Climate change vis-à-vis soil system modelling possibilities for Vetiver based land use in West coast of Karnataka, India

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Vetiver (*Vetiveria zizinoides)* is an important aromatic plant and its roots are widely used in medicinal preparations, handicrafts and for essential oil. Vetiver is a perennial grass which grows in the tropical and sub-tropical parts of the world. This grass grows in a wide range of climatic and soil conditions, at different temperatures (- 15^0C to > 55^0C), soil pH (< 3 to > 10), annual rainfall (< 300 mm to > 5000 mm) and tolerant to salinity, prolonged waterlogged conditions and is resistant to pests and diseases (Grimshaw, 2008).Vetiver has significant environmental and economic benefits and is used in soil conservation, phytoremediation, essential oil production, medicinal preparations, handicrafts, production of forage, mulch, thatches etc. Its wide adaptability and multiple uses make it an ideal plant for mitigation strategies such as C- sequestration.

Vetiver oil with its heavy, woody and earthy character, is one of the most important perfumery raw material. Its viscocity makes its persistent and has lower base note and due to its solubility in alcohol, it is highly compatible in fragrance formulations. Vetiver oil is present in more than 36% of commercial perfumes (e.g. Channel svo 5, Miss Dior, Craracho and Shalimar)(Thiraites, 2010). Current world wide production of vetiver oil is nearly 250 t/year with India's production of nearly 20 t/year. The demand of natural vetiver oil is increasing tremendously, especially in the event of recent earth quake in Haiti which is the largest vetiver oil producing country (100 t/year).

Thus, there is a great scope for economic utilization of vetiver, besides environmental benefits (Prakasa Rao *et al.,* 2008).

In India, South Indian variety of vetiver is widely cultivated in coastal Karnataka, especially in Uttara Kannada district followed by Dakshin Kannada district. It is estimated that vetiver is grown in nearly 3000 ha in South India. The vetiver oil produced in this region has been accepted commercially and has good chemical profile (tab 1). Vetiver is incorporated in existing cropping systems of rice, arecanut and cashewnut.(Fig 1). However, poor understanding of the soils and the impact of vetiver cultivation on soil properties coupled with poor agronomic practices threaten the vetiver production systems in this agro-climatic region. For example, unscientific harvesting methods(Fig 2), poor nutrient recycling can impact the economic and environmental benefits of vetiver.

Therefore, in the present paper information on the soils of the vetiver growing regions in coastal and foot hills of western Ghats in Karnataka has been presented(Figs 3, 4).Also, changes in soil properties with time has been discussed. It is also proposed to develop quantitative models to project the impact of vetiver on the soils system and also the environmental benefits of vetiver such as soil conservation and C-sequestration.

Soils of Vetiver growing areas of Karnataka

In Karnataka, vetiver is mostly grown in West coast and Western Ghats of Udupi, Dakshina Kannada and Uttara Kannada districts.

West Coast of Karnataka covers an area of 7425 sq. km in Uttara Kannada and Dakshina Kannada districts. The annual rainfall ranges from 3000 to 4700 mm(Fig. 5)and most of the rainfall occurs during June-September (Fig. 6). Potential evapotranspiration exceeds rainfall from November to April, giving more than 150 moisture-deficit days. Constraints for agriculture are low base saturation, low nutrient status and severe erosion. The major land uses of this region are cashew on undulating uplands and laterite mounds and paddy and ground nut in valleys. The region includes laterite uplands and coastal plains. Vetiver cultivation is restricted to laterite uplands. Maximum and minimum temperature remains between 28^0 to 32^0C and 19^0 to 26.3^0C respectively (Fig. 7). LGP(length of growing period) varies between 180 to 240 days.

Soils of laterite uplands

Laterite uplands have moderately shallow, or moderately deep to very deep, somewhat excessively drained or well-drained (Fig. 4), gravelly clay soils, associated with ironstone crust on the surface. The soils have low or medium base saturation, and low or medium cation exchange capacity. They are strongly to medium acidic, have medium to high organic carbon content. Cashew, arecanut and coconut are the plantation crops grown. Constraints for agriculture are low base saturation, low nutrient status, crusting and steep slopes and moderate or severe erosion.

Description of soils

1. Very deep, well-drained, gravelly clay soils with low AWC on laterite mounds, with slight erosion; associated with moderately shallow, well-drained, gravelly clay soils with low AWC and surface crusting (*Clayey skeletal Kaolinitic Kanhaplic Haplustults*). These soils cover an area of 82027 ha

2. Moderately deep, well-drained, gravelly clay soils with low AWC and surface crusting on undulating uplands, with moderate erosion; associated with moderately deep, well-drained, gravelly clay soils (*Clayey skeletal Kaolinitic Kanhaplic Haplustults*). These soils cover an area of 141279 ha

Soils of low hill, foothills and undulating uplands of Western Ghats

Vetiver is confined to low hill ranges, foothill slopes and undulating uplands of Western Ghats. Low hill ranges have deep, well drained or somewhat excessively drained clayey and gravelly clay soils (Fig. 4). Foothills and undulating uplands have deep and moderately deep, well drained, gravelly clay and clay soils. The major land use is forest, coconut and arecanut on uplands.

Description of soils

1. Deep, well drained, clayey soils with medium AWC on foothill slopes, with severe erosion; associated with moderately deep, well drained, loamy soils (*Fine Kaolinitic Kandic Paleustalfs*).

These soils cover an area of 204321 ha.

2. Moderately shallow, well drained, clayey soils with low AWC on foothills slopes, with moderate erosion, associated with deep, well drained, clayey soils with medium AWC (*Fine Kaolinitic Ustoxic Dystropepts*). These soils cover an area of 63488 ha.

3. Very deep, well drained, gravelly clay soils with low AWC on low hill ranges, with moderate erosion; associated with moderately deep, somewhat excessively drained, gravelly clay soils (*Clayey skeletal Kaolinitic Ustic Haplohumults*). These soils cover an area of 212673 ha.

4. Very deep, well drained, gravelly clay soils with surface crusting and compaction on undulating uplands, with moderate erosion; associated with very deep, well drained, gravelly clay soils with surface crusting and compaction (*Clayey skeletal Kaolinitic Typic Kandiustults*). These soils cover an area of 272234 ha.

5. Moderately shallow, somewhat excessively drained, gravelly clay soils with hard ironstone on coastal plateau summits, with moderate erosion; associated with ironstone crust (*Clayey skeletal Kaolinitic, Peteroferric Haplustults*). These soils cover an area of 66614 ha.

Soil studies conducted over a period of 14 years have shown significant changes in soil properties. Sand content in different depths decreased in general and silt and clay fractions have accumulated in lower soil horizons in one location (Gantihole). This may be due to erosion of sand particles and vertical movement of silt and clay in the profile because of high intensity rainfall. In another location(Kalatodu), the trend of changes in soil particles indicate that sand and silt are susceptible to lateral and vertical movement respectively due to high intensity rainfall. The soil organic carbon which is a primary indicator of soil health and productivity has declined significantly. The other indicators such as soil pH, CEC, base saturation and the concentration of various cations of soil indicate the process of changes in the capacity to support and sustain agricultural productivity and environmental sustainability (Figs. 8-15).There were no studies published so far on the changes in soil processes in vetiver growing regions of India. The present study helps in understanding vetiver- soil interface and also aids in developing management methods to derive greater economic and environmental benefits of vetiver systems in this agro-climatic region.

A potential area of application of vetiver is in sustainable mitigation of climate change. Because of its economic benefits and moderate input requirements for its growth, vetiver is a promising plant for non-disruptive phyto-remediation. However, it is necessary to assess and project quanitative requirements of quantities such as cropping area and duration to determine the feasibility and expected impact. Such quantitative assessment and projections require sensitivity experiments with comprehensive and validated climate model, which can be used to simulate vetiver vs non-vetiver scenarios. Although the basic models and expertise are now available in India, a comprehensive effort is needed to address this critical issue.

References

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Table 1: Chemical composition of vetiver oil distilled in 3 villages in north Kannada dist.

Location	Khusimol(%)	Beta Vetivone (%)	Alpha Vetivone (%)
Village 1	13.50	7.42	5.97
Village 2	13.96	6.97	4.69
Village 3	8.32	4.07	5.46

Fig 1. Vetiver alongside rice-based cropping systems in Uttara Kannada dist.

Fig 2. Unscientific harvesting method of vetiver

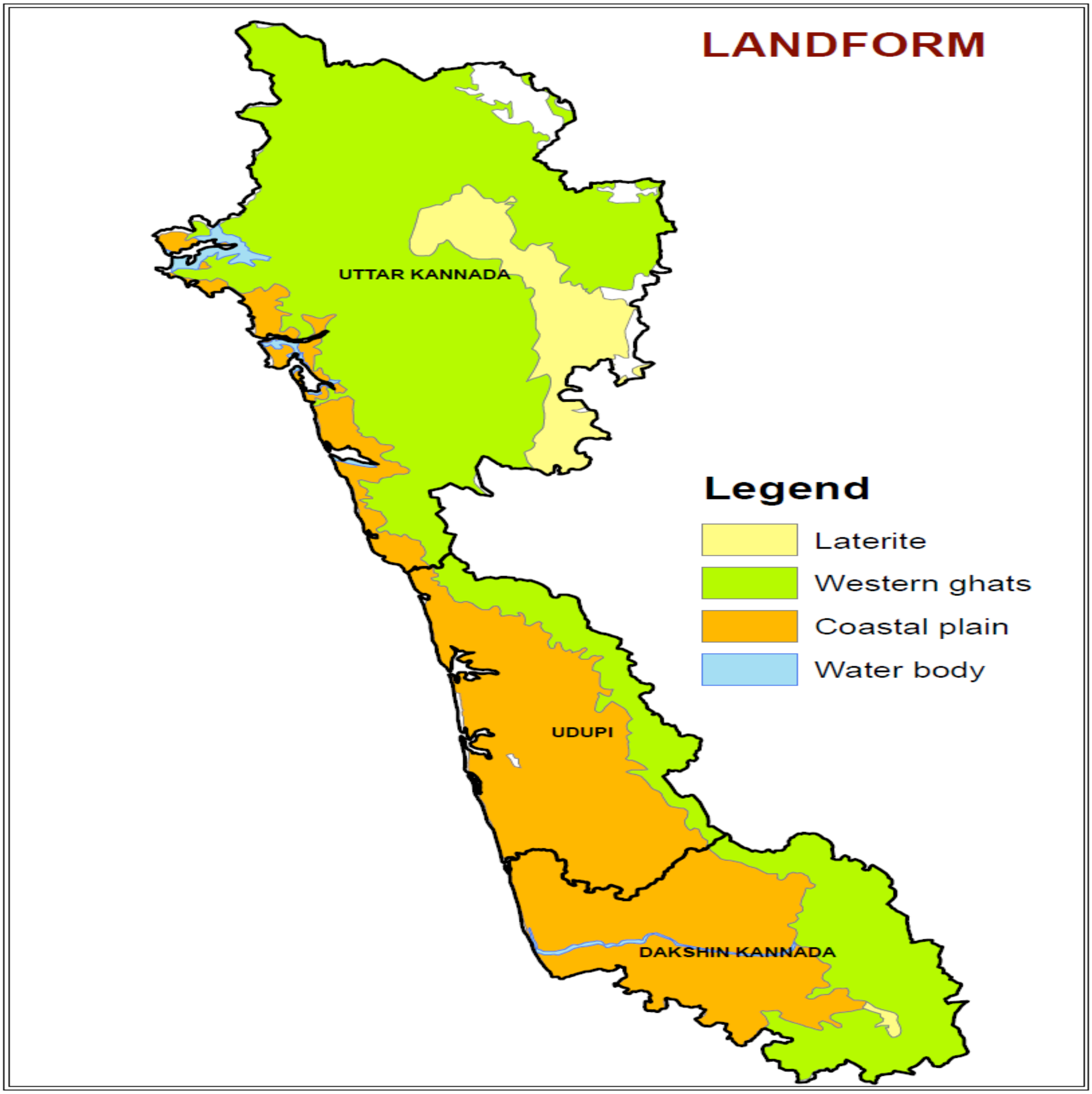


Fig 3. Land forms in Uttara and Dakshina Kannada

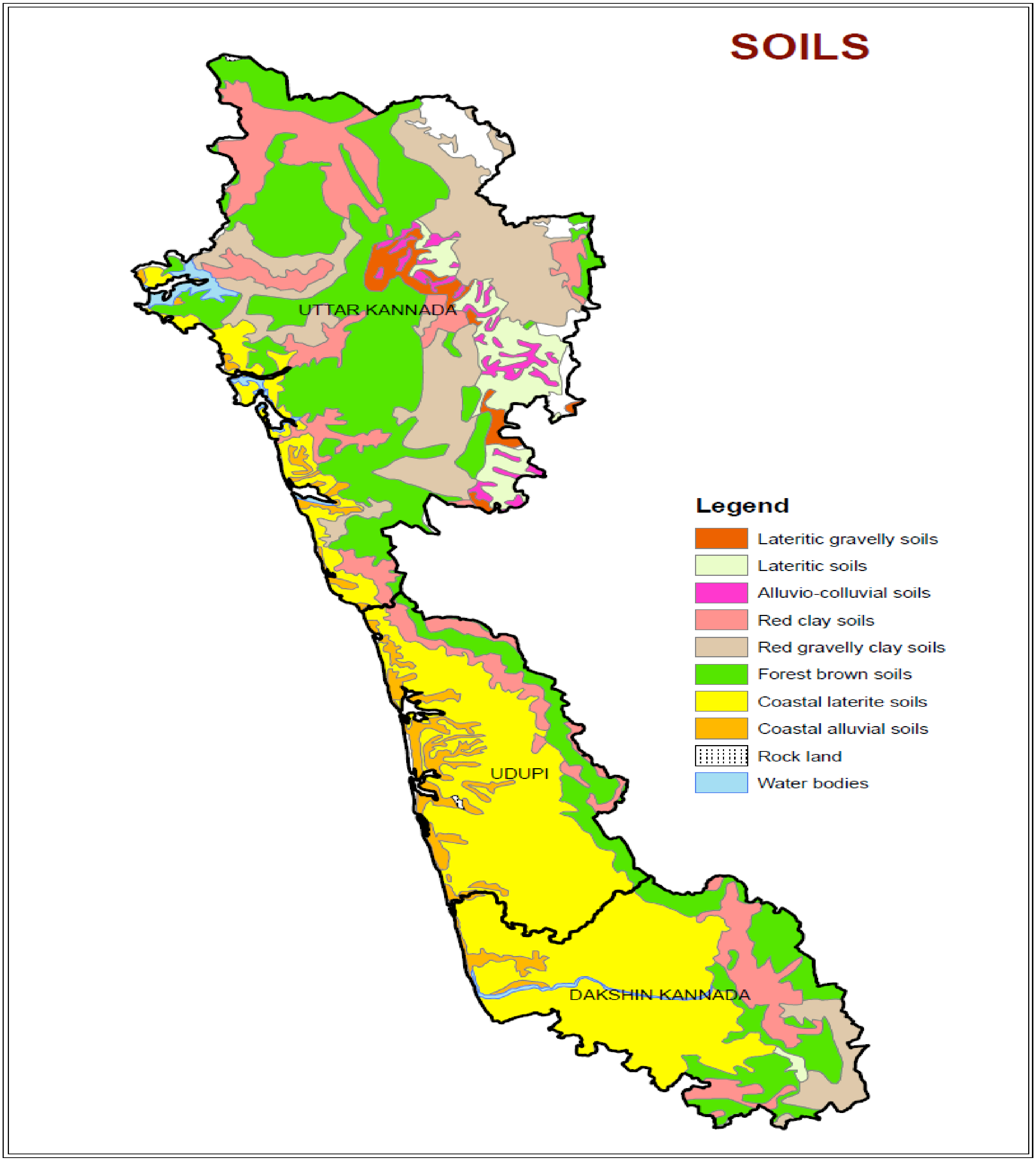


Fig 4. Soil types in Uttara and Dakshina Kannada

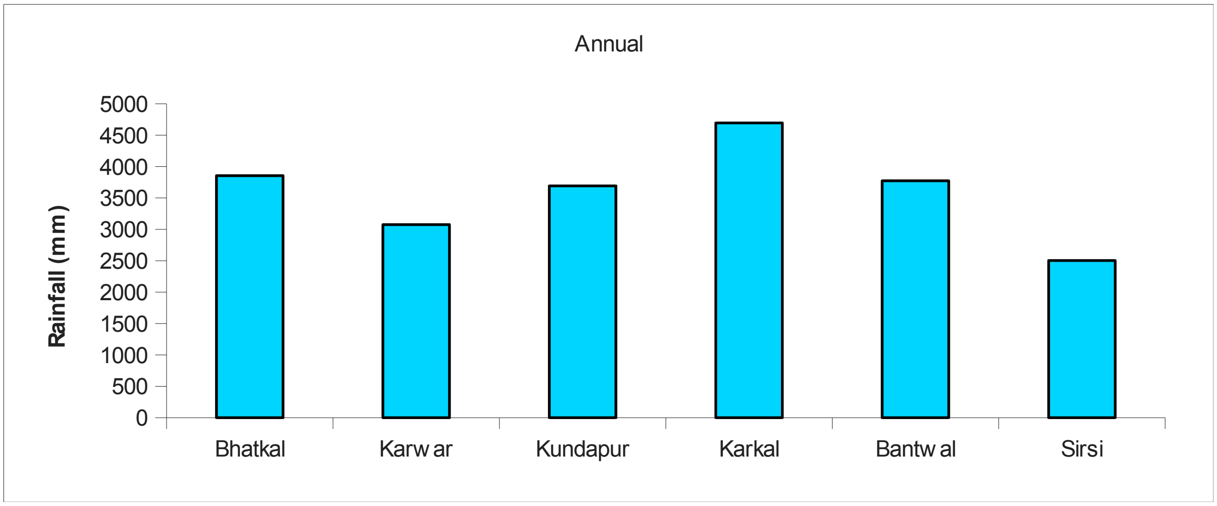


Fig 5. Annual rainfall in some places in Uttara and Dakshina Kannada districts

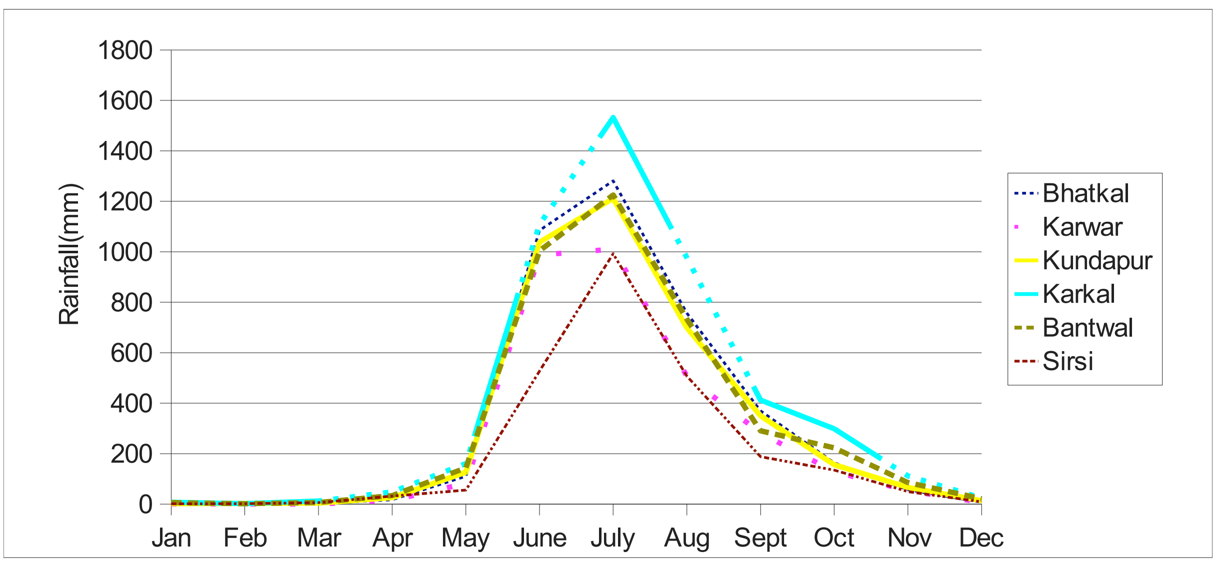


Fig 6. Rainfall pattern in Uttara and Dakshina Kannada districts

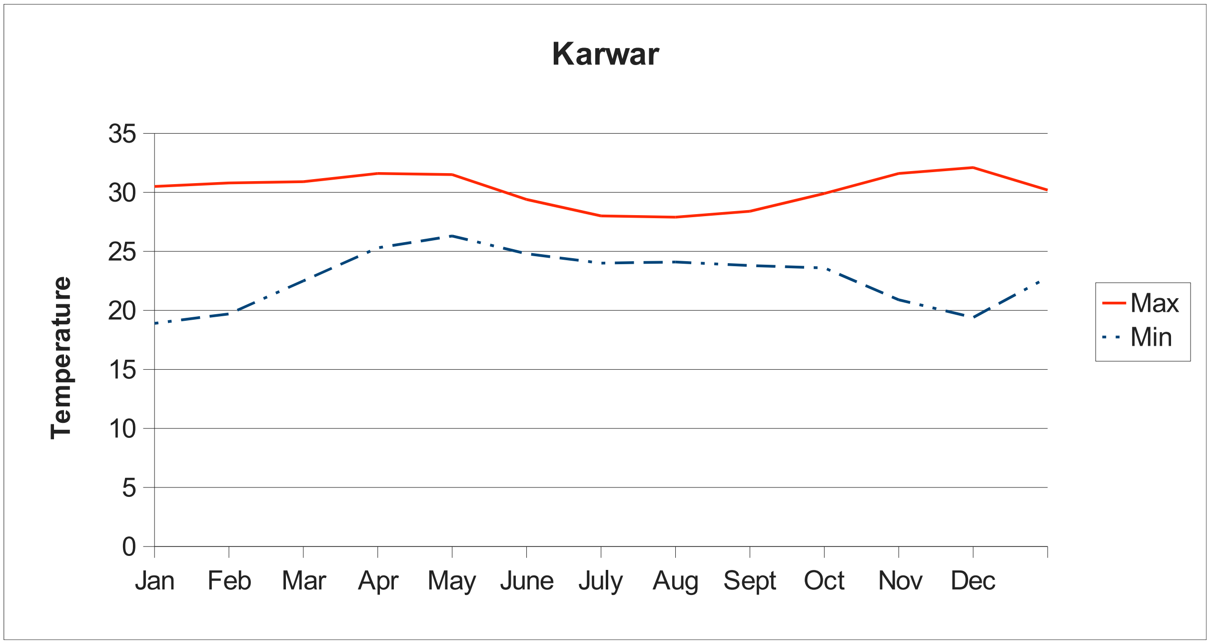


Fig 7. Temperature regime in Uttara Kannada district

Physico- chemical properties of soils over two dates of two locations in Dakshina Kannada district of Karnataka

Gantihole village, Kundapur Taluk, Dakshina Kannada District

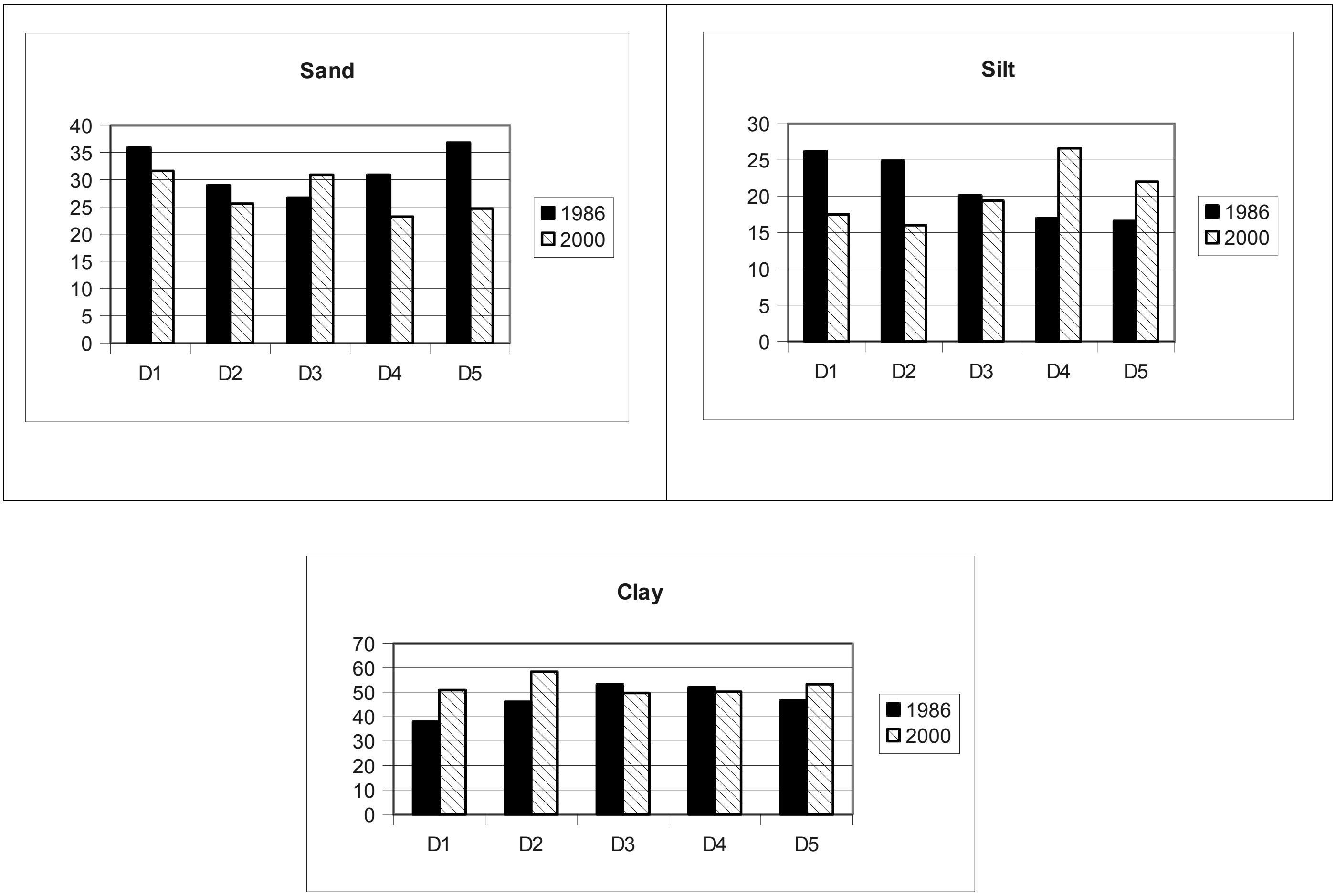


Fig.8. Particle size distribution

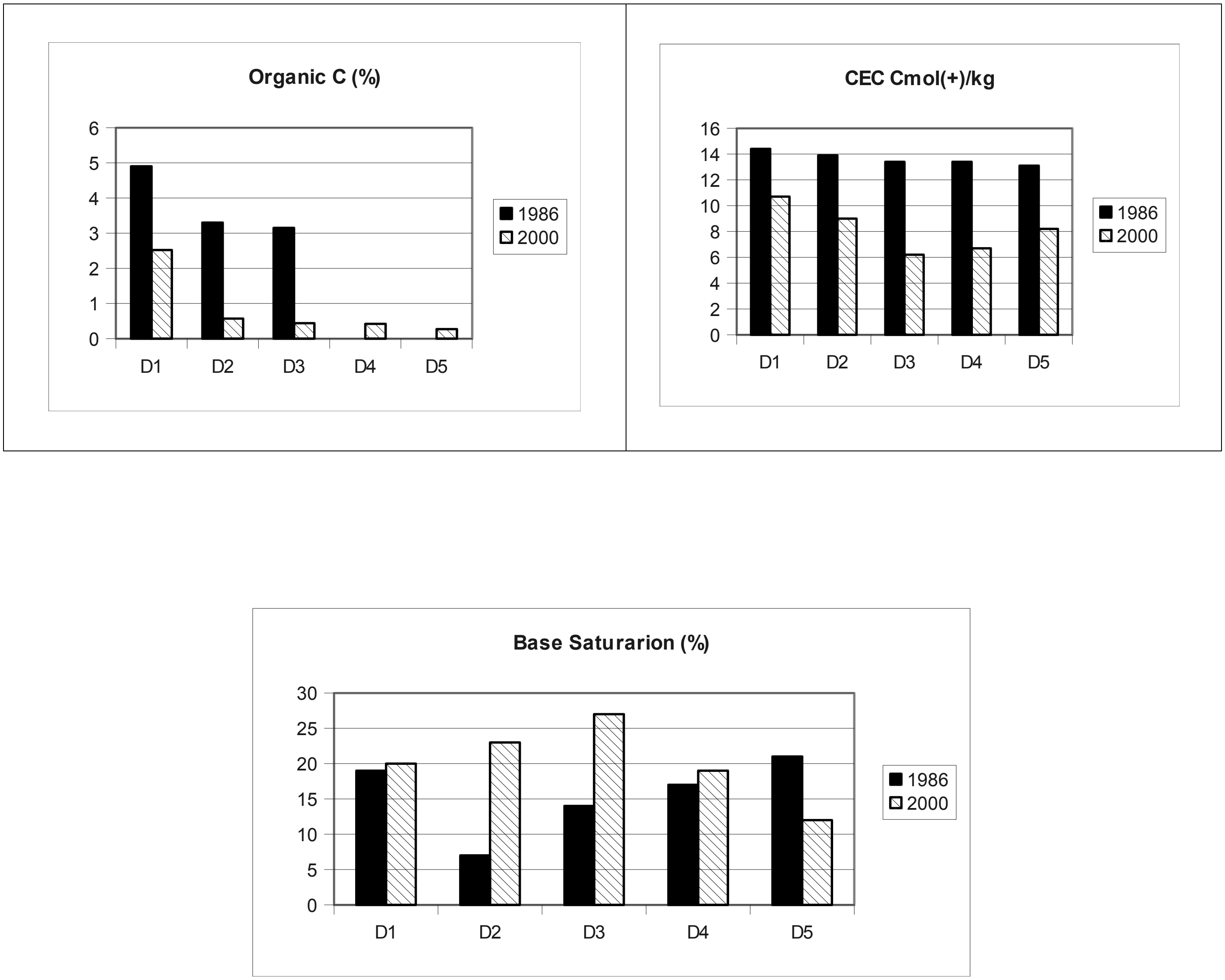


Fig. 9.Organic matter, CEC and Base Saturation

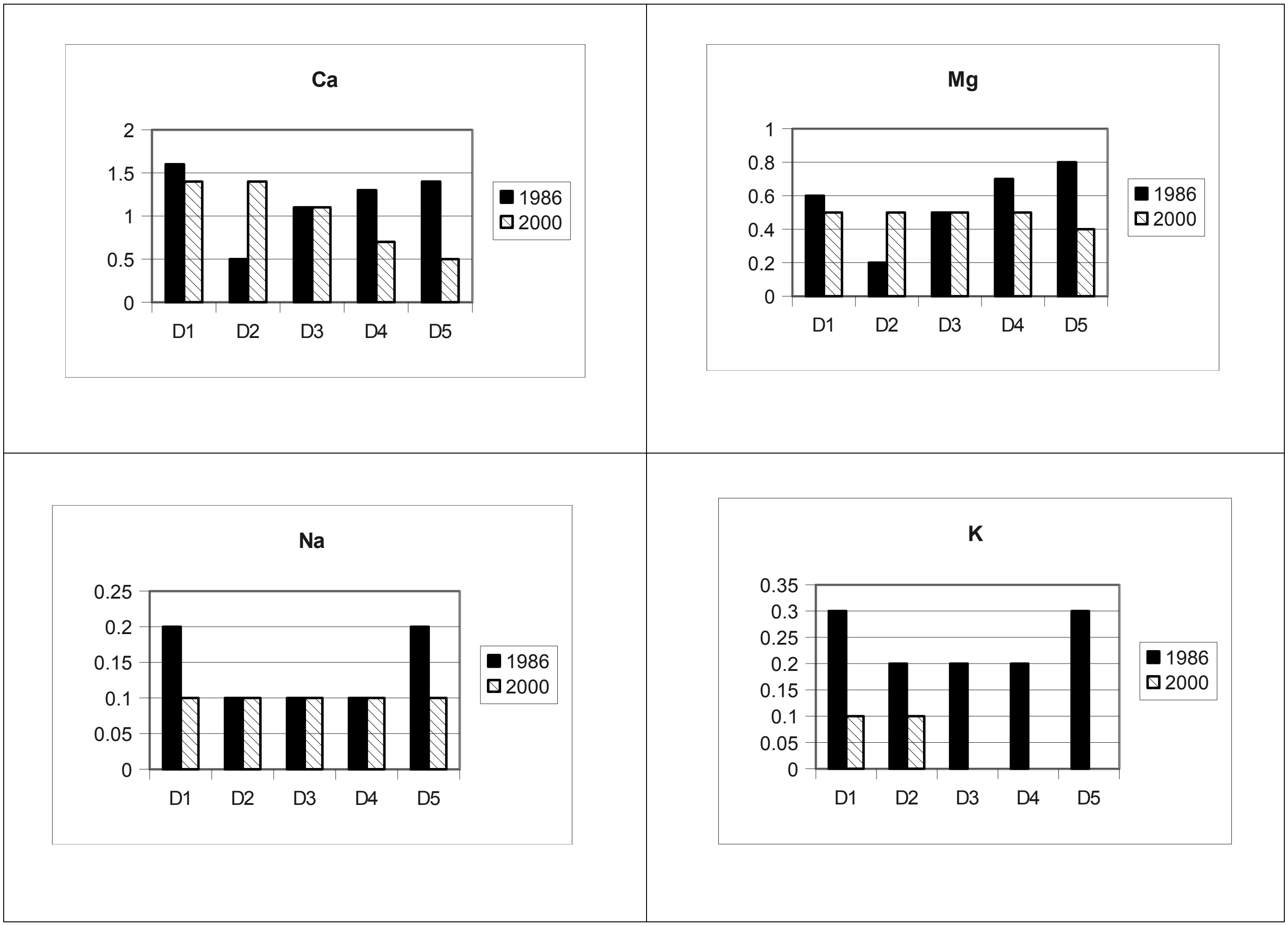


Fig. 10. Exchangeable bases Cmol (+)/kg

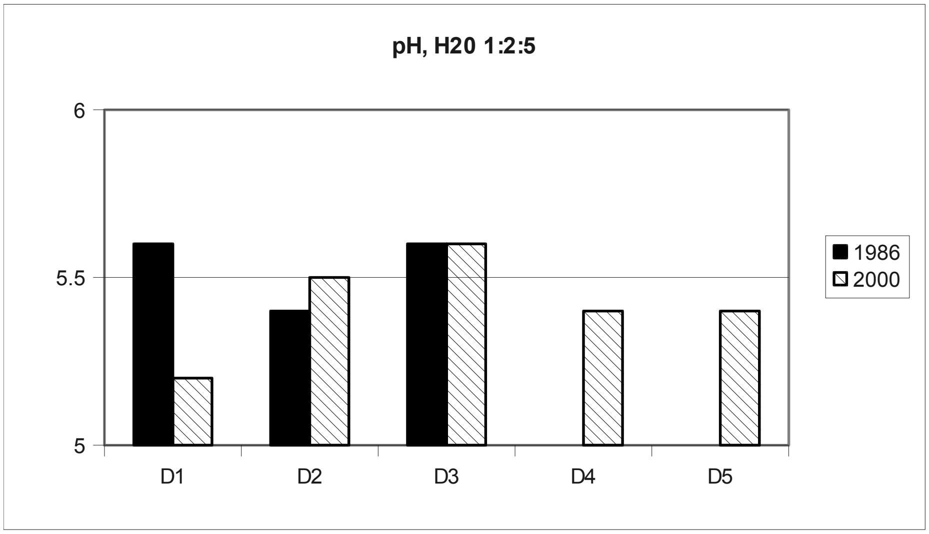
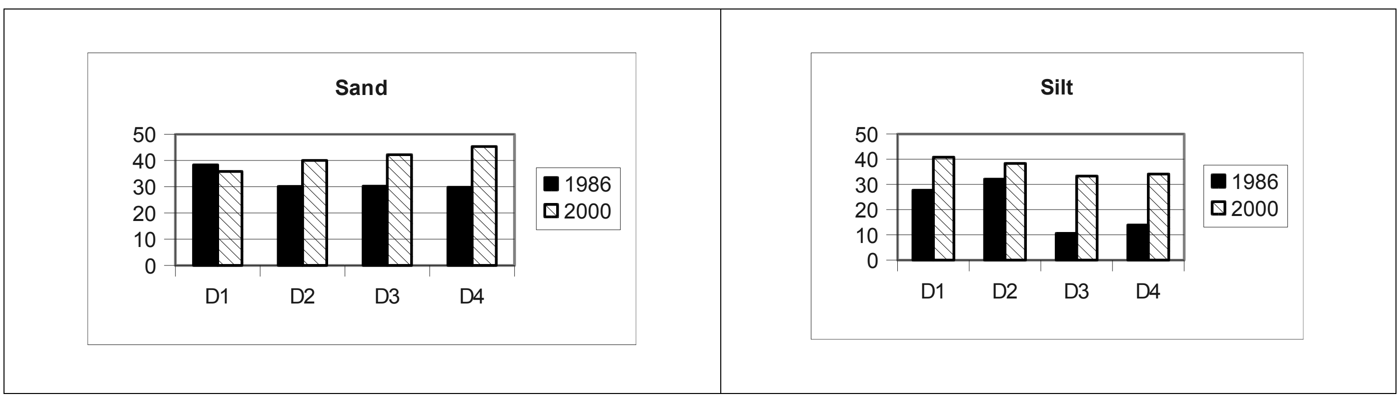


Fig.11. Soil pH

Kalatodu village, Kundapur Taluk, Dakshina Kannada District



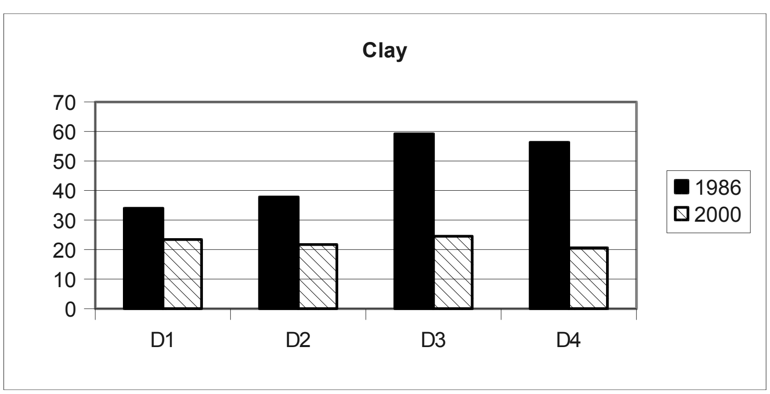


Fig.12. Particle -size distribution

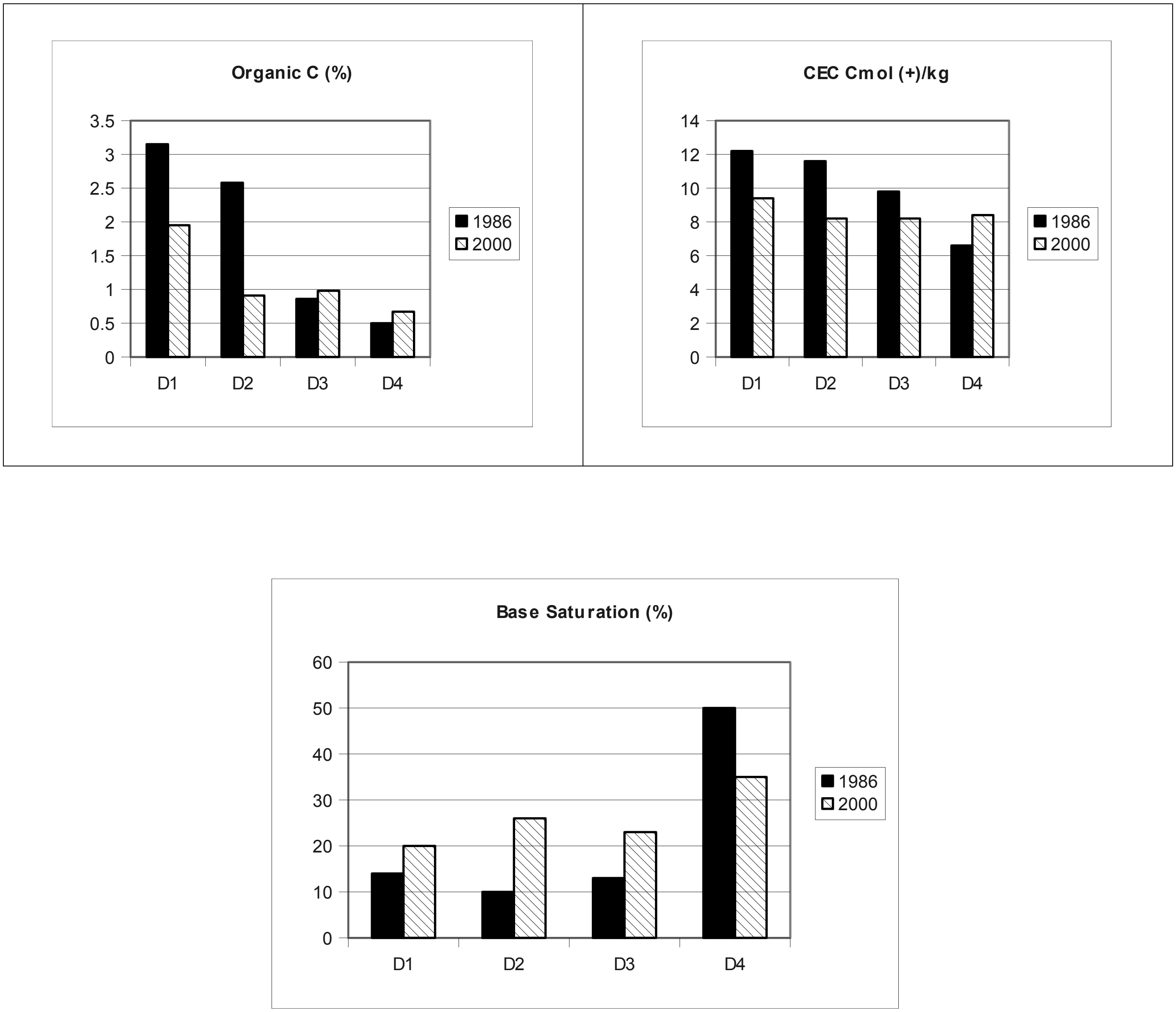


Fig.13. Organic matter, CEC and Base Saturation

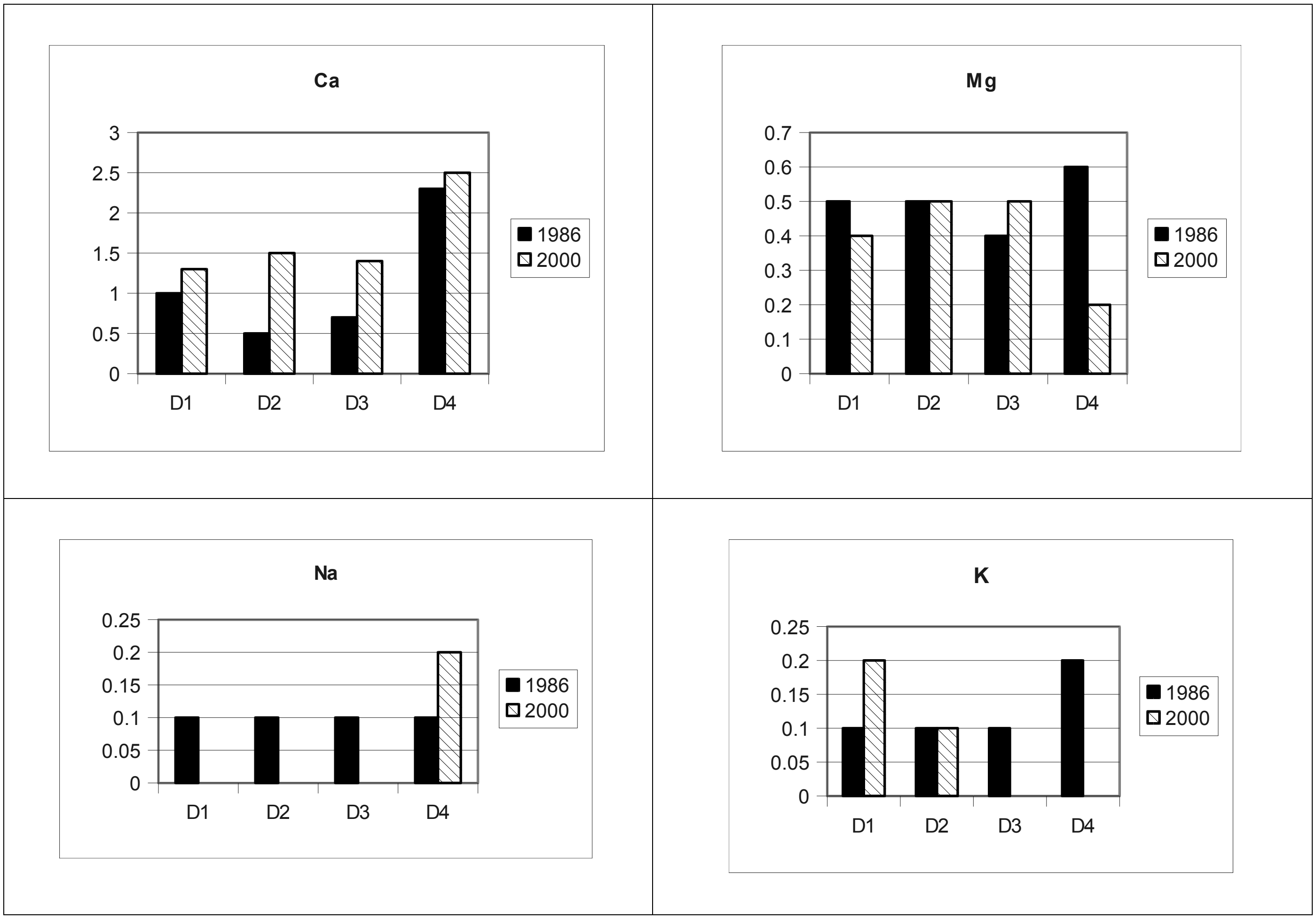


Fig.14. Exchangeable bases Cmol (+)/kg

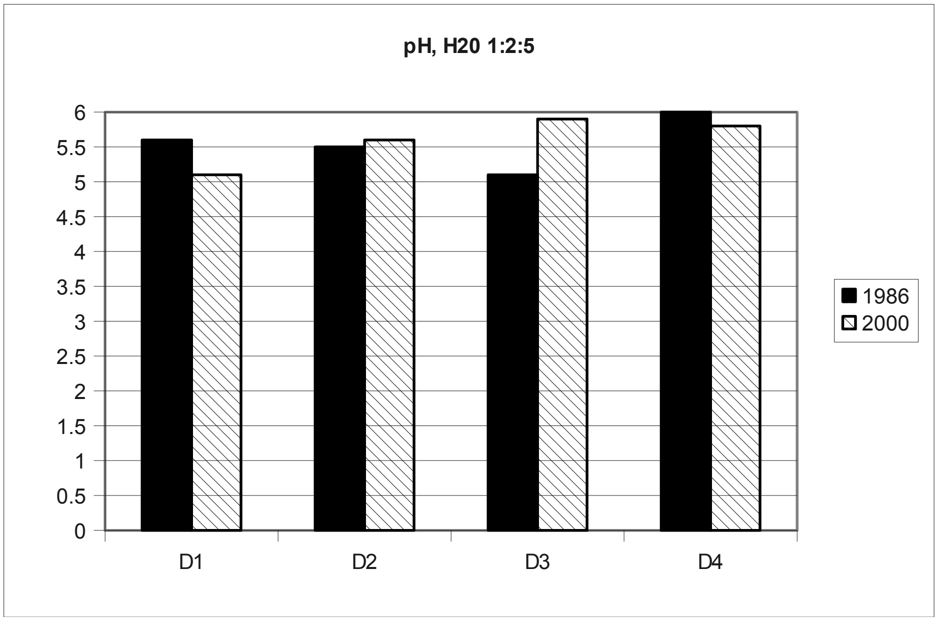


Fig. 15. Soil pH