RELATION BETWEEN SOIL MOISTURE TENSION AND SPECTRAL REFLECTANCE OF DIFFERENT SOIL IN VISIBLE AND NEAR-INFRARED RANGE

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ABSTRACT

Laboratory spectrophotometrical measurements extending from 440 to 860 nm have been used to determine the mathematical relation between soil water tension and spectral reflectance of bare soils. They were conducted on samples belonging to initial loose denudative soils, typic and eroded grey brown podsolic soils, typic and degraded black earths. Each of the 88 analysed soil samples was tested in 12 different moisture conditions from 0 to 7 pF. The discussed relation was described by quadratic equations. Using the relative spectral reflectance coefficient enables the practical elimination from this relation of the influence of the soil texture and soil genesis.

Keywords: Soil Spectral Reflectance, Soil Moisture, Visible and Near-Infrared Range

1. INTRODUCTION

A soil surface moisture is besides soil surface cloddiness one of the most dynamicly changing element of bare soil cover, essentially influenting a soil spectral level in the visible and near-infrared range.

The aim of the discussed research is mathematical description of the soil moisture influence, expressed by soil water tension, on spectral reflectance of bare soils in sensitive range of photographic techniques /0.4-0.9 μm/. This research has been undertaken during the studies devoted to elaboration of a mathematical model of bare soil spectral reflectance including its surface moisture conditions and cloddiness state in the mentioned above spectral range /Refs. 1, 2/. These studies have been sponsored by the Institute of Land-Surveying and Cartography in Warsaw.

2. METHODS

The discussed influence of soil water tension on the soil spectral reflectance was analysed on a basis of laboratory spectrophotometrical measurements. These measurements were made by the SPEKOL reflectometer R 45/0 of Zeiss Jena. The percentage of soil spectral reflectance in comparison to the barium sulphate standard reflectance were carried out of the five wavelengths 440, 540, 640, 740 and 860 nm. They were determined on 88 smooth samples of 2.4 cm diameter and 1 cm height brought to 12 following water tension values: 0, 1, 1.5, 2, 2.5, 3, 4, 4.5, 5, 5.5, 6 and 7 pF. The soil moisture conditions corresponded to water tension from 1 to 3 pF were obtained in the Richard's apparatus, except of 4 to 6 pF in a chamber filled with a saturated vapor of sulphuric acid solution.

The typical soil surface layers of Kościan diluvial plateau in Wielkopolska Lowland were laboratory investigated. Their texture was determined by aerometric method, while organic matter content by burning at temperature 460°C. Their colour in full water saturation and air dry conditions was described by Munsell Color Charts.

3. RESULTS

The studied soils belong, according to the Classyfication System of Polish Soils, to: initial loose denudative soils, typic and eroded brown posolic soils, typic and degraded black earths. Data in Table 1 and Figures 1,2 supplement general properties of these soils.

Curves in the Figure 3 show typical relation between soil water tension and spectral reflectance of analysed soil units corresponding to five measured wavelengths. Each of the investigated samples was characterised by constant reflectance level above 5 - 5.5 pF. It appears also the

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Table 1.

Soils	Texture	Clay content /%/	Organic matter content /%/
Initial loose denudative soils	s - ls	0 - 1	0.3 - 1.2
Typic brown podsolic soils	ls - sl	0 - 2	0.9 - 1.8
Eroded brown podsolic soils	sl	10 -15	1.2 - 2.2
Degraded black earths	ls - sl	0 -12	1.8 - 3.5
Typic black earths	sl	6 -14	2.9 - 5.2

s - sand, ls - loamy sand, sl - sandy loam

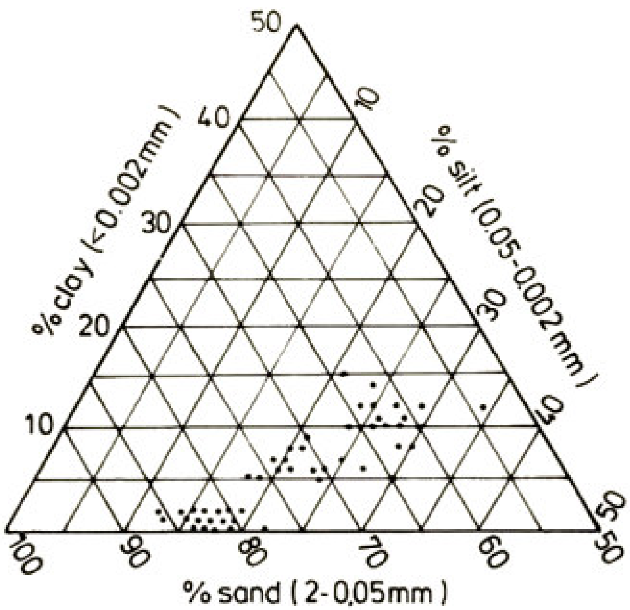

Figure 1. Soil samples on the ground of textural three-coordinate graph

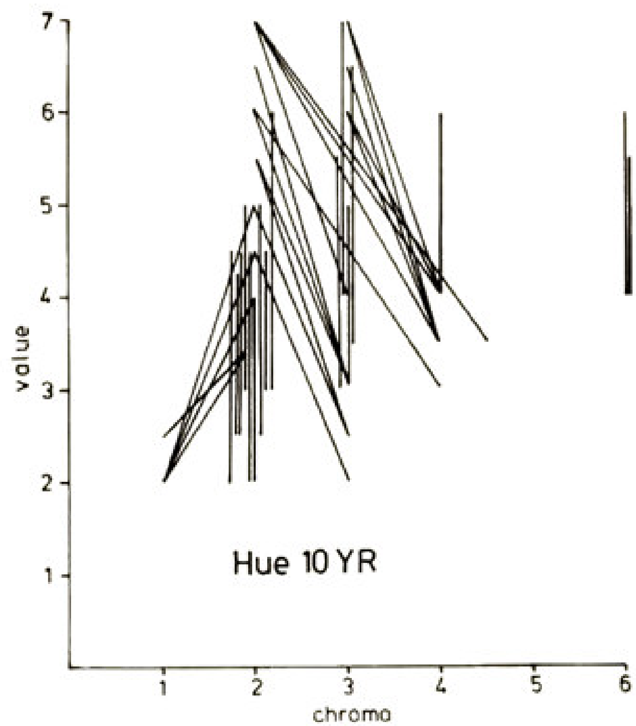

Figure 2. Lines showing ranges of soil samples colour changes from full water saturation to dry weight soils

shine effect of wet samples. As a result of this, the lowest soil reflectance is noted at soil water potential of 1.5-2 pF. In this relation described by the spectral reflectance coefficient /Rp/ defined with regard to the barium sulphate standard reflectance appears level differences among analysed soil units. Generally, initial loose denudative soils and typic brown podsolic soils demonstrate about twice higher reflectance than typic and degraded earths in the whole moisture tension range. Using the relative spectral reflectance coefficient /βp/ enables radical level of these differences between the soil units. This coefficient,refered to defined wavelengths, expresses the ratio of the soil reflectance at given water tension to the reflectance of the same soil, but dried, i.e. at higher water potential than 5.5 pF. Distribution of the coefficient in relation to soil water potential was described by square curve supplemented by paralleled to soil water potential axis. Inconsiderable differentation of the quadratic functions corresponding to soil samples populations differented by clay contents of 0-1%, 2-6% and 7-15%, sugest the possibility of using in discussed relation only one function for describing the whole investigated soil at given wavelength /Figure 4/. This function is:

at 440 nm

$\beta p=0.534-0.145P+0.047P^2$ for $0<P\leqslant 5.08$ and $\beta p=1$ for $P>5.08$ /1/

at 540 nm

$\beta p=0.544-0.148P+0.047P^2$ for $0<P\leqslant 5.10$ and $\beta p=1$ for $P>5.10$ /2/

at 640 nm

$\beta p=0.518-0.174P+0.051P^2$ for $0<P\leqslant 5.03$ and $\beta p=1$ for $P>5.03$ /3/

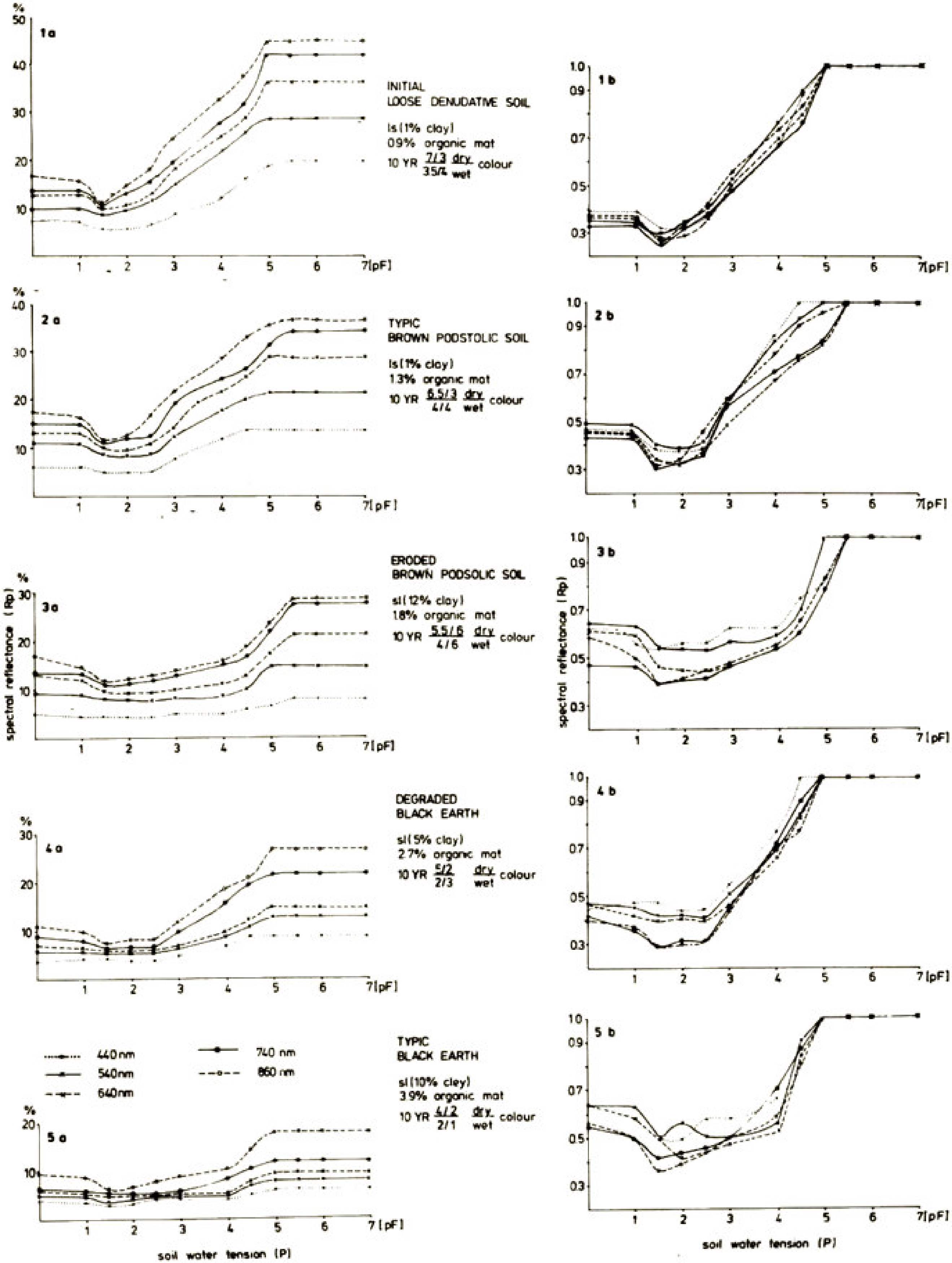

Figure 3. Typical relation between soil water tension and reflectance and relative reflectance of analysed soil units

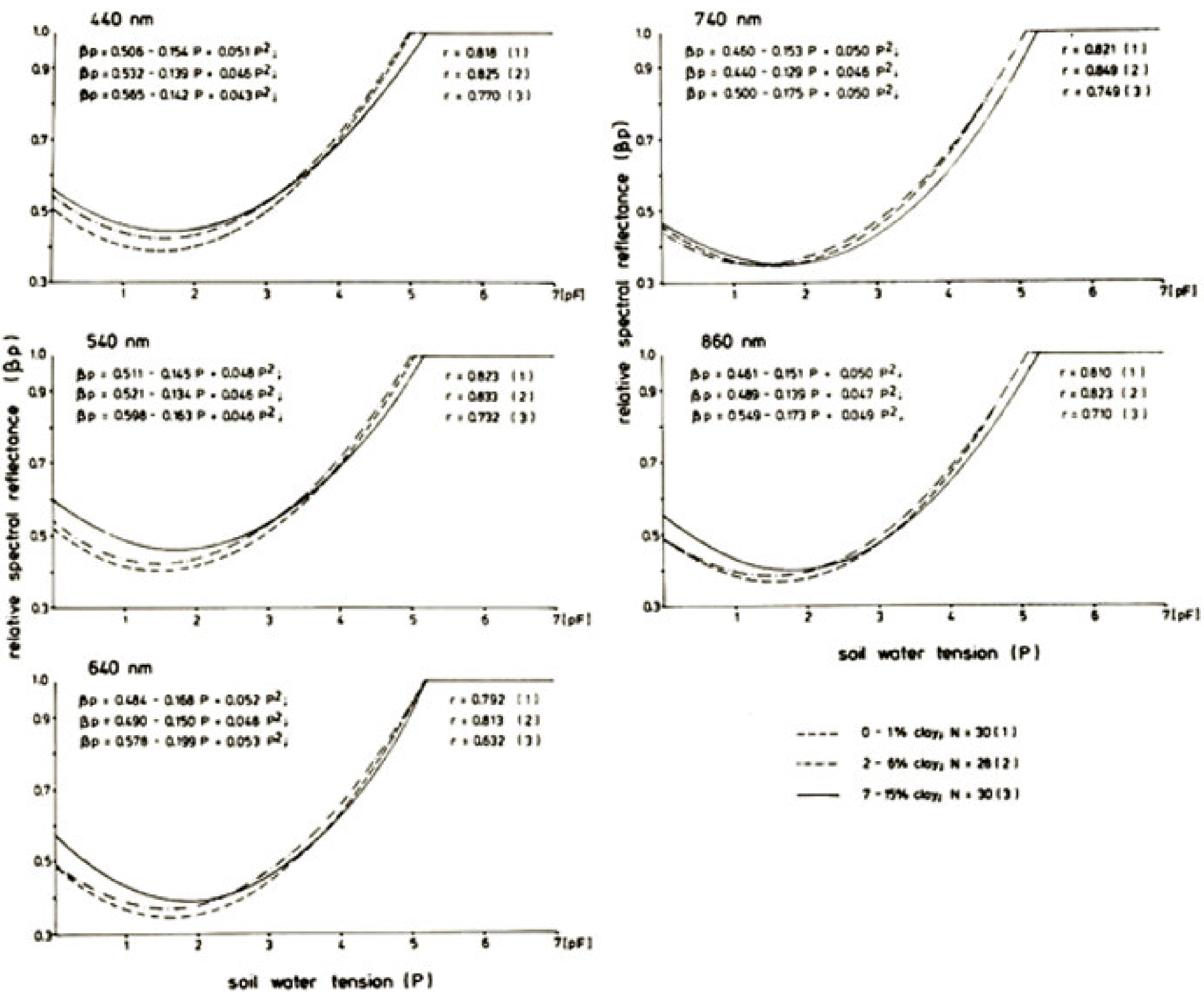

Figure 4. Quadratic curves described the relation between soil water tension and relative reflectance of soils differented by clay content

at 740 nm

$$\beta p=0.467-0.153P+0.049P^2 \quad \text{for } 0<P\leqslant 5.21$$
$$\text{and } \beta p=1 \quad \text{for } P>5.21 \qquad /4/$$

at 860 nm

$$\beta p=0.475-0.159P+0.050P^2 \quad \text{for } 0<P\leqslant 5.18$$
$$\text{and } \beta p=1 \quad \text{for } P>5.18 \qquad /5/$$

where βp = relative spectral reflectance and P = soil water tension in pF.

4. OUTLOOK

Equetions 1-5 included into mentioned in the introduction, the soil spectral model taking into account the most dynamic changing bare soil elements, i.e. its moisture and cloddiness state, will anable to precise define the best natural soil conditions for cartographic distinction of soil units by remote sensing in visible and near-infrared range. They also move us towards working out digital classification methods of soil cover. However the practical application of this model to soil cartographic research require its verification on the another soil samples and its checking up in conditions of field radiometric measurements.

5. REFERENCES

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