206	Talu Bhura Parmar T	7.3	0.36	0.63	285	11.28	457	18.86	0.54	7.17	2.91	0.5
207	Talu Bhura Parmar	7.6	0.54	0.62	288	9.71	417	16.54	1.18	4.71	2.19	0.42
208	Prakash Lalu Parmar	7.5	0.55	0.53	212	9.6	394	17.9	0.61	5.19	2.28	0.21
209	Dalla Dhanna Parmar	7.2	0.36	0.55	224	9.97	376	18.3	0.59	5.64	2.34	0.36
210	Kalia Babu Parmar	7.5	0.36	0.51	204	10.4	476	16.29	1.94	4.65	2.21	0.34
211	Amru Ikiya Munia	7.4	0.45	0.54	280	10.52	468	22.36	0.54	5.6	2.53	0.28
212	Amru Ikiya Munia	7.6	0.29	0.56	230	12.64	359	15.02	0.52	5.26	2.66	0.37
213	Ramchandra Irka Tad	7.1	0.23	0.58	267	8.63	447	14.04	0.9	3.78	2.59	0.31
214	Ramchandra Irka Tad	7.3	0.36	0.52	208	14.72	379	17.36	0.82	6.01	2.46	0.42
215	Badda Varda	7.2	0.29	0.75	276	18.38	376	16.54	0.71	6.34	2.67	0.35
216	Hari Singh	7.6	0.29	0.68	289	17.25	450	18.97	0.25	5.88	2.66	0.37
217	Kalyan Singh	7.3	0.36	0.66	248	11.46	447	19.18	0.64	6.21	2.49	0.4
218	Ayodhyasingh	7.4	0.27	0.78	280	9.97	476	16.82	0.57	6.42	2.34	0.35
219	Kamal singh	7.1	0.33	0.53	210	17.44	314	17.57	0.71	4.48	2.67	0.34
220	Leelam Singh	7.4	0.30	0.49	294	13.64	394	15.87	0.74	5.12	2.46	0.25
221	Malkan Singh	7.2	0.53	0.43	294	12.64	397	18.75	0.54	5.65	2.16	0.35
222	Badri Singh	7.5	0.31	0.39	276	12	394	17.37	1.52	5.36	2.88	0.38
223	Antar Singh	7.3	0.39	0.29	238	18.43	444	17.11	0.65	6.87	2.63	0.37
224	Sandal Singh	7.6	0.28	0.34	262	22.34	303	19.1	0.52	6.21	2.85	0.34
225	Lakhan Singh	7.4	0.23	0.46	284	24.84	335	18.27	0.68	4.75	2.55	0.29
226	Udhya Singh	7.2	0.24	0.34	262	16.58	400	16.41	0.57	5.19	2.48	0.27
227	Rajendra Singh	7.1	0.36	0.36	298	23.14	347	19.42	0.51	6.24	2.57	0.41

VITA

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