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SOILS OF MOREL RIVER SUB-CATCHMENT (RAJASTHAN) AND SUGGESTED PRODUCTION SYSTEM

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Abstract

This paper is an attempt to understand main soil types associated with Morel river's sub-catchment area located in the eastern part of Rajasthan with respect to their morphological, physico-chemical and biological properties. It also deals in suggesting production systems based on main soil type associations.

Available published and unpublished informations have been utilized to interpret soils of the study area by traversing extensively in the area as per field variations. Soil types and their associations have been delineated and mapped based on their occurrence (up to 65 per cent or more), and their associations have been considered covering (about 25 to 35 per cent) in respect to spatial extent.

Coarse loamy non calcareous, calcareous loamy and fine loamy mixed are the three main soil type associations covering more than 53 per cent of the total reporting area of the study.

Information and knowledge of the inherent properties of the soils are the essential prerequisite for their proper utilization, management and conservation. Not only the soil nutrient status but also their morphological characteristics play a very important role in deciding productivity of the soils and crops as well.

Introduction

All natural resources are indeed important but the soil resource is more important as it provides support to plants, animals and human societies. No two types of soils are exactly alike in their morphological and productive qualities. Their delineation is the core and key step to know their needs and the activities to be adopted for their conservation on the one hand and maintain as well as uplift the production potential on the other. Information and knowledge of soils are the essential prerequisites for their proper utilization, management and conservation. It also helps in proper selection of crops and better landuse planning. 'Recently, a renewed attention is being given to soils as the knowledge and understanding about soils is either not available or is not being interpreted as per the users needs for practical applications' (Sehgal et al 1999).

'Primary nutrients are required in larger amount by the plants. The soils developed under varied situations behave differently in terms of these nutrients. Moreover, primary nutrients play a very important role in deciding productivity of the soil as well as crops. However, more degradation of the soil resulted from their unsystematic and non-scientific use' (Diwakar and Sharma, 1997). These vary greatly in their morphological, physico-chemical and biological properties. Therefore, 'during a general soil resource inventory programme, a lot of information on various aspects of soils is collected as primary data. Since many soil properties have a great spatial variability within short distances a range of classes is chosen to overcome the scale limitations

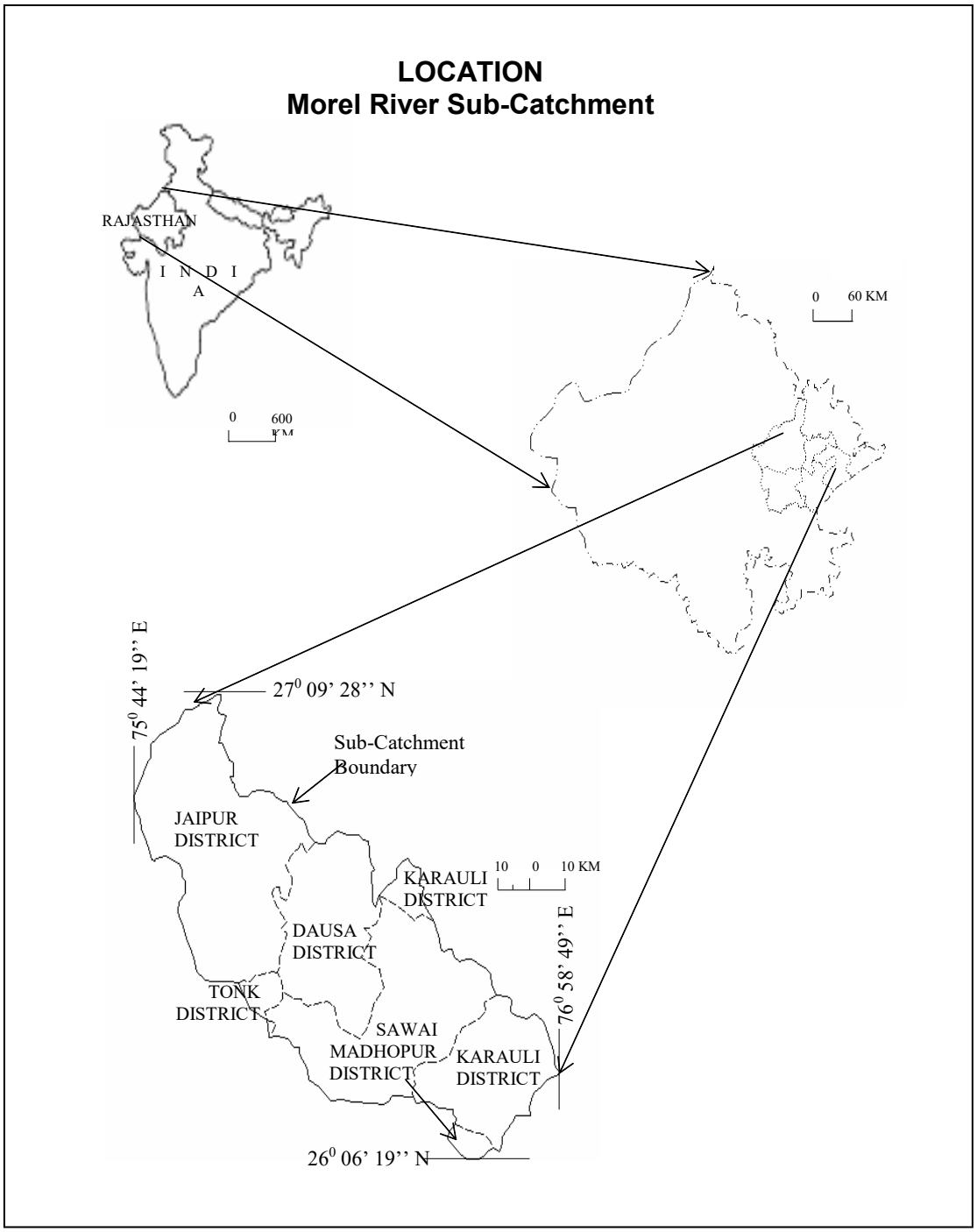

LOCATION
Morel River Sub-Catchment
RAJASTHAN
I N D I A
0 600 KM
0 60 KM
75⁰ 44' 19'' E
27⁰ 09' 28'' N
Sub-Catchment Boundary
JAIPUR DISTRICT
10 0 10 KM
KARAULI DISTRICT
DAUSA DISTRICT
TONK DISTRICT
SAWAI MADHOPUR DISTRICT
KARAULI DISTRICT
76⁰ 58' 49'' E
26⁰ 06' 19'' N

Fig. 1

within the constraints of specific soil survey applications' (Chaturvedi, 1992).

Vaidyanathan (1977) as cited by (Singh A.L and Hasmi S.N.I. 1987) indicates that after a decade of rapid spread of technology, growth rates of production have not increased, and may have in fact fallen, compels a sober assessment of the prospects based on current strategy. Based on district level growth data the similar view that it is more difficult to increase the rate of growth in foodgrains produced in future than in the past had also been expressed by Bhalla (1977). It is a matter of concern to all that 'the productivity of agricultural soils worldwide has started showing some kind of fatigue; the per capita foodgrain production has been on decline' (Sehgal et al 1999).

Soils of the study area are complex, and highly variable, reflecting a variety of differing parent materials, morphology, range and distribution of rainfall and its effects etc. The soil survey is a scientific process of mapping different soils based on variations in their morphological and physico-chemical properties. Soil types and associations have been designated as soil units.

The soils are generally evaluated for their production capacity through the study of their ability to supply plant growth requirements in terms of water, nutrients and rooting media. The capacity to retain, as also to conduct soil moisture in profile, depends upon the soil texture, soil porosity and soil structure. For example, heavy soils due to their fine texture and porosity, provide effective capillary tubes for moisture movement. In loose sandy soils, due to big particles and pores, with fewer fine capillary pores, there is lesser soil moisture movement. Further, heavy soils are more difficult to work with implements than in light soils. Soils are thus, variable in their soil-water-plant relationship, conservation needs and production potentials.

To assess the potential of agricultural development and to plan proper conservative landuse, soil survey is the basic requisite. The knowledge of soils gathered through such surveys is not only useful in finding out agriculturally potential areas but also those areas which have remained unnoticed under one or the other soil degradation process for a long period and are now considered as problematic areas. It is also by this means that plan for developed, underdeveloped and problematic soils may be made with the desired variability.

Location and Extent of the Study Area

The Morel river sub-catchment is situated between 26^0 6'19" N to 27^0 9' 28" N latitudes and 75^0 44' 19" E to 76^0 58' 49" E longitudes covering an area of 5892.78 km^2. It extends wholly or partially in 17 tehsils of 5 districts namely Jaipur, Sawai Madhopur, Dausa, Karauli and Tonk of Rajasthan (Fig. 1).

Objectives

The present study primarily aims at the following objectives:

(i) To study soil types and their associations in study area based on published as well as field and laboratory study of soils done by reconnaissance traversing, and

(ii) to suggest suitable production systems.

Data Base and Methodology

'In view of the variability of soils, it seems impossible to device an entirely satisfactory method for sampling. It is obvious that the details of the procedure should be determined by the purpose for which the sample is taken' (Singh, 1989). Therefore, a two-stage strategy was adopted to delineate and map the soils of the Morel river sub-catchment:

(i) Collection of information from various available sources.

(ii) Field visit and collection of soil samples by traversing and study of

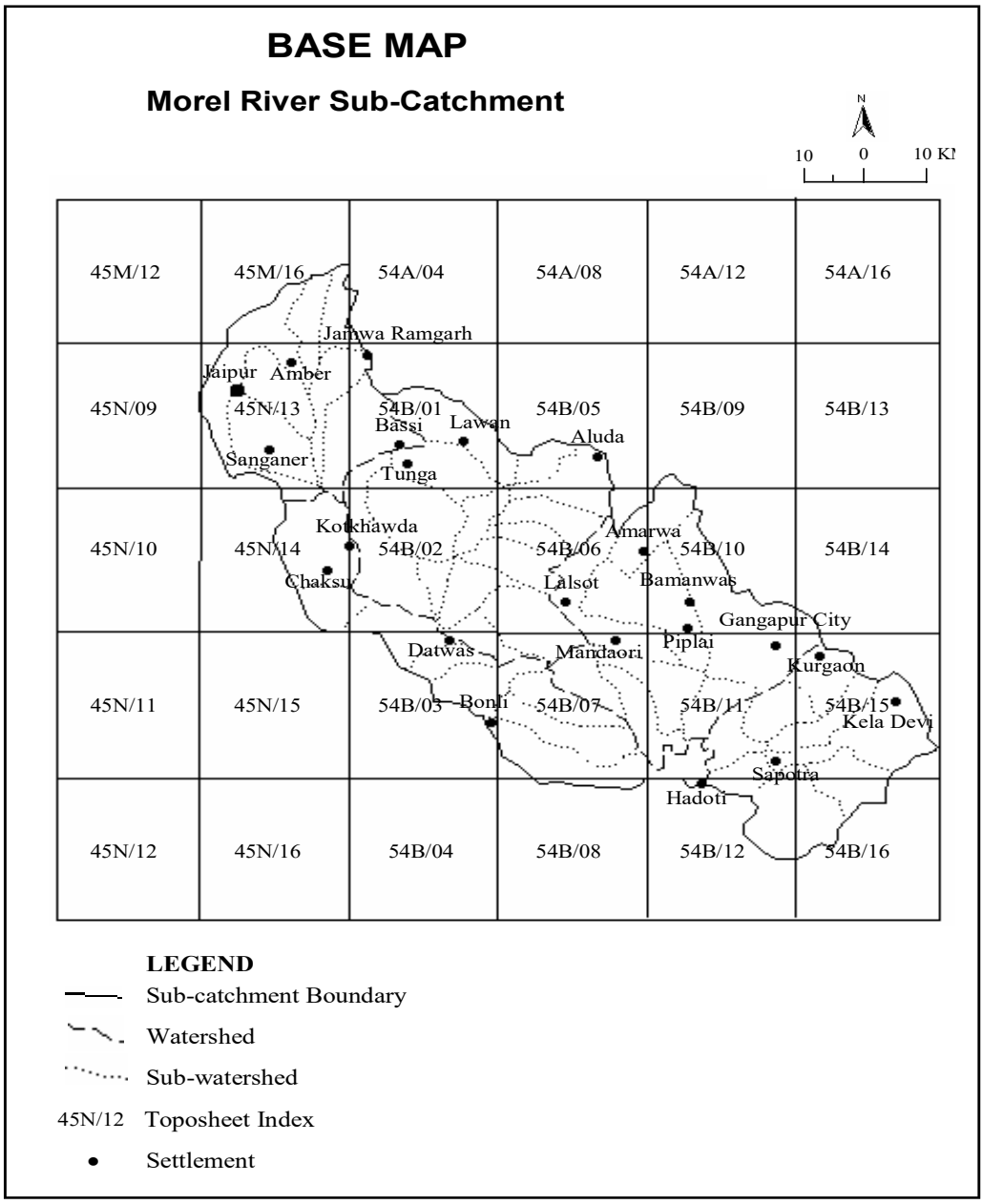

BASE MAP
Morel River Sub-Catchment
N
10 0 10 KI
45M/12
45M/16
54A/04
54A/08
54A/12
54A/16
Jamwa Ramgarh
Jaipur
Amber
45N/09
45N/13
54B/01
54B/05
54B/09
54B/13
Bassi
Lawan
Aluda
Sanganer
Tunga
Kookhawda
Amarwa
45N/10
45N/14
54B/02
54B/06
54B/10
54B/14
Chaksu
Lalsot
Bamanwas
Gangapur City
Datwas
Mandaori
Piplai
Kurgaon
45N/11
45N/15
54B/03
Bonli
54B/07
54B/11
54B/15
Kela Devi
Sapotra
Hadoti
45N/12
45N/16
54B/04
54B/08
54B/12
54B/16
LEGEND
Sub-catchment Boundary
Watershed
Sub-watershed
45N/12 Toposheet Index
Settlement

Fig. 2

soil augur and profile examination at the site.

Various published and unpublished reports and other related informations were collected from the Department of Agriculture, Watershed Development and Soil Conservation, Government of Rajasthan, Jaipur. Soils of India Series - Soils of Rajasthan for Optimizing Land Use, 1995, No. 51 released by NBSS and LUP, Nagpur in coordination to CAZRI, Jodhpur and Department of Watershed Development and Soil Conservation, Government of Rajasthan, Jaipur were also consulted by the author.

After interpretations of available information, the study area was extensively traversed by the author and a soil scientist following a tentative track with modifications of route as per field variations. Sites were selected in a way to cover and examine each variable type of soil in all the four directions and also adjacent as well as far from the river and *nallahs*. The base map of the study area is (Fig. 2) ready reference of sites/places.

Based on soil variability, soil samples of about 50 augur holes and 16 profiles were collected from the study area representing all main soil types. Selected soil samples were got analyzed for their mechanical analysis (to verify texture) and for pH, EC and fertility status. Water samples were also examined. Soil samples were collected wherever required or essential for soil analysis. The results are interpreted and incorporated in subsequent discussion.

Extent of Different Units of Soil Types and their Associations

The texture of a soil is a basic physical property, which reflects its hydrological response, productivity and behaviour, and the type of conservation measures required and best suitable production system. Therefore the mapping of soils was done based on textural differences at the first stage. However, in depth study was done on the basis of calcareousness and salinity characteristics of the soils.

Occurrence of different soils is very intermittent spreading over small-scattered patches, but at places covering long stretches. As such to map each soil texturally from field to field is very difficult. Therefore soils of the study area have been mapped as association of two soil texture types, the dominant and the associated. The naming of mapped soils is done based on soils of dominant coverage of their occurrence up to 65 per cent or more. However its association has also been mentioned covering about 25 to 35 per cent.

The study area shows various types of soils occurring on gently to very gently sloping plains, pediments, plateau and valleys. In all 10 main soil associations are delineated on map along with two miscellaneous units based on field observations and soil analysis as shown in soil type associations (Fig. 3). All the three dominant texture of soils, i.e., sandy, loamy and clayey occur in the area. The extent of main soil types and their association is given in Table 1.

Sandy soils

Sandy soils (coarse and loamy sand) covering 3.52 per cent of the Morel river sub-catchment are very deep, well to excessively drained, mostly non-calcareous and moderately eroded. These are occurring on gently sloping plains and occasionally on pediments. These are light yellowish brown in colour. The areas show occasional presence of dotted hillocks. The texture of surface soils varies from coarse sand to fine sand. These particularly exist in the mid-eastern part of the study area.

Coarse loamy soils

These are deep to very deep (>100 cm to >150 cm) well drained, slight to moderately eroded non calcareous soils

Table 1
Morel River Sub-Catchment: Soil Type Associations

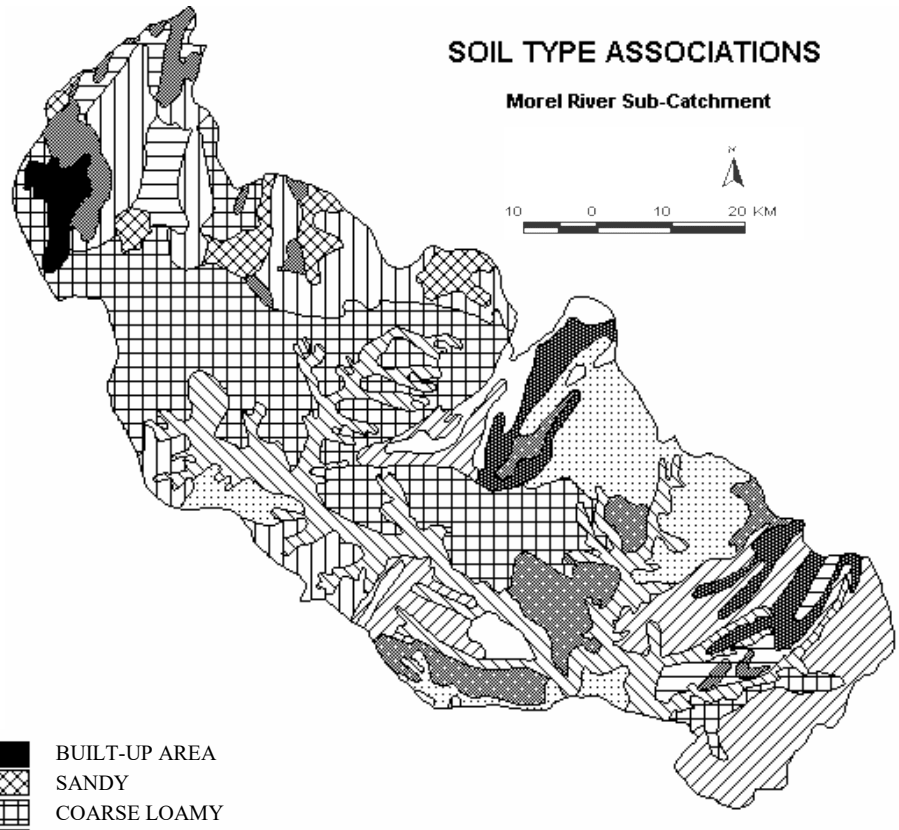
Sr. No.	Main Soil Types Coverage (65-75 per cent)	Association Coverage (25-35 per cent)	Extent of Area (Km^2)	Per cent of Total Study Area
1	Sandy	Coarse Fine Loamy	207.50	3.52
2	Coarse Loamy	Sandy/ Fine Loamy	1520.00	25.80
3	Fine Loamy Mixed (deep to very deep)	Coarse Loamy	733.00	12.45
4	Calcareous Loamy (severely eroded)	Coarse Loamy	900.50	15.28
5	Loamy Mixed (moderately shallow)	Moderately Deep Coarse / (Fine Loamy to moderately deep)	678.50	11.51
6	Fine Textured Clayey	Occasional Fine Loamy	227.50	3.86
7	Calcareous Fine Textured	Non Calcareous Fine Loamy	604.00	10.25
8	Salt Affected (Loamy Fine to Fine Textured)	Normal Soils	309.00	5.24
9	Loamy Skeletal	Occasional Shallow Loamy Scattered	189.50	3.22
10	Skeletal Intermixed with Loamy (shallow/ deep)	Coarse Loamy	257.00	4.36
Miscellaneous Units				
11	Rock Outcrops	Skeletal	187.00	3.17
12	Built-up Area		79.00	1.34
	Total		5892.78	100.00

Source: Computed and compiled by the author.

spreading over one fourth (25.80 per cent) of the study area are extensively located in the central part of gently sloping plains. These soils are also occurring on dissected and gently sloping pediments. Occasional occurrence on rocky plateau is also noticed. The texture of sub soil varies from sandy loam to loam while at the surface loamy sand makes occasional presence. These are moderately prone to wind and water erosion. Very deep, slight to moderately eroded, partly calcareous fine and loamy soils are also found in association to these soils.

Fine loamy mixed (deep to very deep) soils

These are mostly deep (>100 cm) well drained, non calcareous, moderately to slightly eroded loam to sandy clay loam soils with sandy loam to loam texture at the surface. Occasionally very deep moderately well drained soils are also encountered. These soils are occurring over a notable area comprising 12.45 per cent of the study area. These occur



BUILT-UP AREA
SANDY
COARSE LOAMY
FINE LOAMY MIXED (Deep to Very Deep)
CALCAREOUS LOAMY (Severely Eroded)
LOAMY MIXED (Mod. Shallow to Mod Deep)
FINE TEXTURED CLAYEY
CALCAREOUS FINE TEXTURED
SALT AFFECTED (Loamy Fine to Fine Textured)
LOAMY SKELETAL
SKELETAL INTERMIXED WITH LOAMY (Shallow/Deep)
ROCK OUTCROPS

Source :

- National Bureau of Soil Survey & Land Use Planning, Nagpur
- All India Soil & Land Use Planning,New Delhi
- Soil Survey Wing of Dept. of W.D. & S.C. Durgapura, Jaipur
- Soil Samples taken during the Field Work.

Fig. 3

mostly on gently sloping plateau (extreme south eastern part), on gently to very gently sloping lands in Lalsot area and very gently sloping margins of dissected lands in the extreme southern part of the Morel river sub-catchment.

These are most potentially productive soils having favourable conditions for plant growth. These respond well to fertilizers and water. Mostly coarse loamy well-drained soils and occasionally sandy soils are found associated with these soils.

Calcareous loamy (severely eroded) soils

These are very deep, well drained calcareous, fine loamy (fine sandy loam to sandy clay loam) severely eroded soils of the river valley found on gently sloping dissected lands. These are extensively present in thin width along the *nallahs*, drains and ravines in the central part of the area under investigation. These soils fall next to coarse loamy soils in coverage embracing 15.28 per cent of the study area. The area exhibits wide variation of erodibility expressed by existence of variable width and depth of gullie/revines. Calcareous coarse loamy soils are found associated to these soils. The delineated area shows scattered occurrence of salinity and sodaicity.

Severe erosion, undulating surface, and lack of continuous tablelands are some of the factors that make these soils to be especially cared and managed. Obviously, these require land treatment, soil conservation strategy for making economically suitable production system.

Loamy mixed (moderately shallow to moderately deep soils)

These are mostly moderately shallow (50 - 75 cm. deep) non-calcareous to calcareous, well drained, slight to severely eroded, fine loamy (loam to sand clay loam) soils of gently sloping plains and pediments with interspersed monadnocks. The surface soils are mostly loamy in texture. Such soils are present in larger areas in north-western and south-western part of the study area. These cover 11.51 per cent of the total area. The soils associated to these are moderately deep (75-100 cm), severely eroded, coarse loamy and occasionally deep and fine loamy in nature. Moderate erodibility, depth limitation and reduced choice of crops to be grown are limitations of these soils. The production potential is however moderate.

Fine textured clayey soils

These are mostly deep (>100 cm), moderately well to poorly drained, non-calcareous, slightly eroded and fine textured (clay loam to sandy/silty clay) soils. These are occurring on very gently sloping plains and plateau cover only 3.86 per cent of the total study area. Surface texture in these soils varies from fine loam to clay loam. Partly occurrence of fine well-drained soils with fine loamy surface is also observed. However these soils suffer with problem of poor drainage, low permeability, slow infiltration and cracking, but water holding capacity and nutrient availability in these soils is good.

Calcareous fine textured soils

These are generally moderately deep to deep (75-100 cm) and occasionally very deep (>100 cm) moderately drained, calcareous, fine loamy to clay, slight to moderately eroded soils with fine loamy surface. These soils occur on gently to very gently sloping plains with interspersed monadnocks. These are spreading over a larger area (10.25 per cent) than non-calcareous fine soils. These soils are present in the north-eastern part of thestudy area around Gangapur city and south-western part of Chaksu tehsil.

Salt affected (loamy fine to fine textured) soils

These are usually very deep (>150 cm) and occasionally deep (100 -150 cm), mostly calcareous, moderately drained, slight to moderately eroded, loamy fine to fine textured (loam to clay loam) soils

occurring on very gently sloping plain with occasional presence of interspersed monadnocks with fine loam surface soils. These also occur on margins of dissected plains, alluvial plains and very gently sloping pediment where these are severely eroded. Occasionally clayey surfaces are also observed. These soils cover 5.24 per cent of the total study area. These soils are found in scattered patches and long stretches but suffering from the problems of salinity, sodaicity or both. However, the intensity of problem is variable. Such soils being associated with calcareousness pose serious problem of cracking and poor soil physical properties therefore, require proper reclamation and management.

Loamy skeletal soils

These are very shallow (10-25 cm deep) moderately drained loamy skeletal soils occurring on the steeply sloping slopes of dissected hills and ridges covering 3.22 per cent area of the study area. These are reddish brown in colour with presence of stones, pebbles and cobbles on the surface and below. These are moderately to severely eroded. Steep slopes, erodibility, limited soil depth and stoniness are the factors, which limit their agricultural importance. Therefore, these soils require very careful management before these are put to any production use/production system. These are prominent in Lalsot area.

Skeletal intermixed with loamy (shallow/deep soils)

Very shallow to moderately shallow loamy (10-25 cm to 50-75 cm deep) skeletal soils are found after intermixed with deep to very deep well to moderately drained, sandy to course soils on gently sloping pediment, sloping hills, sloping escarpments covering 4.36 per cent of the study area. Loamy skeletal soils are severely eroded while intercepting or intermixed loamy soil areas are slight to moderately eroded. These areas show variations in stoniness at surface and below. The management of these areas is most difficult, as these are found in close association and in small patches. Use of *Alley* cropping (narrow strip tree plantation) and *mixed* production system may prove to more suitable. Owing to variable texture of intermixed associated soils, the area requires site-specific treatments.

Rock outcrops

These areas show the presence of out-cropped rocks associated with moderately shallow well-drained loamy skeletal, severely eroded and strongly stony soils of hilly terrain with ridges and furrows covering 3.17 per cent of the study area. These areas are occasionally found associated with moderately shallow fine, moderately eroded soils. Owing to the presence of rock outcrop, the area poses difficulty in its use for agricultural purposes.

Built-up Area

The study area has many towns and villages. It is not possible to separately demarcate each habitation on the scale used for survey. Therefore, only the built up area of significance has been demarcated, which covers only 1.34 per cent of the total study area representing the city of Jaipur.

Physico-chemical Properties of Different Soils

Physico-chemical properties namely, surface and sub-surface textures are presented in Table 2. The presence of calcium carbonate is also given representing as calcareous and for absence of non calcareous. The productive quality of soils, which is mainly governed by physico-chemical properties, is also incorporated. Table 2 indicates that area under loamy soils (coarse and fine) is most productive and responsive

Table 2

Morel River Sub-Catchment: Physical and Chemical Properties of Soils

S. No.	Soil Type	Texture		CaCo3	pH
		Control Section	Surface	Presence	
1.	Sandy	S-LS	S	Non Cal	7.5 - 8.5
2.	Coarse Loamy	SL – L	LS – SL	Non Cal	7.5 - 9.0
3.	Fine Loamy Mixed (deep to very deep)	SL – SCL	SL-L	Non Cal	8.0 - 9.5
4.	Calcareous Loamy (severely eroded)	L - SCL	SL - L	5 - 25%	7.5 - 9.0
5.	Loamy Mixed (moderately shallow to moderately deep)	L - SCL	L	Non Cal	7.5 - 8.5
6.	Fine Textured Clayey	CL-Clay	L-CL	Non Cal to 0-5 per cent	8.0 - 9.5
7.	Calcareous Fine Textured	L - Clay	L - CL	15->30	8.5 - 9.0
8.	Salt Affected (loamy fine to fine textured)	L - CL	L	15%	8.0 - >9.5
9.	Loamy Skeletal	(Stony) Loam	Coarse Loamy	-	7.5 - 8.5
10.	Skeletal Intermixed with Loamy (shallow/deep)	(Stony) Loam to Loam	SL - L	-	7.5 - 8.5

Source: Compiled by the author based on laboratory tests.

Texture
L - Loam
SL - Sandy Loam
LS - Loamy Sand
S - Sand
CL - Clay Loam
SCL - Sandy Clay Loam
C - Clay

Presence of Calcium Carbonate ($CaCo_3$)
Cal = Calcareous - Present
Non Cal = Non calcareous – Absent/Negligible
pH = Measure of Reaction
acid/ normal/ Alkali
<7.0 7.0 >7.0

to human efforts. Fine textured, clayey soils require careful management for harvesting optimum production.

Suitable Production Systems for Different Soils

The capacity of a soil to produce is limited. However, its inherent characteristics, agro-ecological settings, use and management put the limits. Different types of production systems may be selected looking to the limitations in soils. Table 3 indicates comparatively suitable production systems suggested for different soils:

Table 3

Morel River Sub-Catchment: Suitable Production Systems Suggested for Different Soils

Soil Type	Suitable for
1. Sandy	Occasional cultivation single cropping.
2. Coarse Loamy facility exists.	Single cropping - double if irrigation
3. Fine Loamy Mixed (deep to very deep)	Double cropping with ensured water supply.
4. Calcareous Loamy (severely eroded)	Afforestation, silvi pasture, silvi horticulture.
5. Loamy Mixed (moderately shallow to moderately deep)	Agriculture, shallow rooted (selected crops), mixed cropping, pasture.
6. Fine Texture Clayey	Agriculture, horticulture, double cropping
7. Calcareous Fine Textured	Agriculture and horticulture.
8. Salt Affected (loamy fine to fine textured)	Plantation and cropping of only salt tolerant crop varieties.
9. Loamy Skeletal	Afforestation, pasture, agro-forestry, silvi-pasture.
10. Skeletal Intermixed with Loamy (shallow/deep)	Mixed cropping, alley cropping.
11. Rock Outcrops	Site specific selection of production system.
12. Built-up Area	N. A.

Conclusion

All the ten main soil types are delineated alongwith two miscellaneous land units based on field observations and soil analysis in respect to associations of soil types. Coarse loamy non calcareous soils are covering the maximum area (25.8 per cent) followed by the calcareous loamy soils (15.28 per cent) and fine loamy mixed soils (12.45 per cent) of the study area occurring on a wide range of geomorphic units. On pediments moderately shallow loamy mixed and skeletal soils are common while sandy soils show occasional occurrences. Calcareous loamy soils are mostly found in river/*nallah* valleys and are dissected.

Shallow loamy skeletal soils are found alone as well as in association with moderately deep loamy soils. Normally, the sandy soils and coarse loamy soils are poor in nutrients, while fine and fine textured clayey soils are moderate in nutrient status.

In studied soil samples, salt affected soils exhibit high pH values upto 9.5. Calcium carbonate is present in powdery form as well as in concretions. It usually increases with depth.

The sandy or light soils that are loose and single grained. These are more prone to wind erosion and are often subject to sand drift. But due to their coarse and open texture, coarse pores and resultant high infiltration capacity, these are not susceptible to water erosion, even during heavy cloud bursts. Different soils create different types of habitats for plant growth,

and therefore, the crop choice and cropping patterns on such kinds of soils greatly vary. Different types of production systems have been suggested taking into account the limitations of different soil types and associations. Efficient use and management of natural resources particularly the soil is essential to meet the food challenges.

Acknowledgements

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