Status of Available Major and Micronutrients in Vertisols of Ashoknagar District of Madhya Pradesh

THESIS

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In

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by

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CERTIFICATE – I

This is to certify that the thesis entitled **"Status of available major and micronutrients in Vertisols of Ashoknagar district of Madhya Pradesh"** submitted in partial fulfilment of the requirement for the degree of **MASTER OF SCIENCE in AGRICULTURE (SOIL SCIENCE AND AGRICULTURAL CHEMISTRY)** of Rajmata Vijayaraje Scindia Krishi Vishwa Vidhyalay, Gwalior is a record of the bona-fide research work carried out by **Mr. Ravi Kumar Richhariya (RA/GW/062/2008)** under my guidance and supervision. The subject of the thesis has been approved by the student's Advisory Committee and the Director of Instruction.

No part of the thesis has been submitted for any other degree or diploma or has been published. All the assistance and help received during the course of this investigation has been acknowledged by the scholar.

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CERTIFICATE –II

This is to certify that the thesis entitled **"Status of available major and micronutrients in Vertisols of Ashoknagar district of Madhya Pradesh''** submitted by **Mr**. **Ravi Kumar Richhariya (RA/GW/062/2008)** to the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior in partial fulfilment of the requirements for the degree of **Master of Science** in **AGRICULTURE** in the Department of **(Soil Science and Agricultural Chemistry)** has been accepted after the evaluation by the External Examiner and by the Student's Advisory Committee after an oral examination on the same.

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Place: Gwalior

Date: July 22, 2016 **(Ravi Kumar Richhariya)**

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Abbreviations and Acronyms

Abbreviations/ Acronyms	Meaning
Ag.	Agriculture
&	And
et al.	And co-workers
@	At the rate of
B	Boron
CD	Critical difference
Cu	Copper
dSm^{-1}	Deci Siemens per meter
^{o}C	Degree centigrade
Dist.	District
E	East
EC	Electrical conductivity
Fig.	Figure
Fe	Iron
FYM	Farm Yard Manure
g	Gram
>	Greater than
ha	Hectare
i.e.	In reference to; that is
kg	Kilogram
$kg\ ha^{-1}$	Kilogram per hectare
<	Less than
Max.	Maximum
m	Meter
$mg\ kg^{-1}$	Milli gram per kilogram
min	Minimum
mm	Milli meter
Mn	Manganese

'	Minutes
Mo	Molybdenum
viz	Namely
N	Nitrogen
No.	Number
OC	Organic carbon
ppm	Parts per million
%	Per cent
K	Potassium
P	Phosphorus
PSB	Phosphorus Solubilizing Bacteria
RH	Relative humidity
R.V.S.K.V.V.	Rajmata Vijayaraje Scindia Krishi Vishwa Vidhyalaya
"	Seconds
pH	Soil reaction
S	Sulphur
SE (m)	Standard error of mean
Temp.	Temperature
Vol.%	Volume per centage
vs	Verses
Zn	Zinc

Chapter – I

INTRODUCTION

Soil is a critical component of the earth system, functioning not only for the production of food, fodder and fiber but also in the maintenance of local, regional and global environmental quality.

Soil fertility which refers to the inherent capacity of a soil to supply essential nutrients to plants in adequate and right proportion for optimum growth, is one of the key components to determine soil productivity. Management of the fertility of Indian soils demands for sustainable production at a high level to produce adequate food to feed its burgeoning population. Proper management of soil fertility demands careful identification of constraints of current nutrient deficiencies and monitoring changes in soil fertility to predict its deficiency. These deficiencies need to be alleviated through sound and proven practices of nutrients, water, crops and energy to soil management, so as to sustain food production at a reasonable level to ensure continued high productivity in the future. Thus management of soil fertility vis-à-vis nutrient management at optimum level is one of the key factors in achieving high and sustainable productivity.

Soil fertility is one of the important factors controlling yields of the crops. Macronutrients (N, P, K) and micronutrients (Zn, Cu, Fe and Mn) are important soil elements that control its fertility. Soil characterization in relation to evaluation of fertility status of the soil of an area or region is an important aspect in context of sustainable agriculture production. Because of imbalanced and inadequate fertilizers use and coupled with low efficiency of other inputs, the response (production) efficiency of chemical fertilizers nutrients declined tremendously under intensive cultivation in recent years. Variation in nutrients supply is a natural phenomenon and some of them may be sufficient where others deficient.

Nitrogen being an essential constituent of protein is a vitally important plant nutrient. Nitrogen is one of the 17 essential plant nutrients indispensable for growth and development of crop plants. According to Katyal (2016), currently N deficiency affected 99% of the soils and crops grown on them invariably show deficiency symptoms in

almost all the fields where it is not applied. An adequate supply of nitrogen is generally associated with vigrous vegetative growth of plants and deep green colour of leaves, as it is a constituent of chlorophyll as well as DNA and RNA.

Phosphorus stands next in importance among the essential nutrients and the soils of the region are low in P content. Phosphorus, amongst NPK can be called “The master key” with respect to the yield and quality of crops. It is useful for the absorption of different nutrients as the most prominent effect of P has been observed on the root system of plants as it promotes the formation of lateral and fibrous roots and a constitute of ATP and ADP, the energy supplying sources of plant.

Potassium is essential for various metabolic activities of living cell, transformation of carbohydrates, reduction of nitrates, synthesis of protein and normal meristematic activities where it acts as a catalyst or as a co-factor in enzymatic reaction of living cells. It has been suggested that potassium may also affect photosynthesis maintenance of turgor in plant cells as well as formation of oil and imparting disease and insect resistance. Its negligence in use has provoked widening of its deficiency in soils across length and breadth of the country. Laha *et al.* (2003) have also confirmed depletion of soil reserves.

Sulphur (S) has been recognized as the fourth important plant nutrient after nitrogen (N), phosphorus (P) and potassium (K). It is one of the essential elements for plant growth and activated many enzymes which are involved in photosynthesis and nitrogen fixation are attributed to the type of sulphur linkage present. Sulphur has been found to help the synthesis of amino acid and hence increase protein content of plants, boosts the oil content. Heavy removal of sulphur by high yielding varieties particularly oil seed crops, intensive cropping with high S requiring crops and losses of sulphur from soil through leaching and erosion causes sulphur deficiency in soil. It is also becoming deficient in soil due to continuous use of sulphur free fertilizers. The deficiency of S in general causes accumulation of nitrates and amides in plants failed to utilize N, entire plant becomes yellow, growth is stunted and spindly.

Indian soils are generally poor in fertility, as these have consistently been depleted of their finite nutrient resources due to continuous cultivation for many

centuries without proper replacement of nutrients. Soil-test summaries indicate that 98 per cent Indian soils have low to medium in available P and 60 per cent soil have low to medium in K status, whereas N continues to be universally deficient. In last one and half decades a phenomenal increase in S deficiency has been witnessed under intensive cropping system where high-analysis fertilizers devoid of S are used.

There are reports of reduction in yield even due to constant use of NPK fertilizers. The reduction in the yield is generally traced due to deficiency of secondary nutrients and micronutrients. According to Rattan *et al.* (2009) more than 2.5 lakh soil samples were analyzed under All India Coordinated Research Project on Micronutrient from 20 states of the country and it was found that the 49, 33, 13 and 7 % of the samples were deficient in zinc, boron, iron and molybdenum, respectively. In Madhya Pradesh, deficiency of zinc was observed in about 58% of soil samples, in some states and crops, the deficiency of B and Mo are also limiting the crop production.

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 need 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 temporarily.

Information of soil fertility of different blocks of district is essential for classification of fertility status. Hence, the efforts have been made to study the fertility status in soil of different block of Ashoknagar district with following objectives:

Objectives:

- To determine important physico-chemical properties of soil.
- To estimate available N, P, K, S and micronutrient cations (Zn, Cu, Fe and Mn) status in soil.

- To workout the nutrient index (N, P, K & S) of Ashoknagar district.
- To find out the relationship of available nutrients (N, P, K, S, Zn, Cu, Mn and Fe) with important soil properties (pH, EC, OC, $CaCO_3$, Sand, Silt and Clay)

Chapter - II

REVIEW OF LITERATURE

In this chapter, an attempt has been made to bring out review relating to the **"Status of available major and micronutrients in Vertisols of Ashoknagar district of Madhya Pradesh"** A brief resume of the work done in the past by various workers is reviewed under appropriate heads.

2.1: Physico-Chemical parameters of different soils

2.2: Available macro-nutrients (N, P, K) and sulphur in soils

2.3: Status of available micronutrient under different soils

2.4: Relationship of available nutrients (N, P, K, S, Zn, Cu, Mn, Fe) with soil properties

2.1: Physico-chemical parameters of different soils

Sharma (1992) reported that continuous application of fertilizers to Typic Chromusterts with soybean-wheat-maize crop rotation continuously for 16 years caused a small decrease (0.11 dSm^{-1}) in the electrical conductivity (EC) due to application of inorganic fertilizers.

Tembhare *et al.* (1998), found that even after continuous cropping and fertilizer application to Typic Haplustert for 24 years period the soil pH and the salt concentrations (EC) remained unchanged.

Hulugalle *et al.* (1999), noticed that amongst the soil chemical fertility indicators, the soil pH was not affected consistently by either wheat or field pea.

Santhy *et al.* (1999) has also reported that application of FYM and inorganic fertilizer either alone or in combination, to finger millet maize cowpea crop rotation under irrigated tropical garden land condition, had resulted in meager change in E.C. of the soil. The conjoint use of FYM and inorganic fertilizer may cause meager change that could be due to solubilising effect of the decomposition products of the organic manure used on insoluble sources.

Prasad *et al.* (2010) observed that the increase in the fertilizers levels decreased the soil pH. Organic carbon in the soil increased significantly with the increase in level of NPK fertilizers up to 100% of recommended dose. However, a much higher contented was observed where NPK fertilizer were combined with 25% or 50% N through different organic sources.

Rajput *et al*. (2015) reported that the soils of Bhind district contained relatively higher amount of clay. The soils were normal to slightly alkaline with pH ranging between 7.0 and 8.2. Electrical conductivity varied between 0.10 and 0.97 dSm^{-1}, characteristic of normal soils. The soils had low organic carbon content ranging from 1.12 to 8.10 g kg^{-1} (mean 4.08 g kg^{-1}). Calcium carbonate content of the soils varied from 0.5 to 9.5% with a mean value of 2.21%.

2.2: Status of available macro-nutrients (N, P, K) and sulphur in soils

Subba Rao *et al*. (1993), reported that the application of potassium at high rate and optimum NPK+FYM, increased the available K (NH_4OAc-K) in surface soil (0-15 cm) but not in subsurface soils (15-30 cm). Perceptible decreases occurred in sub surface soil K when K was not added.

Tiwari *et al.* (1995) analysed 7430 soil samples collected from 11 districts of Uttar Pradesh. The extent of S deficiency ranged from 18 percent in Lalitpur to 64 percent in Hardoi.

Aggarwal and Nayyar (1998) reported that available sulphur contents ranged from 14.0 to 35.2 mg kg^{-1} soil in the surface layers with a mean value of 22.2 $mgkg^{-1}$ soil in wheat fields of Punjab.

Datt *et al.* (2000) reported that in Tripura soil, available nitrogen varied from high to medium status. A sharp decline from 589 to 522 kg/ha and 567 to 511 kg/ha with the rise in shifting cultivation cycle. Available phosphorus was low and varied from 1.05 to 8.02 kg/ha. Available potassium varying from low to medium status also showed a decreasing trend from 150 to 125 kg/ha and 319 to 203 kg/ha in soils under shifting cultivation.

Sharma and Singh (2001) observed that the available K varied from 90 to 520 kg/ha and available phosphorus from 7 to 55 kg/ha. Medium and fine textured soils contained higher content of both phosphorus and potassium in the soils of western Rajasthan.

Ved Prakash *et al*. (2002), reported that the available K content in the soil after 27 crop cycles of soybean-wheat, showed differential changes, depending on the yield response to added fertilizers. In surface layer, the available K remained unchanged under 100% NK and 100% N + FYM treatments, whereas significant build up of K was noticed under 100% NPK + FYM. Significant depletion of available K was observed under control, 100% NP and 100% NPK treatments.

Arora and Chahal (2003) found that available potassium ranged from 41.5 to 314.0 mg kg $^{-1}$ in the surface and 32.0 to 243.0 mg kg^{-1} in the subsurface soil of the 20 soil series, five were low, fourteen medium and only one high in mean available potassium content.

Meena *et al.* (2006) considering the concept of soil nutrient index, the soils of Tonk district of Rajasthan were found in category of medium fertility status for nitrogen and phosphorus and high with respect to potassium. The value worked out from nutrient index for NPK were 1.75, 1.70 and 2.54 respectively, against the nutrient index values <1.67 for low, 1.67-2.33 for medium and >2.33 for high fertility status.

Jat and Yadav (2006) reported that the mean value of, available - S was 14.25 mg kg^{-1} and approximately, 33.75 percent investigated soils were deficient in available sulphur.

Tripathi *et al.* (2007) reported N, P and K status in the hill soils of North-Western Himalayas. The available N-content of the surface soils varies from 142 to 615 kg ha^{-1} this variation may be attributed to the differences in soil properties, crop, and management practices and addition of FYM. The available phosphorus and potassium content varies from 12.0 to 42.6 and 84 to 368 kg ha^{-1} respectively. Forest soils showed higher values of available NPK as compared to the cultivated and pasture scrub land. The average values of N, P and K is agricultural land, forest land and pasture land are 328, 343, 214; 22.4, 25.8, 17.6, and 196, 224 and 162 kg ha^{-1}, respectively.

Mahajan *et al*. (2007) reported that available sulphur in Saharanpur soils ranged from 8.0 – 47.9 mg $kg^{-1}$with the mean value of 15.68 mg kg^{-1}.

Rao Vara Prasad *et al. (*2008) reported the nutrient status of soils in Ramachandra puram Mandal of Chittoor District in Andhra Pradesh. The available nitrogen content of surface soil samples varied from 54 to 103 (mean of 110) kg ha^{-1} Low nitrogen status of soil could be attributed to low amount of organic carbon in these soils. The available phosphorus content varied from 9.29 to 23.96 kg ha^{-1}. The soils are medium in available phosphorus. The available potassium content of soil samples varied from 135-320 kg ha^{-1}.

Sharma *et al.* (2008) observed that the content of available N varied from 63 to 170 kg ha^{-1}, available P from 9.4 to 84.9 kg ha^{-1}, available K from 84 to 700 kg ha^{-1}, and available S from 24.6 to 60.0 kg ha^{-1}, respectively in the soils of Amritsar district of Punjab. A significant positive correlation occurred between organic carbon and N. K and S.

Pattanayak *et al*. (2009) reported that the Indian soils have adequate available P, 49.3% are under low category, 48.85 under medium and 1.9% under high category. A soil of Madhya Pradesh was observed in medium category with 1.84 value of nutrient index.

Tandon (2010) reported from the data base of 135000 soil analyses, about 42.3%, Indian soils samples have been found to be deficient /low in available sulphur. Sulphur deficiency is now estimated to be a problem in about 300 districts as compared to 70 districts in 1991.

Singh and Mishra (2012) revealed that soil samples of Chaiaigoan block of Varanasi district were found low in organic carbon, available nitrogen and phosphorus while medium in potassium. About 62% of the samples were found in deficient in available sulphur.

Singh *et al.* (2014) reported that the ranges of available N, P, K and S were 126 to 361, 7.0 to 29.5, 128 to 391 and 6.8 to 33.5 kg ha^{-1} in alluvial soil; 179 to 408, 7.9 to 28.8, 122 to 386 and 8.5 to 34.4 kg ha^{-1}in medium black soil and 125 to 301, 6.2 to

25.3, 252 to 406 and 11.5 to 38.8 kg ha^{-1} in ravinous land respectively in Chambal region of Madhya Pradesh. Of alluvial soil samples, 97% were low and 3% in medium in N; 14% low, 68% medium and 18% high in P; 1% low, 35% medium, and 64% high in K and 59 % low and 41% medium in Sulphur.

Rajput *et al*. (2015) observed that the Available -S ranged of 4.36 to 19.58 mg kg^{-1} under studied area with the mean value of 11.68 mg kg^{-1}. The soils of Bhind district contained relatively higher amount of available sulphur as compared to other district. About 25% samples were found deficient and 75% medium and none of samples under sufficient category of available sulphur.

2.3: Status of available micronutrient under different soils

Sharma and Singh. (2003) observed that the DTPA extractable Zn, Cu, Fe & Mn ranged from 0.1 to 1.7, 0.5 to 3.9, 1.0 to 6.6 and 2.7 to 7.2 mg kg^{-1}, respectively, in Nagaur district of Rajasthan.

Panwar and Totawat (2004) reported that DTPA extractable Zn, Cu, Fe & Mn ranged from 0.21 to 0.74, 0.27 to 1.04, 1.13 to 4.28 and 2.76 to 7.79 mg kg^{-1}, respectively.

Meena *et al*. (2006) reported that Zn, Fe, Cu and Mn varied from 0.19 to 1.93, 2.23 to 14.16, 0.21 to 1.87 and 6.85 to 45.25 mg $kg^{-1}$with mean value of 0.83, 5.38, 0.61 and 21.56 mg kg^{-1}, respectively.

Verma *et al.* (2007) reported that the DTPA extractable Zn, Cu, Fe and Mn varied from 0.12 to 1.38, 21 to 41, 2.31 to 4.10 and 1.26 to 11.4 mg kg^{-1}, respectively.

Rajeswar *et al*. (2009) reported that the content of DTPA-Zn varies from 0.13 to 2.79 mg kg^{-1}. The DTPA-Cu varied from 0.49 to 1.79 mg kg^{-1}. Available Fe in the soils varied from 0.40 to 40.2 mg $kg^{-1}$and available Mn varied from 2.6 to 19.7 mg $kg^{-1}$with a mean value of 0.50 mg kg^{-1}.

Somasundaram *et al.* (2009) observed that DTPA-Mn, Zn, Fe and Cu in surface soils varied from 6.98 – 23.85, 0.44 – 1.41, 2.14 – 11.59 and 0.23 – 2.88 mg kg^{-1}, respectively.

Kumar *et al*. (2011) observed that the content of Fe, Mn, Zn and Cu varied from 2.7 to 32.0, 4.0 to 35.0, 0.18 to 4.6 and 0.14 to 2.8 mg kg^{-1} with the mean values of 7.3, 11.4, 0.82 and 0.87 mg kg^{-1}, respectively in arid soils of Churu district of western Rajasthan.

Pachauri and Trivedi (2011) found that the Shivpuri soils contained adequate amounts of available Cu, Fe and Mn, however, deficiency of Zn was found in 54.4 % of the soils and 39.1 and 6.5% of the studied samples fell in marginal and sufficient categories, respectively.

Singh *et al.* (2014) recorded the extent of deficiency of micronutrients was 64.5, 11.7, 14.3, and 14.5 % in Zn, Fe, Mn and B, respectively, in alluvial soils of Chambal region of Madhya Pradesh.

Rajput *et al*. (2015) noticed that the DTPA- extractable Zn, Cu, Fe and Mn content varied from 0.18 to 2.56, 0.12 to 4.62, 1.25 to 18.65 and 0.36 to 16.65 mg kg^{-1} with the mean values of 0.69, 1.14, 5.55 and 4.36 mg kg^{-1}, respectively. The available Zn and Fe were deficient in 46.0 and 35.3 % while Cu and Mn both deficient in 6.66 % of the samples of studied area.

2.4: Relationship of available nutrients (N, P, K, S, Zn, Cu, Mn, Fe) with soil properties.

Jha *et al.* (1995) reported that available - S was significantly and positively correlated with O.C., clay and silt contents and negatively correlated with sand content.

Arora and Takkar (1988) analyzed twenty one soil samples from Inceptisol and Entisol of Ludhiana district for physico-chemical characteristics and different forms of S and found that the available -S was positively correlated with EC, OC and fine soil fraction.

Mongia and Bandyopadhyaya (1991) found that the available -K was significant and positively correlated with the organic carbon content.

Sadashiva et al. (1995) analysed the saline-alkali soils of Kabini command area, which showed a significantly positive correlation between the organic carbon content and DTPA-extractable Zn (r=0.559) , Fe (r= 0.457), Cu (r = 0.722) and Mn (r=0.708). Soil pH

was also significantly and positively correlated with the DTPA –extractable trace elements.

Arora and Chahal (2003) found that available K content was positively and significantly correlated with silt (r=0.34*), clay (r=0.42*) and CEC(r=0.42*) while negatively and significantly correlated with sand content (r=-0.44*).

Sharma *et al.* (2004) revealed that the DTPA-extractable micronutrients (Zn, Cu, Fe and Mn) increased with an increase in organic carbon content and decreased with increasing pH, sand and calcium carbonate content in inceptisols of Punjab. The available micronutrient contents depended largely on the organic carbon content.

Meena *et al.* (2006) reported that a significant and negative correlation was found with soil pH. Available Fe and Cu positively correlated with organic carbon.

Das *et al.* (2006) reported that organic carbon has significant and positive correlation (r = 0.253) with available sulphur of soil.

Sharma *et al.* (2006) reported that there was a significant positive correlation between available phosphorus and potassium (0.241 and 0.240, respectively) with pH.

Verma *et al.* (2007) revealed that the soil pH and sand had negative correlation with all the DTPA-extractable micronutrients but there was a significant negative effect of pH on the DTPA-Mn.

Chauhan (2008) reported that the application of sulphur with major nutrients through fertilizer did not influence the soil pH and electrical conductivity, organic carbon and available nitrogen in soil. However, its influenced the available phosphorus and potassium content of soil.

Sharma *et al*. (2009) found that the available K had positive and significant correlation with organic carbon (r=0.506**) and clay content (r=0.326**).

Yadav and Meena (2009) found that DTPA- extractable Zn, Cu, Fe and Mn increased significantly with an increase in clay, organic carbon, CEC, EC, whereas, the same decreased with increase in $CaCO_3$ and pH.

Somasundaram *et al*. (2009) noticed that the DTPA- Zn, Fe and Cu showed negative correlation with pH and EC of soils, whereas, DTPA-Mn exhibited positive correlation. DTPA-Mn, Zn, Fe and Cu showed positive correlation with organic carbon.

Kumar *et al.* (2011) observed a significant and positive correlation of DTPA extractable Zn, Cu, Fe and Mn with organic carbon content and negative with $CaCO_3$ and pH in arid soils of Churu district of western Rajasthan.

Singh and Mishra (2012) noticed the significant positive correlation to organic carbon and available N, P, K and S status of soil of Chaiaigoan block of Varanasi district of U.P.

Kumari and Kumari (2014) found that the available potassium showed significant correlation with organic carbon, and negative significant correlation with $CaCO_3$.

Kumar *et al*. (2014) observed a significant and positive correlation 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.

Rajput *et al*. (2015) noticed that the DTPA extractable Zn showed a highly significant and positive correlation (0.543**) with organic carbon and clay content of the soils. DTPA extractable Fe showed a highly significant and positive correlation with organic carbon and clay content and negatively with calcium carbonate of the soils. Significantly positive relationship between available Mn and organic carbon was found in all the soils under study.

Chapter – III

MATERIALS AND METHODS

The study entitled “Status of available major and micronutrients in Vertisols of Ashoknagar district of Madhya Pradesh” was carried out during 2015-16 in the department of Soil Science, College of Agriculture, Gwalior (M.P.). This chapter has dealt in the following heads.

1. **A general feature of the area under study in respect to**

   (a) Location and extent
   (b) Agro-ecological region
   (c) Physiography, relief and drainage
   (d) Area
   (e) Climate
   (f) Hydrology
   (g) Soils
   (h) Major crops.
2. **Collection and preparation of soil samples.**
3. **Analytical methods employed.**

General features of Ashoknagar district

(a) Location and extent :

Ashoknagar is located in the northern part of Madhya Pradesh, between the rivers Sindh and the Betwa. It comes under the northern part of Malwa plateau, though main part of its district lies in the Bundelkhand Plateau. The eastern and western boundaries of the district are well defined by the rivers. The Betwa flows along the eastern boundary separating it from Sagar District and Lalitpur District of Uttar Pradesh.

The Sindh is the main river flowing along the western boundary.

The Coordinates of the district are 24° 34′ 48″ N and 77° 43′ 48″E with average elevation of 507 metres (1640 ft) above sea level.

(b) Agro-ecological region

Agro-ecological region of investigated area is N8D2 (Seghal, 1996)

(c) Physiography, relief and drainage

On the basis of morphological observations, slope and other features, soils are well drained. It is in the plateau region and has an agricultural topography. The plateau is an extension of the Deccan Traps, formed between 60 and 68 million years ago at the end of the Cretaceous period.

(d) Area:

Ashoknagar district covered **3.12** million hectare area which is **8.04** per cent of the total area of Madhya Pradesh.

(e) Climate :

The climate of Ashoknagar is sub-tropical. In summers, the temperature reaches 47°C, while dropping to 4°C in the winter. Rainfall is adequate and sometimes less. In this region year is popularly divided into three seasons: summer, the rains, and winter. Summer extends over the months of Chaitra to Jyestha (mid-March to mid-May). The average daily temperature during the summer months is 35 °C, which typically rises to around 46 °C on a few days. The rainy season starts with the first showers of Aashaadha (mid-June) and extends to the middle of Ashvin (September). Most of the rain falls during the southwest monsoon spell, and ranges from about 100 cm in the west to about 165 cm in the east. Ashoknagar and surrounding areas receive an average of 140 cm of rainfall a year. The growing period lasts from 90 to 150 days, during which the average daily temperature is below 30 °C, but seldom falls below 20 °C. Winter is the longest of the three seasons, extending for about five months (mid-Ashvin to Phalgun, i.e., October to mid-March). The average daily temperature ranges from 15 °C to 20 °C, though on some nights it can fall as low as 5 °C.

(f) Hydrology :

The investigated area is irrigated by canal, wells and tube wells. The main source of irrigation of the area is canal. Apart from this, wells and tube wells are also used for irrigation.

(g) Soils :

Soils of the investigated area are generally variable in colour, depending on the timing period and sources of irrigation system. In this region, the main classes of soil are black, brown and bhatori (stony) soil. The volcanic, clay-like soil of the region owes its black colour to the high iron content of the basalt from which it is formed. The soil requires less irrigation because of its high capacity for moisture retention. The other two soil types are lighter and have a higher proportion of sand.

(h) Major crops :

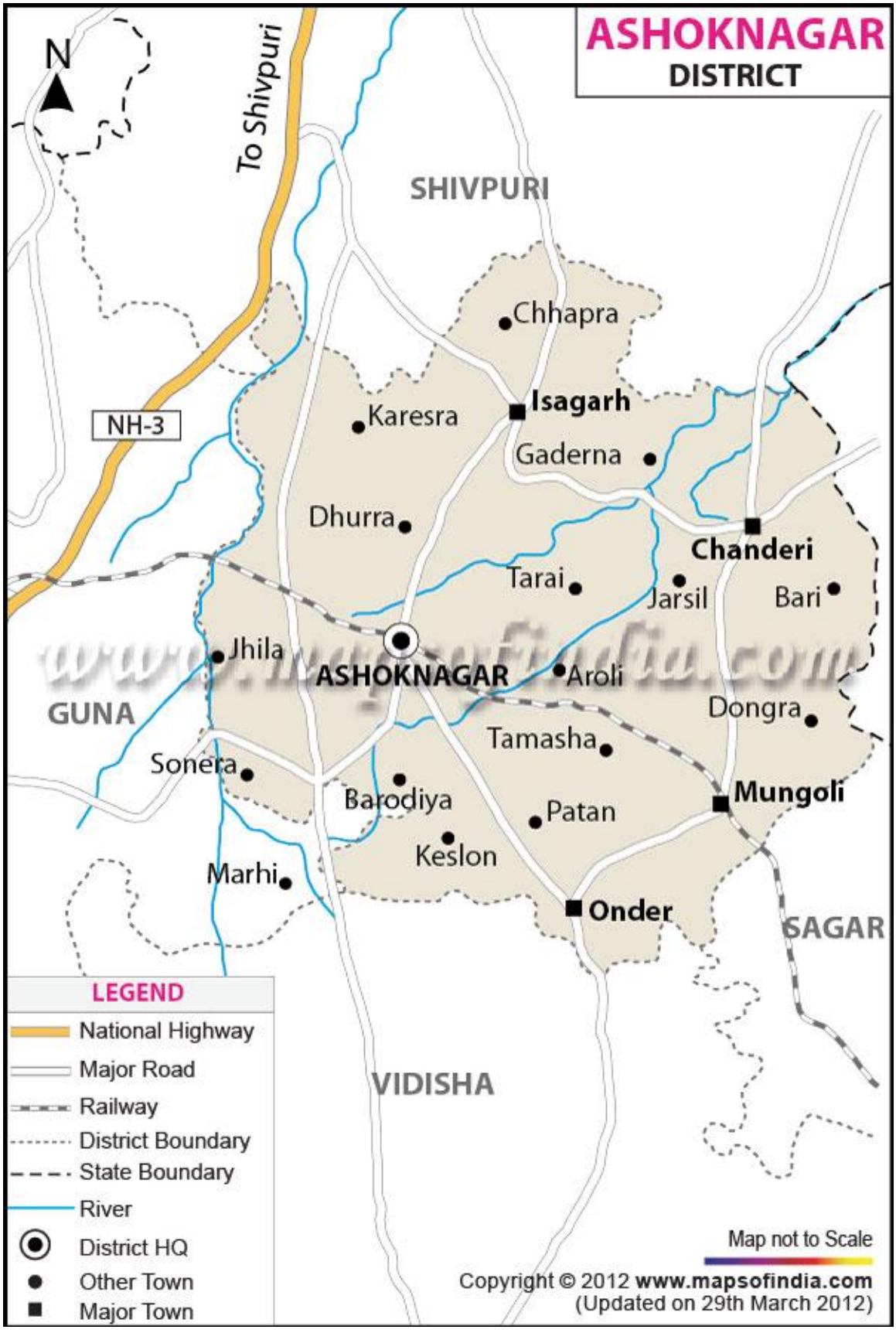
The major crops of the investigated area are Soybean, Blackgram, Greengram, Jowar, and Pearl millet in *Kharif* and Mustard, Gram and Wheat in *Rabi.*

2. Collection and preparation of soil samples

For the present study, 125 surface (0-15 cm) soil samples (GPS basis, detail given in appendix) collected from cultivators fields of five blocks (namely; Mungaoli, Chanderi, Ishagarh, Ashoknagar and Sadora) of Ashoknagar district. The representative soil samples were collected with the help of soil auger. The soil samples were put in the polythene bags properly, labeled and carried to the laboratory. After collection, the samples were brought to Soil Science laboratory, College of Agriculture, Gwalior and samples were air dried, crushed and sieved through 2 mm plastic sieve. Details of soil samples of different blocks are given in table 3.1 and general information of individual sample are given in appendix 1-5.

Table 3.1: Details of soil samples collected from various villages of different blocks of Ashoknagar district

S. No.	Block	Village name	No. of samples	Total samples
1	Mungaoli	Aathaikheda	05	25
		Bilakhedi	05	
		Mudrakhana	05	
		Chamrai	05	
		Shyampur	05	
2	Chanderi	Barodiya	05	25
		Sangampur	05	
		Tarai	05	
		Mohalichak	05	
		Salona	05	
3	Isagarh	Korwas	05	25
		Kotharkhedi	05	
		Vijaypura	05	
		Pachlana	05	
		Bamnawar	05	
4	Ashoknagar	Mau	05	25
		Banyga	05	
		Diyadhari	05	
		Ratikheda	05	
		Ashoknagar	05	
5	Sadora	Kherai	05	25
		Bamuria	05	
		Parwai	05	
		Gugor	05	
		Bagulya	05	
Grand total		25	125	125


ASHOKNAGAR
DISTRICT
N
To Shivpuri
SHIVPURI
Chhapra
Isagarh
Karesra
NH-3
Gaderna
Dhurra
Chanderi
Tarai
Jarsil
Bari
Jhila
ASHOKNAGAR
Aroli
GUNA
Dongra
Tamasha
Sonera
Barodiya
Patan
Mungoli
Keslon
Marhi
Onder
SAGAR
VIDISHA
LEGEND
National Highway
Major Road
Railway
District Boundary
State Boundary
River
District HQ
Other Town
Major Town
Map not to Scale
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(Updated on 29th March 2012)

3. Analytical methods employed in the soil analysis:

(A) Chemical analysis

3.1. pH

The soil pH was determined by glass electrodes in 1:2 soil water suspensions (Piper 1967).

3.2. Electrical conductivity (EC)

It is an important soil property which indicates the total soluble salt of the soil. Electrical conductivity is commonly used for indicating the salt concentration of the ionized constituents of the solution. Conductivity increases with the total dissolved salts and provides a useful scale for availability of different nutrients in the soil. The soil water suspension used for pH determination was allowed to settle down and conductivity of the supernatant liquid was determined by solubridge conductivity meter.

3.3. Organic carbon

Organic carbon was estimated by the Walkley-Black (1934) Method. In this method organic matter in the soil is oxidized with a mixture of potassium dichromate ($K_2Cr_2O_7$) and concentrated H_2SO_4 utilizing the heat of dilution of H_2SO_4. Unused $K_2Cr_2O_7$ is back titrated with ferrous ammonium sulphate.

3.4. Determination of available nutrients

3.4.1: Available Nitrogen :

Available nitrogen was determined by the alkaline permanganate method (Subbiah and Asija, 1956).

In this method, 5 g of soil was taken in a digestion tube with little water. Now add 20 ml. of 0.32% $KMnO_4$ solution to the sample and fit the tube in the distillation unit. Add 20 ml of 2.5% NaOH solution through the distyl-em-dosing pump. Pipette out 20 ml. of 2.5% of boric acid in a conical flask and clip the receiving end of the distyl-em in it. Distilled ammonia gas from the tube was collected in the boric acid and it was titrated with 0.02N H_2SO_4 after adding five drops of mixed indicator. Blank correction (without soil) is to be made for final calculations.

3.4.2: Available phosphorus :

Available phosphorus in the soil was determined colorimetrically by Olsen's method (Olsen *et al.* 1954).

Extraction:

2.5 g of the soil sample was shaken with 50 ml of 0.5M $NaHCO_3$ (adjusted to pH 8.5) as an extractant together with 1g of darco G-60 (Free from soluble phosphorus) for 30 minutes in 100 ml, conical flask on mechanical shaker and then filtered through filter paper.

Development of colour :

5 ml of the colourless filtrate was taken in 25 ml volumetric flask for determination and then 4 ml of regent B (ammonium molybdate + Ascorbic acid) solution was added. The contents were diluted to the mark, and shaken thoroughly. The colour intensity was measured in photo-electric colorimeter at 660 nm wavelength. The amount of available phosphorus was calculated as P with the help on standard curve and the results were expressed in kg ha^{-1}.

3.4.3: Available potassium :

Five gram of soil was shaken with 25ml of neutral normal ammonium acetate solution as an extractant in 100 ml conical flask for 5 minutes and then filtered through filter paper. The potassium content in the extracts was estimated by flame photometer (Jackson, 1973).

3.4.4: Available sulphur

Available sulphur in soil was determined by turbidimetric method after extracting the soil with 0.15% $CaCl_2$ solution as described by (Chesnin and Yien, 1951).

3.4.5: Available micronutrient cations (Zn, Fe, Mn and Cu) :

Available Zn, Fe, Mn and Cu were determined by Atomic Absorption Spectrophotometer using 0.005M DTPA (Diethylene Triamine Penta Acetic Acid) as an extractant proposed by Lindsay and Norvell (1978).

This method consisted of shaking a few grams of soil with a buffered solution, containing DTPA (Diethylene Triamine Penta Acetic Acid). This chemical acts as a mild chelating agent, which extracts the easily soluble zinc, iron, copper and manganese. The extracting solution is buffered at pH 7.3 by Triethnolamine (TEA), and in addition, includes calcium chloride to prevent the dissolution of calcium carbonate. These conditions permit the right amount of zinc, iron, copper and manganese to be dissolved and $CaCl_2$ is to stabilize the pH of the extractant.

The dissolved elements in the extract are, then measured by the atomic absorption spectrophotometer, where in, the extracted sample is converted first into an atomic vapour, usually by a flame and irradiated by the metal being sought, the absorption of the light by the vaporized samples is related to the concentration of the derived metal in it.

DTPA extracting solution

0.005 M DTPA ($C_{14}H_{23}N_3O_{10}$)
0.01 M Calcium chloride ($CaCl_2.2H_2O$)
0.1 M Triethanol amine ($C_5H_{15}NO_3$)

In order to prepare 0.005 M DTPA solution, 74.6 gram of TEA, 9.84 g of DTPA and 7.35 g of Calcium chloride were taken in approximately 200 ml distilled (double distilled) water and allowed sufficient time for DTPA to dissolve. The solution was diluted to about 4.5 litres. The pH of the solution was adjusted to 7.3 using 1 N Hydrochloric acid. The volume was then made upto 5 liters.

Procedure :

Weighed 10 gram soil into a 100 ml polyethylene flask and added 20 ml DTPA solution, shacked for 2 hours in mechanical shaker. The suspension was filtered through a Whatman No. 42 filter paper into a suitable plastic bottle and Zn, Fe, Mn and Cu were determined by Atomic Absorption Spectrophotometer.

DTPA extraction for micronutrient observations:

Weight of soil taken = 10 gm.
Volume of DTPA extract made = 20 ml.
Digital reading or reading on the galvanometer = T
Concentration (ppm) of heavy metal as read from
the standard curve against T for sample = C.
Concentration of heavy metal in the blank solution = cb

Calculation

Dilution factor = 20/10

Now available heavy metal in the soil (ppm) = (C- cb) x 2

Table 3.2 : Limits of different nutrients for classification.

Constituents	Limits for different categories		
	Low	**Medium**	**High**
1.Av. N (kg ha^{-1})	< 250	250 – 400	> 400
2. Av. P (kg ha^{-1})	< 10	10 – 20.0	> 20.0
3. Av. K (kg ha^{-1})	< 250	250 – 400	> 400
4. Av. S (mg kg^{-1})	< 10	10 – 20	> 20
5. Organic carbon (%)	< 0.5	0.5 – 0.75	> 0.75
	Normal	**Toward critical**	**Above critical**
6. pH	6.5 ≤ 7.5	7.5 – 8.5	> 8.5
7. E.C. (dSm^{-1})	< 0.5	0.5 – 1.0	> 1.0
Av. Micronutrient	**Critical limits ($mgkg^{-1}$)**		
	Deficient	**Sufficient**	
8. Zn	< 0.6	> 0.6	
9. Fe	< 4.5	> 4.5	
10. Cu	< 0.2	> 0.2	
11. Mn	< 1.0	> 1.0	

4: Nutrient Index :

Nutrient index was calculated by the formula given by Biswas and Mukherjee, (1989).

$$\frac{NL+2NM+3NH}{NL+NM+NH}$$

Where,

NL = Number of sample in low categories.

NM = Number of samples in medium categories.

NH = Number of samples in high categories.

The nutrient index classes were categorized into low, medium and high class by comprising the calculated value of nutrient index (NI) with the recommended levels as per the following standard classes :

Low < 1.5, medium 1.5 - 2.5 , High > 2.5

5. **Statistical analysis**

The data obtained were subjected to statistical analysis for Coefficient of correlation. (Panse and Sukhatme, 1954).

$$r = \frac{\sum xy}{\sqrt{\left(\sum x^2\right)\left(\sum y^2\right)}}$$

where,

r = Coefficient of correlation

$x = X - \bar{X}$

$y = Y - \bar{Y}$

Chapter-IV
RESULTS

In the present study, one hundred twenty five GPS based soil samples (0-15 cm.) were collected from cultivator's fields of five blocks (namely; Mungoli, Chanderi, Isagarh, Ashoknagar, and Sadora) of Ashoknagar district of Madhya Pradesh and analyzed for different available nutrients (N, P, K, S, Zn, Cu, Fe, & Mn) and for physical as well as chemical characteristics. Results of the present study are described under the following heads.

4.1: Mechanical composition of the soils

4.2: Physical and chemical characteristics of soils.

4.3: Status of available N, P, K & S in soils of different blocks.

4.4: Status of available micronutrient cations (Zn, Cu, Fe & Mn) in soils of different blocks

4.5: Correlation between soil properties and available nutrients.

4.6: Workout the nutrient index (N, P, K & S) of Ashoknagar district.

4.1: Mechanical composition of the soils

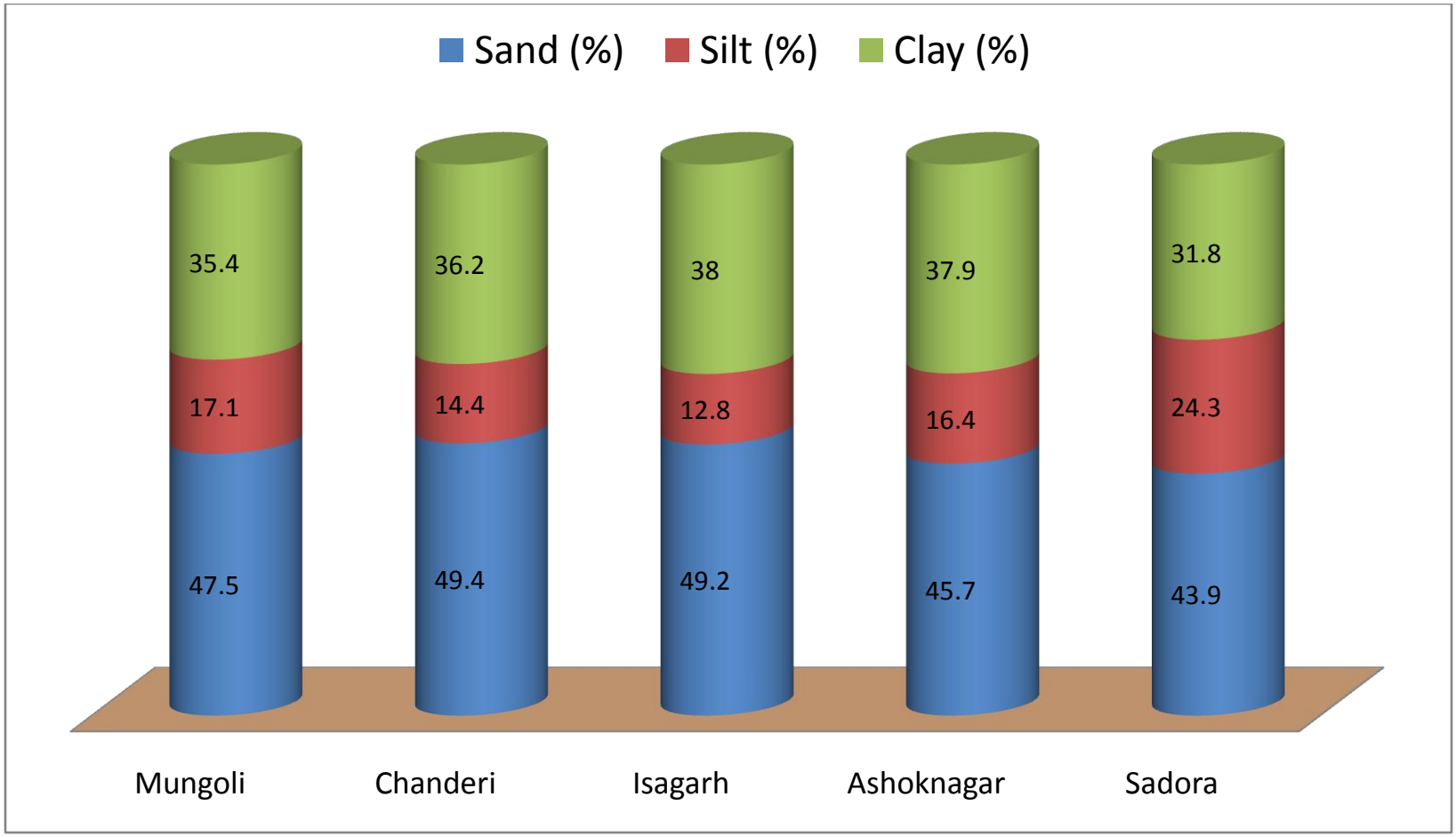
Mechanical composition (sand, silt and clay) of soils of different blocks of Ashoknagar district are presented in (Table-4.1).

Under studied area sand, silt and clay per cent varied from 36.6 – 56.7, 3.9 – 38.0 and 25.4 – 42.4 percent with the mean value of 47.1, 17.0 and 35.9 percent, respectively (Table 4.1). Under different blocks, maximum average content of sand (49.4%), silt (24.3%) and clay (38.0%) were recorded in Chanderi, Sadora and Isagarh block, respectively.

Table 4.1: Mechanical composition of soils in different blocks of Ashoknagar district

S. No.	Block	Sand (%)		Silt (%)		Clay (%)	
		Range	Mean	Range	Mean	Range	Mean
1	**Mungaoli (25)**	44.0 – 51.8	47.5	12.2 – 23.8	17.1	31.2 – 39.1	35.4
2	**Chanderi (25)**	39.7 – 55.6	49.4	05.8 – 32.7	14.4	27.6 – 41.6	36.2
3	**Isagarh (25)**	39.6 – 56.7	49.2	03.9 – 19.2	12.8	34.0 – 41.5	38.0
4	**Ashoknagar (25)**	38.3 – 54.4	45.7	07.8 – 24.6	16.4	30.9 – 42.4	37.9
5	**Sadora (25)**	36.6 – 51.8	43.9	13.1 – 38.0	24.3	25.4 – 42.3	31.8
Whole district		**36.6 – 56.7**	**47.1**	**03.9 – 38.0**	**17.0**	**25.4 – 42.4**	**35.9**

Fig. 4.1: Mechanical composition of soils in different blocks of Ashoknagar district



4.2: Physical and chemical characteristics of soils:

4.2.1: Soil pH:

Soil pH of studied area was found in the range of 7.2 - 8.6 under different villages with the average value of 8.0 (Table 4.2). However, pH value in different villages of Mungaoli, Chanderi, Isagarh, Ashoknagar, and Sadora block varied from 7.2 – 8.6, 7.2 – 8.6, 7.5 – 8.4, 7.6 – 8.5, and 7.3 – 8.4 with an average value of 8.0, 8.0, 8.0, 8.1 and 7.9 respectively. Maximum average value of soil pH (8.1) was observed in Ashoknagar block whereas minimum value (7.9) noted in Sadora block of Ashoknagar district. Higher pH (>8.5) in some of the samples of Ashoknagar district indicate towards the fact that the soils are infested with alkalinity.

4.2.2: Electrical conductivity (dSm^{-1}):

Value of electrical conductivity in Ashoknagar district varied from 0.32 - 0.62 with the average value of 0.45 dSm^{-1} (Table 4.3). However, EC value in different villages of Mungaoli, Chanderi, Isagarh, Ashoknagar, and Sadora block varied from 0.32 - 0.61, 0.37–0.56, 0.38–0.62, 0.38– 0.61 and 0.38 – 0.59 dSm^{-1}, with an average value of 0.44, 0.45, 0.45, 0.44, and 0.45 dSm^{-1} respectively.

Highest value of electrical conductivity (0.62 dSm^{-1}) was observed in Korwas village of Isagarh block whereas minimum value (0.32 dSm^{-1}) was found in Shyampur village of Mungaoli block of Ashoknagar district.

Table 4.2: Soil pH in various villages of different blocks of Ashoknagar district

S. No.	Block	Village name	Range	Mean
1	Mungaoli (25)	Aathaikheda	7.9 – 8.3	8.1
		Bilakhedi	8.0 – 8.6	8.2
		Mudrakhana	7.6 – 8.1	8.0
		Chamrai	7.9 – 8.2	8.0
		Shyampur	7.2 – 8.4	7.8
			7.2 - 8.6	8.0
2	Chanderi (25)	Barodiya	7.2 – 8.6	7.8
		Sangampur	7.8 - 8.6	8.2
		Tarai	7.9 – 8.3	8.1
		Mohalichak	7.6 – 8.4	8.0
		Salona	7.2 - 8.4	7.9
			7.2 – 8.6	8.0
3	Isagarh (25)	Korwas	7.8 – 8.4	8.1
		Kotharkhedi	7.9 – 8.3	8.1
		Vijaypura	8.0 – 8.4	8.1
		Pachlana	7.5 – 8.2	7.9
		Bamnawar	7.6 – 7.9	7.8
			7.5 – 8.4	8.0
4	Ashoknagar (25)	Mau	8.0 – 8.3	8.1
		Banyga	8.0 - 8.2	8.1
		Diyadhari	8.0 – 8.4	8.1
		Ratikheda	7.6 – 8.5	8.0
		Ashoknagar	7.8 – 8.4	8.1
			7.6 – 8.5	8.1
5	Sadora (25)	Kherai	7.7 – 8.4	8.0
		Bamuria	7.3 – 8.1	7.8
		Parwai	7.6 – 8.3	8.0
		Gugor	7.4 – 8.2	7.9
		Bagulya	7.6 – 8.3	7.9
			7.3 – 8.4	7.9
Whole district			7.2 – 8.6	8.0

Table 4.3: Status of electrical conductivity (dSm^{-1}) in soils of different blocks of Ashoknagar district

S. No.	Block	Village name	Range	Mean
1	Mungaoli (25)	Aathaikheda	0.39 – 0.51	0.47
		Bilakhedi	0.37 – 0.51	0.44
		Mudrakhana	0.38 – 0.48	0.41
		Chamrai	0.39 - 0.61	0.49
		Shyampur	0.32 – 0.50	0.41
			0.32 – 0.61	0.44
2	Chanderi (25)	Barodiya	0.37 – 0.43	0.41
		Sangampur	0.39 – 0.53	0.46
		Tarai	0.41 – 0.53	0.45
		Mohalichak	0.38 – 0.56	0.46
		Salona	0.38 - 0.50	0.44
			0.37 – 0.56	0.45
3	Isagarh (25)	Korwas	0.41 – 0.62	0.46
		Kotharkhedi	0.39 – 0.49	0.43
		Vijaypura	0.39 – 0.52	0.45
		Pachlana	0.38 – 0.47	0.43
		Bamnawar	0.43 – 0.61	0.50
			0.38 – 0.62	0.45
4	Ashoknagar (25)	Mau	0.42 – 0.46	0.44
		Banyga	0.38 – 0.51	0.45
		Diyadhari	0.38 – 0.45	0.41
		Ratikheda	0.39 – 0.53	0.45
		Ashoknagar	0.39 – 0.61	0.45
			0.38 – 0.61	0.44
5	Sadora (25)	Kherai	0.42 – 0.59	0.47
		Bamuria	0.38 – 0.52	0.44
		Parwai	0.39 – 0.47	0.43
		Gugor	0.41 – 0.46	0.44
		Bagulya	0.43 – 0.52	0.46
			0.38 – 0.59	0.45
Whole district			0.32 – 0.62	0.45

4.2.3: Organic Carbon :

Status of organic carbon under studied area was in the range of 2.14 - 7.15 g kg^{-1} under different villages with the average value of 4.42 g kg^{-1} (Table 4.4). However, organic carbon status in different villages of Mungaoli, Chanderi, Isagarh, Ashoknagar, and Sadora block varied from 2.25 – 5.47, 2.14 – 7.15, 2.88 – 6.15, 2.25 – 5.88 and 2.85 – 7.06 g kg^{-1}, with an average value of 3.94, 4.57, 4.74, 4.50 and 4.32 g kg^{-1} , respectively.

Maximum average organic carbon content (4.74 g kg^{-1}) was obtained in Isagarh whereas minimum value (3.94 g kg^{-1}) in Mungoli block of Ashoknagar district.

4.2.4: Calcium carbonate :

Calcium carbonate of studied area of Ashoknagar district was found in the range of 0.5 – 3.5 % under different villages with an average value of 1.8% (Table 4.5). However, calcium carbonate status in different villages of Mungaoli, Chanderi, Isagarh, Ashoknagar, and Sadora block varied from 0.5 – 3.0, 0.5 – 3.5, 0.5 – 2.5, 0.5 – 3.0 and 0.5 – 2.5 %, with a mean value of 1.7, 1.8, 1.8, 1.9 and 1.7 % respectively.

Highest content of calcium carbonate (3.5%) was noted in Barodiya village of Chanderi block of Ashoknagar district.

Table 4.4: Status of organic carbon (g kg^{-1}) in soils of different blocks of Ashoknagar district

S. No.	Block	Village name	Range	Mean
1	Mungaoli (25)	Aathaikheda	3.48 – 5.20	4.20
		Bilakhedi	2.55 – 4.16	3.15
		Mudrakhana	2.70 – 5.28	3.86
		Chamrai	2.82 – 5.25	3.90
		Shyampur	3.85 – 5.47	4.59
			2.55 – .547	3.94
2	Chanderi (25)	Barodiya	4.25 – 7.15	5.80
		Sangampur	2.25 – 5.25	3.47
		Tarai	3.96 – 5.88	4.85
		Mohalichak	2.14 – 5.24	4.01
		Salona	3.58 – 6.22	4.74
			2.14 – 7.15	4.57
3	Isagarh (25)	Korwas	4.72 – 5.35	5.09
		Kotharkhedi	2.88 – 5.85	4.60
		Vijaypura	3.15 – 6.15	4.73
		Pachlana	3.15 – 5.85	4.73
		Bamnawar	3.88 – 4.88	4.56
			2.88 – 6.15	4.74
4	Ashoknagar (25)	Mau	2.25 – 4.88	3.51
		Banyga	3.96 – 5.88	5.12
		Diyadhari	2.58 – 5.25	3.97
		Ratikheda	4.82 – 5.88	5.37
		Ashoknagar	3.88 – 5.25	4.56
			2.25 – 5.88	4.50
5	Sadora (25)	Kherai	2.85 – 5.25	3.80
		Bamuria	3.15 – 6.06	4.36
		Parwai	3.25 – 4.88	3.87
		Gugor	2.86 – 7.06	5.15
		Bagulya	3.15 – 5.55	4.42
			2.85 – 7.06	4.32
Whole district			2.14 – 7.15	4.42

Fig. 4.2: Organic carbon content (g kg^{-1}) in soils of different blocks of Ashoknagar district

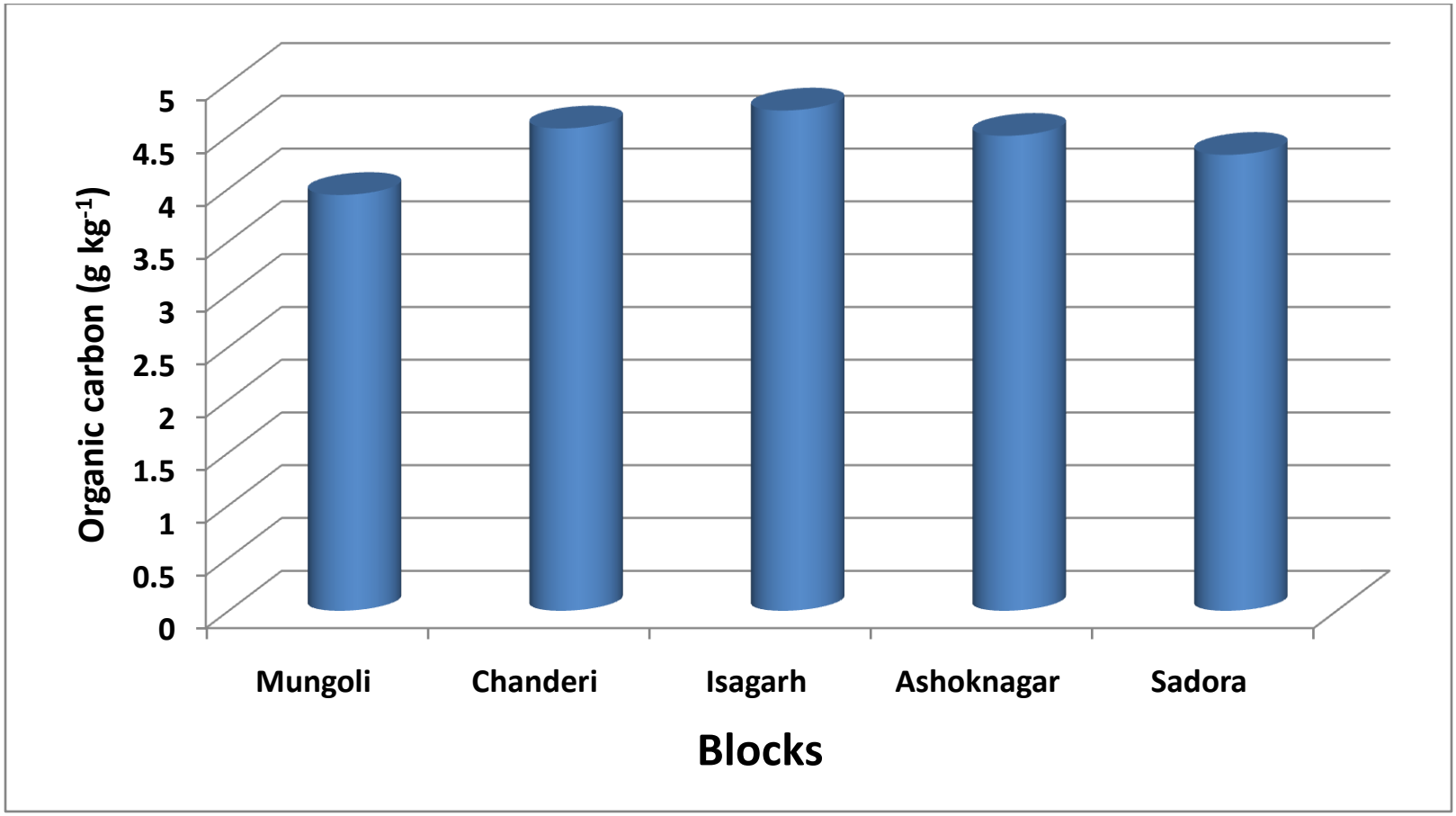


Table 4.5: Status of $CaCO_3$ (%) in soils of different blocks of Ashoknagar district

S. No.	Block	Village name	Range	Mean
1	Mungaoli (25)	Aathaikheda	1.5 – 2.5	2.1
		Bilakhedi	1.5 – 3.0	2.2
		Mudrakhana	1.0 – 2.5	1.6
		Chamrai	0.5 – 1.5	1.2
		Shyampur	1.0 – 2.5	1.6
			0.5 – 3.0	1.7
2	Chanderi (25)	Barodiya	0.5 – 3.5	1.7
		Sangampur	1.5 – 2.5	1.8
		Tarai	1.5 - 2.5	1.9
		Mohalichak	1.0 – 2.5	1.9
		Salona	0.5 - 2.5	1.8
			0.5 – 3.5	1.8
3	Isagarh (25)	Korwas	1.5 – 2.5	1.8
		Kotharkhedi	1.0 – 2.5	1.7
		Vijaypura	1.5 – 2.5	2.0
		Pachlana	0.5 – 2.5	1.6
		Bamnawar	1.5 – 2.0	1.7
			0.5 – 2.5	1.8
4	Ashoknagar (25)	Mau	2.0 – 2.5	2.3
		Banyga	1.5 – 2.0	1.8
		Diyadhari	1.5 – 3.0	2.1
		Ratikheda	0.5 – 2.5	1.5
		Ashoknagar	1.0 – 2.5	1.7
			0.5 – 3.0	1.9
5	Sadora (25)	Kherai	1.5 – 2.5	1.9
		Bamuria	0.5 – 2.5	1.7
		Parwai	1.5 – 2.5	2.0
		Gugor	1.0 – 2.0	1.5
		Bagulya	1.0 – 2.5	1.5
			0.5 – 2.5	1.7
Whole district			0.5 – 3.5	1.8

4.3: STATUS OF AVAILABLE N, P, K & S IN SOILS OF DIFFERENT BLOCKS

4.3.1: Available –Nitrogen (kg ha^{-1})

Status of available nitrogen under investigated area is presented in table 4.6. It is observed in the range of 158.2 – 326.4 kg ha^{-1} under different villages of Ashoknagar district with the average value of 220.6 kg ha^{-1}. Whereas, status in different villages of Mungaoli, Chanderi, Isagarh, Ashoknagar, and Sadora block varied from 165.2 – 288.4, 164.2 –326.4, 158.2 – 324.4, 176.2 – 296.2, and 164.8 – 288.6 kg ha^{-1} with an average value of 220.2, 225.0, 219.5, 227.9 and 210.2 kg ha^{-1} respectively.

Maximum average value of available nitrogen (227.9 kg ha^{-1}) was observed in Ashoknagar block, whereas minimum value (210.2 kg ha^{-1}) in Sadora block of Ashoknagar district. Average values indicate that soils are deficient in available –N as most of the samples are sowing less than 250 kg ha^{-1} value.

4.3.2: Available – Phosphorus (kg ha^{-1})

Status of available –P under studied area of Ashoknagar district is presented in table 4.7. In these blocks, it ranged from 5.29 – 31.80 kg ha^{-1} under different villages of district with an average value of 12.17 kg ha^{-1}. Whereas, status in different villages of Mungaoli, Chanderi, Isagarh, Ashoknagar, and Sadora block varied from 5.42 – 21.65, 5.29 – 31.80, 7.35 – 25.87, 8.02 – 21.50 and 6.86 – 28.56 kg ha^{-1} with an average content of 12.60, 12.31, 11.65, 11.75, and 12.51 kg ha^{-1} respectively.

Highest mean value of available phosphorus (12.60 kg ha^{-1}) was observed in Mungaoli block, whereas minimum value (11.75 kg ha^{-1}) in Ashoknagar block of the district.

Table 4.6: Status of available nitrogen (kg ha^{-1}) in soils of different blocks of Ashoknagar district

S. No.	Block	Village name	Range	Mean
1	Mungaoli (25)	Aathaikheda	172.6 – 288.4	209.2
		Bilakhedi	188.6 – 256.3	227.6
		Mudrakhana	165.2 – 286.2	215.7
		Chamrai	184.2 – 255.2	214.8
		Shyampur	187.2 – 278.5	233.7
			165.2 – 288.4	220.2
2	Chanderi (25)	Barodiya	202.4 – 326.4	260.6
		Sangampur	164.2 – 234.1	197.0
		Tarai	196. 2 – 255.2	224.1
		Mohalichak	165.2 – 241.2	201.3
		Salona	214.2 – 312.5	242.1
			164.2 – 326.4	225.0
3	Isagarh (25)	Korwas	196.2 – 266.2	229.4
		Kotharkhedi	162.5 – 324.5	221.9
		Vijaypura	192.3 – 302.3	229.5
		Pachlana	164.8 – 274.2	215.7
		Bamnawar	158.2 – 235.2	201.2
			158.2 – 324.5	219.5
4	Ashoknagar (25)	Mau	188.4 – 296.2	227.7
		Banyga	196.2 – 274.2	241.4
		Diyadhari	176.2 – 245.2	205.1
		Ratikheda	222.5 – 265.2	238.7
		Ashoknagar	196.2 – 265.2	226.7
			176.2 – 296.2	227.9
5	Sadora (25)	Kherai	182.0 – 254.2	206.6
		Bamuria	164.8 – 224.2	198.0
		Parwai	176.4 – 231.2	204.5
		Gugor	172.2 – 288.6	223.5
		Bagulya	188.4 – 235.2	218.5
			164.8 – 288.6	210.2
Whole district			158.2 – 326.4	220.6

Table 4.7: Status of available phosphorus (kg ha^{-1}) in soils of different blocks of Ashoknagar district

S. No.	Block	Village name	Range	Mean
1	Mungaoli (25)	Aathaikheda	10.61 – 21.03	16.09
		Bilakhedi	5.78 – 17.84	10.70
		Mudrakhana	6.90 – 21.65	14.96
		Chamrai	5.42 – 20.25	11.02
		Shyampur	6.86 – 13.52	10.24
			5.42 – 21.65	12.60
2	Chanderi (25)	Barodiya	7.52 – 31.80	18.12
		Sangampur	5.29 – 10.47	7.66
		Tarai	6.85 – 15.51	11.08
		Mohalichak	6.22 – 19.61	12.21
		Salona	6.72 – 18.38	12.49
			5.29 – 31.80	12.31
3	Isagarh (25)	Korwas	8.01 – 16.13	12.01
		Kotharkhedi	7.87 – 14.58	10.61
		Vijaypura	7.35 – 11.74	9.66
		Pachlana	9.29 – 25.87	13.89
		Bamnawar	9.30 – 16.80	12.08
			7.35 – 25.87	11.65
4	Ashoknagar (25)	Mau	9.21 – 11.88	10.10
		Banyga	9.22 – 18.65	13.88
		Diyadhari	9.39 – 21.50	12.49
		Ratikheda	9.20 - 17.69	11.86
		Ashoknagar	8.02 – 13.58	10.42
			8.02 – 21.50	11.75
5	Sadora (25)	Kherai	6.86 – 11.93	9.64
		Bamuria	9.57 – 20.55	13.48
		Parwai	8.66 – 17.44	11.33
		Gugor	11.82 – 28.56	16.75
		Bagulya	9.40 – 14.00	11.35
			6.86 – 28.56	12.51
Whole district			5.29 – 31.80	12.17

4.3.3: Available –Potassium (kg ha^{-1})

Status of available potassium under studied village of Ashoknagar is presented in table 4.8 and was in the range of 200.5 – 575.2 kg ha^{-1} under different villages of district with an average value of 385.6 kg ha^{-1}. Whereas, status of available -K in different villages of Mungaoli, Chanderi, Isagarh, Ashoknagar, and Sadora block varied from 200.5 – 493.9, 218.6 – 506.2, 303.5 – 509.6, 248.5 - 488.5 and 256.4 – 575.2 kg ha^{-1} with an average value of 361.5, 372.0, 402.0, 388.9 and 403.6 kg ha^{-1} respectively.

Maximum average value of available potassium (403.6 kg ha^{-1}) was recorded in Sadora block, whereas minimum (361.5 kg ha^{-1}) in Mungoli block. Minimum available-K found in Mungoli (200.5 kg ha^{-1}), Chenderi (218.6), and Ashoknagar (248.5) indicate that soils are suffering from the deficiency of potassium which may be deter mental for future sustainability of production.

4.3.4: Available – Sulphur (kg ha^{-1})

Status of available sulphur in different villages is presented in table 4.9. Available sulphur ranged from 3.95 – 40.25 mg kg^{-1} under different villages of Ashoknagar district with an average value of 14.91 mg kg^{-1}. Whereas, status of available sulphur in different villages of Mungaoli, Chanderi, Isagarh, Ashoknagar, and Sadora block varied from 4.36 – 22.56, 6.95 – 24.51, 3.95 – 27.44, 5.27 – 40.25 and 4.62 – 26.55 mg kg^{-1} with an average value of 13.52, 14.47, 14.82, 17.08 and 13.72 mg kg^{-1} respectively.

Highest average value of available sulphur (17.08 mg kg^{-1}) was observed in Ashoknagar block, whereas lowest value (13.52 mg kg^{-1}) in Mungaoli block of Ashoknagar district.

Table 4.8: Status of available potassium (kg ha^{-1}) in soils of different blocks of Ashoknagar district

S. No.	Block	Village name	Range	Mean
1	Mungaoli (25)	Aathaikheda	275.5 – 420.0	343.2
		Bilakhedi	200.5 – 493.9	306.0
		Mudrakhana	303.5 – 480.5	373.6
		Chamrai	255.2 – 483.8	403.4
		Shyampur	312.4 – 455.6	381.1
			200.5 – 493.9	361.5
2	Chanderi (25)	Barodiya	284.5 – 416.6	363.5
		Sangampur	255.6 – 474.9	353.7
		Tarai	320.3 – 416.6	373.2
		Mohalichak	218.6 – 506.2	422.7
		Salona	319.2 – 378.6	346.8
			218.6 – 506.2	372.0
3	Isagarh (25)	Korwas	367.4 – 487.2	422.9
		Kotharkhedi	333.8 – 446.9	395.6
		Vijaypura	312.5 – 509.6	417.8
		Pachlana	303.5 – 437.9	355.5
		Bamnawar	340.5 – 495.0	418.4
			303.5 – 509.6	402.0
4	Ashoknagar (25)	Mau	248.5 – 427.8	328.3
		Banyga	341.6 – 426.7	385.1
		Diyadhari	317.0 - 474.9	380.4
		Ratikheda	370.7 - 488.5	435.7
		Ashoknagar	325.9 – 483.8	415.1
			248.5 – 488.5	388.9
5	Sadora (25)	Kherai	316.5 – 471.5	379.1
		Bamuria	337.1 – 575.2	427.1
		Parwai	302.5 – 406.8	351.8
		Gugor	256.4 – 525.5	397.2
		Bagulya	429.0 – 506.2	463.0
			256.4 – 575.2	403.6
Whole district			200.5 – 575.2	385.6

Table 4.9: Status of available sulphur (mg kg^{-1}) in soils of different blocks of Ashoknagar district

S. No.	Block	Village name	Range	Mean
1	Mungaoli (25)	Aathaikheda	12.13 – 21.11	15.87
		Bilakhedi	4.36 – 17.25	11.22
		Mudrakhana	7.56 – 20.87	13.72
		Chamrai	12.14 – 22.56	18.63
		Shyampur	5.67 – 10.56	8.17
			4.36 – 22.56	13.52
2	Chanderi (25)	Barodiya	7.55 – 23.49	17.03
		Sangampur	6.95 – 24.51	12.14
		Tarai	7.65 – 16.76	12.92
		Mohalichak	7.91 – 17.55	12.62
		Salona	15.22 – 19.73	17.65
			6.95 – 24.51	14.47
3	Isagarh (25)	Korwas	7.98 – 17.18	14.15
		Kotharkhedi	9.67 – 16.84	13.77
		Vijaypura	9.13 – 21.67	16.28
		Pachlana	7.36 – 22.09	14.26
		Bamnawar	3.95 – 27.44	15.62
			3.95 – 27.44	14.82
4	Ashoknagar (25)	Mau	6.54 – 20.82	14.64
		Banyga	14.42 – 26.44	18.68
		Diyadhari	7.78 – 21.33	16.47
		Ratikheda	5.27 – 24.98	15.18
		Ashoknagar	8.88 – 40.25	20.43
			5.27 – 40.25	17.08
5	Sadora (25)	Kherai	4.62 – 26.55	13.91
		Bamuria	7.42 – 15.60	12.17
		Parwai	9.95 – 19.52	13.85
		Gugor	8.32 – 18.55	15.24
		Bagulya	7.92 – 19.42	13.41
			4.62 – 26.55	13.72
Whole district			3.95 – 40.25	14.91

4.4: Status of available micronutrient cations (Zn, Cu, Fe & Mn)

4.4.1: Available –Zinc (mg kg^{-1})

Status of available zinc (DTPA-extractable) is presented in table 4.10. DTPA-extractable Zn observed in the range of 0.18 – 1.58 mg kg^{-1} under different villages of Ashoknagar district with an average value of 0.63 mg kg^{-1}. Whereas, status in different villages of Mungaoli, Chanderi, Isagarh, Ashoknagar, and Sadora block, it varied from 0.28 – 0.88, 0.18 – 1.25, 0.35 – 0.88, 0.24 – 1.08 and 0.27 – 1.58 mg kg^{-1} with an average value of 0.54, 0.63, 0.67, 0.66 and 0.66 mg kg^{-1} respectively.

Highest average value of available zinc (0.67 mg kg^{-1}) was obtained in Isagarh block, whereas lowest value (0.54 mg kg^{-1}) in Mungaoli block of Ashoknagar district.

4.4.2: Available – Copper (mg kg^{-1})

Available copper status of different blocks is presented in table 4.11. It ranged from 0.22 – 1.04 mg kg^{-1} under different villages of Ashoknagar district with an average value of 0.55 mg kg^{-1}, whereas, status in different villages of Mungaoli, Chanderi, Isagarh, Ashoknagar, and Sadora block it varied from 0.22 – 0.88, 0.28 – 0.88, 0.38 – 0.96, 0.33 – 1.02 and 0.35 – 1.04 mg $kg^{-1}$with an average value of 0.50, 0.56, 0.61, 0.61 and 0.60 mg kg^{-1} respectively.

Maximum (1.04 mg kg^{-1}) and minimum (0.22 mg kg^{-1}) copper content in soils was recorded in Kherai and Mudrakhana villages of satora and Mungaoli blocks, respectively.

Table 4.10: Status of available zinc (mg kg^{-1}) in soils of different blocks of Ashoknagar district

S. No.	Block	Village name	Range	Mean
1	Mungaoli (25)	Aathaikheda	0.36 – 0.70	0.51
		Bilakhedi	0.28 – 0.55	0.40
		Mudrakhana	0.29 – 0.88	0.58
		Chamrai	0.40 – 0.75	0.59
		Shyampur	0.44 – 0.78	0.61
			0.28 – 0.88	0.54
2	Chanderi (25)	Barodiya	0.52 – 1.08	0.84
		Sangampur	0.32 – 0.52	0.42
		Tarai	0.44 – 0.88	0.63
		Mohalichak	0.18 – 0.74	0.51
		Salona	0.48 – 1.25	0.77
			0.18 – 1.25	0.63
3	Isagarh (25)	Korwas	0.66 – 0.88	0.76
		Kotharkhedi	0.35 – 0.83	0.65
		Vijaypura	0.36 – 0.75	0.60
		Pachlana	0.45 – 0.88	0.70
		Bamnawar	0.55 – 0.69	0.65
			0.35 – 0.88	0.67
4	Ashoknagar (25)	Mau	0.32 – 0.72	0.54
		Banyga	0.41 – 1.08	0.76
		Diyadhari	0.24 – 0.86	0.55
		Ratikheda	0.68 – 0.83	0.76
		Ashoknagar	0.55 – 0.76	0.67
			0.24 – 1.08	0.66
5	Sadora (25)	Kherai	0.38 – 0.85	0.62
		Bamuria	0.45 – 0.86	0.62
		Parwai	0.46 – 0.69	0.55
		Gugor	0.27 – 1.58	0.82
		Bagulya	0.45 – 1.04	0.68
			0.27 – 1.58	0.66
Whole district			0.18 – 1.58	0.63

Table 4.11: Status of available copper (mg kg^{-1}) in soils of different blocks of Ashoknagar district

S. No.	Block	Village name	Range	Mean
1	Mungaoli (25)	Aathaikheda	0.29 – 0.88	0.47
		Bilakhedi	0.25 – 0.65	0.41
		Mudrakhana	0.22 – 0.88	0.52
		Chamrai	0.41 – 0.72	0.56
		Shyampur	0.42 – 0.65	0.55
			0.22 – 0.88	0.50
2	Chanderi (25)	Barodiya	0.44 – 0.85	0.61
		Sangampur	0.28 – 0.84	0.58
		Tarai	0.49 – 0.73	0.59
		Mohalichak	0.33 – 0.62	0.46
		Salona	0.38 – 0.88	0.56
			0.28 – 0.88	0.56
3	Isagarh (25)	Korwas	0.38 – 0.82	0.62
		Kotharkhedi	0.38 - 0.73	0.58
		Vijaypura	0.44 – 0.96	0.70
		Pachlana	0.48 – 0.90	0.67
		Bamnawar	0.38 – 0.56	0.46
			0.38 – 0.96	0.61
4	Ashoknagar (25)	Mau	0.38 – 0.80	0.59
		Banyga	0.35 – 1.02	0.64
		Diyadhari	0.39 – 0.80	0.52
		Ratikheda	0.33 – 0.72	0.55
		Ashoknagar	0.44 – 0.94	0.73
			0.33 – 1.02	0.61
5	Sadora (25)	Kherai	0.48 – 1.04	0.73
		Bamuria	0.42 – 0.86	0.60
		Parwai	0.48 – 0.84	0.61
		Gugor	0.35 – 0.68	0.56
		Bagulya	0.38 – 0.73	0.51
			0.35 – 1.04	0.60
Whole district			0.22 – 1.04	0.55

4.4.3: Available – iron (mg kg^{-1})

Available iron (DTPA-extractable) status is presented in table 4.12. DTPA-extractable Fe ranged from 3.18 – 15.32 mg kg^{-1} under different villages of Ashoknagar district with an average value of 7.14 mg kg^{-1}, whereas, status of Fe in different villages of Mungaoli, Chanderi, Isagarh, Ashoknagar, and Sadora block, varied from 3.22 – 11.33, 3.61 – 13.40, 3.18 – 13.91, 3.61 – 11.08 and 3.35 – 15.32 mg kg^{-1} with an average value of 6.76, 7.32, 7.74, 6.66 and 7.21 mg kg^{-1} respectively.

Maximum average value of available iron (7.74 mg kg^{-1}) was observed in Isagarh block, whereas minimum (6.66 mg kg^{-1}) in Ashoknagar block of Ashoknagar district. It is evident from table 4.12, that minimum value obtained in all five blocks is below prescribed critical limit (5.0 mg kg^{-1}), which reflects that the soils of area may become deficient in near future.

4.4.4: Available – Manganese (mg kg^{-1})

Available manganese status is presented in table 4.13 and it ranged from 2.12 – 10.08 mg kg^{-1} under different villages of Ashoknagar district with the average value of 4.95 mg kg^{-1}. Whereas, status of Mn in different villages of Mungaoli, Chanderi, Isagarh, Ashoknagar, and Sadora block varied from 2.12 – 7.46, 2.37 – 8.81, 3.22 – 9.15, 2.37 – 8.65 and 2.20 – 10.08 mg kg^{-1} with an average value of 4.71, 4.90, 5.44, 4.84 and 4.85 mg kg^{-1} respectively.

Maximum (5.44 mg kg^{-1}) and minimum (4.71 mg kg^{-1}) contents were found in Isagarh and Mungaoli blocks, respectively.

Table 4.12: Status of available iron (mg kg^{-1}) in soils of different blocks of Ashoknagar district

S. No.	Block	Village name	Range	Mean
1	Mungaoli (25)	Aathaikheda	4.77 – 11.33	6.38
		Bilakhedi	3.22 – 8.37	5.49
		Mudrakhana	5.30 – 11.33	7.48
		Chamrai	3.28 – 9.27	6.76
		Shyampur	6.18 – 8.44	7.69
			3.22 – 11.33	6.76
2	Chanderi (25)	Barodiya	5.67 – 13.40	9.46
		Sangampur	3.61 – 8.37	5.52
		Tarai	6.31 – 9.40	7.57
		Mohalichak	4.25 – 7.99	6.22
		Salona	5.14 – 11.33	7.84
			3.61 – 13.40	7.32
3	Isagarh (25)	Korwas	5.80 – 10.56	8.41
		Kotharkhedi	3.18 – 9.40	6.92
		Vijaypura	5.67 – 13.91	9.22
		Pachlana	5.67 – 11.52	7.95
		Bamnawar	4.89 – 7.21	6.22
			3.18 – 13.91	7.74
4	Ashoknagar (25)	Mau	3.86 – 7.08	5.45
		Banyga	4.51 – 11.08	7.27
		Diyadhari	3.61 – 6.83	5.36
		Ratikheda	5.67 – 9.27	7.88
		Ashoknagar	5.02 – 11.08	7.34
			3.61 – 11.08	6.66
5	Sadora (25)	Kherai	3.35 – 8.37	6.26
		Bamuria	4.89 – 11.85	7.93
		Parwai	4.89 – 7.99	6.62
		Gugor	3.35 – 15.32	8.11
		Bagulya	5.54 – 9.40	7.11
			3.35 – 15.32	7.21
Whole district			3.18 – 15.32	7.14

Table 4.13: Status of available manganese (mg kg^{-1}) in soils of different blocks of Ashoknagar district

S. No.	Block	Village name	Range	Mean
1	Mungaoli (25)	Aathaikheda	3.14 – 7.46	4.20
		Bilakhedi	2.12 – 6.50	4.22
		Mudrakhana	3.49 – 7.46	5.05
		Chamrai	2.16 – 6.10	4.68
		Shyampur	4.07 – 7.25	5.41
			2.12 – 7.46	4.71
2	Chanderi (25)	Barodiya	3.73 – 8.81	6.22
		Sangampur	2.37 – 5.51	3.63
		Tarai	4.41 – 6.24	5.40
		Mohalichak	2.80 – 5.25	4.09
		Salona	3.38 – 7.46	5.16
			2.37 – 8.81	4.90
3	Isagarh (25)	Korwas	3.81 – 8.35	5.81
		Kotharkhedi	3.22 – 6.19	5.01
		Vijaypura	3.73 – 9.15	6.07
		Pachlana	3.73 – 6.48	5.33
		Bamnawar	3.70 – 6.44	4.98
			3.22 – 9.15	5.44
4	Ashoknagar (25)	Mau	2.54 – 4.66	3.58
		Banyga	4.66 – 7.29	5.73
		Diyadhari	2.37 – 4.49	3.53
		Ratikheda	3.73 – 8.65	5.85
		Ashoknagar	3.73 – 7.29	5.49
			2.37 – 8.65	4.84
5	Sadora (25)	Kherai	2.20 – 5.51	4.12
		Bamuria	3.22 – 7.80	5.22
		Parwai	4.07 – 5.25	4.65
		Gugor	2.20 – 10.08	5.59
		Bagulya	3.64 – 6.19	4.68
			2.20 – 10.08	4.85
Whole district			2.12 – 10.08	4.95

4.5: Relationship of available nutrients (N, P, K, S, Zn, Cu, Mn and Fe) with important soil properties

The results of correlation study (coefficient of correlation) of available nutrients and soil properties are presented in Table-4.14.

Table 4.14: Coefficient of correlation (r) of available nutrient and soil properties

Available nutrient	pH	E.C.	O. C.	$CaCO_3$	Sand	Silt	Clay
N	0.083	-0.126	0.510**	0.095	-0.245**	-0.161	0.219*
P	-0.368**	-0.095	0.527**	-0.224*	-0.072	-0.145	0.214*
K	-0.143	0.130	0.489**	-0.109	-0.295**	0.045	0.288**
S	-0.045	-0.083	0.219*	-0.063	-0.012	-0.134	0.077
Zn	-0.333*	-0.063	0.792**	-0.184*	-0.255*	-0.105	0.237**
Cu	-0.084	-0.044	0.151	-0.183*	-0.138	0.095	0.032
Fe	-0.308*	-0.054	0.678**	-0.205*	-0.188*	-0.150	0.184*
Mn	-0.281**	-0.011	0.216*	-0.179*	-0.202*	-0.170	0.224*

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

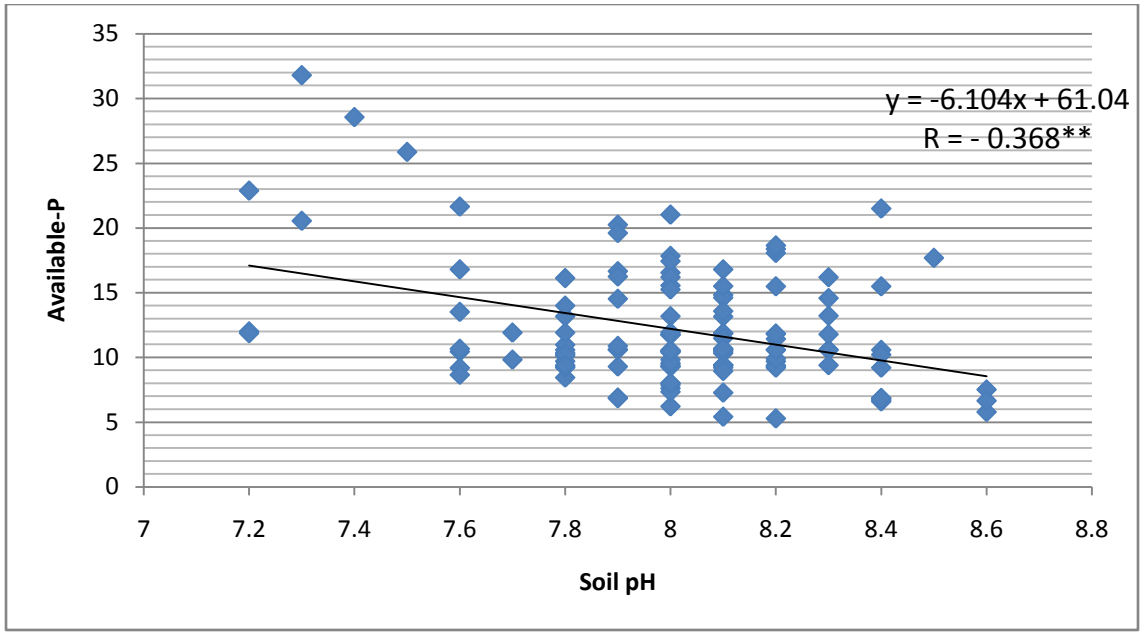
4.5.1: Relationship between available N and soil properties :

A significant positive correlation (r= 0.510**) was noticed between organic carbon and available nitrogen. However there was a negative and significant correlation between N and sand content (r = -0.245*). Its correlation was also positive (r = 0.219*) with clay content.

4.5.2: Relationship between available P and soil properties:

A significant positive correlation (r = 0.527**) was observed between P and organic carbon but its correlation with pH (r = -0.368**) and calcium carbonate (r = -0.224*) was negative and significant.

Fig. 4.3: Relationship between available P and Fe with soil pH



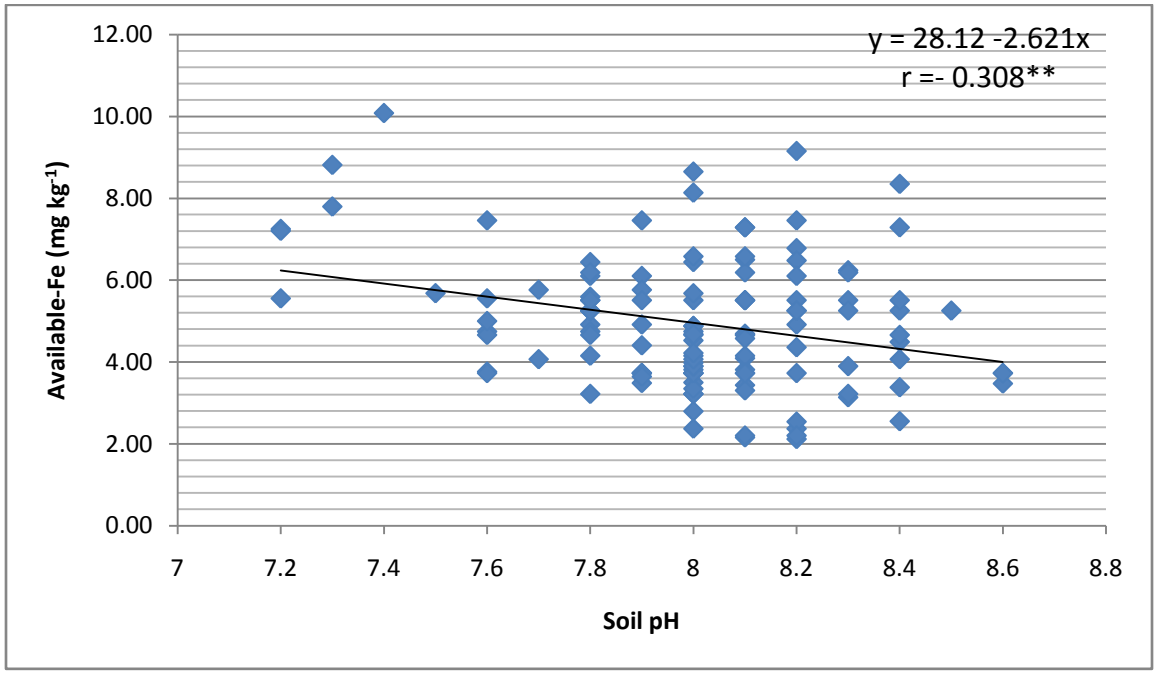
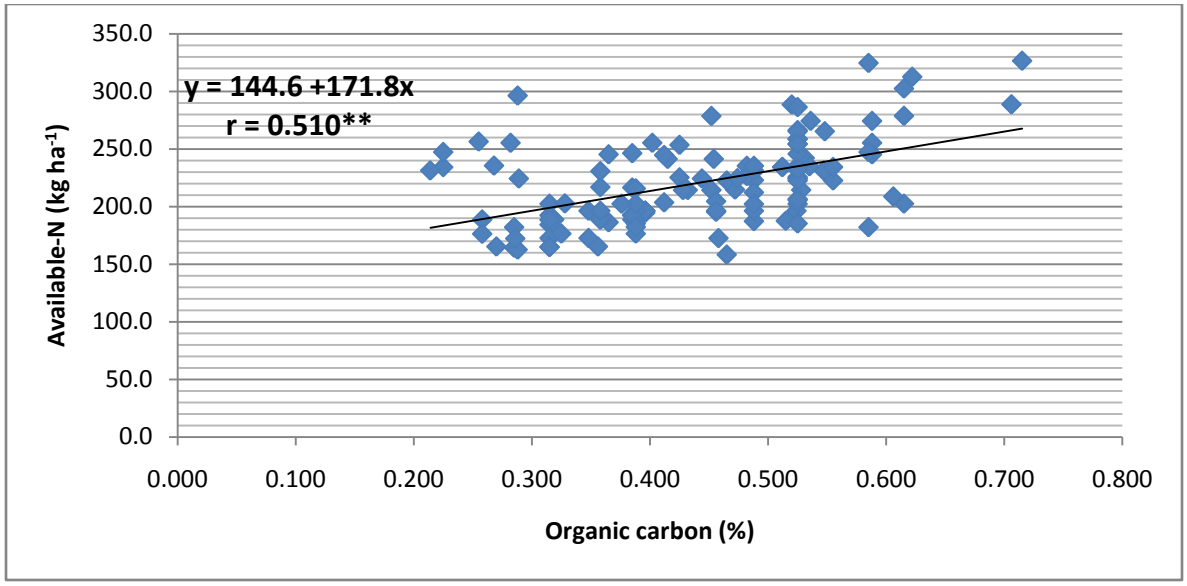
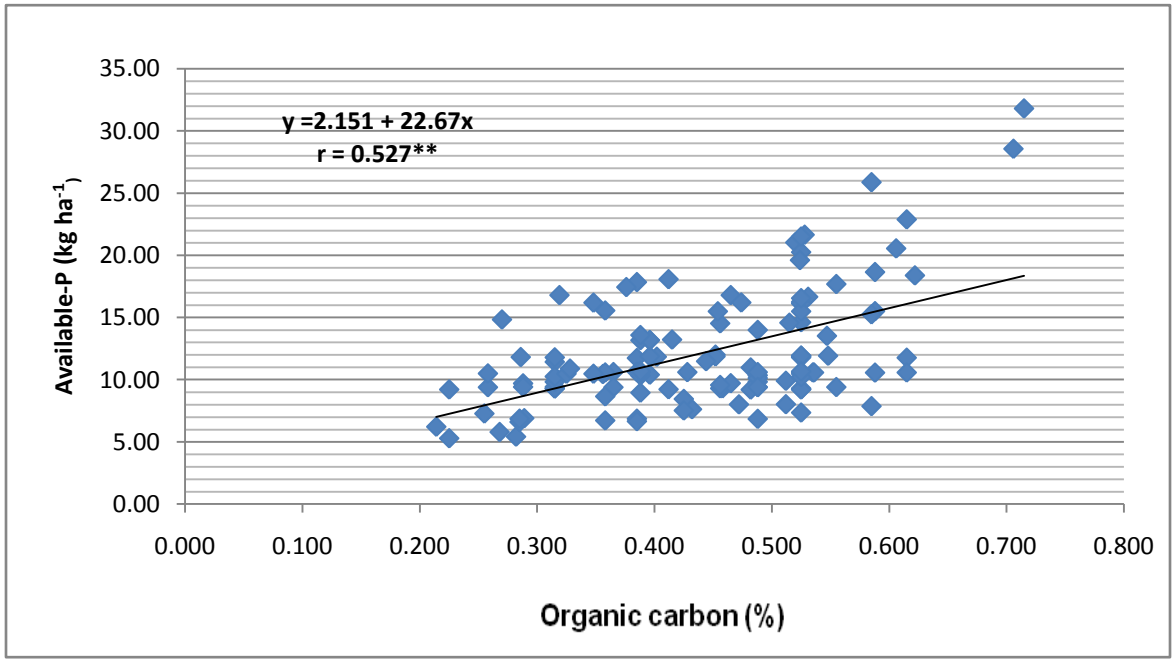


Fig. 4.4: Relationship between available N and P with organic carbon





4.5.3: Relationship between available K and soil properties :

A highly significant positive correlation (r = 0.489**) was recorded between organic carbon and available potassium content. It was significant and negatively correlated with sand particles (r= -0.295*). However, its correlation was significantly positive with clay particles (r = -0.288**).

4.5.4: Relationship between available S and soil properties :

There was a highly and significant positive correlation (r = 0.219*) between S and organic carbon but its relationship with electrical conductivity (r= - 0.083) and calcium carbonate (r= -0.063) was negative.

4.5.5: Relationship between available Zn and soil properties :

The availability of zinc increased significantly with increase in organic carbon content (r =0.792**). Zinc was negatively and significantly correlated with pH (r = -0.333**), $CaCO_3$ (r = -0.184*) and sand particles (r = -0.255*).

4.5.6: Relationship between available Cu and soil properties :

The availability of Cu decreased with increase in calcium carbonate content of soil and increased with increase in organic carbon content (r =0.151). It was non-significantly and negatively correlated with pH (r = - 0.084), EC (r = - 0.044) and sand content (r = - 0.138).

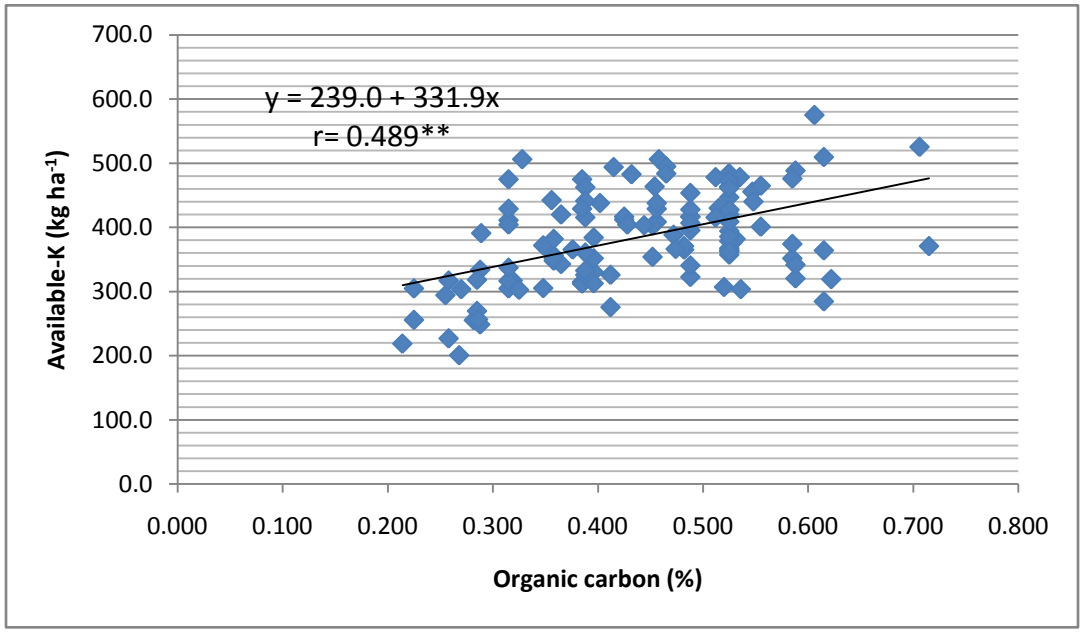
4.5.7: Relationship between available Fe and soil properties :

The DTPA –Fe had negative and significant correlation with pH (r = - 0.308*) and $CaCO_3$ (r = -0.205*). However, it was significantly and positively with organic carbon (r =0.678*) and clay content (r =0.184*).

4.5.8: Relationship between available Mn and soil properties:

A significant positive correlation (r = 0.216*) was obtained between organic carbon and available Mn content. However, it showed significant and negative correlation with pH (r = - 0.281) and $CaCO_3$ (r = - 0.179*).

Fig. 4.5: Relationship between available K and S with organic carbon



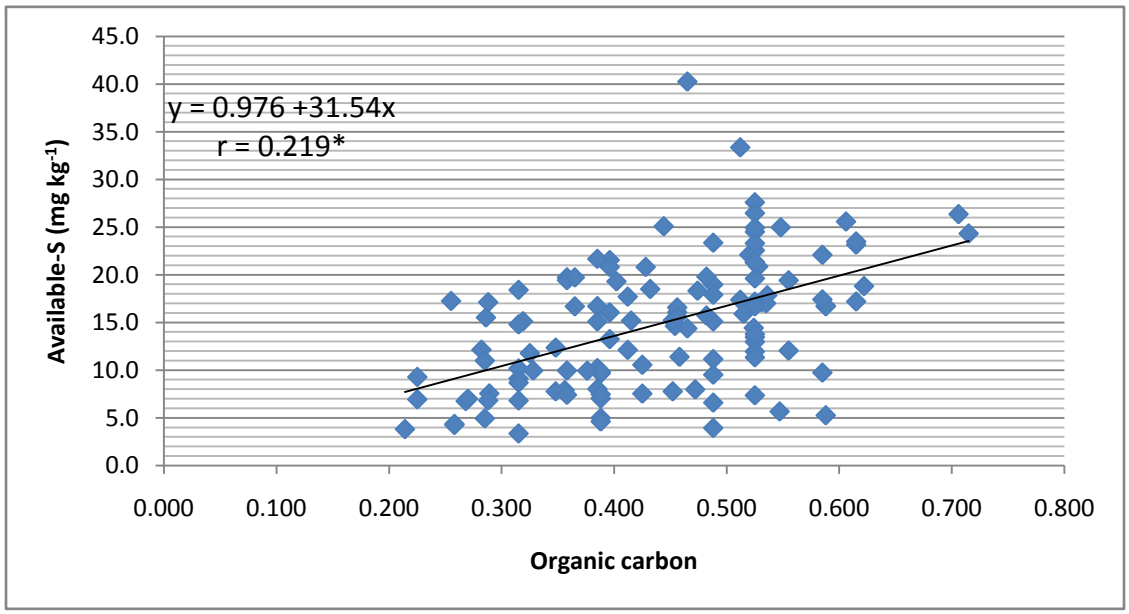
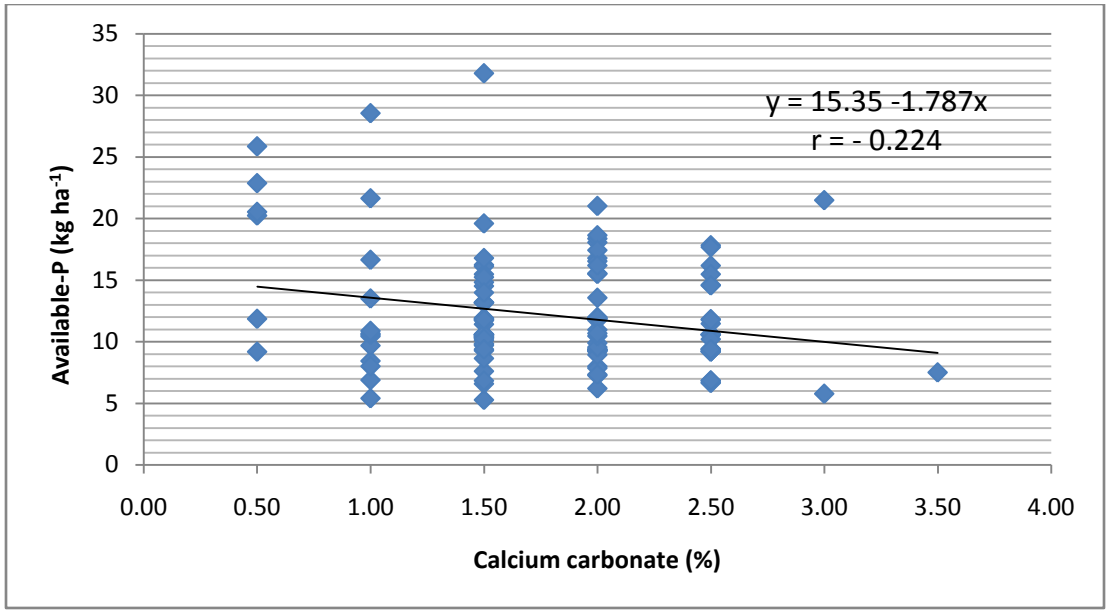


Fig. 4.6: Relationship between available P and Zn with calcium carbonate



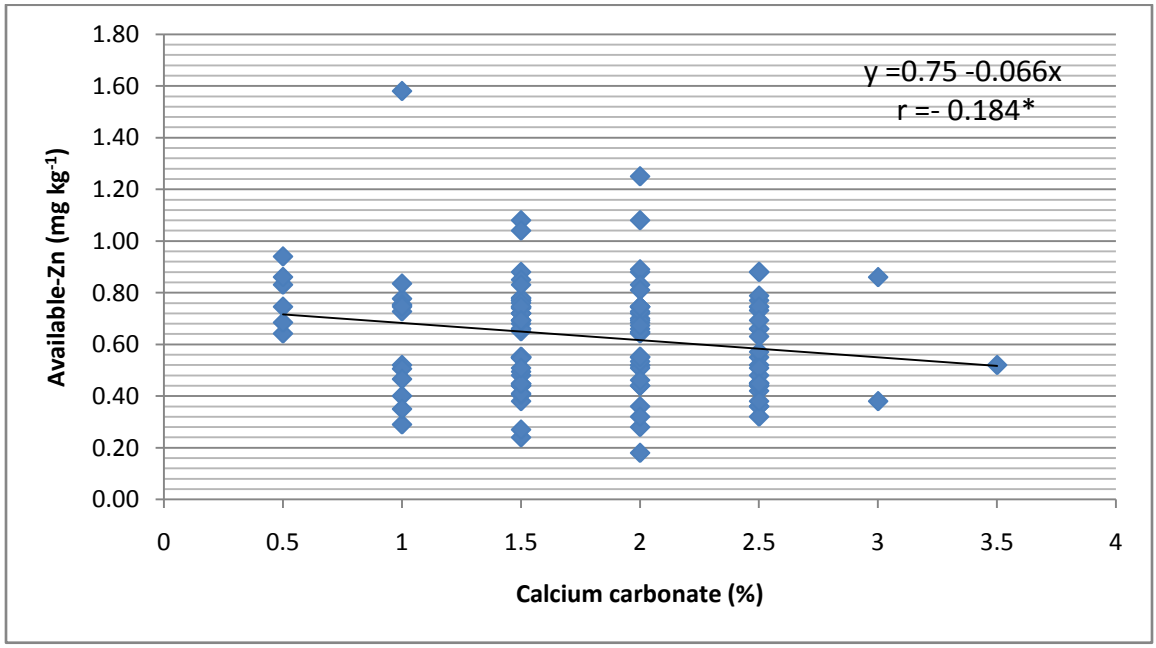
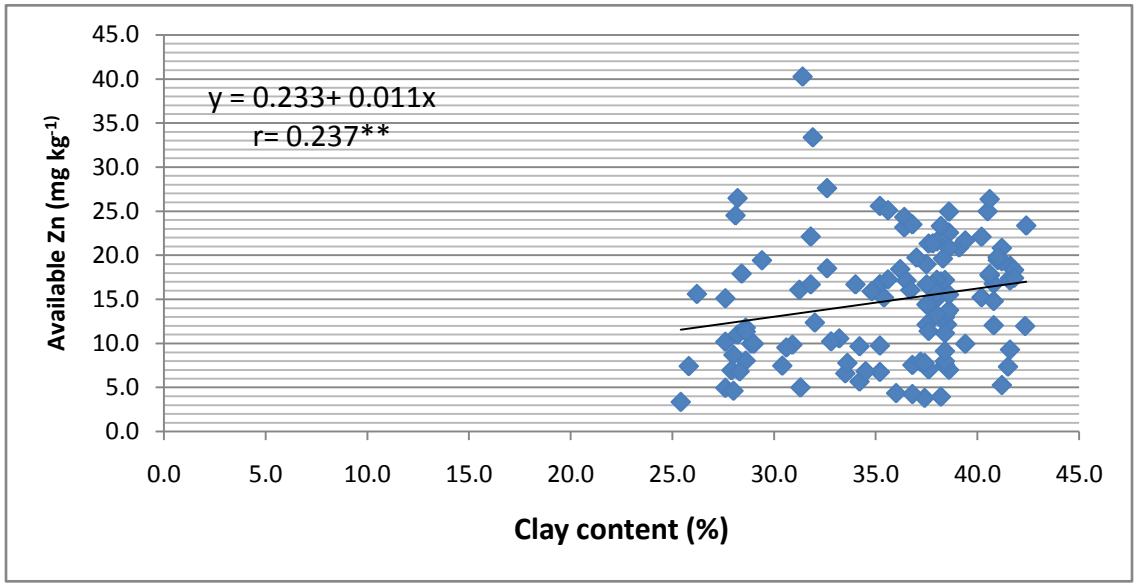
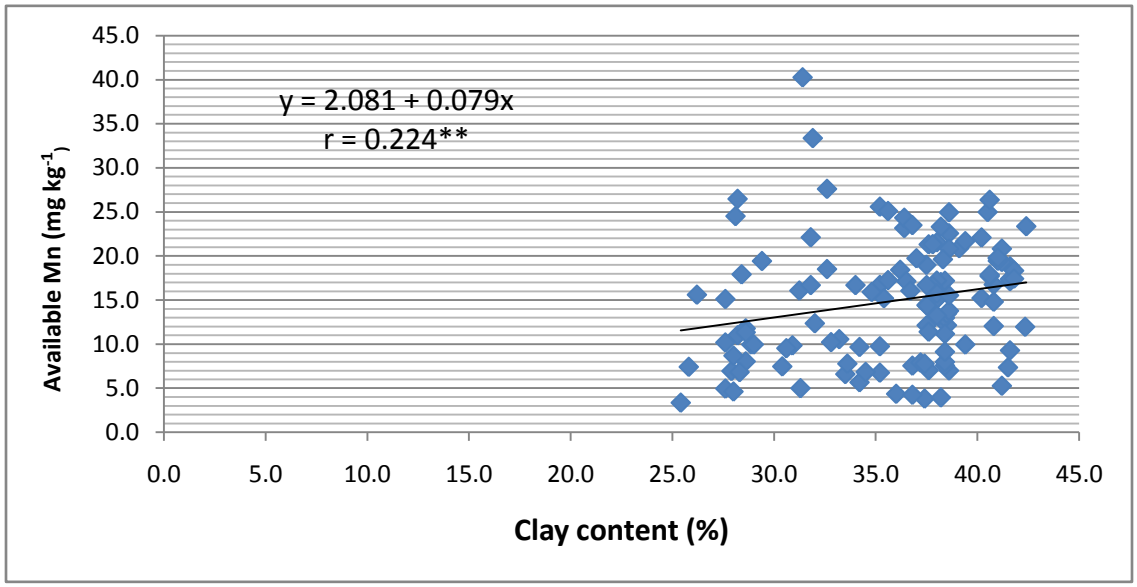


Fig. 4.7: Relationship between available P and Fe with clay content





4.6: Categorization of the available nutrients

All the soil samples were categorized in low, medium and high category for available N, P, K & S and deficient and sufficient for available macronutrient on the basis of critical limit presented in table 3.2 and the results are presented in table 4.15 & 4.16.

Under available nitrogen, about 91 % soil samples of Ashoknagar district were found to be under low category (< 250 kg N ha^{-1}) and remaining in the category of medium (250-500 kg N ha^{-1}). Approximate 35, 58 and 7 % of the soil samples were found in low, medium and high category in respect of available phosphorus.

In available potassium, 3.2, 52.0 and 44.8 percent of the soil samples were found in low, medium and high category. However, for available sulphur, About 28, 58.4 and 13.6 % samples were found under low, medium and high category.

Consider the critical limit of DTPA – Zn (<0.6 mg kg^{-1}) Out of 125 samples, 42.4 and 57.6 percent of the samples were found to be deficient and sufficient categories.

Considering 0.2 mg kg^{-1} as critical limit for Cu deficiency, all the samples were found under sufficient category.

Considering 4.5 mg kg^{-1} as critical limit for Fe deficiency, about 7.% soil samples were found under deficient and 93% were sufficient category.

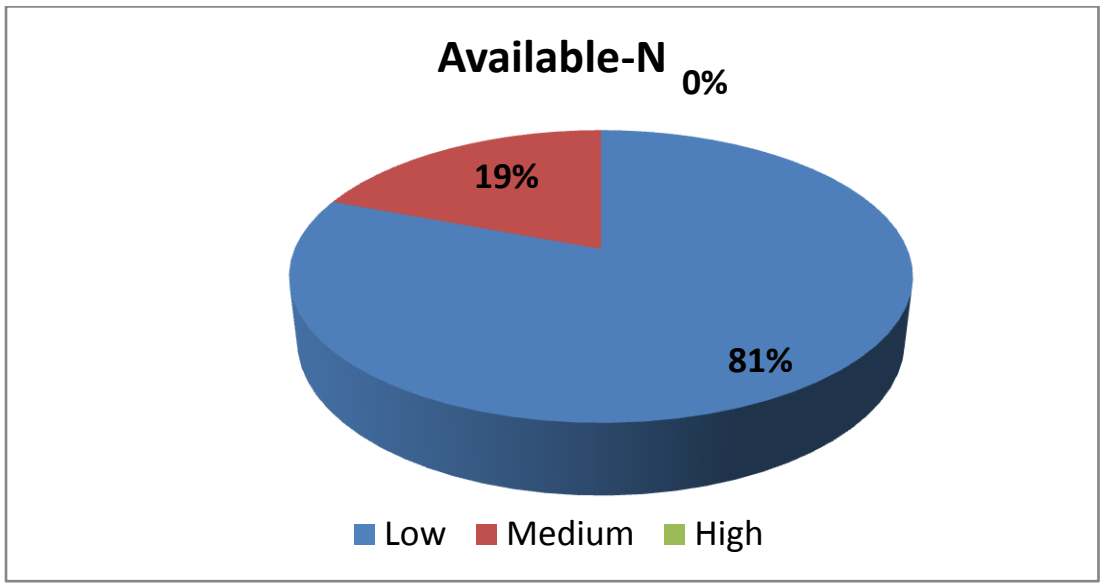
Considering 1.0 mg kg^{-1} as critical limit for Mn deficiency, all the samples were found under sufficient category.

Table 4.15 : Categories of macro-nutrients in different blocks of the Ashoknagar district.

Block	No. of samples analysed	Available Macronutrient											
		Available Nitrogen (%)			Available Phosphorus (%)			Available Potassium (%)			Available Sulphur (%)		
		L	M	H	L	M	H	L	M	H	L	M	H
Mungaoli	25	20 (80.0)	05 (20.0)	00 (0.0)	08 (32.0)	14 (56.0)	03 (12.0)	02 (8.0)	13 (52.0)	10 (40.0)	07 (28.0)	14 (56.0)	04 (16.0)
Chanderi	25	20 (80.0)	05 (20.0)	00 (0.0)	11 (44.0)	12 (48.0)	02 (8.0)	01 (4.0)	16 (64.0)	08 (32.0)	06 (24.0)	17 (68.0)	02 (8.0)
Isagarh	25	18 (72.0)	07 (28.0)	0 (0.0)	09 (36.3)	15 (60.0)	01 (4.0)	00 (0.0)	12 (48.0)	13 (52.0)	07 (28.0)	15 (60.0)	03 (12.0)
Ashoknagar	25	20 (80.0)	05 (20.0)	0 (0.0)	09 (36.0)	15 (60.0)	01 (4.0)	01 (4.0)	12 (48.0)	12 (48.0)	07 (28.0)	11 (44.0)	07 (28.0)
Sadora	25	23 (92.0)	02 (8.0)	0 (0.0)	07 (28.0)	16 (64.0)	02 (8.0)	0 (0.0)	12 (48.0)	13 (52.0)	08 (32.0)	16 (64.0)	01 (4.0)
Whole district	**125**	**101 (80.8)**	**24 (19.2)**	**0 (0.0)**	**44 (35.2)**	**72 (57.6)**	**09 (7.2)**	**04 (3.2)**	**65 (52.0)**	**56 (44.8)**	**35 (28.0)**	**73 (58.4)**	**17 (13.6)**

L – Low
M – Medium
H – High

Fig. 4.8: Status of available – N and P in soils of Ashoknagar district



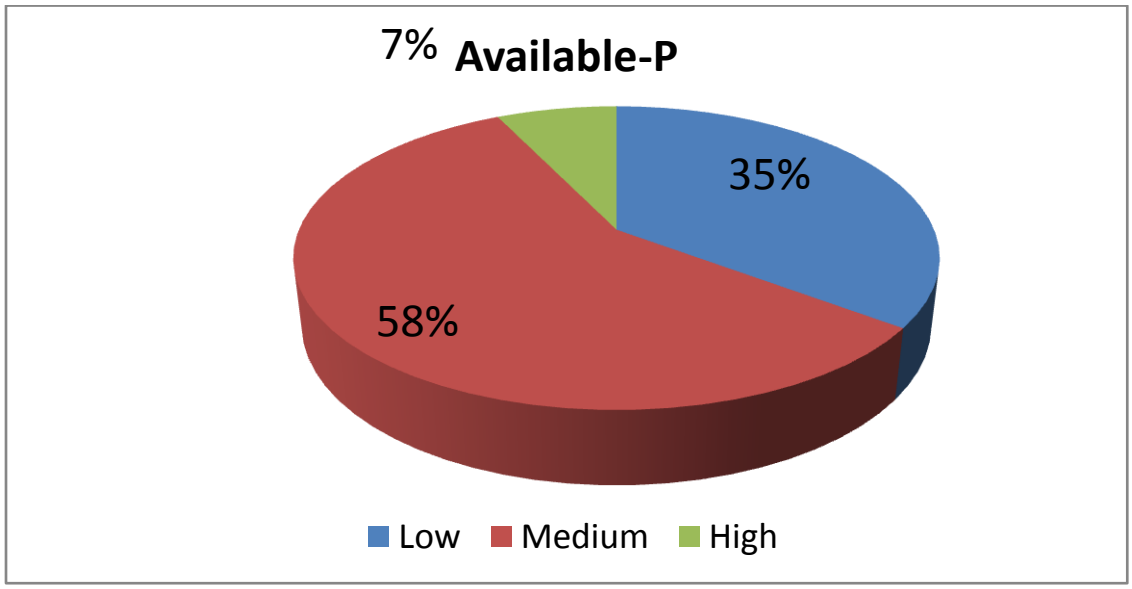
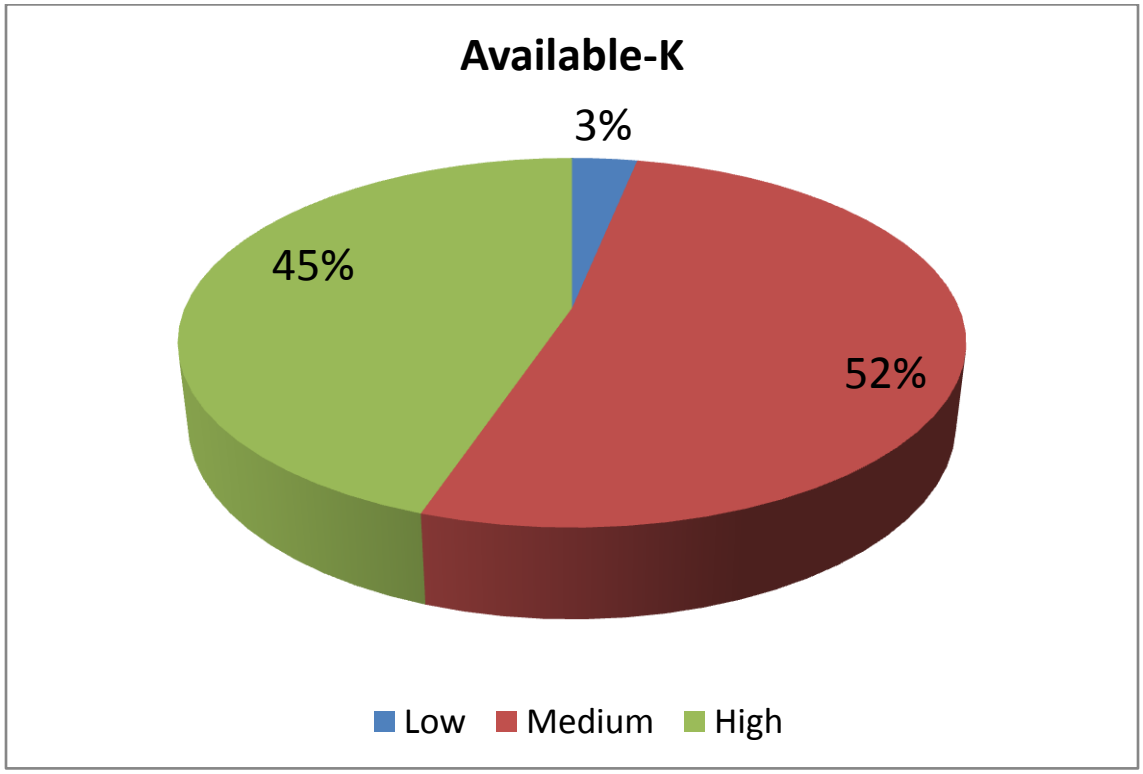


Fig. 4.9: Status of available – K and S in soils of Ashoknagar district



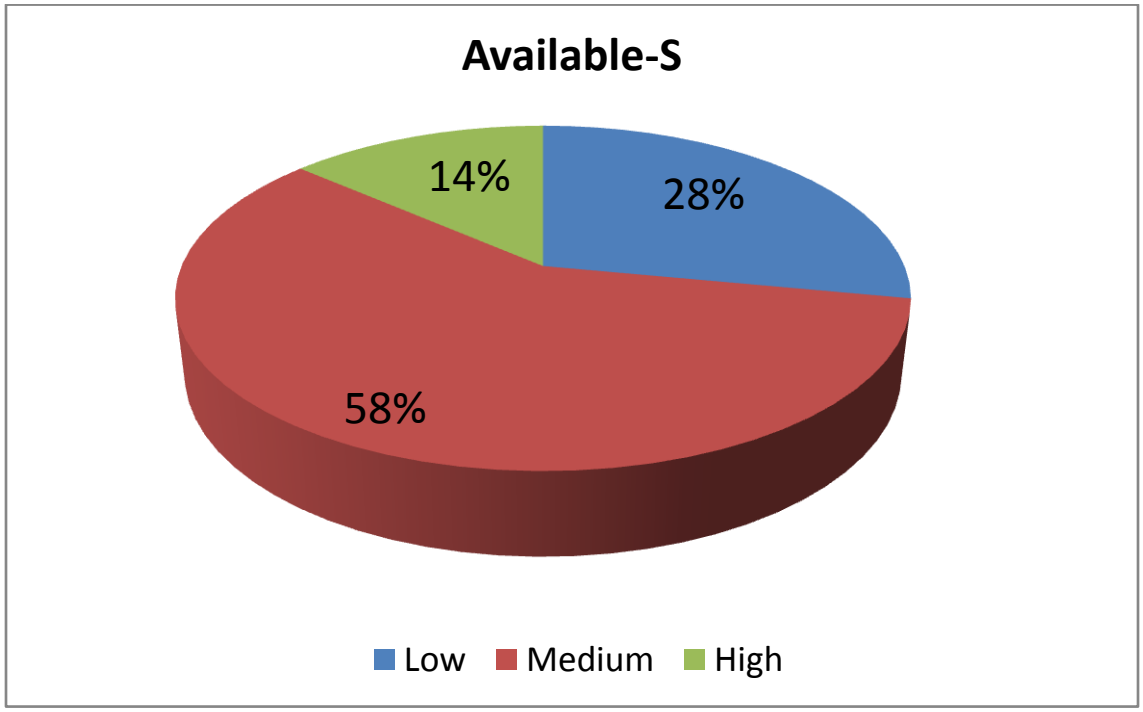
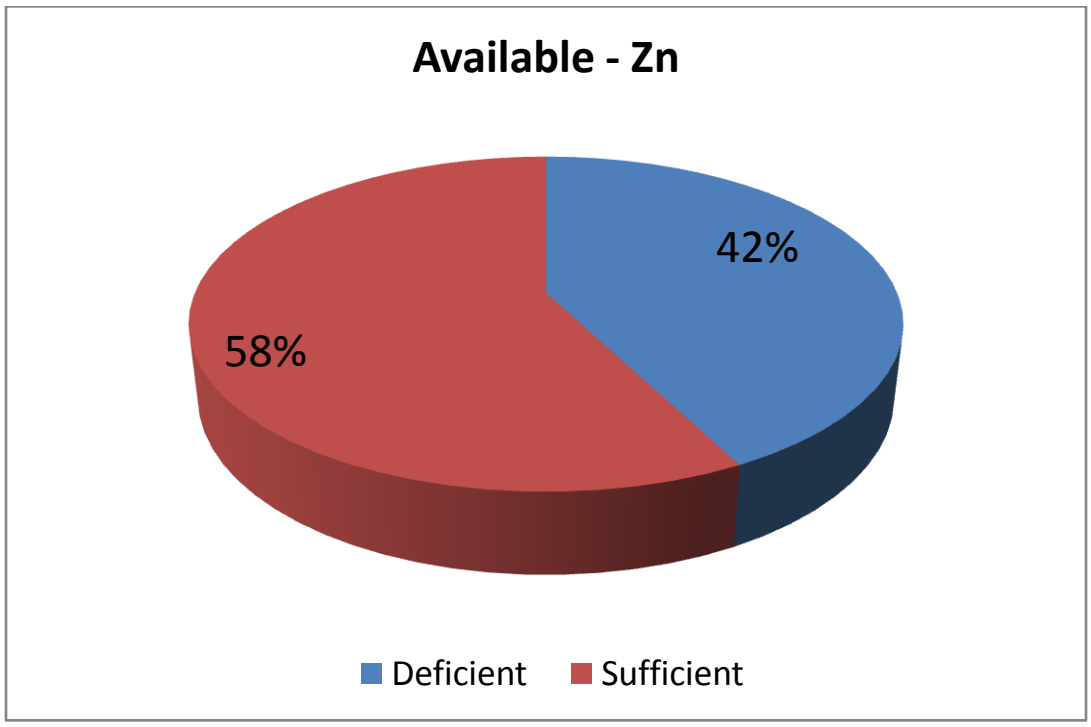


Table 4.16 : Categories of micro-nutrients in different blocks of the Ashoknagar district.

Block Name	No. of samples analysed	Micronutrients (mg kg^{-1})							
		Zn		Cu		Fe		Mn	
		Deficient	Sufficient	Deficient	Sufficient	Deficient	Sufficient	Deficient	Sufficient
Mungaoli	25	15 (60.0)	10 (40.0)	0 (0.0)	25 (100)	02 (8.0)	23 (92.0)	0 (0.0)	25 (100.0)
Chanderi	25	12 (48.0)	13 (52.0)	0 (0.0)	25 (100.0)	03 (12.0)	22 (88.0)	0 (0.0)	25 (100.0)
Isagarh	25	06 (24.0)	19 (76.0)	0 (0.0)	25 (100.0)	01 (4.0)	24 (96.0)	0 (0.0)	25 (100.0)
Ashoknagar	25	09 (36.0)	16 (64.0)	0 (0.0)	25 (100.0)	01 (4.0)	24 (96.0)	0 (0.0)	25 (100.0)
Sadora	25	11 (44.0)	14 (56.0)	0 (0.0)	25 (100.0)	02 (8.0)	23 (92.0)	0 (10.0)	25 (90.0)
Whole district	**125**	**53 (42.4)**	**72 (57.6)**	**0 (0.0)**	**125 (100.0)**	**09 (7.2)**	**116 (92.8)**	**00 (0.0)**	**125 (100.0)**

Fig. 4.10: Status of available – Zn and Fe in soils of Ashoknagar district



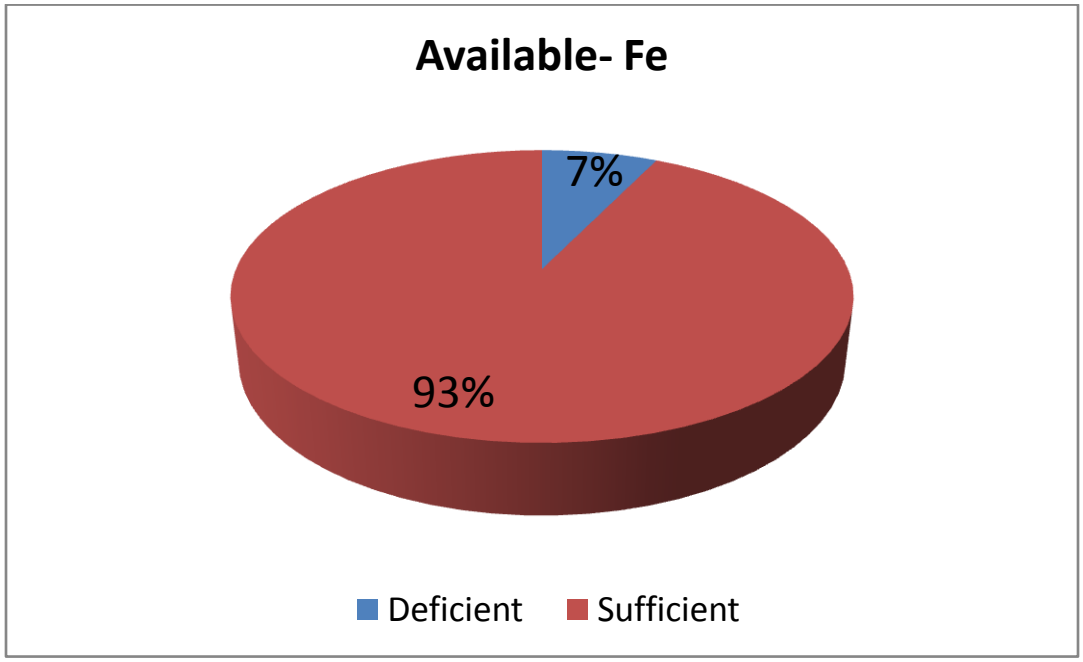


Table 4.17: Nutrient index value of macro-nutrients in different blocks of the district

Block	No. of samples	Available Macronutrient							
		Available Nitrogen (%)		Available Phosphorus (%)		Available Potassium (%)		Available Sulphur (%)	
		Nutrient index value	Category	Nutrient index value	Category	Nutrient index value	Category	Nutrient index value	Category
Mungaoli	25	1.20	Low	1.80	Medium	2.32	Medium	1.75	Medium
Chanderi	25	1.20	Low	1.64	Medium	2.28	Medium	1.55	Medium
Isagarh	25	1.28	Low	1.68	Medium	2.52	High	1.56	Medium
Ashoknagar	25	1.20	Low	1.68	Medium	2.44	Medium	1.39	Low
Sadora	25	1.10	Low	1.80	Medium	2.52	High	1.80	Medium
Whole district	**125**	**1.19**	**Low**	**1.72**	**Medium**	**2.42**	**Medium**	**1.86**	**Medium**

4.7: Nutrient index:

After classification of soil nutrient status in low, medium and high categories on their according to critical levels given in table 3.2, nutrient index was calculated by the formula given by Biswas and Mukherjee, (1989).

$$\frac{NL + 2NM + 3NH}{NL + NM + NH}$$

Where,

NL = Number of sample in low categories.

NM = Number of samples in medium categories.

NH = Number of samples in high categories.

Regarding soil nutrient index, the soils of Ashoknagar district of Madhya Pradesh were found in category of low fertility status for nitrogen and medium with respect to phosphorus, potassium and sulphur (Table 4.18). The value worked out from nutrient index for NPKS were 1.19, 1.72, 2.42 and 1.86 respectively, against the nutrient index values <1.50 for low, 1.50-2.50 for medium and >2.50 for high fertility status.

Table 4.18: Nutrient index (NI) value of Ashoknagar district

S. No.	Name of nutrients	Nutrient index value	Categories
1	Available Nitrogen	**1.19**	**Low**
2	Available Phosphorus	**1.72**	**Medium**
3	Available Potassium	**2.42**	**Medium**
4	Available Sulphur	**1.86**	**Medium**

Chapter – V
DISCUSSION

Global Position System (GPS) based one hundred Twenty five surface soil (0-15 cm) samples were collected from five blocks (Mungaoli, Chanderi, Ishagarh, Ashoknagar and Sadora) of Ashoknagar district during April to May 2016 and were analysis for their mechanical, physical, chemical characteristics and status of different available nutrient (N, P, K, S, Zn, Cu, Mn and Fe). The relationship between available nutrients with different soil properties were also workout. The results obtained during the study are discussed in this chapter.

5.1: Mechanical composition of soils

Under studied area sand, silt and clay per cent varied from 36.6 – 56.7, 3.9 – 38.0 and 25.4 – 42.4 percent with the mean value of 47.1, 17.0 and 35.9 percent, respectively. Under different blocks, maximum average content of sand (49.4%), silt (24.3%) and clay (38.0%) were recorded in Chanderi, Sadora and Isagarh block, respectively.

5.2: Physical and chemical properties of soil

5.2.1: Soil pH -

Soil pH of studied area was found in the range of 7.2 - 8.6 under different villages with the average value of 8.0. Maximum average value of soil pH (8.1) was observed in Ashoknagar block whereas minimum value (7.9) noted in Sadora block of Ashoknagar district. Higher pH (>8.5) in some of the samples indicate towards the fact that the soils are infested with alkalinity. According to Thangaswamy *et al.* (2005) the higher pH could be due to increase in accumulation of exchangeable sodium and calcium carbonate.

5.2.2: Electrical conductivity -

In the present study conductivity values for five blocks of Ashoknagar district ranges from 0.32 to 0.62 d S m^{-1} with the average value of 0.45 d S m^{-1}. It showed a considerable variation with type of topography of soils. All the soil samples were found to be normal (EC < 1.0 dSm^{-1}) category. The normal EC may be ascribed to leaching of

salts to lower horizons. Similar result was also reported by Sharma *et al.* (2008) and Rajput *et al.* (2015).

5.2.3: Organic carbon -

Status of organic carbon under studied area was in the range of 2.14 - 7.15 g kg^{-1} of under different villages with the average value of 4.42 g kg^{-1}. Maximum average organic carbon content (4.74 g kg^{-1}) was obtained in Isagarh whereas minimum value (3.94 g kg^{-1}) in Mungaoli block of Ashoknagar district.

The low organic carbon content in these soils may be attributed to the poor vegetation and high rate of organic matter decomposition under hyperthermic temperature regime which leads to extremely high oxidizing condition. Removal of the surface soils containing high organic carbon due to erosion was responsible for the lower organic carbon (Rajeswar *et al.* 2009). Beside this, course-textured soils are generally low in organic carbon (Yadav and Meena, 2009). These results confirm the finding of Singh *et al.* (1997).

5.2.4: Calcium carbonate -

Calcium carbonate content in the surface soil samples of different blocks of Ashoknagar district was distributed in varied from 0.5 to 3.5% with an mean value of 1.8 %, In semi-arid regions, since rainfall is less as compared to annual evapo-transpiration, less water in available for the leaching of insoluble carbonates and bicarbonates of calcium.

5.3: Status of available N, P, K & S

5.3.1: Available nitrogen -

The value for available nitrogen varies from 158.2 – 326.4 kg ha^{-1} with an average value of 220.6 kg ha^{-1}. About 81 % soil samples were found to be under low category (< 250 kg N ha^{-1}) and remaining in the category of medium (250-500 kg N ha^{-1}). It is quite obvious that efficiency of applied N is very low due to the fact that N is lost through various mechanisms, like NH_3 volatilization, nitrification, succeeding denitrification, chemical and microbial fixation, leaching and run off (Sharma *et al.* ,

2008). Similar results were also reported by Meena *et al.* (2006) and Raghubanshi *et al*. (2011).

A significant positive correlation (r= 0.510**) was noticed between available nitrogen and organic carbon, since most of the soil nitrogen is in organic form, therefore this relationship was observed. Similar results were also reported by Raghubanshi *et al*. (2011).

5.3.2: Available phosphorus -

Status of available –P under studied area of Ashoknagar district ranged from 5.29 – 31.80 kg ha^{-1} under different villages with an average value of 12.17 kg ha^{-1}. Approximate 35, 58 and 7 % of the soil samples were found in low, medium and high category, respectively. On the basis of nutrient index value all the blocks were found in medium category.

Available phosphorus registered significant negative correlation (r = -0.368**) with pH. Because at higher pH calcium can precipitate with phosphorus as Ca-phosphate and reduces phosphorus availability. A significant positive correlation (r = 0.527**) was observed between P and organic carbon. This relationship might be due to the presence of more than 50% of phosphorus in organic form and after the decomposition of organic matter humus is formed which forms complex with Al and Fe that is a protective cover for P fixation with Al and Fe (Tisdale *et al.,* 1997) .

5.3.3: Available potassium -

Available potassium was in the range of 200.5 – 575.2 kg ha^{-1} under different villages of district with an average value of 385.6 kg ha^{-1}. Minimum available-K found in Mungaoli (200.5 kg ha^{-1}), Chenderi (218.6), and Ashoknagar (248.5) indicate that soils are suffering from the deficiency of potassium which may be deter mental for future sustainability of production.

A highly significant positive correlation (r = 0.489**) was recorded between organic carbon and available potassium content. This is probably due to the fact with increase in organic matter in soils, the clay-humus complex become more active thereby providing more exchange sites and access to K. These results are in agreement

with the findings of Das *et al.* (2000), Sharma *et al*.(2009) and Kumari and Kumari (2014).

5.3.4: Available – Sulphur-

Available sulphur ranged from 3.95 – 40.25 mg kg^{-1} under different villages of Ashoknagar district with an average value of 14.91 mg kg^{-1}. Almost similar content of available sulphur were also reported by Sharan *et al.* (2004) for alluvial soils of Uttar Pradesh and Das *et al.* (2006) of West Bengal. About 28, 58 and 14% samples were found under low, medium and high category.

A significant positive correlation (r = 0.219*) was between S and organic carbon because most of the sulphur was associated with organic matter. These results corroborated with the findings of Trivedi *et al*. (2000), and Jat and Yadav (2006). Earlier, Takkar *et al.* (1984) also observed that the soil organic matter regulates markedly the content of available-S in alluvial soils.

5. 4: Status of available micronutrient cations (Zn, Cu, Fe & Mn)

5.4.1: Available –Zinc

DTPA-extractable Zn observed in the range of 0.18 – 1.58 mg kg^{-1} under different villages of Ashoknagar district with an average value of 0.63 mg kg^{-1}. The soils of Mungaoli block contained relatively lesser content of available zinc as compared to other block. Consider the critical limit of DTPA – Zn (<0.6 mg/kg) as suggested by Bansal and Takkar (1986). Out of 125 samples, 42% samples were found to be deficient in DTPA-Zn. Rajput *et al. (*2015) also reported that the available Zn was deficient in 46.0% soils samples in northern Madhya Pradesh.

DTPA extractable Zn showed a highly significant and positive correlation (0.792**) with organic carbon content of the soils. This clearly indicates that organic carbon content increases the availability of Zn. A large number of studies have showed highly significant linear positive relationship between these two parameters. Singh and Rao (2001) Sharma *et al*. (2004) and Rajput *et al. (*2015) also reported significant and positive relationship between available Zn and organic carbon.

In the present investigation, the available Zn showed negative correlation with pH and calcium carbonate, because, in calcareous soils, Zn adsorption by CO_3^{--}, precipitations of Zn carbonates or formation of insoluble calcium zincate are partially responsible for lower Zn availability. This finds support from similar observation reported by Yadav and Meena (2009) and Rajput *et al. (*2015).

5.4.2: Available – Copper

Available Cu content varied from 0.22 to 1.04 mg kg^{-1} under Ashoknagar district with the average value of 0.55 mg kg^{-1}. Considering 0.2 mg kg^{-1} as critical limit for Cu deficiency, all the samples were found under sufficient category.

DTPA extractable Cu showed positive correlation with organic carbon content of the soils. This may be attributed to increased stability of Cu complexes implicating presence of greater amount of DTPA – Cu bound with organic matter. These observations confirmed those made by Sadashiva *et al.* (1995) and Sharma *et al. (*2004).

5.4.3: Available – iron

DTPA-extractable Fe ranged from 3.18 – 15.32 mg kg^{-1} under different villages of Ashoknagar district with an average value of 7.14 mg kg^{-1}. Considering 4.5 mg kg^{-1} as critical limit for Fe deficiency, about 7% soil samples were found under deficient and 93% were sufficient category.

DTPA extractable Fe showed a highly significant and positive correlation with organic carbon content (r =0.678**) and negatively with calcium carbonate (r = -0.205*) of the soils. Organic matter may hasten soil reduction, cause more CO_2 production and therefore bring about faster and greater accumulations of available Fe. This is substantiated by the significant positive correlation between available Fe and organic carbon in the soils under present study. Sharma *et al.* (2003) and Yadav and Meena (2009) also reported significant and positive relationship between available Fe and organic carbon.

Significant and negative relationship of Fe with calcium carbonate content of soils, suggest that the free or active $CaCO_3$ which release bi- carbonate ions in to the soil solution, decreases the solubility of Fe. These results are in agreement with the findings of Ibrahim *et al.* (2001) and Sharma *et al.* (2004).

5.4.4: Available – Manganese

Available manganese ranged from 2.12 – 10.08 mg kg^{-1} under different villages of Ashoknagar district with the average value of 4.95 mg kg^{-1}. Considering 1.0 mg kg^{-1} as critical limit for Mn deficiency, all the samples were found under sufficient category.

Significantly positive relationship between available Mn and organic carbon (r =0.216*) was found in all the soils under study. It is thus apparent that the availability of Mn increased with increasing organic matter content in the soils. Which may be due to either its addition to the soil through plant residues or because the decomposing organic matter promotes its extraction. This finds support from similar observation reported by Singh and Rao (2001) and Sharma *et al*. (2003).

5.5: Nutrient index :

Regarding soil nutrient index, the soils of Ashoknagar district were found in category of low fertility status for nitrogen and medium with respect to phosphorus, potassium and sulphur. The value worked out from nutrient index for NPKS were 1.19, 1.72, 2.42 and 1.86 respectively, against the nutrient index values <1.50 for low, 1.50-2.50 for medium and >2.50 for high fertility status.

Meena *et al.* (2006) also worked out from nutrient index for NPK were 1.75, 1.70 and 2.54 respectively in soils of Tonk district of Rajasthan. According to Pattanayak *et al.* (2009) soil of Madhya Pradesh was observed in medium category with 1.84 value of nutrient index.

Chapter – VI

SUMMARY, CONCLUSION & SUGGESTIONS FOR FURTHER WORK

In the present study, one hundred twenty five GPS based soil samples (0-15 cm.) were collected from cultivator's fields of five blocks (namely; Mungaoli, Chanderi, Isagarh, Ashoknagar, and Sadora) of Ashoknagar district of Madhya Pradesh and analyzed for different available nutrients (N, P, K, S, Zn, Cu, Fe, & Mn) and for physical as well as chemical characteristics.

The results are summarized as follows:

- Under studied area sand, silt and clay per cent varied from 36.6 – 56.7, 3.9 – 38.0 and 25.4 – 42.4 percent with the mean value of 47.1, 17.0 and 35.9 percent, respectively. Under different blocks, maximum average content of sand (49.4%), silt (24.3%) and clay (38.0%) were recorded in Chanderi, Sadora and Isagarh block, respectively.

- Soil pH of studied area was found in the range of 7.2 - 8.6 under different villages with the average value of 8.0. Maximum average value of soil pH (8.1) was observed in Ashoknagar block whereas minimum value (7.9) noted in Sadora block of Ashoknagar district. Higher pH (>8.5) in some of the samples of Ashoknagar district indicate towards the fact that the soils are infested with alkalinity.

- In the present study conductivity values for five blocks of Ashoknagar district ranges from 0.32 to 0.62 d S m^{-1} with the average value of 0.45 d S m^{-1}. It showed a considerable variation with type of topography of soils. All the soil samples were found to be normal (EC < 1.0 dSm^{-1}) category.

- Status of organic carbon under studied area was in the range of 2.14 - 7.15 g kg^{-1} under different villages with the average value of 4.42 g kg^{-1}. Maximum average organic carbon content (4.74 g kg^{-1}) was obtained in Isagarh whereas minimum value (3.94 g kg^{-1}) in Mungaoli block of Ashoknagar district.

- Calcium carbonate content in the surface soil samples of different blocks of Ashoknagar district was distributed in varied from 0.5 to 3.5% with an mean value of 1.8 %.

- The value for available nitrogen varies from 158.2 – 326.4 kg ha^{-1} with an average value of 220.6 kg ha^{-1}. About 81 % soil samples were found to be under low category (< 250 kg N ha^{-1}) and remaining in the category of medium (250-500 kg N ha^{-1}). A significant positive correlation (r= 0.510**) was noticed between available nitrogen and organic carbon.
- Status of available –P under studied area of Ashoknagar district ranged from 5.29 – 31.80 kg ha^{-1} under different villages with an average value of 12.17 kg ha^{-1}. Approximate 35, 58 and 7 % of the soil samples were found in low, medium and high category, respectively. On the basis of nutrient index value all the blocks were found in medium categories. Available phosphorus registered significant negative correlation (r = -0.368**) with pH and a significant positive correlation (r = 0.527**) was observed between P and organic carbon.
- Available potassium was in the range of 200.5 – 575.2 kg ha^{-1} under different villages of district with an average value of 385.6 kg ha^{-1}. Minimum available-K found in Mungaoli (200.5 kg ha^{-1}), Chenderi (218.6), and Ashoknagar (248.5) indicate that soils are suffering from the deficiency of potassium which may be deter mental for future sustainability of production. A highly significant positive correlation (r = 0.489**) was recorded between organic carbon and available potassium content.

- Available sulphur ranged from 3.95 – 40.25 mg kg^{-1} under different villages of Ashoknagar district with an average value of 14.91 mg kg^{-1}. About 28, 58 and 14 % samples were found under low medium and high category. A significant positive correlation (r = 0.219*) was between S and organic carbon.

- DTPA-extractable Zn observed in the range of 0.18 – 1.58 mg kg^{-1} under different villages of Ashoknagar district with an average value of 0.63 mg kg^{-1}.

The soils of Mungaoli block contained relatively lesser content of available zinc as compared to other block. Consider the critical limit of DTPA – Zn (<0.6 mg/kg). Out of 125 samples, 42% samples were found to be deficient in DTPA-Zn.

- DTPA extractable Zn showed a highly significant and positive correlation (r = 0.792**) with organic carbon content of the soils. In the present investigation, the available Zn showed significantly negative correlation with pH (r = - 0.333**) and calcium carbonate (r = -0.184*).

- Available Cu content in the soils varied 0.22 to 1.04 mg kg^{-1} under Ashoknagar district with the average value of 0.55 mg kg^{-1}. Considering 0.2 mg kg^{-1} as critical limit for Cu deficiency, all the samples were found under sufficient category. DTPA extractable Cu showed positive correlation with organic carbon content of the soils.

- DTPA-extractable Fe ranged from 3.18 – 15.32 mg kg^{-1} under different villages of Ashoknagar district with an average value of 7.14 mg kg^{-1}. Considering 4.5 mg kg^{-1} as critical limit for Fe deficiency, about 7% soil samples were found under deficient and 93% were sufficient category. DTPA extractable Fe showed a highly significant and positive correlation with organic carbon content (r =0.678**) and significantly negative with calcium carbonate content (r = - 0.205*) and pH (r = - 0.308**) of the soils.

- Available manganese ranged from 2.12 – 10.08 mg kg^{-1} under different villages of Ashoknagar district with the average value of 4.95 mg kg^{-1}. Considering 1.0 mg kg^{-1} as critical limit for Mn deficiency, all the soil samples were found under sufficient category. Significantly positive relationship of available Mn with organic carbon and clay content of the soil were found in the present study.

- Regarding soil nutrient index, the soils of Ashoknagar district of Madhya Pradesh were found in category of low fertility status for nitrogen and medium with respect

to phosphorus, potassium and sulphur. The value worked out from nutrient index for NPK and S were 1.19, 1.72, 2.42 and 1.86 respectively, against the nutrient index values <1.50 for low, 1.50-2.50 for medium and >2.50 for high fertility status.

- Under different micronutrient cations, available zinc and iron were deficient to 42 and 7 percent, whereas available Cu and Mn were sufficient.

CONCLUSION

From the preceding summary it can be concluded that

- The soil of Ashoknagar district of Madhya Pradesh is slightly alkaline in reaction and normal to soluble salts. Surface soil samples were non calcareous with low organic carbon content.

- Available N, P, K and S varied from 158.2 – 326.4, 5.29 – 31.80, 200.5 – 575.2 kg ha^{-1} and 3.95 – 40.25 mg kg^{-1} with the mean value of 220.6, 12.17, 385.6 kg ha^{-1} and 14.91 mg kg^{-1}, respectively.

- Available (DTPA-extractable) Zn, Cu, Fe and Mn were observed in the range of 0.18 – 1.58, 0.22 - 1.04, 3.18 – 15.32 and 2.12 – 10.08 mg kg^{-1} with the mean value of 0.63, 0.55, 7.14 and 4.95 mg kg^{-1}, respectively.

- Regarding soil nutrient index, the soils of Ashoknagar district of Madhya Pradesh were found in category of low fertility status for nitrogen and medium with respect to phosphorus, potassium and sulphur. The value worked out from nutrient index for NPKS were 1.19, 1.72, 2.42 and 1.86 respectively, against the nutrient index values <1.50 for low, 1.50-2.50 for medium and >2.50 for high fertility status.

- Under different micronutrient cations, available zinc and iron were deficient to 42.4 and 7.2 percent, whereas available Cu and Mn were sufficient

- The correlation study revealed that organic carbon had greater impact on availability of nutrients. It suggested that organic matter was main contributing factor affecting the nutrient availability in soil.

- Deficiency of available nutrients increased with an increase in pH and calcium carbonate content whereas it decreased with an increase in organic carbon content in soils of Ashoknagar district of northern Madhya Pradesh.

Suggestions for further work -

The present study revealed the fertility status only in surface horizon (0 -15 cm). Further there is a need to study the nutrient status in lower horizons of the soil. Soil testing has played historical role in evaluating soil fertility maintenance and in sustainable agriculture. Soil testing shall also play its crucial role in precision agriculture. At present there is a need to develop basic inventory as per soil test basis and necessary information has to be built into the system for translating the results of soil test to achieve the crop production goal in new era.

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Appendix- I : General information of soil samples of Mungaoli block of Ashoknagar district

S. No.	Village name	Sample No.	Farmer Name	Father Name	Cast	Latitude	Longitude
1	**Aathaikheda**	S-1	Sh. Geet Singh	Sh. Harpal Singh	OBC	24° 27' 05.3"	77° 48' 34.7"
2		S-2	Sh. Dev Singh	Sh. Bilvinder Singh	OBC	24° 26' 34.3"	77° 48' 30.5"
3		S-3	Sh. Gerdev Singh	Sh. Balkar Singh	OBC	24° 26' 35.4"	77° 48' 32.6"
4		S-4	Sh. Daya Singh	Sh. Balkar Singh	OBC	24° 26' 27.2"	77° 48' 32.9"
5		S-5	Sh. Balkar Singh	Sh. Chanchal Singh	OBC	24° 26' 27.8"	77° 48' 32.4"
6	Bilakhedi	S-1	Sh. Inder Singh	Sh. Sirnam Singh	OBC	24° 22' 53.4"	77° 48' 17.3"
7		S-2	Sh. Chandra Jeet	Sh. Virendra Singh	OBC	24° 22' 52.9"	77° 48' 24.3"
8		S-3	Sh. Bhaiya Shab	Sh. Mohkam Singh	OBC	24° 22' 36.6"	77° 48' 00.6"
9		S-4	Sh. Neelam Singh	Sh. Sirnam Singh	OBC	24° 22' 53.7"	77° 48' 23.9"
10		S-5	Sh. Ram Singh	Sh. Devi Singh	OBC	24° 22' 52.8"	77° 48' 17.8"
11	Mudrakhana	S-1	Sh. Ramsavak	Sh. Ghendalal Sharma	Gen	24° 24' 38.9"	77° 48' 38.8"
12		S-2	Sh. Premnarayan	Sh. Sunderlal Sharma	Gen	24° 24' 37.1"	77° 48' 39.4"
13		S-3	Sh. Bhagwal Lal	Sh. Kaluram Sharma	Gen	24° 24' 38.6"	77° 48' 39.8"
14		S-4	Sh. Lakhan Prasad	Sh. Sardar Singh	Gen	24° 24' 35.7"	77° 48' 41.3"
15		S-5	Sh. Jamuna Prasad	Sh. Komal Prasad	Gen	24° 24' 36.4"	77° 48' 41.0"
16	Chamrai	S-1	Smt. Soulat Wai	Sh. Motilal	SC	24° 24' 00.1"	77° 48' 02.4"
17		S-2	Sh. Rajpal Singh	Sh. Chandrabhan Singh	SC	24° 23' 18.8"	77° 47' 51.0"
18		S-3	Smt. Machla Bai	Sh. Bharosilal	OBC	24° 23' 42.7"	77° 47' 46.2"
19		S-4	Sh. Tufan Singh	Sh. Halduram	OBC	24° 23' 43.0"	77° 47' 45.8"
20		S-5	Sh. Mevalal	Sh. Shub Singh	OBC	24° 23' 59.9"	77° 48' 09.6"
21	**Shyampur**	S-1	Sh. Puran Singh	Sh. Moti Lal	OBC	24° 26' 32.4"	77° 47' 45.5"
22		S-2	Sh. Halku Ram	Sh. Shobaram	OBC	24° 26' 19.7"	77° 48' 06.6"
23		S-3	Sh. Gulab Singh	Sh. Moti Lal	OBC	24° 26' 31.1"	77° 47' 53.8"
24		S-4	Sh. Agrej Singh	Sh. Kartar Singh	OBC	24° 26' 24.1"	77° 48' 13.6"
25		S-5	Sh. Karan Singh	Sh. Moti Lal	OBC	24° 26' 20.3"	77° 48' 05.7"

Appendix- II : General information of soil samples of Chanderi block of Ashoknagar district

S. No.	Village name	Sample No.	Farmer Name	Father Name	Cast	Latitude	Longitude
1	**Barodiya**	S-1	Sh. Bharat Singh	Sh. Mishri Lal	OBC	24° 40' 48.6"	78° 00' 43.6"
2		S-2	Sh.Kashriram	Sh. Mishri Lal	OBC	24° 40' 58.5"	78° 00' 42.3"
3		S-3	Sh.Sukhnandan	Sh Harnam Singh.	OBC	24° 40' 59.9"	78° 00' 43.6"
4		S-4	Sh. Kapoor Singh	Sh. Aaman Singh	ST	24° 41' 01.2"	78° 00' 42.6"
5		S-5	Sh. Bhujwal	Sh. Raghuver	ST	24° 40' 48.6"	78° 00' 44.1"
6	Sangampur	S-1	Sh. Bundle Singh	Sh. Laxman Singh	OBC	24° 40' 58.6"	78° 00' 45.7"
7		S-2	Sh. Rajendra Singh	Sh. Amar Singh	OBC	24° 41' 41.7"	78° 00' 35.4"
8		S-3	Sh. Veer Singh	Sh. Bhagun Singh	OBC	24° 41' 42.9"	78° 00' 33.6"
9		S-4	Sh. Mangal Singh	Sh. Narayan Singh	OBC	24° 41' 44.4"	78° 00' 35.8"
10		S-5	Sh. Kalish	Sh. Bhaiya Lal	OBC	24° 41' 43.8"	78° 00' 36.1"
11	Tarai	S-1	Smt. Emarati Bai	Sh. Mahendra Kumar	SC	24° 38' 22.7"	77° 55' 49.6"
12		S-2	Sh. Santosh	Sh. Ghouri Shanker	SC	23° 41' 14.6"	76° 34' 25.6"
13		S-3	Sh.Mahendra Kumar	Sh. Hari Narayan	SC	24° 38' 22.5"	77° 55' 48.7"
14		S-4	Sh. Mintu Lal	Sh. Komal Prasad	SC	24° 38' 21.3"	77° 55' 48.3"
15		S-5	Sh. Ashok	Sh. Babulal	SC	24° 38' 23.5"	77° 55' 48.2"
16	Mohalichak	S-1	Sh. Raghuveer	Sh. Babulal	OBC	24° 44' 13.0"	77° 59' 08.9"
17		S-2	Sh. Guljar Singh	Sh. Bali Singh	OBC	24° 44' 11.5"	77° 59' 01.4"
18		S-3	Sh. Jesdev	Sh. Pooran Singh	OBC	24° 44' 13.8"	77° 59' 05.9"
19		S-4	Sh. Pappi	Sh. Raviendra	OBC	24° 44' 11.3"	77° 59' 01.0"
20		S-5	Sh. Jitendra	Sh. Raghuveer	OBC	24° 44' 11.8"	77° 59' 1.7"
21	**Salona**	S-1	Sh. Nepal Singh	Sh. Babulal	OBC	24° 38' 59.9"	77° 58' 14.0"
22		S-2	Sh. Phalwan Singh	Sh. Babulal	OBC	24° 38' 58.4"	77° 58' 16.1"
23		S-3	Sh. Sultan Singh	Sh. Sartaj Singh	OBC	24° 38' 58.0"	77° 58' 10.7"
24		S-4	Sh. Meharwan Singh	Sh. Harparshad	OBC	24° 39' 00.2"	77° 58' 09.1"
25		S-5	Sh. Indrabhan Singh	Sh. Keman Singh	OBC	24° 39' 00.1"	77° 58' 11.2"

Appendix- III : General information of soil samples of Isagarh block of Ashoknagar district

S. No.	Village name	Sample No.	Farmer Name	Father Name	Cast	Latitude	Longitude
1	**Korwas**	S-1	Sh. Vijay	Sh. Bhagwan Lal	Gen.	24° 51' 09.1"	77° 49' 29.4"
2		S-2	Sh. Raguveer	Sh. Devi Singh	OBC	24° 51' 08.0"	77° 49' 30.6"
3		S-3	Sh. Sita Ram	Sh. Champa Lal	OBC	24° 51' 07.4"	77° 49' 30.9"
4		S-4	Sh. Govind Singh	Sh. Gujraj Singh	OBC	24° 51' 08.7"	77° 49' 31.5"
5		S-5	Sh. Narayan	Sh. Gyasiram	OBC	24° 51' 08.5"	77° 49' 31.2"
6	Kotharkhedi	S-1	Sh. Ram Charan	Sh. Sumera	SC	24° 49' 34.1"	77° 50' 05.3"
7		S-2	Sh. Kalian Singh	Sh. Devuram	SC	24° 49' 35.2"	77° 50' 04.8"
8		S-3	Sh. Phool Chandra	Sh. Palluua	SC	24° 49' 37.0"	77° 50' 01.1"
9		S-4	Sh. Ram Prasad	Sh. Natuha	SC	24° 49' 38.3"	77° 50' 03.9"
10		S-5	Sh. Pran Singh	Sh. Ranveer	SC	24° 49' 34.6"	77° 50' 06.1"
11	Vijaypura	S-1	Sh. Vikram Singh	Sh. Amul Singh	OBC	24° 45' 25.0"	77° 47' 19.0"
12		S-2	Sh. Hari Ram	Sh. Kalian Singh	OBC	24° 45' 28.2"	77° 47' 19.6"
13		S-3	Sh. Suresh	Sh. Babulal	Gen.	24° 45' 22.8"	77° 47' 20.9"
14		S-4	Sh. Mhendra Singh	Sh. Brijbhan Singh	OBC	24° 45' 26.3"	77° 47' 18.8"
15		S-5	Sh. Sisupal	Sh. Sabdal Singh	OBC	24° 45' 26.6"	77° 47' 18.3"
16	Pachlana	S-1	Sh. Maniram	Sh. Lalji Ram	OBC	24° 46' 35.8"	77° 47' 58.1"
17		S-2	Sh. Udham Singh	Sh. Radhey Lal	OBC	24° 46' 37.6"	77° 47' 57.0"
18		S-3	Sh. Balveer	Sh. Jaswant Singh	Gen.	24° 46' 40.1"	77° 47' 57.2"
19		S-4	Sh. Ramveer	Sh. Roop Singh	OBC	24° 46' 35.4"	77° 47' 54.3"
20		S-5	Sh. Haricharan	Sh. Kamarji Lal	OBC	24° 46' 34.0"	77° 47' 55.8"
21	Bamnawar	S-1	Sh. Ganpat Singh	Sh. Bihari Lal	OBC	24° 47' 41.8"	77° 49' 40.9"
22		S-2	Sh. Vajay Singh	Sh. Naman Singh	OBC	24° 47' 43.3"	77° 49' 34.0"
23		S-3	Sh. Arvendra	Sh. Meharwan Singh	OBC	24° 47' 43.8"	77° 49' 42.0"
24		S-4	Sh. Rajesh	Sh. Chattar Singh	OBC	24° 47' 46.7"	77° 49' 34.4"
25		S-5	Sh. Ram Kumar	Sh. Pratvi Singh	OBC	24° 47' 46.9"	77° 49' 32.9"

Appendix- IV : General information of soil samples of Ashoknagar block of Ashoknagar district

S. No.	Village name	Sample No.	Farmer Name	Father Name	Cast	Latitude	Longitude
1	**Mau**	S-1	Sh. Roshan	Sh. Bhagwan Das	OBC	24° 35' 34.8"	77° 42' 15.4"
2		S-2	Sh. Lalji Ram	Sh. Daloop Singh	OBC	24° 35' 33.6"	77° 42' 13.8"
3		S-3	Sh. Govind	Sh. Ramesh Kumar	Gen.	24° 35' 35.8"	77° 42' 16.8"
4		S-4	Sh. Ashok Choudary	Sh. Harvan Singh	Gen.	24° 35' 35.2"	77° 42' 15.1"
5		S-5	Sh. Rumal Singh	Sh. Harbul Singh	OBC	24° 35' 33.5"	77° 42' 14.6"
6	Banyga	S-1	Sh. Veeran Singh	Sh. Kalian Singh	OBC	24° 40' 20.5"	77° 39' 50.8"
7		S-2	Sh. Gopal Singh	Sh. Bhavani Singh	OBC	24° 40' 20.8"	77° 39' 54.0"
8		S-3	Sh. Ram Singh	Sh. Harnam Singh	OBC	24° 40' 20.2"	77° 39' 51.8"
9		S-4	Sh. Nand Lal	Sh. Neelam Singh	OBC	24° 40' 20.0"	77° 39' 54.2"
10		S-5	Sh. Harnam Singh	Sh. Kalian Singh	OBC	24° 40' 19.5"	77° 39' 52.8"
11	Diyadhari	S-1	Sh. Jagannath	Sh. Samarath	OBC	24° 38' 28.2"	77° 39' 39.1"
12		S-2	Sh. Mahendra Singh	Sh. Parmal Singh	OBC	24° 38' 27.1"	77° 39' 43.0"
13		S-3	Sh. Parvet Singh	Sh. Gore Lal	OBC	24° 38' 29.5"	77° 39' 38.6"
14		S-4	Sh. Sunil	Sh. Ram Dayal	OBC	24° 38' 28.8"	77° 39' 41.1"
15		S-5	Sh. Gopal Singh	Sh. Kalian Singh	OBC	24° 38' 27.9"	77° 39' 42.2"
16	Ratikheda	S-1	Sh. Sultan Singh	Sh. Nand Lal	OBC	24° 35' 57.5"	77° 40' 12.8"
17		S-2	Sh. Ram Kumar	Sh. Kok Singh	OBC	24° 35' 56.5"	77° 40' 16.6"
18		S-3	Sh. Bundle Singh	Sh. Deman Singh	OBC	24° 35' 57.1"	77° 40' 15.8"
19		S-4	Sh. Jigdesh	Sh. Divan Singh	OBC	24° 35' 56.9"	77° 40' 15.0"
20		S-5	Smt. Ram Kumara	Sh. Sultan Singh	OBC	24° 35' 57.3"	77° 40' 13.6"
21	**Ashoknagar**	S-1	Sh. Balveer	Sh. Hansraj	Gen	24° 35' 27.9"	77° 43' 35.7"
22		S-2	Sh. Sanboo	Sh. Hansraj	Gen	24° 35' 27.8"	77° 43' 35.2"
23		S-3	Sh. Ram Kumar	Sh. Bansi Lal	Gen	24° 35' 28.1"	77° 43' 27.9"
24		S-4	Sh. Deepak	Sh. Narayan Das	Gen	24° 35' 28.5"	77° 43' 30.4"
25		S-5	Sh. Annop Kumar	Sh. Kedar Nath	Gen	24° 35' 29.4"	77° 43' 33.6"

Appendix- V : General information of soil samples of Sadora block of Ashoknagar district

S. No.	Village name	Sample No.	Farmer Name	Father Name	Cast	Latitude	Longitude
1	**Kherai**	S-1	Sh. Ram Krishna	Sh. Neelam Singh	OBC	24° 37' 40.8"	77° 37' 29.7"
2		S-2	Sh. Neelam Singh	Sh. Sukh Lal	OBC	24° 37' 42.1"	77° 37' 34.2"
3		S-3	Sh. Raju	Sh. Kisan Lal	OBC	24° 37' 44.2"	77° 37' 28.8"
4		S-4	Sh. Girriraj	Sh. Neelam Singh	OBC	24° 37' 41.6"	77° 37' 32.1"
5		S-5	Sh. Rajendra Singh	Sh. Neelam Singh	OBC	24° 37' 40.8"	77° 37' 29.1"
6	Bamuria	S-1	Sh. Krishna	Sh. Bhagirath	SC	24° 37' 06.6"	77° 38' 15.2"
7		S-2	Sh. Babu Lal	Sh. Kasturba	SC	24° 36' 48.1"	77° 38' 17.4"
8		S-3	Sh. Dinesh	Sh. Shera	SC	24° 37' 48.7"	77° 38' 11.3"
9		S-4	Sh. Jagdesh	Sh. Raghuver Singh	SC	24° 37' 07.0"	77° 38' 12.5"
10		S-5	Sh. Khalak Singh	Sh. Lal Shab	OBC	24° 36' 48.6"	77° 38' 16.4"
11	Parwai	S-1	Sh. Ram Kuwar	Sh. Udham Singh	OBC	24° 41' 20.4"	77° 37' 20.3"
12		S-2	Sh. Captan Singh	Sh. Balwant Singh	OBC	24° 41' 20.8"	77° 37' 19.8"
13		S-3	Sh. Vijay Singh	Sh. Gujraj Singh	OBC	24° 41' 19.1"	77° 37' 18.3"
14		S-4	Sh. Ram Singh	Sh. Moti Singh	OBC	24° 41' 19.3"	77° 37' 19.0"
15		S-5	Sh. Jasrath Singh	Sh. Ranjeet Singh	OBC	24° 41' 19.9"	77° 37' 20.4"
16	Gugor	S-1	Sh. Kunja	Sh. Shoba Ram	SC	24° 36' 28.2"	77° 39' 13.3"
17		S-2	Sh. Pranu	Sh. Kok Singh	SC	24° 36' 33.2"	77° 39' 18.0"
18		S-3	Sh. Such Lal	Sh. Soma Singh	SC	24° 36' 33.6"	77° 39' 17.4"
19		S-4	Sh. Suresh	Sh. Bahavra	SC	24° 36' 31.1"	77° 39' 15.6"
20		S-5	Sh. Ramesh	Sh. Ramdeen	SC	24° 36' 30.7"	77° 39' 14.6"
21	**Bagulya**	S-1	Sh. Bajrangi Lal	Sh. Prem Singh	OBC	24° 38' 20.2"	77° 41' 54.0"
22		S-2	Sh. Virendra Singh	Sh. Ashoksingh	OBC	24° 38' 19.8"	77° 41' 54.6"
23		S-3	Sh. Tirlok Singh	Sh. Ranjeet Singh	OBC	24° 38' 20.7"	77° 41' 55.5"
24		S-4	Sh. Amar Singh	Sh. Bhujwal Singh	OBC	24° 38' 21.0"	77° 41' 56.4"
25		S-5	Sh. Pran Singh	Sh. Rameshwar Singh	OBC	24° 38' 21.6"	77° 41' 54.2"

Appendix- I (A) : Value of important soil parameters of Mungaoli block of Ashoknagar district

S. No.	Village name	Sample No.	pH	EC (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Sand (%)	Silt (%)	Clay (%)
1	**Aathaikheda**	S-1	7.90	0.48	0.456	1.50	45.0	23.8	31.2
2		S-2	8.00	0.39	0.520	2.00	45.8	22.4	31.8
3		S-3	8.10	0.47	0.365	2.50	45.8	22.4	31.8
4		S-4	8.30	0.51	0.348	2.50	46.1	21.9	32.0
5		S-5	8.20	0.49	0.412	2.00	44.0	18.5	37.5
6	Bilakhedi	S-1	8.60	0.45	0.268	3.00	50.7	14.1	35.2
7		S-2	8.00	0.37	0.385	2.50	50.7	14.1	35.2
8		S-3	8.30	0.39	0.415	1.50	51.0	13.6	35.4
9		S-4	8.10	0.48	0.255	2.00	51.3	13.1	35.6
10		S-5	8.20	0.51	0.258	2.00	51.8	12.2	36.0
11	Mudrakhana	S-1	8.10	0.38	0.270	1.50	45.6	15.8	38.6
12		S-2	7.90	0.48	0.289	1.00	45.3	16.3	38.4
13		S-3	8.10	0.39	0.525	2.50	45.0	16.8	38.2
14		S-4	8.10	0.41	0.319	2.00	44.7	17.3	38.0
15		S-5	7.60	0.38	0.528	1.00	46.3	14.6	39.1
16	Chamrai	S-1	8.20	0.61	0.315	1.50	48.5	15.3	36.2
17		S-2	8.10	0.51	0.282	1.00	47.4	14.1	38.5
18		S-3	8.00	0.44	0.396	1.50	48.2	13.8	38.0
19		S-4	7.90	0.39	0.525	0.50	45.6	15.8	38.6
20		S-5	8.00	0.48	0.432	1.50	46.9	20.5	32.6
21	**Shyampur**	S-1	7.80	0.43	0.488	1.50	48.2	18.3	33.5
22		S-2	7.60	0.32	0.547	1.00	49.2	16.6	34.2
23		S-3	7.80	0.37	0.425	1.00	47.8	19.0	33.2
24		S-4	8.40	0.41	0.385	2.50	47.2	20.0	32.8
25		S-5	7.20	0.52	0.452	2.00	48.4	18.0	33.6
Minimum			**7.20**	**0.32**	**0.255**	**0.5**	**44.0**	**12.2**	**31.2**
Maximum			**8.60**	**0.61**	**0.547**	**3.0**	**51.8**	**23.8**	**39.1**
Average			**8.02**	**0.44**	**0.394**	**1.7**	**47.5**	**17.1**	**35.4**

Appendix- I (B) : Soil fertility status of Mungaoli block of Ashoknagar district

S. No.	Village name	Sample No.	Available nutrients (kg ha^{-1})			Available S (mg kg^{-1})	Available micro-nutrients (mg kg^{-1})			
			N	P	K		Zn	Cu	Fe	Mn
1	**Aathaikheda**	S-1	195.3	14.53	408.5	16.07	0.55	0.44	5.67	3.73
2		S-2	288.4	21.03	306.9	22.11	0.70	0.38	4.89	3.22
3		S-3	186.2	10.61	420.0	16.69	0.42	0.29	5.22	3.43
4		S-4	172.6	16.19	305.2	12.36	0.36	0.37	4.77	3.14
5		S-5	203.5	18.07	275.5	12.13	0.52	0.88	11.33	7.46
6	Bilakhedi	S-1	235.4	5.79	200.5	12.56	0.38	0.41	5.28	3.47
7		S-2	216.4	17.84	314.7	16.71	0.45	0.35	5.32	3.50
8		S-3	241.2	13.22	493.9	5.20	0.55	0.65	8.37	5.51
9		S-4	256.3	7.28	294.2	17.25	0.36	0.41	5.28	6.50
10		S-5	188.6	9.39	226.8	4.36	0.28	0.25	3.22	2.12
11	Mudrakhana	S-1	165.2	14.84	303.5	15.60	0.44	0.65	8.37	5.51
12		S-2	224.2	6.90	390.9	7.56	0.29	0.22	5.30	3.49
13		S-3	286.2	14.62	480.5	16.94	0.55	0.35	6.22	4.09
14		S-4	188.6	16.80	317.0	7.65	0.88	0.48	6.18	4.69
15		S-5	214.3	21.65	376.3	20.87	0.75	0.88	11.33	7.46
16	Chamrai	S-1	184.2	11.43	411.0	18.42	0.45	0.65	8.37	5.51
17		S-2	255.2	5.42	255.2	12.14	0.40	0.41	3.28	2.16
18		S-3	196.2	10.40	384.2	21.54	0.66	0.56	7.21	4.75
19		S-4	224.2	20.25	483.8	22.56	0.75	0.72	9.27	6.10
20		S-5	214.2	7.62	482.7	18.51	0.68	0.44	5.67	4.88
21	**Shyampur**	S-1	187.2	10.35	322.6	6.60	0.69	0.58	7.47	4.92
22		S-2	231.2	13.52	455.6	5.67	0.78	0.42	8.44	5.55
23		S-3	225.2	8.45	412.2	10.56	0.52	0.62	7.99	5.25
24		S-4	246.2	6.86	312.4	10.22	0.44	0.48	6.18	4.07
25		S-5	278.5	12.01	402.8	7.78	0.64	0.65	8.37	7.25
Minimum			**165.2**	**5.42**	**200.5**	**4.36**	**0.28**	**0.22**	**3.22**	**2.12**
Maximum			**288.4**	**21.65**	**493.9**	**22.56**	**0.88**	**0.88**	**11.33**	**7.46**
Average			**220.2**	**12.60**	**361.5**	**13.52**	**0.54**	**0.50**	**6.76**	**4.71**

Appendix-II (A) : Value of important soil parameters of Chanderi block of Ashoknagar district

S. No.	Village name	Sample No.	pH	EC (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Sand (%)	Silt (%)	Clay (%)
1	**Barodiya**	S-1	8.60	0.42	0.425	3.50	53.0	10.2	36.8
2		S-2	7.20	0.39	0.615	0.50	52.4	11.2	36.4
3		S-3	7.90	0.43	0.531	1.00	52.6	10.9	36.5
4		S-4	7.30	0.42	0.715	1.50	52.4	11.2	36.4
5		S-5	8.00	0.37	0.615	2.00	53.0	10.2	36.8
6	Sangampur	S-1	8.60	0.44	0.385	2.50	41.2	30.2	28.6
7		S-2	8.20	0.47	0.225	1.50	40.2	31.9	27.9
8		S-3	8.40	0.53	0.285	1.50	40.6	31.2	28.2
9		S-4	8.00	0.39	0.525	1.50	40.5	31.4	28.1
10		S-5	7.80	0.48	0.315	2.00	39.7	32.7	27.6
11	Tarai	S-1	8.10	0.45	0.588	2.00	55.0	6.8	38.2
12		S-2	8.10	0.41	0.396	1.50	52.8	10.5	36.7
13		S-3	8.00	0.53	0.525	2.00	55.3	6.3	38.4
14		S-4	8.30	0.41	0.428	2.50	55.6	5.8	38.6
15		S-5	7.90	0.47	0.488	1.50	55.3	6.3	38.4
16	Mohalichak	S-1	8.00	0.38	0.214	2.00	53.9	8.7	37.4
17		S-2	8.20	0.56	0.458	2.50	54.1	8.3	37.6
18		S-3	8.40	0.42	0.454	2.50	54.1	8.3	37.6
19		S-4	7.90	0.49	0.524	1.50	54.0	8.5	37.5
20		S-5	7.60	0.45	0.356	1.00	53.6	9.2	37.2
21	**Salona**	S-1	7.20	0.52	0.452	0.50	45.2	14.6	40.2
22		S-2	7.90	0.43	0.525	1.50	44.6	14.6	40.8
23		S-3	8.20	0.45	0.622	2.00	43.8	14.6	41.6
24		S-4	7.80	0.38	0.412	2.50	45.7	13.7	40.6
25		S-5	8.40	0.44	0.358	2.50	46.8	12.2	41.0
Minimum			**7.20**	**0.37**	**0.214**	**0.5**	**39.7**	**5.8**	**27.6**
Maximum			**8.60**	**0.56**	**0.715**	**3.5**	**55.6**	**32.7**	**41.6**
Average			**8.00**	**0.45**	**0.457**	**1.8**	**49.4**	**14.4**	**36.2**

Appendix-II (B) : Soil fertility status of Chanderi block of Ashoknagar district

S. No.	Village name	Sample No.	Available nutrients (kg ha^{-1})			Available S (mg kg^{-1})	Available micro-nutrients (mg kg^{-1})			
			N	P	K		Zn	Cu	Fe	Mn
1	**Barodiya**	S-1	253.4	7.52	416.6	7.55	0.52	0.44	5.67	3.73
2		S-2	202.4	22.88	284.5	18.55	0.94	0.85	10.95	7.20
3		S-3	242.1	16.66	381.9	17.13	0.75	0.58	7.47	4.92
4		S-4	326.4	31.80	370.7	18.45	1.08	0.44	13.40	8.81
5		S-5	278.6	11.76	364.0	23.49	0.89	0.76	9.79	6.44
6	Sangampur	S-1	188.6	6.66	474.9	8.04	0.52	0.84	5.67	3.73
7		S-2	234.1	5.29	255.6	6.95	0.38	0.28	3.61	2.37
8		S-3	164.2	6.60	269.5	11.00	0.40	0.66	3.88	2.55
9		S-4	225.6	10.47	364.0	24.51	0.48	0.47	6.05	3.98
10		S-5	172.6	9.29	404.3	10.18	0.32	0.65	8.37	5.51
11	Tarai	S-1	255.2	15.51	320.3	16.76	0.44	0.73	9.40	6.19
12		S-2	196.2	13.16	330.4	16.05	0.72	0.55	7.08	4.66
13		S-3	224.2	9.30	394.2	12.98	0.44	0.65	8.37	5.51
14		S-4	214.2	10.60	404.3	7.65	0.88	0.49	6.31	6.24
15		S-5	230.6	6.85	416.6	11.16	0.65	0.52	6.70	4.41
16	Mohalichak	S-1	231.2	6.22	218.6	8.56	0.18	0.33	4.25	2.80
17		S-2	172.5	9.30	506.2	17.55	0.66	0.58	7.47	4.92
18		S-3	241.2	15.49	463.7	14.64	0.45	0.62	7.99	5.25
19		S-4	196.2	19.61	482.7	14.44	0.74	0.44	5.67	3.73
20		S-5	165.2	10.45	442.4	7.91	0.51	0.33	5.72	3.76
21	**Salona**	S-1	214.2	11.87	353.9	15.22	0.64	0.42	8.44	5.55
22		S-2	222.5	16.25	378.6	16.76	0.72	0.88	11.33	7.46
23		S-3	312.5	18.38	319.2	18.82	1.25	0.62	7.99	5.25
24		S-4	244.6	9.22	325.9	17.71	0.77	0.49	6.31	4.15
25		S-5	216.8	6.72	356.2	19.73	0.48	0.38	5.14	3.38
Minimum			**164.2**	**5.29**	**218.6**	**6.95**	**0.18**	**0.28**	**3.61**	**2.37**
Maximum			**326.4**	**31.80**	**506.2**	**24.51**	**1.25**	**0.88**	**13.40**	**8.81**
Average			**225.0**	**12.31**	**372.0**	**14.47**	**0.63**	**0.56**	**7.32**	**4.90**

Appendix-III (A) : Value of important soil parameters of Isagarh block of Ashoknagar district

S. No.	Village name	Sample No.	pH	EC (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Sand (%)	Silt (%)	Clay (%)
1	**Korwas**	S-1	8.40	0.41	0.535	2.50	45.0	16.8	38.2
2		S-2	7.80	0.42	0.525	1.50	45.4	16.1	38.5
3		S-3	8.00	0.62	0.472	2.00	45.3	16.3	38.4
4		S-4	8.00	0.43	0.488	1.50	44.7	17.3	38.0
5		S-5	8.20	0.41	0.525	1.50	45.3	16.3	38.4
6	Kotharkhedi	S-1	8.10	0.39	0.388	1.50	49.2	16.6	34.2
7		S-2	8.20	0.42	0.288	1.00	49.7	15.8	34.5
8		S-3	8.00	0.41	0.585	2.00	50.7	14.1	35.2
9		S-4	7.90	0.45	0.525	1.50	49.0	17.0	34.0
10		S-5	8.30	0.49	0.515	2.50	50.1	15.1	34.8
11	Vijaypura	S-1	8.00	0.39	0.525	2.00	55.6	5.8	38.6
12		S-2	8.10	0.52	0.315	2.50	55.3	6.3	38.4
13		S-3	8.20	0.51	0.615	1.50	54.7	7.3	38.0
14		S-4	8.00	0.42	0.385	1.50	56.7	3.9	39.4
15		S-5	8.40	0.43	0.525	2.50	55.2	6.5	38.3
16	Pachlana	S-1	7.50	0.45	0.585	0.50	42.6	17.2	40.2
17		S-2	8.10	0.38	0.525	2.00	40.8	17.7	41.5
18		S-3	8.00	0.42	0.315	1.50	41.8	17.4	40.8
19		S-4	7.80	0.43	0.536	1.50	40.5	18.9	40.6
20		S-5	8.20	0.47	0.402	2.50	39.6	19.2	41.2
21	Bamnawar	S-1	7.60	0.61	0.465	1.50	54.0	8.5	37.5
22		S-2	7.80	0.53	0.388	1.50	54.1	8.3	37.6
23		S-3	7.90	0.44	0.456	2.00	54.4	7.8	37.8
24		S-4	7.80	0.49	0.482	2.00	54.7	7.3	38.0
25		S-5	7.80	0.43	0.488	1.50	55.0	6.8	38.2
Minimum			**7.50**	**0.38**	**0.288**	**0.5**	**39.6**	**3.9**	**34.0**
Maximum			**8.40**	**0.62**	**0.615**	**2.5**	**56.7**	**19.2**	**41.5**
Average			**8.00**	**0.45**	**0.474**	**1.8**	**49.2**	**12.8**	**38.0**

Appendix-III (B) : Soil fertility status of Isagarh block of Ashoknagar district

S. No.	Village name	Sample No.	Available nutrients (kg ha^{-1})			Available S (mg kg^{-1})	Available micro-nutrients (mg kg^{-1})			
			N	P	K		Zn	Cu	Fe	Mn
1	**Korwas**	S-1	234.8	10.58	478.2	17.02	0.88	0.82	10.56	8.35
2		S-2	266.2	16.13	463.7	13.47	0.74	0.66	8.50	5.59
3		S-3	214.6	8.01	388.4	7.98	0.66	0.45	5.80	3.81
4		S-4	196.2	9.83	416.6	15.11	0.78	0.38	6.88	4.53
5		S-5	235.2	15.49	367.4	17.18	0.75	0.80	10.30	6.78
6	Kotharkhedi	S-1	176.4	10.33	415.5	9.67	0.55	0.65	8.37	5.51
7		S-2	162.5	9.70	333.8	16.84	0.35	0.48	3.18	4.36
8		S-3	324.5	7.87	351.7	9.75	0.83	0.38	4.89	3.22
9		S-4	258.6	10.59	446.9	16.69	0.77	0.68	8.76	5.76
10		S-5	187.5	14.58	430.1	15.91	0.73	0.73	9.40	6.19
11	Vijaypura	S-1	206.5	7.35	364.0	13.78	0.75	0.96	12.36	8.14
12		S-2	192.3	9.42	474.9	9.13	0.36	0.96	5.80	3.81
13		S-3	302.3	10.58	509.6	17.20	0.44	0.48	13.91	9.15
14		S-4	192.4	11.74	312.5	21.67	0.72	0.44	5.67	3.73
15		S-5	254.2	9.21	427.8	19.62	0.75	0.65	8.37	5.51
16	Pachlana	S-1	182.0	25.87	374.1	22.09	0.83	0.72	11.52	5.68
17		S-2	202.2	11.87	357.3	7.36	0.75	0.65	8.37	5.51
18		S-3	164.8	9.29	304.6	14.80	0.45	0.90	5.67	3.73
19		S-4	274.2	10.58	303.5	17.85	0.88	0.62	7.99	5.25
20		S-5	255.2	11.84	437.9	9.22	0.57	0.48	6.18	6.48
21	Bamnawar	S-1	158.2	16.80	495.0	14.38	0.66	0.56	7.21	4.75
22		S-2	185.2	13.17	462.6	27.44	0.55	0.38	4.89	6.44
23		S-3	204.5	9.30	429.0	16.58	0.65	0.44	5.67	3.73
24		S-4	235.2	10.98	365.1	15.73	0.68	0.56	7.21	4.75
25		S-5	222.8	10.13	340.5	3.95	0.69	0.38	6.12	5.25
Minimum			**158.2**	**7.35**	**303.5**	**3.95**	**0.35**	**0.38**	**3.18**	**3.22**
Maximum			**324.5**	**25.87**	**509.6**	**27.44**	**0.88**	**0.96**	**13.91**	**9.15**
Average			**219.5**	**11.65**	**402.0**	**14.82**	**0.67**	**0.61**	**7.74**	**5.44**

Appendix-IV (A) : Value of important soil parameters of Ashoknagar block of Ashoknagar district

S. No.	Village name	Sample No.	pH	EC (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Sand (%)	Silt (%)	Clay (%)
1	**Mau**	S-1	8.00	0.45	0.288	2.50	44.9	13.5	41.6
2		S-2	8.10	0.42	0.396	2.00	43.3	15.5	41.2
3		S-3	8.20	0.44	0.225	2.50	45.6	12.8	41.6
4		S-4	8.30	0.45	0.358	2.50	48.0	11.0	41.0
5		S-5	8.10	0.46	0.488	2.00	45.8	11.8	42.4
6	Banyga	S-1	8.00	0.42	0.525	1.50	45.6	15.8	38.6
7		S-2	8.20	0.48	0.588	2.00	44.0	18.5	37.5
8		S-3	8.00	0.38	0.396	1.50	44.7	17.3	38.0
9		S-4	8.10	0.51	0.525	2.00	44.1	18.3	37.6
10		S-5	8.00	0.45	0.525	2.00	45.0	16.8	38.2
11	Diyadhari	S-1	8.10	0.40	0.488	2.50	54.0	8.5	37.5
12		S-2	8.40	0.38	0.525	3.00	54.4	7.8	37.8
13		S-3	8.00	0.41	0.258	1.50	53.0	10.2	36.8
14		S-4	8.10	0.45	0.365	2.00	53.3	9.7	37.0
15		S-5	8.10	0.41	0.348	1.50	53.9	8.7	37.4
16	Ratikheda	S-1	7.80	0.46	0.548	1.50	38.3	21.2	40.5
17		S-2	8.20	0.39	0.512	2.00	39.9	18.5	41.6
18		S-3	8.50	0.53	0.555	2.50	38.8	20.4	40.8
19		S-4	7.60	0.47	0.482	0.50	39.0	20.0	41.0
20		S-5	8.00	0.39	0.588	1.00	39.3	19.5	41.2
21	**Ashoknagar**	S-1	8.20	0.40	0.388	1.50	45.1	23.6	31.3
22		S-2	8.40	0.42	0.525	2.50	46.9	20.5	32.6
23		S-3	8.00	0.39	0.512	1.00	45.9	22.2	31.9
24		S-4	7.80	0.45	0.465	1.50	45.2	23.4	31.4
25		S-5	8.10	0.61	0.388	2.00	44.5	24.6	30.9
Minimum			**7.60**	**0.38**	**0.225**	**0.5**	**38.3**	**7.8**	**30.9**
Maximum			**8.50**	**0.61**	**0.588**	**3.0**	**54.4**	**24.6**	**42.4**
Average			**8.09**	**0.44**	**0.450**	**1.9**	**45.7**	**16.4**	**37.9**

Appendix-IV (B) : Soil fertility status of Ashoknagar block of Ashoknagar district

S. No.	Village name	Sample No.	Available nutrients (kg ha^{-1})			Available S (mg kg^{-1})	Available micro-nutrients (mg kg^{-1})			
			N	P	K		Zn	Cu	Fe	Mn
1	**Mau**	S-1	296.2	9.42	248.5	17.13	0.32	0.74	5.09	3.35
2		S-2	194.5	11.88	312.6	20.82	0.72	0.55	7.08	4.66
3		S-3	247.2	9.21	304.6	9.29	0.44	0.80	3.86	2.54
4		S-4	188.4	10.58	347.9	19.44	0.51	0.38	4.89	3.22
5		S-5	212.2	9.39	427.8	6.54	0.69	0.49	6.31	4.15
6	Banyga	S-1	258.6	11.79	385.6	14.55	0.77	0.55	7.08	4.66
7		S-2	274.2	18.65	341.6	16.69	1.08	1.02	7.99	5.25
8		S-3	196.2	13.18	351.7	26.44	0.41	0.44	5.67	6.58
9		S-4	245.6	9.22	420.0	21.31	0.75	0.86	11.08	7.29
10		S-5	232.5	16.55	426.7	14.42	0.81	0.35	4.51	4.88
11	Diyadhari	S-1	202.1	10.60	395.4	18.98	0.66	0.44	5.67	3.73
12		S-2	205.6	21.50	474.9	21.33	0.86	0.53	6.83	4.49
13		S-3	176.2	10.50	317.0	14.55	0.24	0.80	3.61	2.37
14		S-4	245.2	9.39	342.7	19.73	0.52	0.39	5.02	3.31
15		S-5	196.2	10.47	371.8	7.78	0.49	0.44	5.67	3.73
16	Ratikheda	S-1	265.2	11.92	440.2	24.98	0.78	0.65	8.37	5.51
17		S-2	234.2	9.91	478.2	17.38	0.73	0.72	9.27	6.10
18		S-3	222.5	17.69	401.0	8.45	0.79	0.62	7.99	5.25
19		S-4	226.4	9.20	370.7	19.80	0.68	0.44	5.67	3.73
20		S-5	245.2	10.57	488.5	5.27	0.83	0.33	8.11	8.65
21	**Ashoknagar**	S-1	196.2	10.59	325.9	28.56	0.55	0.94	5.67	3.73
22		S-2	265.2	10.22	408.8	14.60	0.75	0.86	11.08	7.29
23		S-3	234.2	8.02	415.5	8.88	0.73	0.44	5.67	3.73
24		S-4	222.5	9.71	483.8	40.25	0.76	0.72	9.27	6.10
25		S-5	215.6	13.58	441.3	9.85	0.55	0.68	5.02	6.58
Minimum			**176.2**	**8.02**	**248.5**	**5.27**	**0.24**	**0.33**	**3.61**	**2.37**
Maximum			**296.2**	**21.50**	**488.5**	**40.25**	**1.08**	**1.02**	**11.08**	**8.65**
Average			**227.9**	**11.75**	**388.9**	**17.08**	**0.66**	**0.61**	**6.66**	**4.84**

Appendix- V (A) : Value of important soil parameters of Sadora block of Ashoknagar district

S. No.	Village name	Sample No.	pH	EC (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Sand (%)	Silt (%)	Clay (%)
1	**Kherai**	S-1	7.70	0.59	0.315	1.50	40.8	30.9	28.3
2		S-2	7.90	0.43	0.385	1.50	39.7	32.7	27.6
3		S-3	8.00	0.48	0.525	2.00	40.6	31.2	28.2
4		S-4	8.40	0.42	0.285	2.50	39.7	32.7	27.6
5		S-5	8.10	0.45	0.388	2.00	40.3	31.7	28.0
6	Bamuria	S-1	7.80	0.48	0.315	1.50	36.6	38.0	25.4
7		S-2	7.30	0.52	0.606	0.50	50.7	14.1	35.2
8		S-3	8.00	0.41	0.358	2.00	37.2	37.0	25.8
9		S-4	8.10	0.38	0.444	2.50	51.3	13.1	35.6
10		S-5	8.00	0.42	0.456	2.00	37.7	36.1	26.2
11	Parwai	S-1	7.60	0.45	0.358	1.50	41.6	29.5	28.9
12		S-2	8.00	0.47	0.325	2.00	41.2	30.2	28.6
13		S-3	8.30	0.43	0.488	2.50	44.1	25.3	30.6
14		S-4	8.00	0.40	0.376	2.00	46.7	13.9	39.4
15		S-5	8.10	0.39	0.388	2.00	43.8	25.8	30.4
16	Gugor	S-1	7.70	0.45	0.525	1.50	41.6	16.1	42.3
17		S-2	7.40	0.46	0.706	1.00	44.2	15.2	40.6
18		S-3	8.00	0.41	0.474	2.00	40.6	17.6	41.8
19		S-4	8.20	0.42	0.286	1.50	45.4	16.0	38.6
20		S-5	8.00	0.45	0.585	1.50	44.5	13.7	41.8
21	**Bagulya**	S-1	7.60	0.46	0.525	1.00	48.6	22.8	28.6
22		S-2	8.30	0.43	0.315	2.50	50.3	21.7	28.0
23		S-3	7.80	0.52	0.555	1.50	47.3	23.3	29.4
24		S-4	7.90	0.44	0.328	1.00	51.8	19.2	29.0
25		S-5	7.80	0.46	0.488	1.50	50.9	20.7	28.4
Minimum			**7.30**	**0.38**	**0.285**	**0.5**	**36.6**	**13.1**	**25.4**
Maximum			**8.40**	**0.59**	**0.706**	**2.5**	**51.8**	**38.0**	**42.3**
Average			**7.92**	**0.45**	**0.432**	**1.7**	**43.9**	**24.3**	**31.8**

Appendix- V (B) : Soil fertility status of Sadora block of Ashoknagar district

S. No.	Village name	Sample No.	Available nutrients (kg ha^{-1})			Available S (mg kg^{-1})	Available micro-nutrients (mg kg^{-1})			
			N	P	K		Zn	Cu	Fe	Mn
1	**Kherai**	S-1	202.3	9.83	316.5	6.82	0.85	0.48	6.18	4.07
2		S-2	192.4	10.63	429.0	15.11	0.55	0.65	8.37	5.51
3		S-3	254.2	11.93	471.5	16.47	0.75	1.04	6.31	4.15
4		S-4	182.0	6.86	318.1	26.55	0.38	0.74	7.08	4.66
5		S-5	202.2	8.95	360.6	4.62	0.55	0.76	3.35	2.20
6	Bamuria	S-1	164.8	10.26	337.1	13.36	0.45	0.78	4.89	3.22
7		S-2	208.6	20.55	575.2	15.58	0.86	0.42	11.85	7.80
8		S-3	196.2	15.56	381.9	7.42	0.51	0.46	5.92	3.90
9		S-4	224.2	11.48	403.2	8.88	0.63	0.86	11.08	7.29
10		S-5	196.2	9.57	437.9	15.60	0.65	0.46	5.92	3.90
11	Parwai	S-1	230.6	8.66	351.7	9.96	0.51	0.55	7.08	4.66
12		S-2	176.4	10.47	302.5	11.78	0.46	0.48	6.18	4.07
13		S-3	231.2	9.40	406.8	19.52	0.69	0.62	7.99	5.25
14		S-4	202.3	17.44	365.4	9.95	0.53	0.84	4.89	4.68
15		S-5	182.2	10.69	332.6	18.04	0.55	0.54	6.96	4.58
16	Gugor	S-1	185.2	11.92	361.8	18.55	0.75	0.68	8.76	5.76
17		S-2	288.6	28.56	525.5	16.36	1.58	0.44	15.32	10.08
18		S-3	224.5	16.20	366.2	8.32	0.67	0.35	4.51	4.22
19		S-4	172.2	11.82	256.4	15.53	0.27	0.66	3.35	2.20
20		S-5	247.2	15.25	476.0	17.42	0.83	0.67	8.63	5.68
21	**Bagulya**	S-1	232.2	10.67	461.4	11.34	0.75	0.38	7.60	5.00
22		S-2	188.4	11.79	429.0	18.42	0.45	0.46	5.92	3.90
23		S-3	234.2	9.40	464.8	19.42	1.04	0.73	9.40	6.19
24		S-4	202.6	10.89	506.2	9.96	0.47	0.43	5.54	3.64
25		S-5	235.2	14.00	453.6	7.92	0.69	0.55	7.08	4.66
Minimum			**164.8**	**6.86**	**256.4**	**4.62**	**0.27**	**0.35**	**3.35**	**2.20**
Maximum			**288.6**	**28.56**	**575.2**	**26.55**	**1.58**	**1.04**	**15.32**	**10.08**
Average			**210.2**	**12.51**	**403.6**	**13.72**	**0.66**	**0.60**	**7.21**	**4.85**

VITA

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Academic qualifications

Sr. No.	Name of degree Awarded	Year in which obtained	Division/ Class	Name of awarding university	Subjects
1.	SSC	2004	IInd	M. P. State Board	Math, Science, Social Science
2.	HSC	2006	IInd	M. P. State Board	Agriculture
3.	B. Sc (Ag.)	2012	Ist	R.V.S.K.V.V. Gwalior	Agriculture
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