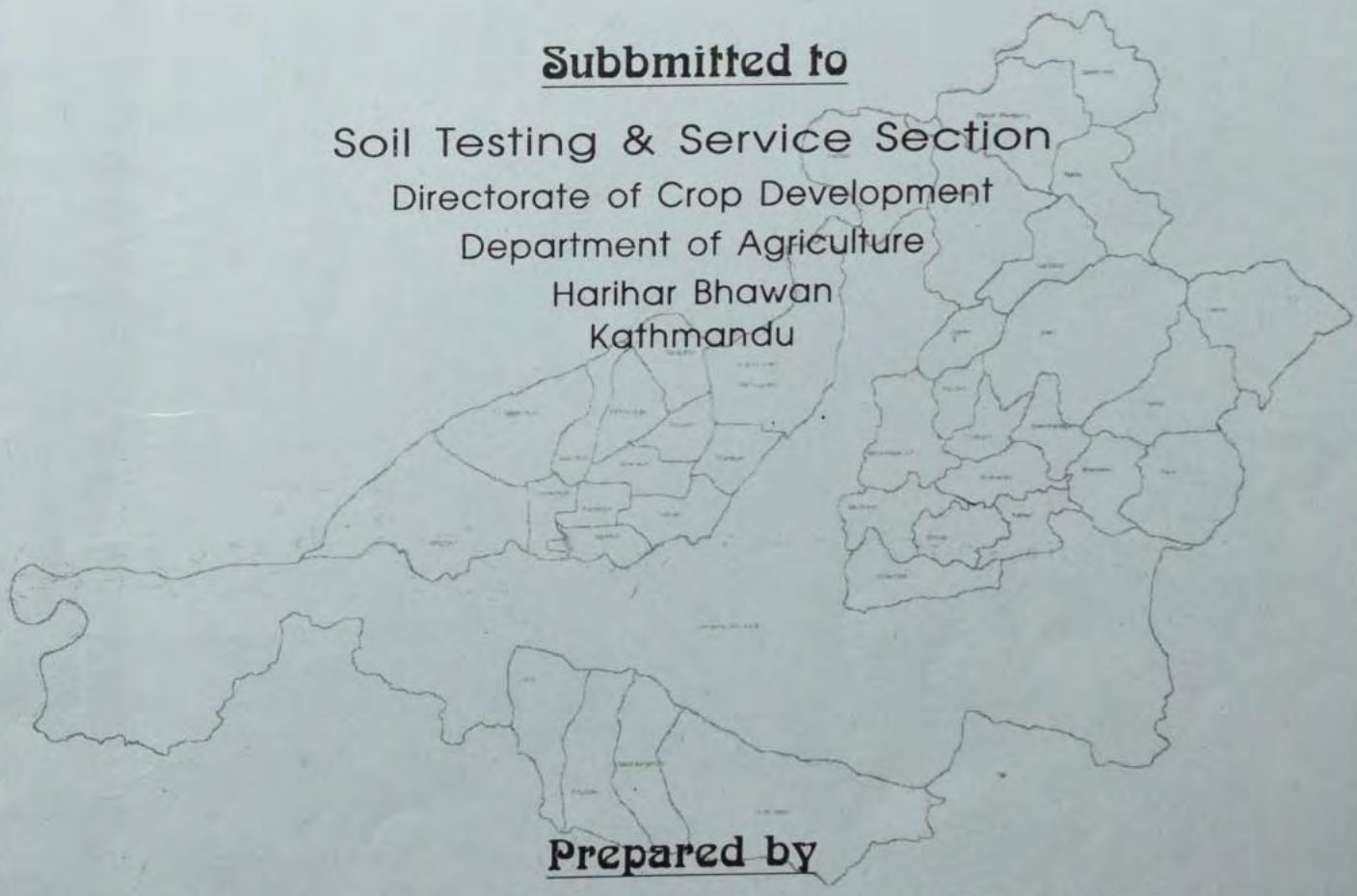
Soil Fertility Map of Chitwan Irrigation and East Rapti Irrigation Command Area of Chitwan District



Subbmitted to

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Soil Fertility Status of Chitwan District

With agriculture as the mainstay of the national economy, Nepal is basically an agricultural country. Since the inception of five year plans this sector has been getting priorities and accordingly within the past decades government institutional supports have increased remarkably, as a result of which areas under irrigation, improved seeds and use of chemical fertilizers seem to have increased significantly as well. Despite these efforts, the productivity trend of major crops seem to be far from being impressive as in most crops it has remained almost stagnant and in some cases it has shown even decreasing trend and as a result once food grain exporting country is slowly turning to be a food grain importing one. This indicates, perhaps, to the growing need to comprehensibly understand the natural resource base (soil resources) as it provides the vital medium for plant growth and stores and supplies them with the nutrients essential for their growth. Hence a comprehensive understanding and information of the physico-chemical characteristics of the vital nonrenewable natural base (Soil) becomes imperative for planning and implementing any sustainable agricultural development activities. This seems to have been fully realized by concerned development institutions. Soil Testing and Service Section (STSS) of the Department of Agriculture has already initiated activities to conduct soil fertility survey works and map and document fertility status of soils at the district level. As per the annual program of this fiscal year Chitwan district has been surveyed to assess and prepare soil fertility status maps of the district.

1. GENERAL INTRODUCTION OF THE SURVEY AREA

Located between 27 ^{0} 27' north latitude and 83^{0} 53' to 85^{0} 27' east longitude, Chitwan is one of the districts in the central development region. The district is bounded in the east, by parts of Makwanpur and Parsa districts; in the west by parts of Nawalparasi and Tanahun districts and in the north by parts of Dhading and Tanahun districts and in the south by parts of Bihar state of India. The district has 2218 sq. km area. The elevation above sea level ranges from 244 to 1945 meters. According to the population census of 1991 the district has a total population of 354488 out of which 175656 are male and 178832 are female. It has 65147 households with an average family size of 5.4. The population density per square kilometer is159.8. The district head quarter is Bharatpur.

1.1 Climate

Influenced by diverse topography and elevation the district has diverse climate sub tropical to cool temperate. However major parts of the district have hot and humid subtropical climate while the northern higher altitude mountainous areas have warm to cool temperate climate. According to the meteorological records of Rampur agriculture station situated at an elevation of 228m above mean sea level which

represents major areas of the district, monthly mean maximum temperature range from 22 degree in January and about 35 degree Celsius in April while monthly mean minimum temperature range from 8 degree Celsius in the month of January to about 25 degree Celsius in April. The district receives an annual rainfall of 2393 mm about 99 % of which falls within 5 active monsoon months (June - October)

Figure 1 Maximum and minimum temperature during different months.

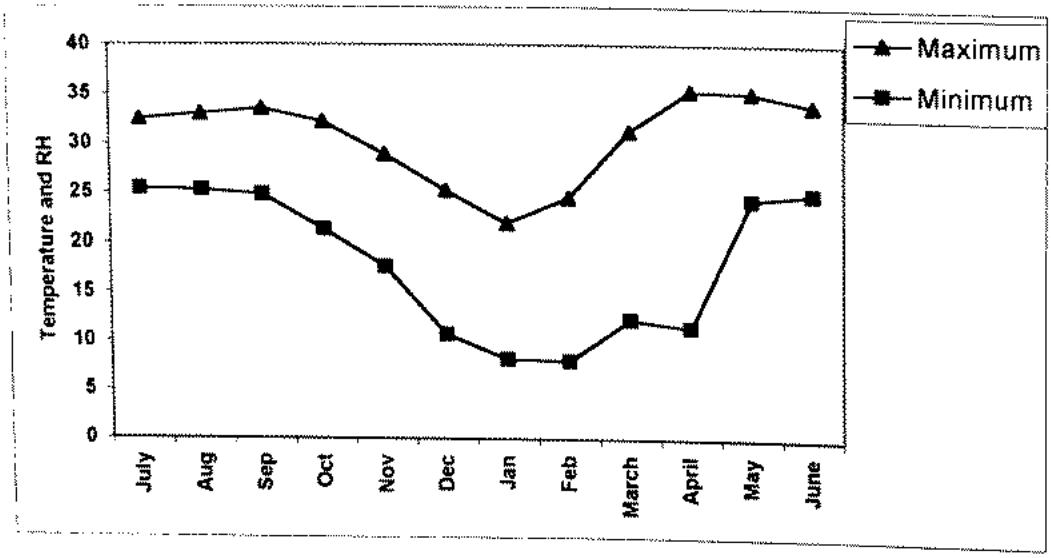


Figure 2 Rainfall distribution pattern of Chitwan district.

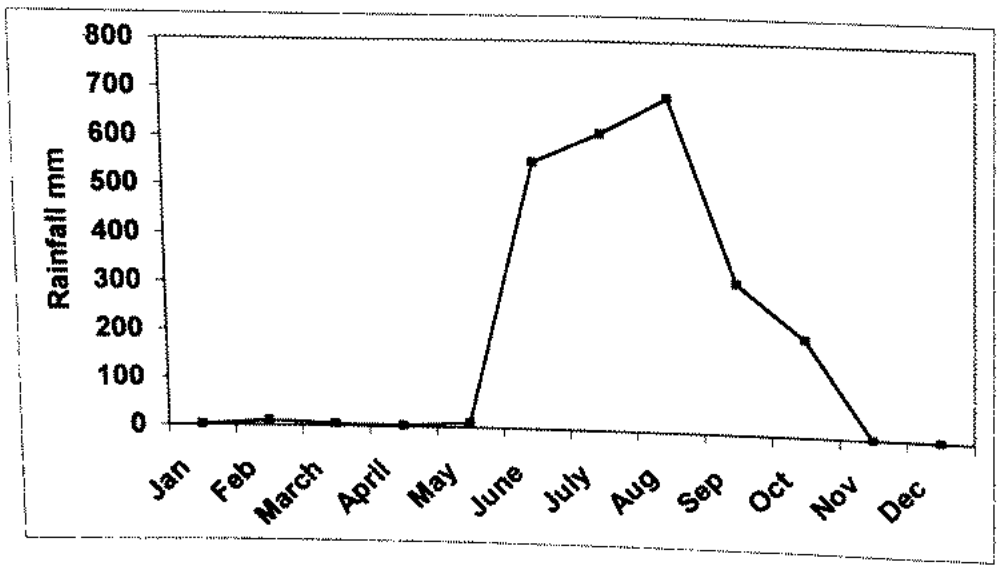


Table 1. Meteorological records of Rampur Agriculture Station (27^0 40' N, latitude; 84^0 19' E longitude)

Month (1999/2000)	rainfall (mm)	Max. temp (° Celsius)	min. temp (° Celsius)	Rel. humidity (%)
July	611.4	32.5	25.4	86
August	686.6	33	25.3	86
September	312.4	33.5	24.8	90
October	202.1	32.2	21.3	86
November	0.2	28.9	17.6	91
December	0	25.3	10.7	100
January	0.8	22	8.2	98.5
February	9.8	24.6	8	91.7
March	4.9	31.3	12.2	74.2
April	2.4	35.4	11.4	63.6
May	10.5	35.2	24.4	76.8
June	551.9	34	25	82.7
Total	2393			

1.2 Agriculture and present land use

The district has a total area of 220500 hectare of which 57330 ha. is under agricultural land and rest 163170 ha under grazing , forest and others GIS Unit, PDDP NEP/95/008, 1999). Paddy, Maize, wheat, Oilseeds, Potato and Mustard are the major crops grown in the district. The table and figures below show the productivity of these major crops and their trend over the last one-decade.

Table 2. Productivity of major field crops from 1988/89 to 1997/98

Year	Yield kg/ha					
	Rice	Wheat	Maize	Millet	Mustard	Potato
1988/89	2700	1600	1794	1099	540	11587
1989/90	2764	1651	1984	1173	600	13235
1990/91	3296	1660	2109	1157	621	13912
1991/92	3161	1696	1810	1143	616	11845
1992/93	2900	1700	1737	1171	590	10493
1993/94	2842	1605	1958	1034	600	10564
1994/95	2482	1662	2046	1045	599	10654
1995/96	2615	1850	2071	980	700	9500
1996/97	2631	1867	2088	1000	723	9495
1997/98	2598	1765	2115	970	656	8774

Figure 3 Productivity of major field crops from 1988/89-1997/98

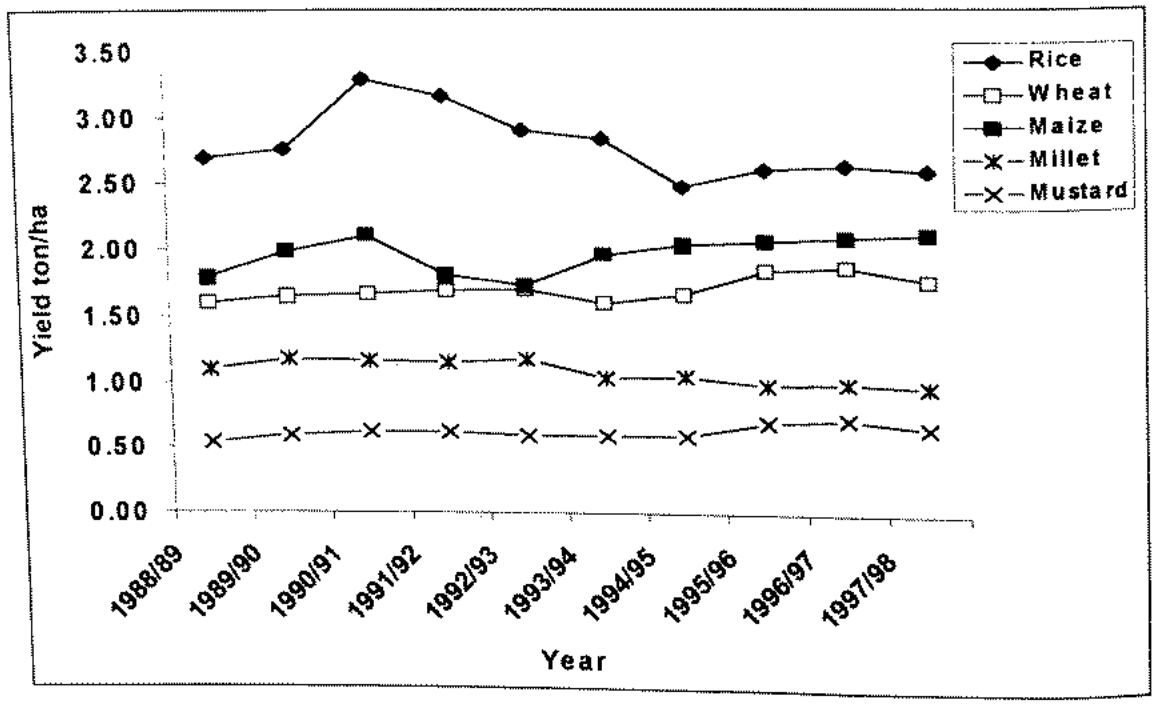
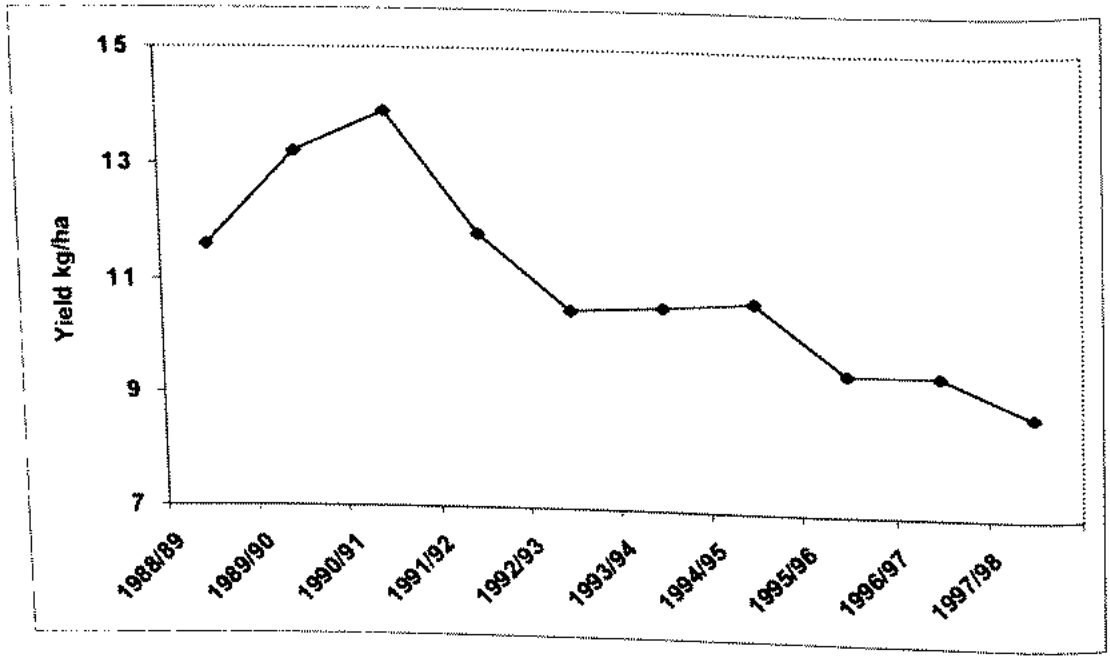


Figure 4 Productivity of potato from 1987/88-1997/98



1.3 Irrigation Facility

The district has a total irrigated area of 28614 ha out of which only12726 ha receives round the year irrigation facility, whereas 15648 ha area are only seasonally irrigated. The rest 240 ha is irrigated by shallow tube wells. 16017 ha area has rainfed agriculture. Narayani Lift, Khageri and Panchakanya irrigation system are managed by government agencies. The Kahgeri irrigation system is the oldest government manged system with a command area of 4900 ha. The Kahgeri system provides irrigation to Sivanagar, Gitanagar, Patihani, Jagatpur, Parbatipur, and sardanagar VDCs, Narayani lift irrigation system with the command area of 4700 ha provides irrigation to covers Bharatpur Municipality, Mangalpur, Phulbari, Gitanagar, and Shivnagar VDCs; and the Panchakanya system with the command area of 600 ha provides irrigation to Ratnanagar Municiapality.

Besides there are many farmers managed irrigation system especially in eastern Chitwan and Madi. The details of farmers managed irrigation canal in eastern part of Chitwan, their source and command area is presented in appendix 5.

1.4 Major Cropping Patterns of the district

Rice – Wheat - Maize
Rice – Fallow – Maize
Rice – Wheat – Fallow
Rice - fallow
Rice - Rice - fallow
Rice - Rice – Oil seed
Rice – Oil seed
Rice – Pulses
Rice- Mixed crops (winter)
Rice –Rice - Mixed crops (winter)
Rice / Mixed crops
Rice –Buckwheat - Maize
Maize/finger millet – fallow
Maize - fallow
Maize- Wheat – Other
Upland Rice- pulses
Maize – Pulses
Maize – Potato
Rice – pulses

2. OBJECTIVE

The main objective of the project is to assess the chemical characteristics of the soils of Chitwan district and prepare soil fertility map. The specific objectives are;

i. Conduct soil survey and collect soil samples from different representative locations
ii. Analyze the collected soil samples for soil reaction (pH), organic matter, total nitrogen, available phosphorus and potassium.
iii. Based on the soil reaction and nutrient status recommend sound and sustainable soil management practices
iv. Prepare soil fertility maps showing occurrence and distribution of soil reaction and major nutrient statuses in the district.

3. METHODOLOGY

3.1 Table work

Kenting earth science ltd. Canada under Land Resources Mapping Project (LRMP) in 1986 has prepared Land Systems Maps of the whole country. These maps show extent and distribution of different land systems and land types. These maps with physiographic details published at the scale of 1:50000 have been used as the base maps for conducting the field survey works. Prior to the actual fieldwork, tentative sampling sites were fixed on the base maps. These sampling sites were set and distributed in such a way that all the agriculturally important land system units are proportionately represented.

3.2 Field work

Following the sampling sites fixed in the base map, field works were conducted and surface soil samples were collected by using soil auger and packed in plastic sample bags with proper labels. The samples were collected only from the presently cultivated areas. The table below depicts the locations (VDCs, wards and villages) and the land systems units from where the samples were collected. In total 192 soil samples were collected. In order to make the field works and interpretation easier, the district was divided into four blocks viz.

i East Chitwan (north and east of National Park and south of Korak, Siddhi, Saktikhor and Dahakhani VDC)
ii West Chitwan (west of National Park and east of Narayani river)
iii Madi (southern cultivated area surrounded on the north and west by National Park, and on the south by India) and
iv Hills(north of East Chitwan).

Out of 192 samples collected, 74 (38.5%) were from West Chitwan, 34 (17.7%) were from Madi area, 59 (30.8%) were from East Chitwan and 25 (13%) were from Hills. Three survey teams were involved in conducting the field works and the scientists from the Soil Testing and Services Section of the Department of Agriculture regularly monitored them. After the completion of the field works these auger-boring locations were geographically linked with the digitized land systems map of the district.

3.3 Laboratory work:

Soil samples received from the field were air dried first by spreading in shade. These air-dried samples were then crushed with a wooden pestle and mortar and sieved through 2-mm sieve. Part of the soil samples less than 2 mm diameter were again sieved through 0.2 mm sieve which were used for the determination of organic matter and total content. Following chemical properties were assessed using the standard laboratory methods

Soil reaction (pH): Soil reaction was determined by measuring 1: 1 Soil: Water suspension with the calibrated pH meter.

Organic matter: Organic matter content was determined by following modified Walkley- Black method.

Total Nitrogen: Total nitrogen was determined by micro Kjeldhal digestion method.

Available Phosphorus: Available phosphorus was determined by modified Olsen's bicarbonate method. This available phosphorus is expressed in P_2O_5 by using conversion factor.

Available Potash: Available potash was determined by extracting the sample with neutral ammonium acetate and the K content was determined by flame photometer. The available potassium is expressed in K_2O by using the conversion factor.

3.4 Data compilation and Mapping:

The laboratory data were linked with the corresponding auger points in the digitized land systems maps and soil reaction and nutrient status maps were prepared using GIS techniques. The soil reaction rating chart of the Soil Science Division of is as follow.

Soil Reaction class	pH
Extremely acid	<4.5
Strongly acid	4.5-5.2
Moderately acid	5.3-5.9
Slightly acid	6.0-6.5
Nearly neutral	6.6-7.0
Slightly alkaline	7.1-7.5
Moderately alkaline	7.6-8.3
Strongly alkaline	8.4-9.0
Extremely alkaline	>9.0

Note: Although this rating chart is widely accepted and used for interpreting the soil reaction status, in our project considering the difficulty in preparing map and limited number of sample only 6 category have been made viz

Strongly acidic	<4.5
Moderately acidic	4.6-5.5
Slightly acidic	5.6-6.5
Nearly neutral	6.6-7.5
Moderately alkaline	7.6-8.5
Strongly alkaline	>8.5

Nutrient Rating

Nutrient status	OM%	Total N %	Avail. P_2O_5 kg/ha	Avail. K_2O kg/ha
Very low	<0.75	<0.03	<10	<55
Low	0.75-1.5	0.03-0.07	10-30	55-110
Medium	1.5-3	0.07-0.15	30-55	110-280
High	3.0-5.0	0.15-0.25	55-110	280-500
Very high	>5	>0.25	>110	>500

As stated earlier, physiography and land systems within each of these physiography were considered as the major basis for conducting field survey and assessment of the present soil fertility status of the district. The brief descriptions and characteristic features of these land types occurring in the district are as follows:

3.4.1 Description of Physiography and Land systems

LRMP (1986) have identified five physiographic regions in the country based on the repeating patterns of landforms. Of these five physiographic regions Chitwan district falls within two regions: Siwalik and Middle Mountain

3.4.1.1 Siwalik Physiographic Region This region includes predominantly north dipping semi consolidated tertiary sand stones, silt stones, shale and conglomerates.. This region is characterized by rugged landscapes and flashiness of the river systems as evidenced by the presence of a large number of dry river channels. All the Dun valleys are located in this region and Chitwan is one of them. These inner valleys are the most potential area from the cultivation and settlement point of view and are rightly considered the breadbasket of the region. The valley was originally a lake basin. But, due to the alluvial infuence of bigger rivers like Narayani and Rapti, much of the original lacustrine characteristics of the valley soils have been eliminated. This region constitutes about 86.5% of the total area of the district.

A brief description of the land types

Active and recent alluvial plains: This includes sand and gravel bars, active and recent alluvial plains formed by the major rivers of the district. The river terraces are positioned both at higher and lower levels. The lower terraces are annually flooded and hence are generally not under cultivation. Most of the cultivation in the recent alluvial plains occurs in the higher level terraces. These higher level terraces are very undulating. In these undulating terraces the depressions have somewhat poorly drained soils and hence are put to Rice based productions. In the ridges soils are relatively drier and hence generally maize and other upland crops are cultivated.

Fans and ancient river terraces: These fans and ancient alluvial terraces formed by the major rivers flowing through the district have diverse land types ; very gently sloping to undulating with the slope variation from 0 to 20 degree and this

microtopographic variation have remarkable influence on soil types and cultivation. These fans and ancient terraces constitute major portion of cultivated lands and settlements.

Depositional Basins (Doons): These depositional basins with its original lacustrine characteristics constitute only a small portion of the district. Because of its lacustrine nature these areas are very fertile and have deep moderately well drained fine loamy soils. Most of its portions are non-dissected and plain with very gently undulating plains occupying only a small portion.

Moderately steep to steep mountainous terrain: Constituting only about 0.08 percent of the district, these terrain have a general slope of 15- 20 degree slope and have very little agriculture and population density. Cultivation is done generally on sloping bench terraces with mostly maize-based production systems. Soils are generally coarse and rapidly drained.

Steep to very steep mountainous terrain: These steeply sloping mountainous terrains with a general slope gradient of 20- 50 degree constitute about 33 percent of the district. Because of steepness and shallowness and coarse nature of the soils cultivation is not possible.

3.4.1.2 Middle Mountain Physigraphy:

Located at north western border of the district and constituting about 13 percent of the total area this region has diverse topography from relatively flat alluvial plains and ancient river terrace to very steep mountains. The elevation diversity is also high and accordingly climate also ranges from humid subtropical to cool temperate.

Brief description of land types

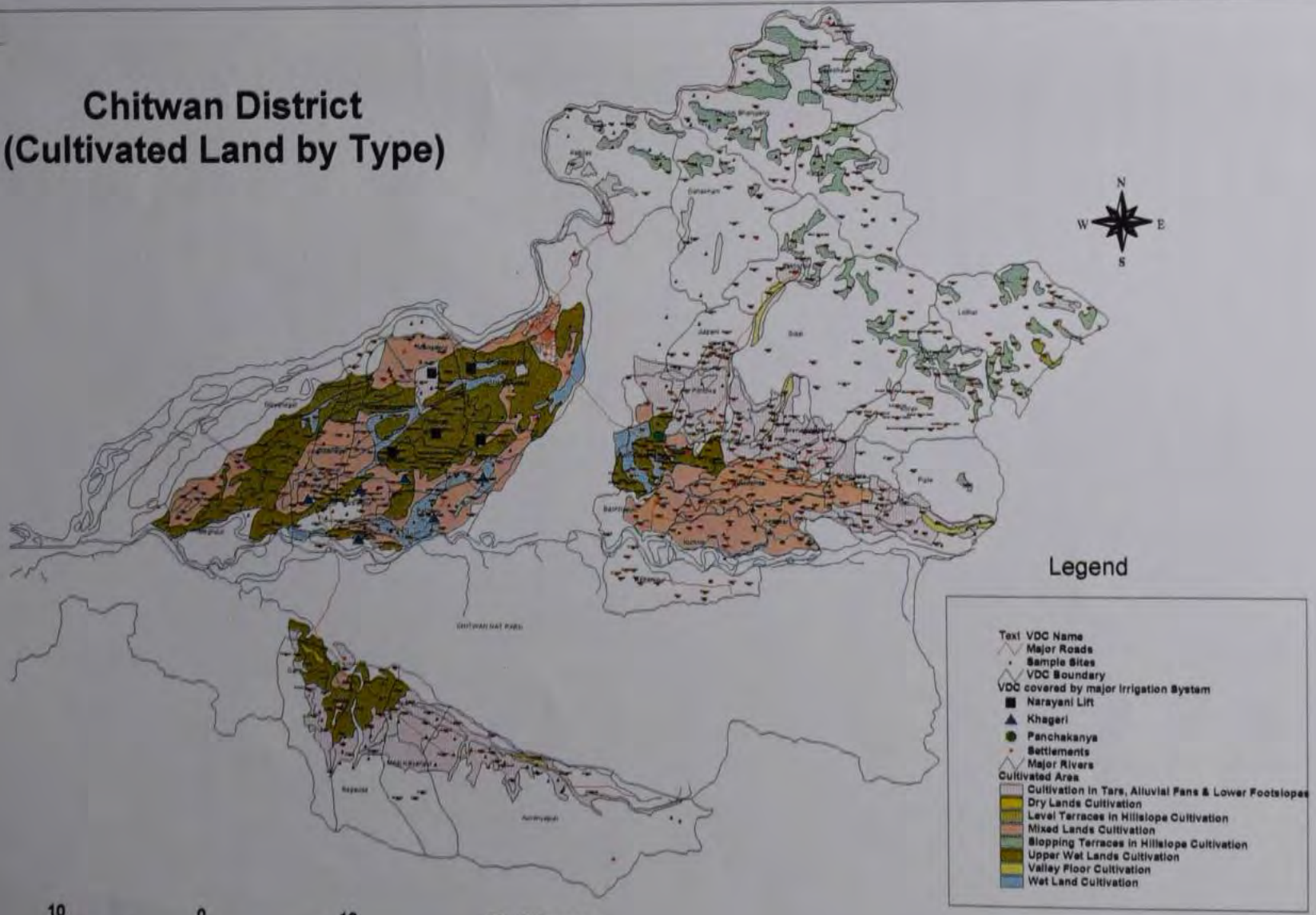
Sandbars, alluvial plains and ancient river terraces: These agriculturally important areas occupy only a very small portion (about 0.3%) of the district and even within this also a large portion is occupied by riverbeds sand and gravel bars.

Moderately steep to steep mountainous terrain: Covering a little above 3% of the district this type of terrain has a general slope gradient of 15-25 degree. Cultivation is done on level as well as sloping bench terraces. Wherever some water is available rice based production is followed in the level bench terraces and in the rainfed conditions maize based production system is followed both in level as well as slopping terraces.

Steep to very steep mountainous terrain Covering about 10 percent of the district these terrain are too steep with slope ranging from 25-45 degree. Because of the steepness and shallowness of the soils cultivation is generally not done.

Fig. 5

Chitwan District
(Cultivated Land by Type)



Source : LRMP landuse classification1987,collected from NPC.

Table 3 Area under different land system:

Siwaliks (86.4%)		Mid. mountains (13.6 %)	
Land system	**ha**	**Land system**	**ha**
Sand & gravel bars(4a)	9866.5	Sand and gravel bars(9a)	357.3
Low terraces(4b)	5368.5	Alluvial plains(9b)	237.3
Higher undulating terraces(4c)	25289.5	Ancient river terraces(10)	142.1
Very gentle slopes(5a)	29767.6	Mod. steep to Steep mountain terrain(11)	7408.5
Gentle slopes(5b)	13301.2	Steep to very steep mountain terrain(12)	21697.6
Undulating slopes(5c)	15136.0		
Rolling slopes(5c)	2474.0		
Nondissected basins(6b)	6931.3		
Gently rolling basins(6c)	7687.9		
Mod.sloping hills(7)	1771.8		
Steeply slopping hills(8)	72016.8		
Total	**189611.1**		**29842.8**

4. SOIL FERTILITY SURVEY FINDINGS

The following chapter deals with the findings of the survey and laboratory analysis works.

4.1 Soil Reaction (pH): The table below depicts soil reaction status of different Areas on sample basis.

Table 4 Soil reaction (pH) status of Chitwan district

Region	SA	MA	NN	M. Alk	Total
West	47(64)	13(18)	13(18)	1(1)	74
Madi	18(53)	8(24)	8(24)	-	34
East	21(36)	13(22)	24(41)	1(2)	59
Hill	19(76)	2(8)	4(16)	-	25
District	105(55)	36(19)	49(26)	2(1)	192

Note: NN = Nearly neutral, SA = Slightly acidic, MA= Moderately acidic, M.Alk = Moderately alkaline. Figs. in the parenthesis indicate percentage.

Majority of the samples analyzed were acidic in nature. In total 192 samples were analyzed for pH and it was found that 36 samples were moderately acidic (4.6-5.5), 105 were slightly acidic (5.6-6.5), 49 were nearly neutral (6.6-7.5) and only two of them were in alkaline range (>7.5). The two samples in the alkaline range were having pH slightly more than 7.5, therefore, practically they can also be considered as nearly neutral.

Fig. 6 Soil reaction status of Chitwan

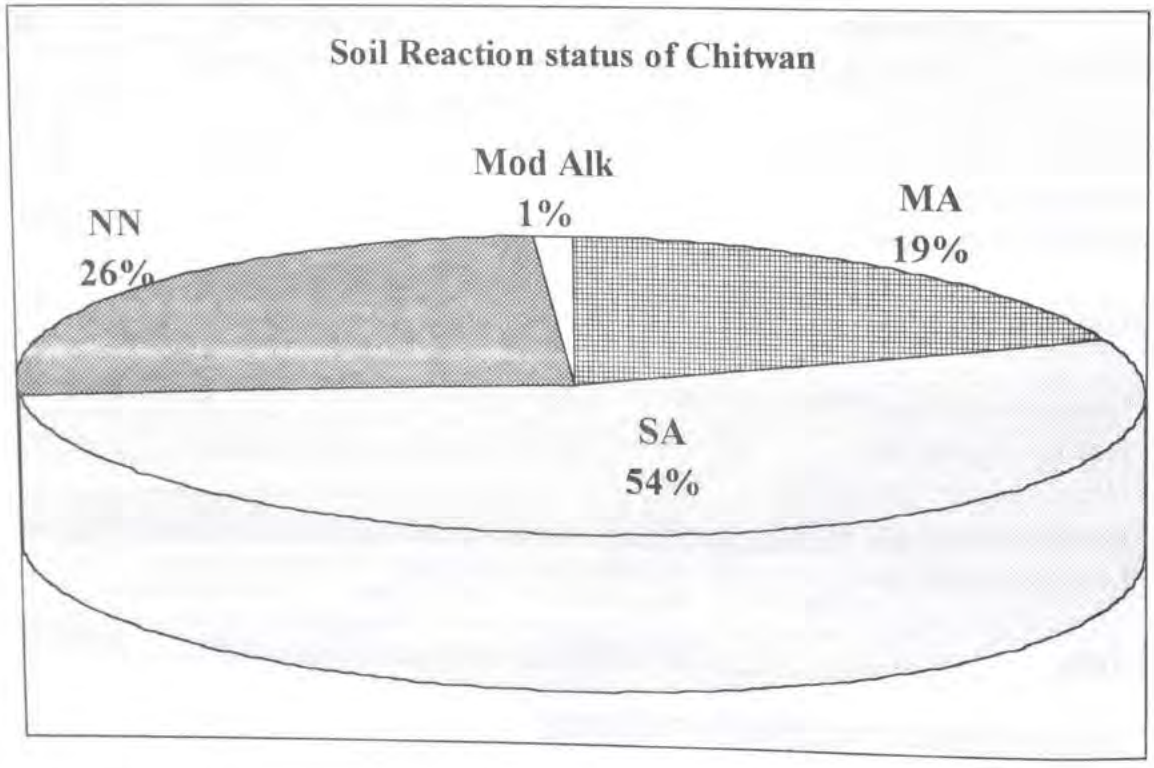
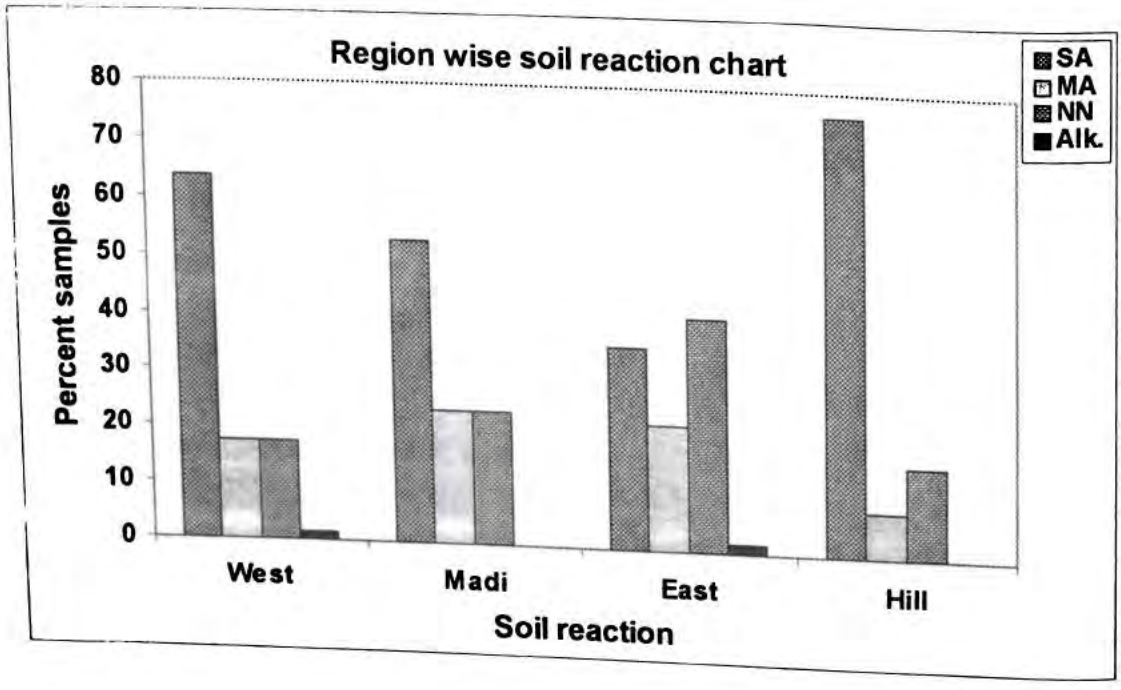


Fig. 7 Region wise soil reaction (pH) status of Chitwan



Region wise, 74 samples were analyzed from west Chitwan, of which 18% were moderately acidic, 64% were slightly acidic, 18% were nearly neutral and 1% were in moderately alkaline range. In Madi Chitwan out of 34 samples analyzed 24% were moderately acidic, 52% slightly acidic and 24% were nearly neutral. Similarly, out of 59 samples from East Chitwan 22% were moderately acidic, 34 % were slightly acidic, 40% nearly neutral and 2% were alkaline. In hill region out of 25 samples 8% were moderately acidic 76% were slightly acidic, and 16% nearly neutral.

The data indicate that about one fifth of the sample analyzed are moderately acidic and pH may be a limiting factor for crop production in these areas. Similarly about half of the samples analyzed are slightly acidic. In these soil, soil reaction (pH) may not be a limiting factor for crop production at present but are potentially endangered in future if no proper soil management practices are followed.

Extrapolation of the analytical results on the basis of soil type and land system is presented in figure 7. The total area under different soil reaction class is presented in table 5

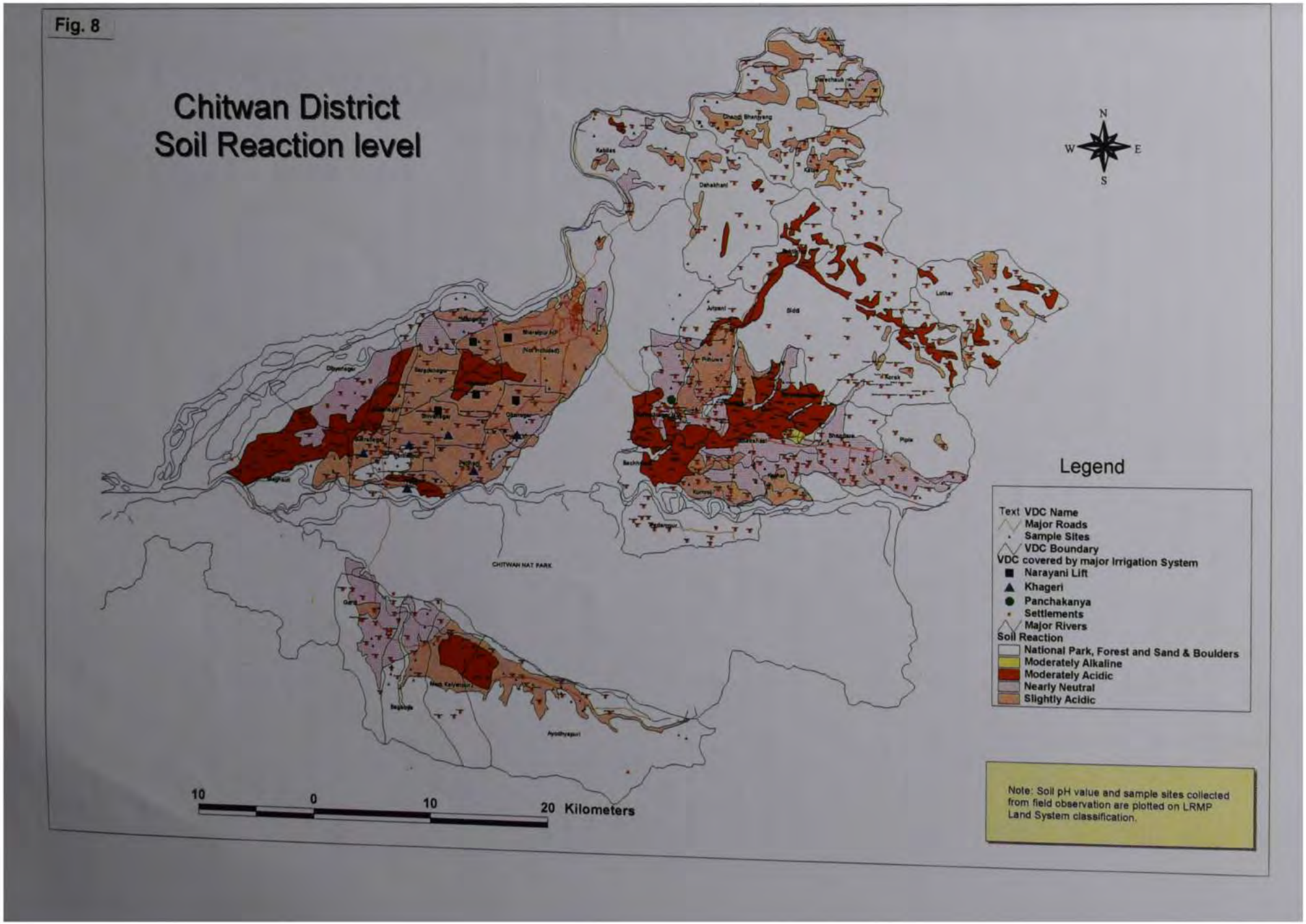
Table 5 Soil reaction status of Chitwan district on area basis

Soil reaction (pH)status	**Area (ha)**
Slightly acidic	27300
Moderately acidic	14800
Nearly Neutral	15100
Alkaline	100
Total	57300

Acid soil management

The pH requirement of different crop is different (appendix 1). Therefore, it is difficult to say anything about correction of soil pH unless we know about the crop that farmers grow. However extreme soil pH, either acidic or alkaline, limits the crop growth in various ways. For example in highly weathered acid soil with high iron (Fe) and aluminum (Al) oxides, crops may suffer due to unavailability of phosphorus due to high rate of fixation of soil phosphorus and applied phosphatic fertilizer too. Under such condition rice crops may suffer due to toxicity of iron and aluminum because of high solubility. In highly acidic condition crops also suffer due to deficiency and unavailability of calcium and magnesium. Similarly in highly alkaline soil with pH more than 8, crops may suffer due to deficiency of micronutrient like Fe, Mn, Zn, Cu and Mo. In highly alkaline soil phosphorus availability is also reduced due to fixation by calcium compounds in soil. In general a soil having pH from 6.5 to 7.5 (nearly neutral) is considered best for growing almost all of the crops. The soil with pH 6 to 6.5 although categorised slightly acidic are safe for growing most of the crops except a few high calcium requiring plants but in the same category the soils having pH 5.6 to 6.5 requires liming to get good crop, and efficient utilization of soil and fertilizer nutrient elements. The soil with pH 5 to 5.5 are considered moderately acidic and

Fig. 8


Chitwan District
Soil Reaction level
N
W
E
S
Legend
Text VDC Name
Major Roads
Sample Sites
VDC Boundary
VDC covered by major Irrigation System
Narayani Lift
Khageri
Panchakanya
Settlements
Major Rivers
Soil Reaction
National Park, Forest and Sand & Boulders
Moderately Alkaline
Moderately Acidic
Nearly Neutral
Slightly Acidic
CHITWAN NAT PARK
10 0 10 20 Kilometers
Note: Soil pH value and sample sites collected from field observation are plotted on LRMP Land System classification.

requires liming. At this pH range liming gives very good result. Under such condition pH might be the major limiting factor of crop production. The soils with pH 4.5 to 5,although categorised as moderately acidic, are seriously limited of crop production by soil acidity. Under such condition amelioration of soil pH is a must for soil fertility management and higher crop production.

Liming : Agriculture lime application is highly recommended for the soils with strongly and moderately acidic reaction. Lime application dose is recommended based on the pH reading. The lime recommendation for amelioration of acid soil given in appendix 2. Careful attention should be paid about the time and dose of lime application. Standing crops should never be limed, as land should be left fallow for at least about 2-3 weeks after liming. In case of higher dose split application is recommended. Increasing the pH by more than one unit at a time is not desirable because sudden increase in soil pH may affect the soil environment affecting the growth of soil microorganisms and availability of plant nutrients.

Crop management

Amelioration of acidic soil, although pays with higher crop production, is a costly process. Under resource poor farming condition and in remote areas lime recommendation may not be very much practicable because of inability of farmers to buy it and difficulty in transportation. Therefore, low cost alternative solution is required to such condition. In recent years, the concept of "fitting the soil as per crop requirement" has been changed to " fitting the crop as the soil" to solve this problem. The pH requirement of different crop is different. With proper crop management practice liming may not be necessary, as there are some acid loving plants which grow well on acid soils. So it would be desirable to manage crops according to pH. However soil pH from 6.0 to 7.5 is considered to be suitable for most of the crops. Very strongly acid soils can be used for tea, coffee, pine apple, and blue berry, In slightly alkaline soil asparagus barley, bean, cotton, peas, soybean, spinach, sugar beat, sunflower, are suitable to grow. Black berry, cabbage, corn, peanut, sweet potato, tobacco, wheat are medium lime desiring plants. Incase of lowland irrigated rice the field is flooded, hence the soil chemistry is different than that of upland crops. Rice can tolerate wide range of soil pH but in highly acidic soil the crop may suffer due to iron and aluminium toxicity and unavailability of phosphorus and other plant nutrients.

In acid soil management the type of nitrogenous fertilizer that farmers use is also very important. In general the ammoniacal and urea nitrogen aggravate the soil acidity. Therefore, use of nitrate nitrogen instead of these ones, if available, will help to reduce the problem. Organic manures have high buffering capacity and helps to maintain the soil reaction. They always keep the soil reaction near neutral range. Therefore, both in acidic and alkaline soil use of high dose of organic manure helps to ameliorate the problem.

4.2 Organic Matter (OM) in soil:

The table below depicts the organic matter status of the district by region on sample basis.

Table 6 Organic matter (OM) status of Chitwan district

Region	VH	High	Med	Low	V. low	Total
West	-	-	22(30)	51(69)	1(1)	74
Madi	-	-	1(3)	29(85)	4(12)	34
East	-	-	6(10)	45(76)	8(14)	59
Hill	-	6(24)	12(48)	7(28)	-	25
District	-	6(3)	41(21)	132(69)	13(7)	192

Note: Figs in parenthesis indicate percentage.

In general the organic matter status of the district is low. Out of 192 samples analyzed only 3% samples from have high organic matter content, whereas 69% samples had low, 21 % samples medium and 7% very low organic matter status. Region wise in west Chitwan out of 74 samples analyzed 30% have medium, 69% low and 1-% very low OM status. In Madi area out of 34 samples analyzed 3% have medium, 85% low and 12% very low OM status. In East Chitwan out of 59 samples analyzed 10% samples have medium 76% low and 14% samples very low OM status. Similarly, out of 25 samples from the Hill Area, 24% samples had high , 48% medium and 28% low organic matter status.

It is found that the organic matter content in hill is higher than that of the plains. It may be due to the altitude and climatic difference between hills and plains. In hill area because of high altitude and low temperature the decomposition of organic matter is slow resulting in high organic matter content in soil.

In general Madi was worst with most of the samples in very low to low organic matter status followed by East, West and Hill area. Since the organic matter status of the whole district is very low to low emphasis must be given in high biomass production and recycling to improve and maintain the organic matter content in soil.

Extrapolation of the organic matter (OM) status of Chitwan district on the basis of land system and soil type is presented in figure 10. The organic matter (OM) status and total area under different class is presented in table 7.

Table 7 Organic matter (OM) status of Chitwan district and area under different class.

Organic matter level	Area(ha)
High	1500
Medium	13800
low	37500
Very low	4500
Total	57300

Figure 9 Organic matter (OM) status of Chitwan district

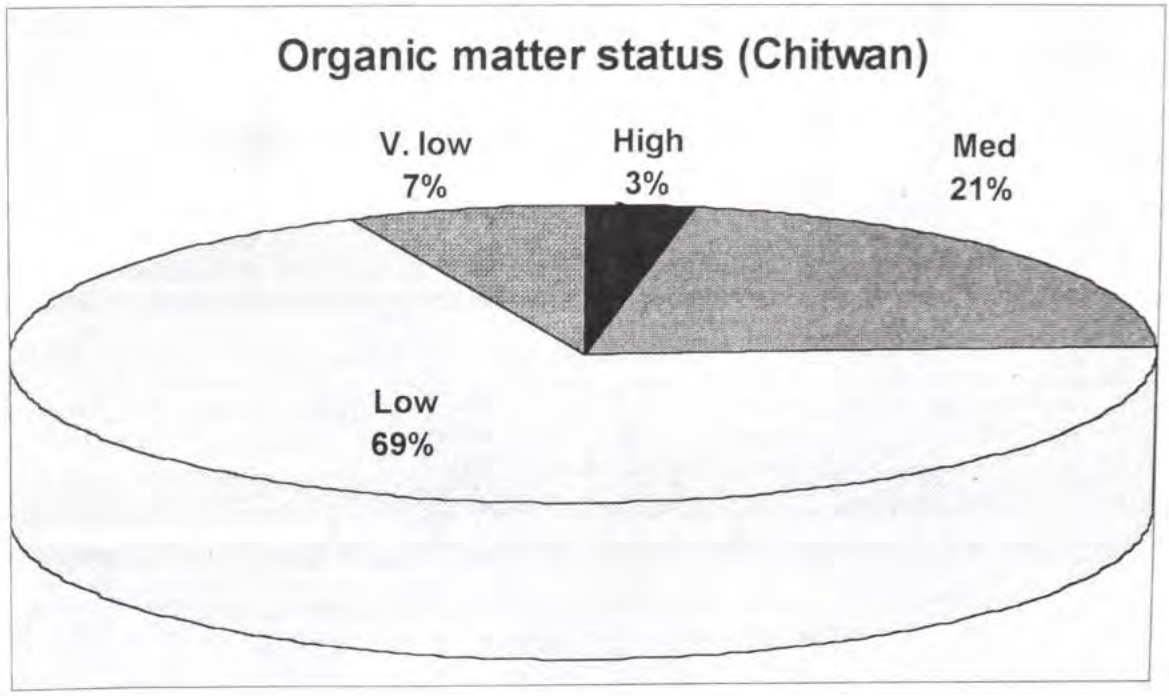


Figure 10 Region wise Organic matter (OM) status of Chitwan district

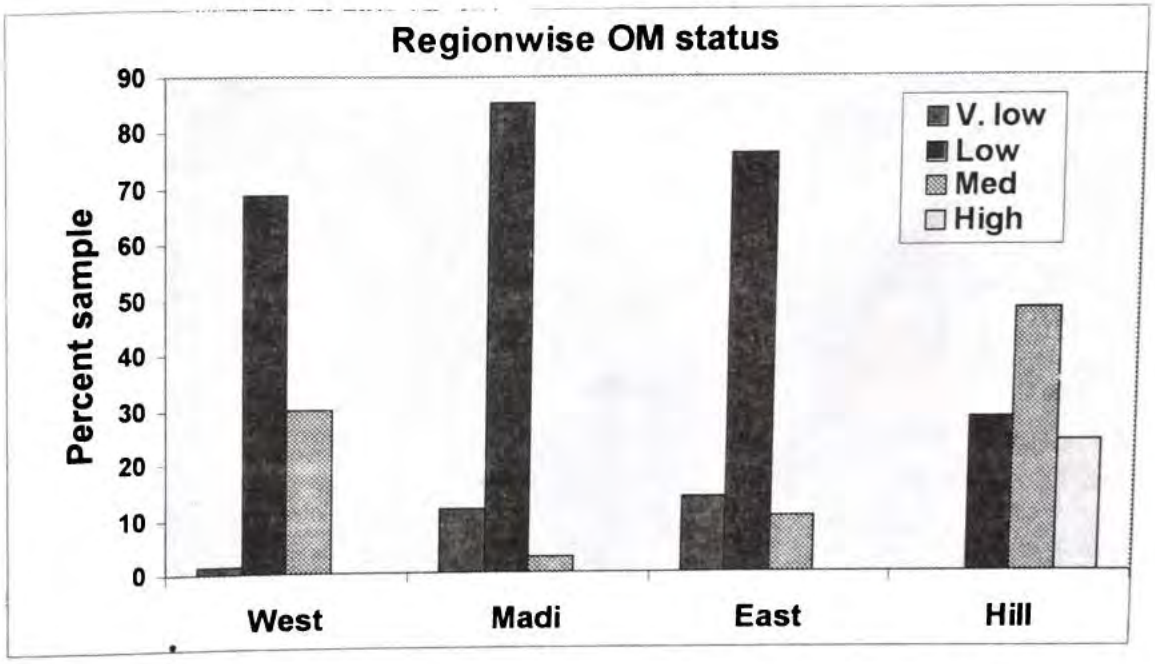
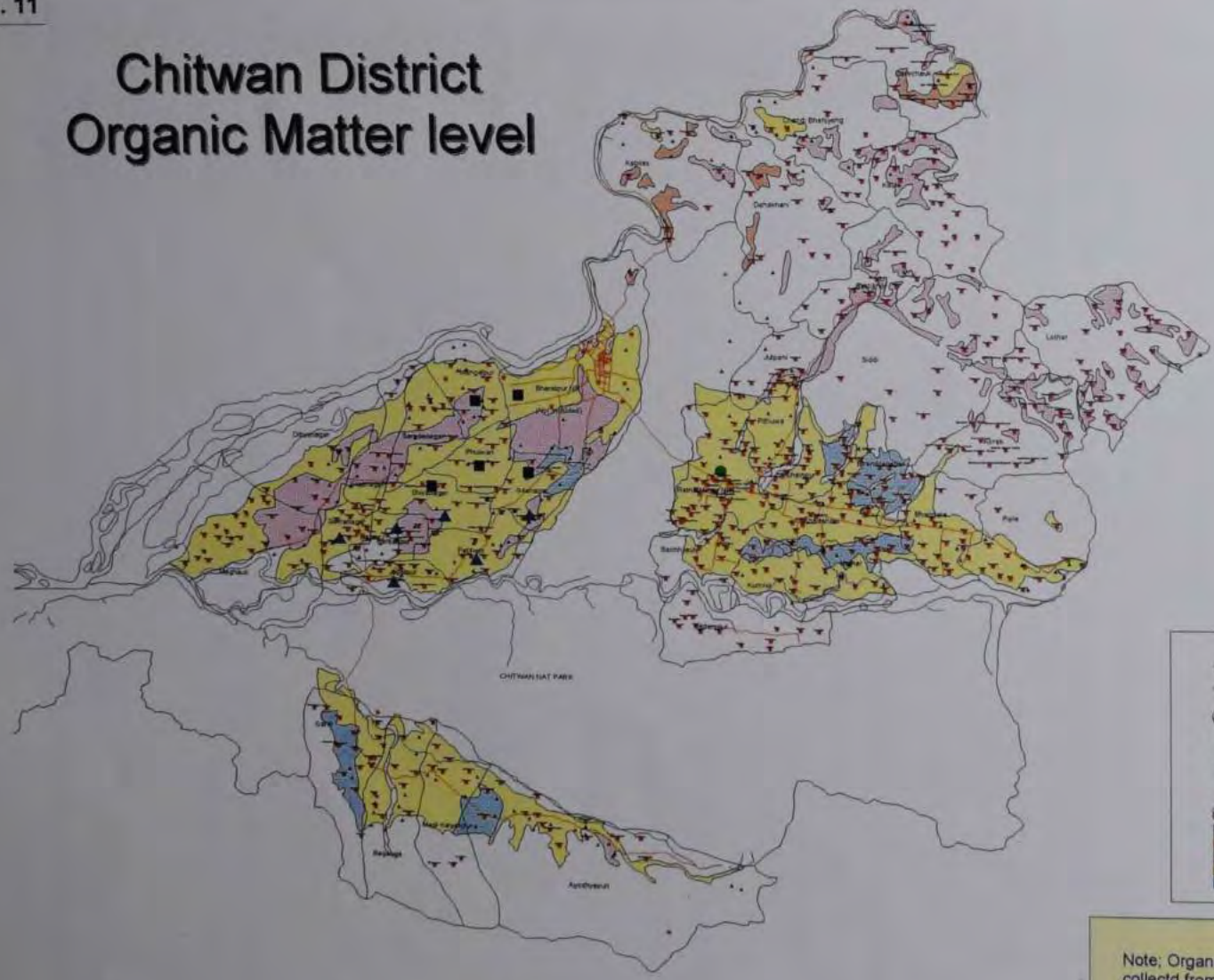


Fig. 11

Chitwan District
Organic Matter level



Legend

- Text VDC Name
- Major Roads
- Sample Sites
- VDC Boundary

VDC covered by major Irrigation System

- Narayani Lift
- Khageri
- Panchakanya
- Settlements
- Major Rivers

Organic Matter Level

- National Park, Forest and Sand & Boulders
- High
- Medium
- Low
- Very Low

Note; Organic Matter value and sample sites collectd from field observation are plotted on LRMP Land System classification.

Management of soil organic matter:

Considering the fact that major parts of the area in the district were put to cultivation relatively very recently this high rate of depletion in organic matter content in the soil seem quite alarming. Highly intensive cultivation of land without the application of adequate amount of organic manure seems to be the major factor responsible for this situation. According to STSS report (1998) more than 90% of the farmers of Chitawan district apply only 6-10 dokos (150kg to250kg) FYM per ropani land. More than 50% of farmers apply FYM only once a year. More than 64 percent of the farmers expressed that use of fertilizer in their field is increasing, while the use of FYM is decreasing and as a result productivity of the soil is declining rapidly (Jaishy et al).

Decrease in animal food and grazing land due to cultivation in marginal land and prohibition of grazing cattle in protected forest and National Park, and use of tractor for ploughing has resulted in decrease in animal manure. On the other hand increase in biogas plant and improper handling of biogas slurry to make compost has resulted in the decrease in quantity and quality of compost. During the survey, farmers complained about the poor quality and ineffectiveness of biogas slurry to improve soil fertility and crop production.

Considering the fact that the depletion rate of organic matter content in the soils is quite high it is very necessary to increase the OM status in the soils for sustained growth in crop production. Hence the following practices are highly recommended to be followed by the farmers in order to enhance the OM level in the soils.

- Promote use of organic manure by utilizing all types of biodegradable wastes through improved composting techniques and through the promotion of biogas plants.
- Promote the inclusion of legumes in cropping sequences and green manuring practices.
- Emphasize more on integrated plant nutrients system
- Plan and implement integrated crops and livestock programs.
- Follow conservation farming in the sloping lands.
- Legume cultivation with rhizobium inoculation
- Use azolla as a green manure in the paddy field.
- Use green manuring as sole crop or relay crop in maize.

4.3 Total Nitrogen

Nitrogen is the most important plant nutrient that limits crop production. Its deficiency is directly related to the organic matter status. Nitrogen deficiency is widespread where organic manure are in short supply.

Total N status and area coverage

In general the total nitrogen status of the district is from low to medium. Out of the total 192 samples analyzed about 51 % showed low, 5% very low, 40% medium and

4% high Nitrogen status. Region wise, in West Chitwan, out of 74 samples an almost equal percent (46 and 47%) of samples showed low and medium N status while 4 % samples had very low N status.

Table 8 Total Nitrogen status (by region, on sample basis)

Region	Very low	low	Medium	High	Total
West	3(4)	34(46)	35(47)	2(3)	74
Madi	-	18(53)	16(47)	-	34
East	6(10)	36(61)	16(27.)	1(2)	59
Hill	-	9(36)	11(44)	5(20)	25
District	9(5)	97(51)	78(40)	8(4)	192

In case of Madi Area, out of 34 samples 53% showed low and 47% medium status. In East Chitwan, out of 59 samples 61 % had low and 27 % had medium status, 10% samples very low and 2% high status. . In case of Hill Area, out of 25 samples 36% samples showed low status, 44 % medium and 20% high status.

Extrapolation of total nitrogen analysis data on the basis of land system and soil type is presented in figure 13. The total nitrogen (N) status and the area under different class is presented in table 9.

Table 9 Status of total nitrogen (N) and area under different class.

Total Nitrogen Level	Area(ha)
Very low	2500
Low	30500
Medium	22800
High	1500
Total	57300

Nitrogen management in soils

Out of all the nutrients essential for plant growth, Nitrogen is by far the most important one and almost all the cultivated areas experience the deficiency of this essential nutrient with varying degree of magnitude.

In lower level of productivity since nitrogen removal is low, it is replenished by local fixation atmospheric nitrogen. Nitrogen is also fixed to some degree by electrical storms during pre monsoon rains. However with the needs to increase more food grain additional application is required in the form of chemical fertilizers and organic manure. Crops invariably respond to N application. Non response to applied N may be due to some other factors. Response to N is very much dependent on climatic conditions, soil moisture status, variety of crop etc. In general in Nepalese midhill conditions maize crop (grain and straw) has been found to remove about 53 kg Nitrogen ; Wheat removes 30 kg and Rice removes about 54 kg (with the yield levels of national average). As the yield level increases so is the removal and equal amount need to be replenished through external source for sustained crop growth.

Figure 12 Total Nitrogen (N) status of Chitwan district

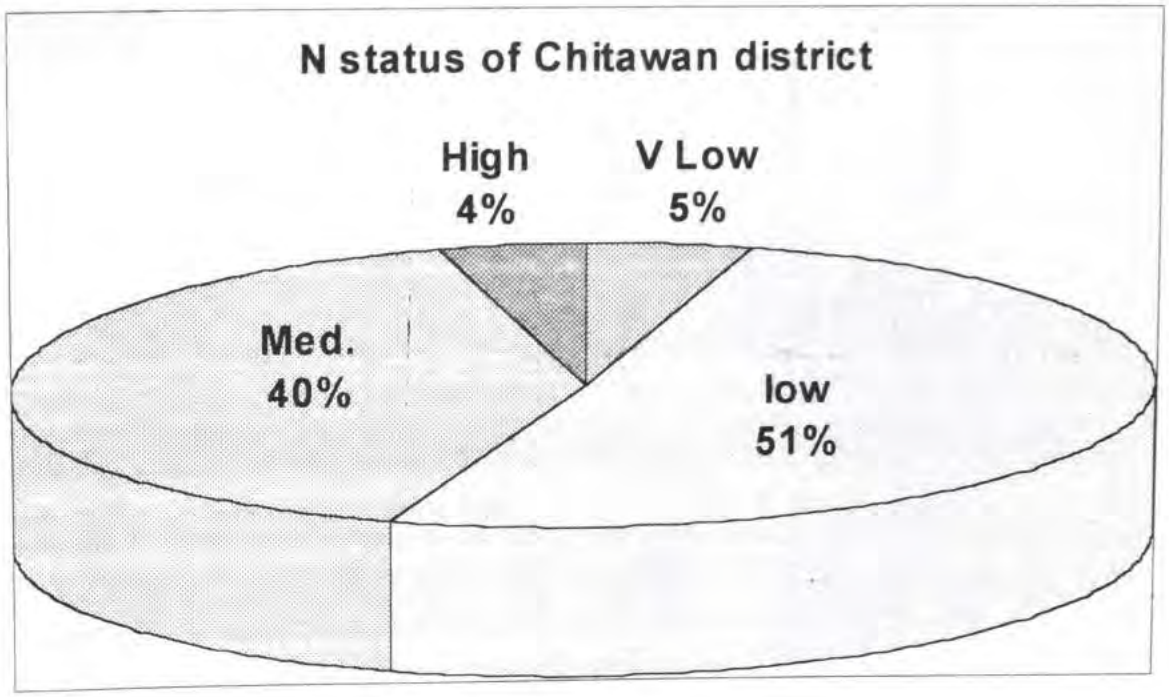


Figure 13 Region wise Nitrogen (N) status of Chitwan district

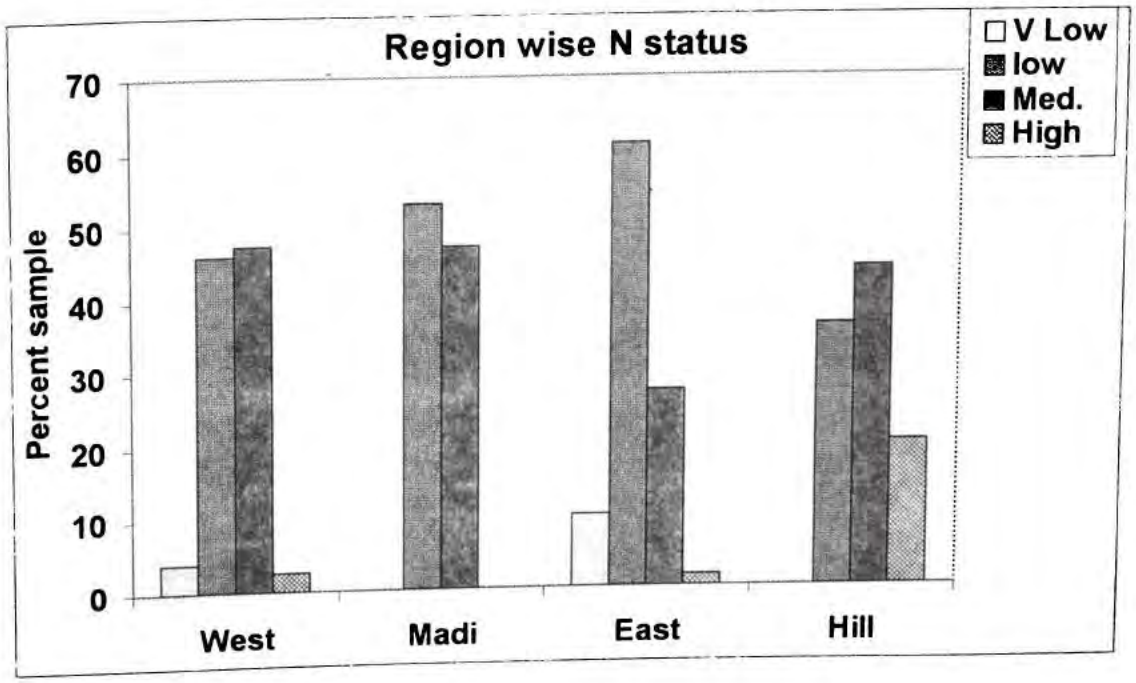
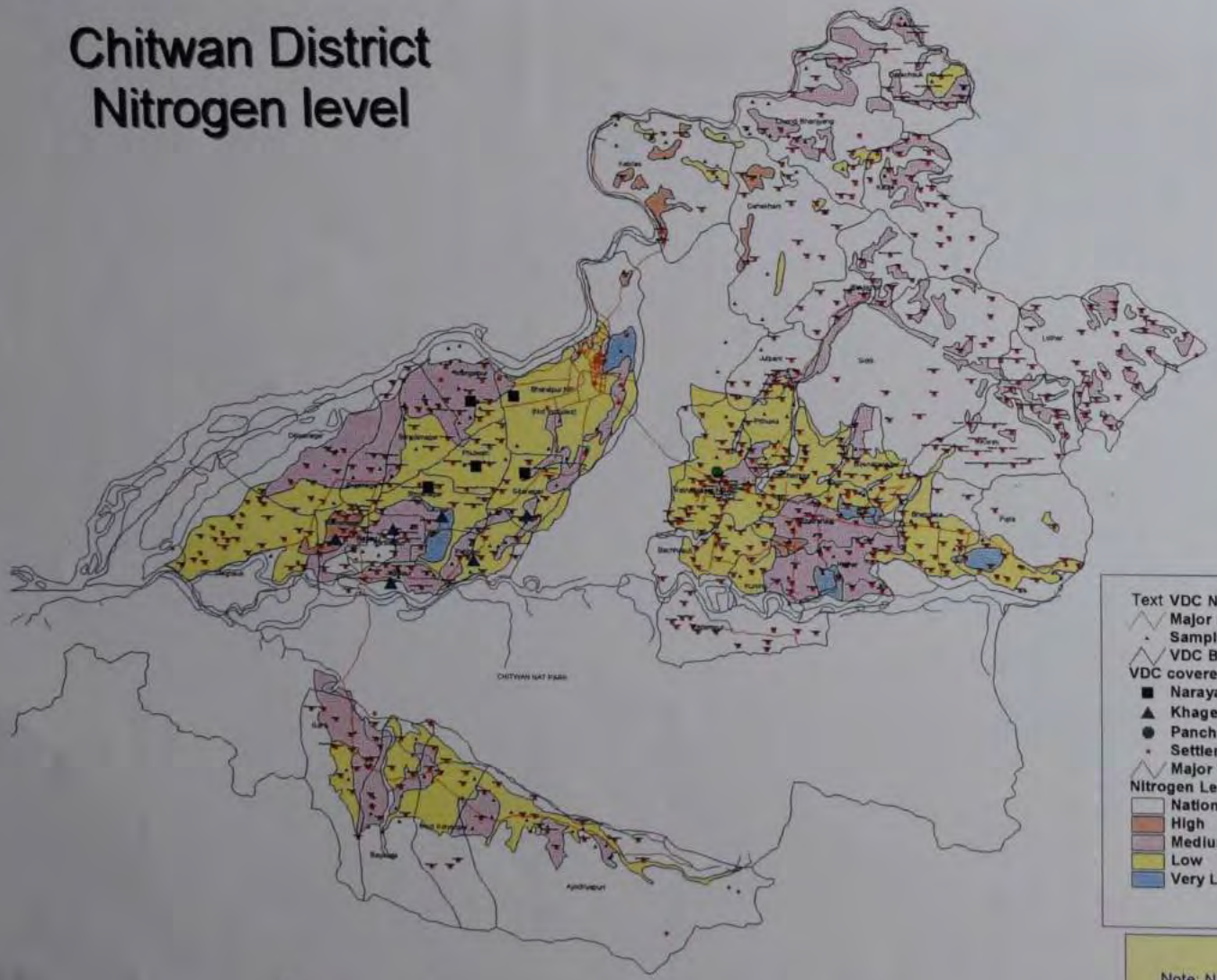


Fig. 14

Chitwan District
Nitrogen level



Legend

Text VDC Name
Major Roads
Sample Sites
VDC Boundary
VDC covered by major Irrigation System
Narayani Lift
Khageri
Panchakanya
Settlements
Major Rivers
Nitrogen Level
National Park, Forest and Sand & Boulders
High
Medium
Low
Very Low

Note: Nitrogen value and sample sites collected from field observation are plotted on LRMP Land System classification.

The nitrogen in soil is mostly in organic form and only a small fraction (1-3%) is present in inorganic form. Therefore, management of Nitrogen is always associated with organic matter management and the practices recommended for OM management also improves N status in the soil. The nitrogen applied in the form of inorganic fertilizer is readily available to crop plant but a substantial proportion of it is lost either by leaching or volatilization. But the nitrogen in organic form is slowly mineralized and becomes available to crop plants. Application of organic manure together with chemical fertilizer also improves the efficiency of chemical fertilizers.
Balanced application as per the recommendation made by Soil Science Division of NARC (Appendix-2) with adjustments on the basis of Soil test value as given below should be followed. One other factor, which is very important in Nepalese agriculture, is the low efficiency of Nitrogen specially in the rice crop as in the present level of management, it is often less than 40%. Therefore, increasing the efficiency of chemical fertilizer will reduce the cost of production and helps to save the foreign exchange, which is spent for import of chemical fertilizer. A number of factors determine the fertilizer use efficiency. The efficiency can greatly be increased by

i. Proper seed bed preparation
ii. Proper seeding
iii. Time sowing
iv. Appropriate crop variety
v. Adequate plant population.
vi. Proper fertilizer placement
vii. Moisture management
viii. Proper plant protection measures including weed control and
ix. Balanced fertilizer application (G.S.Sekhon FAI 1978 from D.Joshy 1997.)

4.4 Available phosphorus

The following table depicts available phosphorus status by area on sample basis.

Table 10 Available phosphorus status of Chitwan district

Area	Very low	low	Medium	High	Very high	Total
West	37(50)	23(31)	9(12)	3(4)	2(3)	74
Madi	15(44)	15(44)	4(12)	0	0	34
East	16(27)	31(53)	6(10)	6(10)	0	59
Hill	3(12)	6(24)	5(20)	9(36)	2(8)	25
District	71(37)	75(39)	24(13)	18(9)	4(2)	192

In general the available phosphorus (P_2O_5) content of the district is very low to low. Of the 192 samples analyzed 37% were having very low, 39% low, 13% medium, 9% high and 2% very high available phosphorus. Region wise, in west Chitwan out of 74 samples 50% were very low, 31% low, 12% medium, 3% high and 2% very high in

Fig. 15 Phosphorus P_2O_5 status of Chitwan district

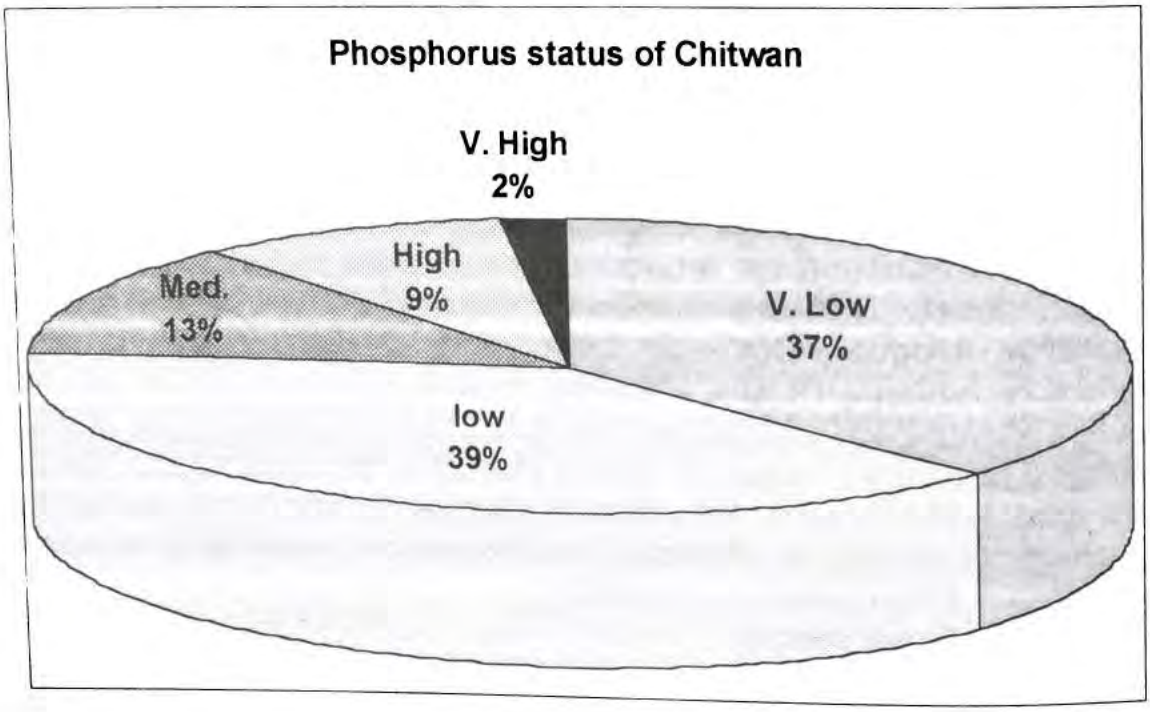
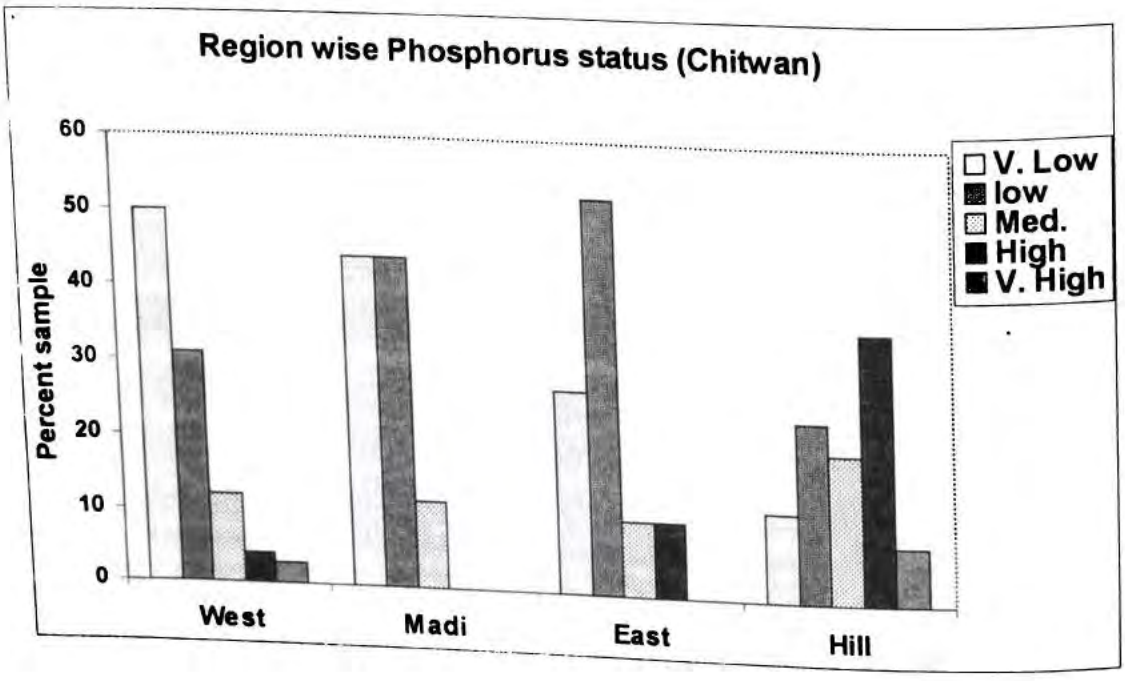


Fig. 16 Region wise Phosphorus P_2O_5 status of Chitwan district



available phosphorus. In Madi Area out of 34 samples 44% showed very low and 44% low status, and 12% medium status. In east Chitwan out of 59 samples 27% were very low, 53% were low and 10% were medium in available phosphorus. Similarly in the Hill Area out of 25 samples analyzed 12 % were very low, 24% low, 20% medium, 36% high and 8% very high in available phosphorus.
Extrapolation of the available phopsphorus data on the basis of land system and soil type is presented in figure 16. The status of available phosphorus and area under different class is presented in table 11.

Table 11 Available phosphorus status and area under different class

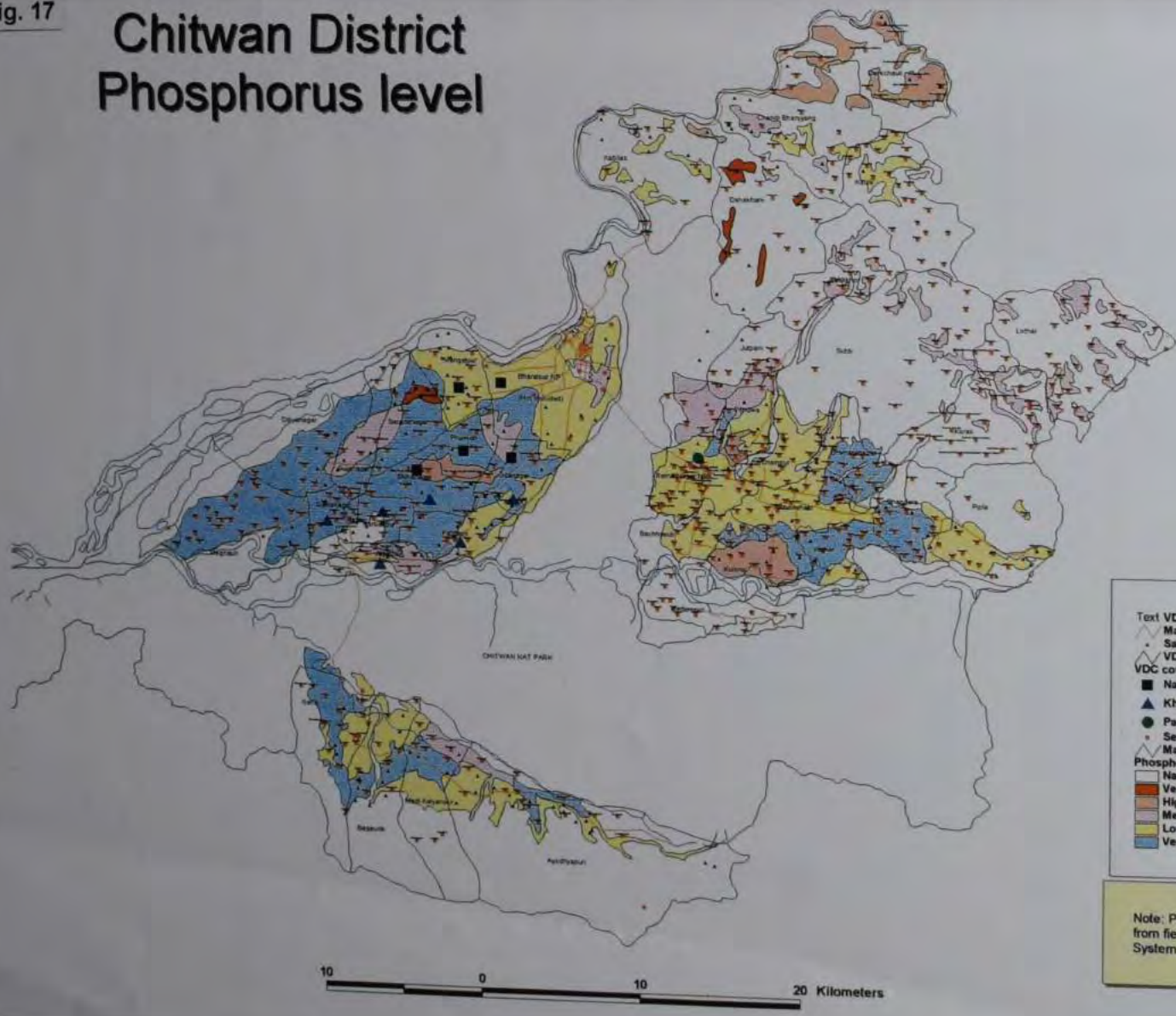
Phosphorus level	Area (ha)
Very high	600
High	4000
Medium	9900
low	21300
very low	21500
Total	57300

Phosphorus management in Soil

In Nepal, after the introduction of chemical fertilizers, farmers gave emphasis more on the use of nitrogenous fertilizers but only a little to phosphorus and potash. Initially because of higher P and K status in the soils, no significant response to the application of applied P and K was observed. But with the continuos application of N fertilizers only and with the reduction in the use of organic manure the status of these nutrients in the soils have remarkably declined. The findings of this survey also confirm to this fact. If the situation continues further, it might have very adverse effect in crop productivity. The long term fertility trials conducted by NARC in its research stations have shown that, if the fields are not supplied with Phosphorus the crop yield can go down to zero level. Hence, only way to improve the situation is to apply Phosphorus as per the requirements of the crop grown (Appendix-3).
The availability of phosphorus is very much related to the soil reaction. The low phosphorus availability may be due to soil pH. Since 19% of the samples analyzed were moderately acidic (4.6-5.5) and 55% were slightly acidic (5.6-6.5), the soil reaction might have reduced the phosphorus availability. In acidic condition P reacts with aluminum, iron and manganese ions and get fixed to non available forms. In the alkaline condition also it reacts with calcium ions and gets fixed to non-available form. Hence P management should always start with the correction of Soil reaction. Phosphorus is most available near pH 6.5 for mineral soil and 5.5 for the organic soil. So it is highly advised to reclaim the highly acidic soil and highly alkaline soils and keep the soil pH between 6.0 to 7.0. Use of sufficient amount of fresh organic matter in the soil helps release the phosphorus as it decomposes. Band application is always better in row crops. Broadcast is recommended where the crops are not

Fig. 17

Chitwan District
Phosphorus level



Legend

Text VDC Name
Major Roads
Sample Sites
VDC Boundary
VDC covered by major Irrigation System
Narayani Lift
Khageri
Panchakanya
Settlements
Major Rivers
Phosphorus Level
National Park, Forest and Sand & Boulders
Very high
High
Medium
Low
Very Low

Note: Phosphorus value and sample sites collected from field observation are plotted on LRMP Land System classification.

grown in rows but proper incorporation is very essential. Balanced application should always be followed as the excess dose can cause zinc deficiency.

4.5 Available Potassium

The table below (table 12) summarizes status of available potash in the district. On the sample basis out of the total 192 samples 26 % ere very low, 39% low, 27% medium, 4% high and 3% very high in available potassium. Block wise, in west Chitwan, out of 74 samples 42% were very low, 39% low, 16% were medium and 3% were high in available potassium. In Madi Area, out of 34 samples 53% were very low, 15% were low and 32% were medium in available potassium. In east Chitwan, out of 59 samples 2% were very low, 69% were low, 27% were medium and 2% were very high in available potassium. Similarly in the Hills, out of 25 samples 4% were very low, 4% were low, 48% were medium, 24% were high and 20% were very high in available potassium.

Table 12 Status of available potassium (K_2O) in Chitwan district.

Area	V Low	LOW	Med	High	VH	Total
West	31(42)	29(39)	12(16)	2(3)	0(0)	74
Madi	18(53)	5(15)	11(32)	0(0)	0(0)	34
East	1(2)	41(69)	16(27)	0(0)	1(2)	59
Hill	1(4)	1(4)	12(48)	6(24)	5(20)	25
District	51(27)	76(39)	51(27)	8(4)	6(3)	192

Extrapolation of the analysis data on available potassium is presented in figure 19. The status of available potassium and area under different class is presented in table 13.

Table 13 Available Potassium status and area under different class

Potash level	area (ha)
Very high	1100
High	900
Medium	14600
low	21800
very low	18900
Total	57300

Management of Potash in the soils:

As has been stated in phosphorus management, potash levels used to be generally high in Nepalese soils, hence the response of potassium fertilizer was not much significant. Therefore, recommendation of potassium fertilizer was much less than that crop removes from soil. Farmers were also reluctant to use potassium fertilizer, because of their invisible response in crop growth and development. This led to the depletion of potassium from soil reserve. Further more, the decomposition of native

Fig. 18 Available Potash (K2O) status of Chitwan district

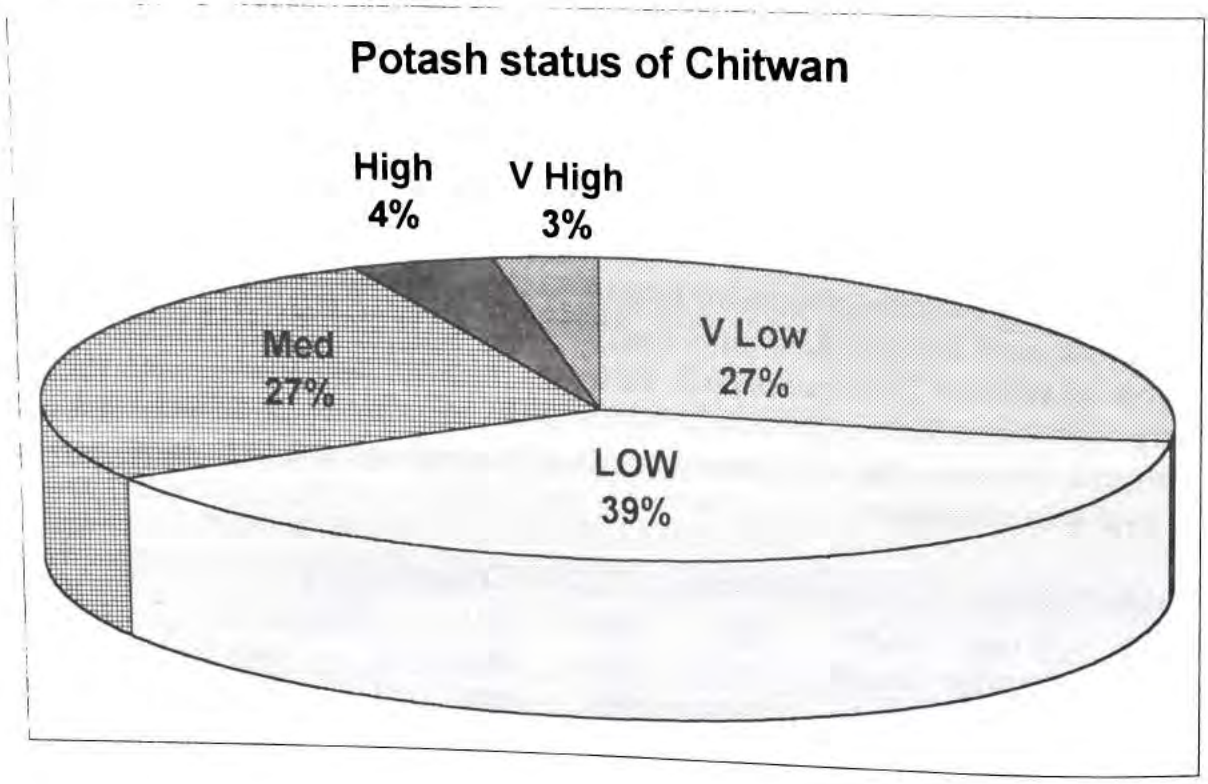


Fig. 19 Region wise Potash (K_2O) status of Chitwan district

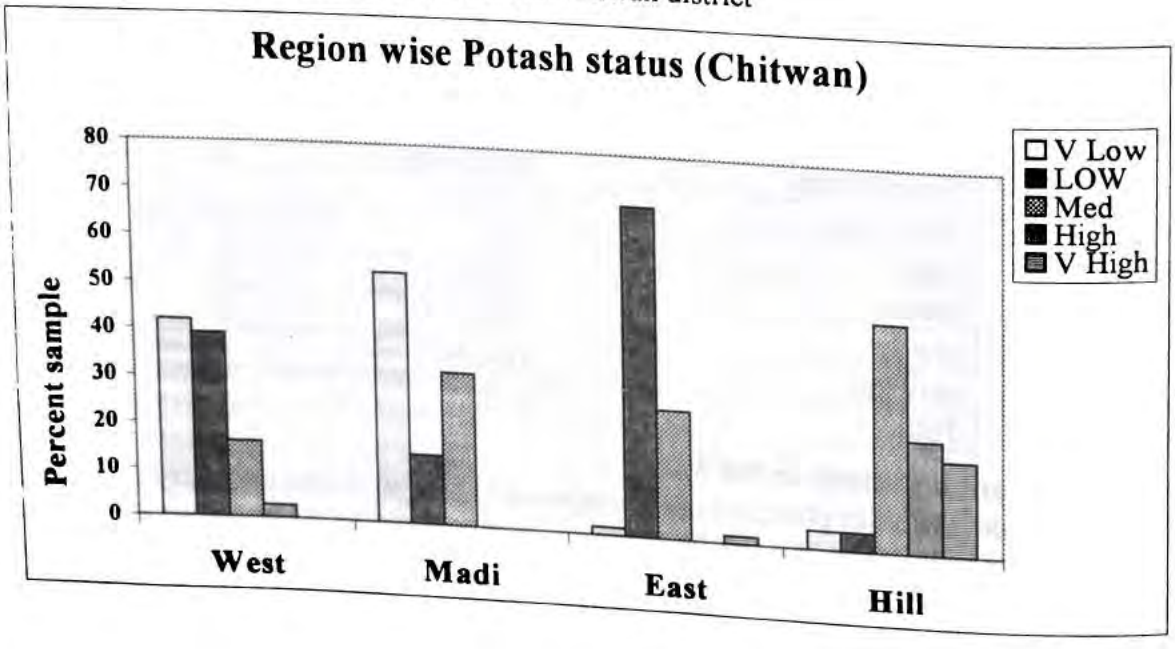
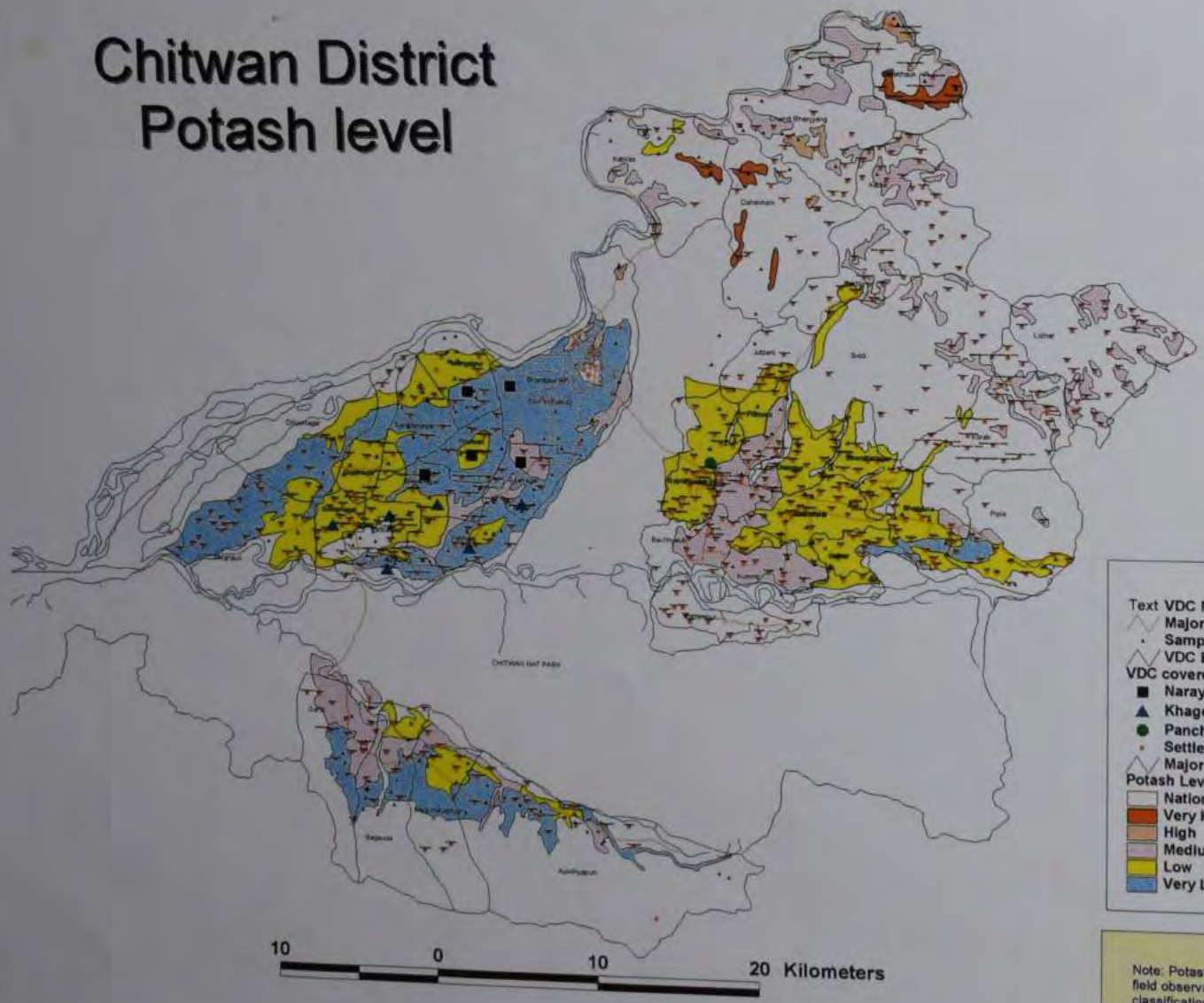


Fig. 20

Chitwan District
Potash level



Legend

- Text VDC Name
- Major Roads
- Sample Sites
- VDC Boundary

VDC covered by major Irrigation System

- Narayani Lift
- Khageri
- Panchakanya
- Settlements
- Major Rivers

Potash Level

- National Park, Forest and Sand & Boulders
- Very High
- High
- Medium
- Low
- Very Low

Note: Potash value and sample sites collected from field observation are plotted on LRMP Land System classification.

soil organic matter and poor organic mater recycling along with higher crop intensity aggravated the depletion of potassium in soil. Since the dominant soil texture of the district is loamy sand with poor potassium retaining capacity, leaching of available of potassium might have added to the depletion of potassium. Therefore, continuous removal of soil potassium without any external addition has resulted into very poor potassium level in the soil. Research data and farmers experience also shows a good response of potassium fertilizer in crop growth and yield too. Since the soil of Chitwan is very poor in available potassium, emphasis should be given in application of potassium fertilizer as that of Nitrogen and Phosphorus to get higher crop yield and soil fertility management in long run.

The amount of potassium fertilizer required depends up on the crop to be grown and potassium status of soil. If only small amount of potassium fertilizer is available, priority in application should be to high potassium requiring crops like rice, potato, other root crops and vegetables. Because of unavailability of potassium fertilizer and inability of poor farmers to buy it, the recommendation to use potassium fertilizer may not be practicable. In such cases, higher application of organic manure/compost could be suggested. Not like nitrogen and phosphorus, most of the potassium in organic manure is immediately (readily) available to crop plant. Therefore balanced application of chemical fertilizer (including potassium), as per requirement of crops, along with complementary use of organic manure is advised for higher crop production and long term soil fertility management of the Chitwan district.

5. CONCLUSION AND RECOMMENDATION:

In general the soil of the Chitwan district is acidic in nature. Out of 192 samples analyzed 74 % were in acidic range of which 19% were having pH less than 5.5. Different crops have their own preferential pH range. Extreme soil pH limits the crop growth and development. To get higher crop production soil reaction must be corrected by liming. The amount of lime required for amelioration of acid soil is given in Appendix2.

The organic matter content of Chitwan district is very low. Of the 192 samples analyzed more than 75% of samples were having very low to low organic matter content. The problem was more serious in East Chitwan and Madi area. Hill area was relatively better in organic matter content with only 28% of samples analyzed having low organic matter content. The organic matter content of soil is very important from soil fertility management point of view. In general the soil organic matter is the indicator of soil fertility. It controls the physical, biological and chemical properties of soil. Therefore, attention must be given in improving the organic matter content of soil.

The total nitrogen and available phosphorus and potassium status of the Chitwan district is also poor with majority of samples analyzed having very low to low nutrient status. The problem is more serious in phosphorus with 37 and potassium with 27% samples having very low nutrient status. Incase of nitrogen the problem is not as

much serious as phosphorus and potassium. Since farmers are using manly urea and DAP, the management of nitrogen and phosphorus is not very difficult. Incase of potassium it's use is almost negligible. Therefore, farmers must be encouraged to apply potassium fertilizer along with other plant nutrients. The nutrient requirement of different crops is given in appendix 3. The value given in appendix three is for soil having low nutrient status. Therefore, depending up on the nutrient status of the soil the fertilizer dose should be adjusted as given in the table below.

Table 14 Application of recommended dose of different fertilizer elements on the basis of soil test value, soil type and irrigation facility.

Percent of recommended dose of fertilizer to be applied	Nutrient status found from soil test
100% of N P and K	Low
75% of N and 60% P and K	Medium (Medium – fine texture)
80% of N and 70% P and K	Medium (Light texture)
50% of N and 40% P and K	High

* Joshy & Deo 1976

** This recommendation is for irrigated agriculture. In case of rainfed condition the recommended dose should be reduced down to 60 %.

The problem of soil fertility deterioration may aggravate in future with increasing cropping intensity, use of high yielding crop varieties, low and unbalanced application of chemical fertilizer, and decreasing use of organic manures. Therefore, a sound soil fertility and crop management practice should be followed to get higher crop production and long term soil fertility management.

The deficiency of micronutrient in vegetables and other cereals like Zinc (Zn) in rice and Boron (B) in wheat has been reported. Farmers, during the survey, reported similar experience. The limit and scope of the survey did not include the micronutrient status of the district. Therefore, micronutrient status could not be studied. However attention should also be paid in micronutrient along with major nutrients to increase the efficiency of applied fertilizers and to get maximum yield.

APPENDIX 1

Optimum pH range for some major crops

S.No.	Crop	Optimum pH	S.No.	Crop	Optimum pH
1	Barley	6.5-8.0	27	Lima Beans	6.0-7.0
2	Buck wheat	5.5-7.0	28	Velvet Beans	5.5-7.0
3	Maize	5.5-7.5	29	Cow Pea	5.0-6.5
4	Oats	5.0-7.5	30	Groundnut	5.3-6.6
5	Rice	5.0-6.5	31	Lucerne	6.2-7.8
6	Rye	5.0-7.0	32	Peas	6.0-7.5
7	Wheat	5.5-7.5	33	Soybeans	6.0-7.0
8	Sugar beet	6.5-8.0	34	Pome Fruits	6.0-8.0
9	Cotton	5.0-6.0	35	Stone Fruits	6.5-8.0
10	Flax	5.0-7.0	36	Mango	5.5-7.0
11	Hemp	6.0-7.0	37	Citrus	5.5-6.5
12	Potato	4.8-6.5	38	Cardamom	4.5-5.5
13	Sweet Potato	5.8-6.0	39	Zinger	6.8-7.0
14	Rape	6.0-7.5	40	Turmeric	5.5-6.5
15	Sugar Cane	6.0-8.0	41	Onion	5.5-6.5
16	Sunflower	6.0-7.5	42	Coriander	6.0-7.0
17	Tobacco	5.5-7.5	43	Garlic	6.5-7.0
18	Turnip	5.5-6.8	44	Chilly	5.5-6.5
19	Olive	6.0-8.0	45	Asparagus	5.5-7.0
20	Banana	6.0-7.5	46	Radish	6.5-7.5
21	Pineapple	5.0-6.5	47	Cauliflower	6.5-7.5
22	Tea	4.0-5.5	48	Cabbage	6.0-7.0
23	Rubber	4.5-7.5	49	Cucumber	6.0-7.3
24	Coconut	6.0-7.5	50	Tomato	5.5-7.0
25	Coffee	4.5-7.0	51	Cowpea	5.0-6.5
26	Field beans	6.0-7.5	52	Fenugreek	6.0-7.0

* S. No. 1-35 taken from Gunti Soil Testing Kit
** S.No 36 onwards taken from Annual Report STSS, 2055-56.

APPENDIX 2

Lime requirement to ameliorate acid soils

pH	Lime recommendation kg/Ropani*					
	Hill			Terai		
	Sandy Loam	Loam	Clay Loam	Sandy Loam	Loam	Clay Loam
6.4	15	20	24	8	14	22
6.3	29	40	48	15	24	44
6.2	43	60	72	23	34	64
6.1	58	78	98	30	44	86
6.0	71	92	120	38	52	106
5.9	85	110	146	45	62	128
5.8	97	128	166	52	72	146
5.7	108	142	188	58	82	166
5.6	119	158	208	64	90	184
5.5	130	170	230	70	100	200
5.4	140	188	252	76	110	220
5.3	150	204	274	81	118	238
5.2	160	218	294	86	126	254
5.1	169	228	314	91	136	270
5.0	176	240	334	96	142	286
4.9	184	252	354	101	150	302
4.8	191	262	374	106	158	316
4.7	199	272	390	111	166	330
4.6	205	280	406	115	174	340
4.5	210	290	420	120	180	350

*1 Ropani = 1.5 Kathha

**Source: Agriculture diary, 2056/57

APPENDIX 3

Table fertilizer recommendation for major field crops

Crop	FYM ton/ha	Recommended dose of Nutrient kg/ha		
		Nitrogen	Phosphorus	Potash
Rice				
Irrigated	6	100	30	30
Unirrigated	6	60	20	20
Maize				
Rainy season	6	60	30	30
Winter	6	90	45	45
Wheat				
Irrigated	6	100	50	25
Unirrigated	6	50	50	20
Millet	6	20	10	10
Barley	6	30	20	10
Sugar cane				
Main crop	10	120	60	40
Ratoon	10	150	60	40
Buckwheat	6	30	20	10
Ginger	24	30	30	60
Potato	30	70	50	40
Cotton	6	60	40	20
Tobacco	10	35	23	60
Rape/Mustard	6	60	40	20
Sunflower	6	60	40	20
Vegetable crops	32	70	50	40
Black gram, Green gram, Lentil	4-6	20	20	20
Cow pea, Pigeon pea	4-6	20	40	30
Chick pea	4-6	20	40	20
Pea	4-6	15	40	10
Soybean	4-6	10	40	30
Groundnut (Peanut)	6	40	60	20
Mulberry				
Terai		300	140	180
Irrigated	-	150	70	90
Unirrigated	-			
Hills		200	80	120
Irrigated	-	100	40	60
Unirrigated	-			

*Source: STSS. Annual report 2055/56

Fertilizer recommendation for fruit trees

Crop	Orchard establishment stage				Non-Bearing trees				Bearing trees			
	FYM	N	P_2O_5	K_2O	FYM	N	P_2O_5	K_2O	FYM	N	P_2O_5	K_2O
Mango	30	40	50	30	50	200	250	150	80	630	245	212
Banana	15	16	10	16	8	80	50	80	15	80	50	80
Litchi	60	33	20	20	33	166	100	100	67	500	333	333
Pineapple	1	1	0.5	1	.45	0.5	2.5	5	.45	5	2.5	5
Guava	30	20	16	26	16	100	83	133	33	250	166	166
Avocado	25	25	20	20	50	150	120	120	80	500	350	300
Citrus	30	30	23	23	30	150	150	170	50	500	333	167

* FYM/Compost in kg/plant and N, P_2O_5 and K_2O in g/plant

** Fruit Development Division, Kirtipur taken from Annual report of STSS 2055/56

Recommended dose of nutrients for Coconut Palm

Crop	FYM Compost KG/plant	Nitrogen gm/plant	Phosphorus gm/plant	Potash gm/plant
Ordinary management crop	20	340	170	680
Good management crop	20	500	320	1200
Hybrid and Improved varieties				
Irrigated	20	1000	500	2000
Unirrigated	20	500	320	1200

*Source: Package of Practice, Kerala Ag University. Taken from Annual report, STSS, 2055/56

Fertilizer Recommendation based on Soil Nutrient status

Percent of recommended dose of fertilizer to be applied	Nutrient status found from soil test
100% of N P and K	Low
75% of N and 60% P and K	Medium (Medium – fine texture)
80% of N and 70% P and K	Medium (Light texture)
50% of N and 40% P and K	High

This recommendation is for irrigated agriculture. In case of rainfed condition the recommended dose is reduced down to 60 %.

APPENDIX 4

Location of the sampling site with the land system unit and VDC

S. No	land sys	VDC & Ward no.	Village/Tole
1	14b	Mangalpur-5	Brahmapur
2	4b	Mangalpur-9	Naranpur
3	4c	Mangalpur-6	Dhadhagari
4	4c	Mangalpur-6	Saranpur
5	4c	Mangalpur-6	Dhadhagari
6	4c	Mangalpur-8	Vijaynagar
7	4c	Mangalpur-7	Rampur
8	5a	Mangalpur-1	Mangalpur
9	5a	Mangalpur-1	Mangalpur
10	5a	Mangalpur-3	Mangalpur
11	5a	Mangalpur-7	Ramppur
12	5a	Shardanagar-1	Shardanagar
13	5a	Shardanagar-7	Kirangunj
14	5a	Gunjanagar-3	Bhimnagar
15	5a	Gunjanagar-1	Gunjnagar
16	5a	Dibyanagar-9	Rodigaun
17	5a	Gunjanagar-5	shashinagar
18	5a	Shukranagar-4	Ratapur
19	5a	Shukra Nagar	Simrani
20	5a	Shukra Nagar	Shukranagar
21	5a	Shukra Nagar	Simrani
22	5a	Shukranagar-6	Sakhuwani
23	5a	Shukranagar-8	Chitai ko mauze
24	4c	Meghauli-8	Parsadhab
25	5a	Dibyanagar-1	Jyotinagar
26	4c	Dibyanagar-3	Koila
27	4c	Dibyanagar-2	Simri
28	4c	Sharda Nagar	Belua
29	4c	Shardanagar-6	Belua
30	4c	Shardanagar-4	Bangaun
31	4c	Shardanagar-4	Bangaun
32	4c	Shardanagar-2	Shardanagar
33	5a	Jagatpur-2	Khagauli
34	5a	Jagatpur-2	Khagauli
35	5a	Jagatpur-1	Jagatpur
36	5a	Jagapur-1	Jagatpur
37	5a	Patihani-2	Birendranagar
38	5a	Patihani-1	Garbhutari
39	5a	Patihani-3	Dhanauji
40	5a	Patihani-6	Patlahara
41	5a	Patihani-7	Brahmapuri
42	5a	Patihani-7	Brahmapuri
43	5a	Gitanagar-2	Prithvinagar
44	5a	Patihani-5	Barauji
45	5a	Patihani-5	Barauji
46	5a	Shivnagar-8	Shantipur
47	5a	Gitanagar-7	Gitanagar
48	5a	Bharatpur-8	Parasnagar

S. No.	land sys	VDC & Ward no.	Village/Tole
49	5a	Bharatpur-7	Prembasti
50	5a	Bharatpur-14	Torikhet
51	5a	Bharatpur-7	Krishnapur
52	5a	Bharatpur-1	Ramnagar
53	5a	Bharat Pur	Baseni
54	5a	Bharatpur-9	Katsigri
55	5a	Bharatpur-9	Katsigri
56	5a	Bharatpur-12	Gondrang
57	5a	Bharatpur-8	Baruwa
58	5a	Gitanagar-9	Parasnagar
59	5a	Gitanagar-4	Deonagar
60	5a	Gitanagar-1	Ujelinagar
61	5a	gitanagar-8	Ganganagar
62	4b	Shukranagar-3	Shukranagar
63	5a	Jagatpur-7	Nayabasti
64	5a	Parbatipur-7	Rangila
65	5a	Parbatipur-6	Ratanpur
66	5a	parbatipur-2	Kanchanbasti
67	5a	Parbatipur-1	Sitapur
68	5a	Patihani-4	sundarbasti
69	5a	Shivnagar-5	Shivnagar
70	5a	Phulbari-6	Gopalgunj
71	5a	Phulbari-1	Phulbari
72	5a	Phulbari-3	Shreepur
73	5a	Bharatpur-13	Narayanpur
74	5d	Ayodhyapuri-2	Devendrapur
75	5a		Jagannathpuri
76	5d	Ayodhyapuri-2	Devendrapur
77	5a	Ayodhyapuri-5	Kharkatta
78	5a	Ayodhyapupri-7	Krishnanagar
79	5d	Ayodhyapuri-8	Ganeshkunj
80	5c	Ayodhyapuri-9	Bandarjhula
81	5c	Ayodhyapuri-9	Bandarjhula
82	5a	Kalyanpur-5	Kirtannagar
83	5a	Kalyanpur-6	Harinagar
84	5a	Kalyanpur-6	Harinagar
85	5d	Ayodhyapuri-6	Kantipur
86	4c	Ayodhyapuri-6	Kantipur
87	5a	Ayodhyapuri-6	Kharkatta
88	5d	Ayodhyapuri-6	Indrabasti
89	4c	Ayodhyapuri-6	Jivanpuur
90	5c	Kalyanpur-3	Lakshmibas
91	5c	Kalyanpur-4	Kalyanpur
92	5c	Baghaura -4	
93	5a	Baghaura-3	Basantpur
94	4c	Baghaura-6	Dhowah
95	4c	Baghaura-6	Dhowah
96	6b	Baghaura	-

S. No.	land sys	VDC & Ward no.	Village/Tole
97	6b	Baghaura	-
98	5d	Baghaura-9	Radhapur
99	5c	Baghaura-1	Nayakhaireni
100	5d	Baghaura-1	Nayakhaireni
101	6b	Baghaura-7	Champapur
102	6b	Baghaura-7	Biranchi
103	6b	Gardi	
104	6b	Gardi-2	Birauli
105	5c	Gardi-2	Kantipur
106	5c	Gardi-2	Kantipur
107	6b	Gardi	
108	11	Darechok-9	Fisling
109	10a	Darechok-3	Kurintar
110	10a	Darechok-3	Kurintar
111	11	Darechok-4	Mungling
112	11	Darechok-5	5 kilo
113	11	Darechok-7	Icchakamana
114	11	Chandi Bhanjyang-9	Ekrang
115	11	Chandi Bhanjyang-9	Ekrang
116	11	Chandi Bhanjyang-9	Ekrang
117	12	Chandi Bhanjyang-8	Thamdanda
118	11	Chandi Bhanjyang-8	Pangre
119	11	Chandi Bhanjyang-3	Dhanubansh
120	11	Kaule-7	Debisthan
121	11	Dahakhani-1	Bhimsenthan
122	11	Dahakhani-2	Tar
123	11	Dahakhani-4	Majhtole
124	11	Kabilash-9	Dhoreni
125	12	Kabilash-8	Lamagaun
126	11	Kabilash-6	Dumre
127	11	Kabilash-7	Taukepani
128	11	Kabilash-2	Tandrang
129	12	Kabilash-1	Jugedi
130	11	Kabilash-7	Chifleri
131	11	Dahakhani-6	Koyalghari
132	11	Darechok-6	Darechok
133	5a	Dahakhani	
134	5a	Dahakhani-9	
135	5a	Dahakhani-9	
136	5c	Dahakhani-9	
137	5a	Jutpani-4	Saguntole
138	6b	Jutpani-4	
139	6b	Padampur-8	
140	5c	Jutpani-5	Kholesimal
141	6b	Ratnanagar	Jamunapur
142	6c	Ratnanagar	
143	6b		
144	4c	Chainpur-1	

S. No.	land sys	VDC & Ward no.	Village/Tole
145	4c	Khairahani-4	Parsa
146	4c	Khairahani-4	
147	5a	Chainpur	Tungara
148	5c	Birendranagar	
149	4a	Birendranagar	
150	4a	Khairahani-1	Dandagaun
151	4c		
152	5a		
153	4c	Bhandara-2	Hardi
154	5a	Bhandara-2	
155		Bhandara	Sericulture farm
156	5a	Piple-9	
157	5a	Piple-7	Gadyauli
158	5a	Piple-6	Mahadevtar
159	4c	Piple-6	
160	4b	Piple-5	Gholkhet
161	4c	Piple-3	Jitpur
162	4c	Piple	Sisabas
163	4b		
164	6c	Ratnanagar-3	Shantichowk
165	6b	Pithua-5	
166	5c	Pithua-3	
167	5c	Pithua-2	
168	5c	Pithua-2	Pithua
169	5c	Pithua-1	Santhi
170	5a	Chainpur-8	Chainpur
171	5c	Chainpur-7	Patihani
172	5c	Birendranagar-9	
173	5a	Khairahani-1	Tungara
174	4c	Khairahani-9	Budhauli
175	4c	Kumroj-7	Sisahaniya
176	4c	Kumroj-5	
177	4c	Kuroj-1	Harnari
178	4c	Kumroj-6	Janakpur
179	4c	Kumroj-8	Kapiya
180	4c		
181	4c	Kathar-9	Pindharni
182	4c	Kathar-3	Kathar
183	4c	Kathar-6	Badgaun
184	4c	Khairahani-5	
185	4c	Khairahani-5	Parsa
186	5a	Birendranagar-4	Badahara
187	6b	Ratnanagar	Bakulahar
188	6b	Ratnanagar-5	
189	4c	Bachauli-4	Padariya
190	4c	Bachauli-6	Gadauli
191	4c	Bachauli-9	Juhuani
192	5a	Phulbari-3	Phulbari

APPENDIX 5

Farmers managed irrigation canals in East Chitwan and their command area.

Source	Irrigation canal	Area ha
1. Rapti River	Pratappur Mahu Kulo, Piple	364
	Mahadev Kulo, Piple	90
	Sisawas Parsaune Kulo, Piple Bhandara	101
	Padaria Kulo, Bhandara	120
	Mudavar Kulo, Bhandara	130
	Janakalyan "Ka" Kulo, Kathar	255
	Janakalyan "Kha" Kulo, Kathar	118
2. Budhi Rapti	Koilidhara Kuch kuche kulo, Bhandara	50
	Budhi Rapti Pahilo Kulo, Janakpur, Kumroj	230
	Amrit Kulo, Kathar	75
	Kharkhutte Tallo Kulo Kathar	70
	Jivanpur Kulo, Kathar	64
	Kapiya Kulo, Kumroj	80
	Sathi Bighe Kulo, Kumroj	60
	Budhirapti second community Kulo Kumroj	275
	Budhirapti chautho, sinchai Kulo Kumroj	209
	Khayarghari Kulo, Kathar	18
	Budhirapti, Kathar Kulo, Kathar	105
3. Dhungre Khola	Purbari number 1 kulo, Bhandara	40
	Hardi Kulo, Bhandara	82
	Dhamaura kulo, Bhandara	221
	Dhungre khola, laungai kulo, Bhandara	90
	Kathar Fafeni kulo, Kathar	125
	Badagaun pipara kulo, Kathar	182
	Sukumbasi "Kha" Kulo, Bhandara	25
	Purbari Naubighe Kulo Bhandara	27
	Gaindadhap Bagar Kulo	30
	Dhungre khola Surtana Kulo, Khairahani	185
	Community Majhui kulo, Khairahani	200
	Salauli Budhauli Kulo, Khairahani	125
	Dhungre Khola Tarauli Kulo, Khairahani	77
	Dhungre Khola Kulo Jhuani Bachhauli	160
	Dhungre Budhi Rapti kulo Jhuani Bachhauli	433
	Khairahani Phant Kulo, Khairahani	32
4. Pampha Khola	Kyampa kulo, Birendra nagar	90
	Pampha Kulo Birendra nagar	80
	Gharedi Dnada farm irrigation kulo,Daitya	60
	Chipleti Kulo, Daitya	142
	Chautara Kulo, Daitya	40
	Annapyrna Sinchai Kulo, Khairahani	158
	Bairahani Kulo, Khairahani	117
	Surtana Kulo, Khairahani	60
	Fasera Farseni Kulo, Khairahani	260

Source	Irrigation canal	Area ha
5. Kayar Khola	Kayar Khola Kulo Chainpur	92
	Kayar Kalika Kulo Chainpur	50
	Kalika Kulo, Cahinpur	368
	Hajipur Kulo Belsi, Ratnanagar	80
	Ameliya Madhavpur Kulo, Ratnanagar	73
	Budhi Kulo, Devauli, Ratnanagar	85
	Pithua subyabasthit Kulo Pithua	1030
	Kayar Khola Bhutya Belchaur Jutpani	150
	Kayar Khola Kalika Kulo	211
	Gangate Chisapani Kulo	47
6. Ladari Pateni Khola	Sitalpani Kulo, Birendranar	30
	Jarua Kulo, Birendranar	30
	Jethi Kulo, Birendranar	79
	Rasauli Dobhan Budhi Kulo, Birendranar	60
	Rasauli Amritpani Kulo, Birendranar	100
	Amilipani Pandheri Kulo, Birendranar	25
	Katunje Kulo, Birendranar	66
	Community Thulo Pteni Kulo, Chainpur	36
	Pateni Tesro Kulo, Chainpur	30
	Una Tole Kulo, Chainpur	33
	Dharapani Ladara Kulo, Chainpur	50
	Ladari Pateni Kulo, Chainpur	50
	Jarua-2 Kulo Birendranagar Amritpani	30
	Butter Kulo, Ratnanagar	131
7.Chyatrang Shkkha ra Dudhakosi	Community Dudhakosi, Kulo, Birendranagar	36
	Community Dudhakosi Sukkha-1,Birendranagar	26
	Dudhakosi Tungara Kulo, Chainpur	20
	Chyatrang Khola Kulo, Birendranagar	30
	Chyatrang Kali Misna Kulo, Birendranagar	210
	Jamune Kulo, Birendranagar	32
	Srijana Kulo, Birendranagar	21
	Dandagaun Dudhakosi Amiliya Ghol Khairahani	26
	Barma Basauli Kulo, Khairahani	50
	Cyatra Pipra Kulo, Khairahani	26
	Karaiya Kulo, Khairahani	30
	Thangbung Kali Khola Kulo Jutpani	450
	188 Khola Kulo, Jutpani	40
8. Tal ra Ghol	Lauri Ghol Kulo Ratnanagar	75
	Tulsipur Kulo Khairahani	35
	Pragati Kulo, Piple	30
	Panisara Dhap Bandh Kulo, Birendranagar	30
	Chiuri Ghol Kulo, Chainpur	40
9. Lothar Mardal Juwa Khola	Chhatiwan Gaindadhap Bagar Kulo, Bhandara	58
	Sivapur Dadua Mardal , Bhandara	60
	Rampur Tandi Kulo, Bhandara	30
10. Underground Boring	Bhumigat Sinchai Brahamasthani, Birendranagar	96
	Bhumigat Sinchai, Dumrichowk, Buirendranagar	23
	Kankali Kulo, Chainpur	368
Total		10233

** Source: Co-operatives of the Irrigation Water Consumer Association in Eastern Chitwan.

Errata

Where			What it is	What it should be
Page	Paragraph	Line		
6	3	1	-	Start wit the sentence, The collected soil samples were delivered to Soil Testing and Service Section for routine analysis as per the term of reference.
13	3	2	Figure 7	Map 8
14	-	-	Fig. 8	Map 8
16	3	2	Figure 10	Map 11
18	-	-	Fig. 11	Map 11
20	3	2	Figure 13	Map 14
22	-	-	Fig. 14	Map 14
25	2	2	Figure 16	Map 17
26	-	-	Fig. 17	Map 17
27	3	1	Figure 19	Map 20
29	-	-	Fig. 20	Map 20