ISSN 0370-0291, UDC 63

ACS

CROATIA

AGRICULTURAE CONSPECTUS SCIENTIFICUS

POLJOPRIVREDNA ZNANSTVENA SMOTRA

VOLUMEN 63 BROJ 3 1998

http://www.agr.hr/smotra/

Inventory of Soils in Croatia

M. BOGUNOVIĆ
Ž. VIDAČEK
S. HUSNJAK
M. SRAKA

SUMMARY

Inventory of soils in Croatia has a very long tradition. Since the first mapping works by Šandor (1911) to the present mapping has been done as a part of scientific, scientific-technical and applied soil mapping projects.

By completion of the Basic Soil Map of the Republic of Croatia at the scale of 1:50,000 numerous soil data have been complied providing the conditions for establishing of larger soil information systems and for computer data processing, simulation and modelling.

The paper contains the list of soils determined on the territory of the Republic of Croatia by classes, types and subtypes, as well as lower classification units, areas and percentage of basic divisions and types.

The original data on pedological profiles and mapping units have been digitally processed on the magnetic tape, and may be used in computers in ArcWiew 3.0 program, processed and synthetized with other resources processed in GIS.

KEY WORDS

inventory of soils, soil register, Basic Soil Map

Soil Science Department
Faculty of Agriculture University of Zagreb
Svetošimunska cesta 25, 10000 Zagreb, Croatia

Received: April 8, 1998

Inventarizacija tala u Hrvatskoj

M. BOGUNOVIĆ
Ž. VIDAČEK
S. HUSNJAK
M. SRAKA

SAŽETAK

Inventarizacija tala u Republici Hrvatskoj ima veoma dugu tradiciju. Počevši od 1911. godine od prvih kartografskih radova Šandora do današnjih dana vršila su se kartiranja u okviru znanstvenih, znanstveno-stručnih i primijenjenih pedokartografskih projekata.

Završetkom Osnovne pedološke karte Republike Hrvatske u mjerilu 1:50 000 prikupljeni su brojni pedološki podaci i stvoreni uvjeti za uspostavu većih informacijskih sustava tala, te mogućnost njihove računalne obrade, simulacija i modeliranja.

U radu se daje popis utvrđenih tala na teritoriju Republike Hrvatske po klasama, tipovima i nižim jedinicama naše klasifikacije, te površine i postotni odnosi osnovnih razdjela i tipova.

Izvorni podaci o pedološkim profilima i kartiranim jedinicama su digitalno obrađeni na magnetskoj vrpci, mogu se računalno koristiti u ArcWiew 3.0 programu, te obrađivati i sintetizirati s drugim resursima računalno i informatički obrađenim u GIS-u.

KLJUČNE RIJEČI

inventarizacija, popis tala, Osnovna pedološka karta

Zavod za pedologiju
Agronomski fakultet Sveučilišta u Zagrebu
Svetošimunska 25, 10000 Zagreb, Hrvatska

Primljeno: 8 travnja 1998.

INTRODUCTION

Soil inventory through pedological mapping was generally in the past the axis of soil science in the Republic of Croatia. Knowledge in the field of soil science, in the major part, was acquired in the framework of agriculture and forestry, although the incentive for the development of soil science was made by experts in petrography and mineralogy already at the end of the last century.

Although there were some earlier soil mapping investigations (Šandor, 1911; Gračanin, 1931, 1935, 1939, 1942) the first more comprehensive works in soils inventory and soil mapping started considerably later, originating in Eastern Slavonia. The study "Ecological Conditions for Agricultural Production in Eastern Slavonia and Baranja" included the agropedological map at the scale of 1:200,000 (Jugo et al., 1953). The principal author of the soil mapping works was the doyen of Croatian soil mapping, Dr Pavao Kovačević. This monography included detailed agropedological maps of individual areas of what were the state farms at the time. In the framework of the Institute of Agroecology Dr Kovačević continued individually and together with associates the inventories of soils in separate regions (Soils of Lika, 1956, Soils of Međimurje, 1956) and administrative districts (Soils of the Koprivnica District, 1957, Soils of the Virovitica District, 1959, etd,). In 1964 he founded the project of the Basic Soil Map at the scale of 1:50,000. For this purpose, in cooperation with Dr. V. Jakšić from Sarajevo he prepared the manual for field soil investigations (1964).

Working out of the Basic Soil Map (BSM) was founded on pedogenetic principles and took very long - 23 years, from 1964 to 1986. It is considered the largest pedological project in Croatia. P. Kovačević as the founder was the project leader until 1970, and later the project leader was Professor A. Škorić who expanded the project on all other scientific pedological institutions and conducted the project until its completion. Thus, there were two periods in working out of the soil map, differing from each other by inventory criteria, classification and methods. In the first period, 22 percent of the territory of Croatia were mapped, and the remaining 78 percent were completed in the second period. In should be pointed out that in the second period mapping was done, in addition to the Institute of Pedology and Soil Technology, which had been the only participant in the first period, by the Faculty of Agriculture, Zagreb, Faculty of Agriculture, Osijek, Agricultural Institute, Križevci, Faculty of Forestry, Zagreb, Forestry Institutes in Zagreb and Jastrebarsko, and the Institute of Mediterranean crops and Karst Amelioration in Split, i.e. all pedological scientific institutions in Croatia were involved. In addition to the project leaders, it is necessary to mention other participants in mapping: J. Martinović, M. Bogunović, Ž. Vidaček, Z. Racz, B. Mayer, F. Bašić, A. Vranković, M. Adam, B. Miloš, A. Čolak, I. Šalinović, V. Pavlić, I. Bašić, B. Vrbek, I. Tomaš, I. Šimunić, J. Perković, P. Rastovski, P. Karavidović, I. Šmanjak, J. Ižotić, B. Radman, V. Paraker, L. Samardžić, and others. The basic reason for expansion of the circle of participants was the need for more rapid completion of the map as the base for various plannings and uses, and the larger possibility of financing by the Science Fund of the Republic of Croatia.

In the second stage of mapping, application of modern methods was started such as telemetric research using aerial photography at various scales. At first, black-and-white photography was used, followed by colour photography, and recently also satelite photos came into use. The use of these methods varied in dependence on the staffing and equipment of various researchers.

In the 23 year period the entire territory of the Republic of Croatia was mapped on maps at the scale of 1:50,000. The total number of leaves is 180. Out of this, 109 leaves have been printed, and 71 leaves, mostly partial, remained in manuscript form due to financial problems. In order to complete this the State Directorate for Environment Protection signed a contract with a group of authors, forestry pedologists, on completion of map printing. This includes working out of several monographies, project of calculation and mapping of critical soil loads and working out of the soil database.

In this period, several monographies were worked out, with pedological maps at medium scales (Kovačević et al., 1972, Škorić et al., 1977, 1978, and 1990). The last one, due to the shortage of funds, has not yet been printed.

Considerable work in pedological soil inventory at detailed scales was done for the purposes of former agrocombinates, cooperatives, agricultural and forestry enterprises, water management communities and associations, tree nurseries, etc. These numerous data are situated mostly in the drawers of the investor's offices, being little used and slowly forgotten, and there in the task to incorporate these data into the information systems. Recently, most institutions concerned with soils have done little research, mainly processing the existing data, and many things have not been done in basic soil investigations, which is the normal practice in the world.

Using the existing data and the Basic Soil Map and other sources, the scientists of the Department of Soil Science of the Faculty of Agronomy in Zagreb have made considerable efforts to modernize and process the soil data. One of the results is the Special Purpose Soil Map of the Republic of Croatia at the scale of 1:300,000, which is computer-processed and used by means of the ArcWiew 3.0 program. Other maps and information systems deal with the individual Counties (Zagrebačka and Primorsko-goranska). The results of the soil inventory refer to the soil inventory during elaboration of the Soil Map of Croatia as the basis for the elaboration of the Special Purpose Pedological Map at the scale of 1:300,000.

MATERIALS AND METHODS

The basic source of data and interpretations for elaboration of the Soil Map of Croatia was the Basic Soil Map at the scale of 1:50,000.

The contours of mapping units were introduced into the existing network of state borders, contours of major settlements, communications, shore line and contours of lakes and major watercourses. Introduction of mapping units was based on digitalization and generalization.

The contours of mapping units was done by the manual digitalizer Calcomp, by AutoCad 13 program. Gaus-Krüger projection was selected for the coordinate system with the central meridian 16°30' and linear scale on the central meridian of 0.9997 and constant x coordinate 2500000.

Generalization was done for all minor and related mapping units or contours, as well as for minor toponimes which were unified into a higher classification category by arraying the subtypes and varieties into the corresponding soil types. In addition, the older classification terminology (Kovačević et al., 1967) was translated into the present classification (Škorić et al., 1985) according to the criteria by Bogunović and Rapaić (1993). During digitalization, partial generalization was also taking place by connecting minor mapping units into larger ones, keeping in mind the pedogenetic similarity of soils. Thus the relations of separate units were generalized, as well as their rockiness and other important external properties shown on the special purpose map at the scale of 1:300,000.

The basis for calculation of the areas of suitability classes was the special purpose map worked out according to the FAO soil classification (1976), refered to elsewhere by the same authors.

All pedological data were entered into the Access database and processed in the ArcInfo program. Connecting was done by ArcWiew 3.0 program package, which provided the basis of using the GIZIS database for all soil types in our country.

RESULTS

Elaboration of the Soil Map was the basis for calculation of areas and distribution of soil types in Croatia. The pedogenetic soil map of the Republic of Croatia at the scale of 1:300,000 which is stored on a magnetic tape in the Department of Soil Science also served as the basis for the special map of soil suitability for cultivation. The soil map distinguished 65 mapping units. For each mapping unit the external properties were described such as rockiness, stoniness, natural drainability, geological structure, way of use, slope, ecological soil depth and the prevailing way of wetting. In addition to these, the soil database also contains the results of physical and chemical properties and fundamental geographic features of the total of 303 pedological profiles.

The mapping units consist of simple and complex soil combinations consisting of two to seven systematic units. The number of determined systematic units is 96, and their list is given in Table 1. They are distributed in mapping units in different relations. The composition and structure of the mapping units, and the denomination and relations of systematic units, their presence and rockiness served for the calculation of soils by divisions, types and classes of suitability for cultivation.

Information on the percentage of different systematic units and the percentage of rockiness obtained from the original data of BMS has made it possible to make for the first time, by means of the ArcInfo program, the calculation of areas of soil divisions, types and suitability classes. The earlier data on soil areas quoted by Škorić (1986) and Martinović (1997), due to the lack of comprehensive information, are rather approximative and differ considerably from those determined now.

On the territory of Croatia, four soil divisions have been determined. The major percentage includes automorphic soils with 56.6 percent, followed by hydromorphic soils with 29.1 percent, while halomorphic and subaquatic soils together make only 0.02 percent of the area. The data exhibited for the first time in the country refer to rockiness which is 14.3 precent (Graph 1).

The mentioned 96 systematic units named on the Special purpose Soil Map belong to 30 soil types. Out of this, 18 belong to the automorphic division, 8 to the hydromorphic, and 2 types to halomorphic and 2 to subaquatic division (Graph 2).

It may be seen from the graph that the largest areas consist of luvisols, followed by pseudogley and hydromorphic gley soils, with the smallest areas consisting of Gytja and Protopedon, or Solonchak and Solonetz.

Finally, we want to give the data on the areas of various soil suitability classes. The suitability of soils in the Republic of Croatia has been determined on the basis of the FAO classification (1976) and Antunović, Vidaček (1979). The areas of the land suitability classes for cultivation are shown on Graph 3.

The largest areas, regardless of the method of their use, belong to suitability classes III and V (32 percent each), and the smallest areas are those of the best quality class I, only 7 percent. Class II comprises 15 percent of all land, and the temporarily unsuitable soil class, which means potentially cultivable land 14 percent.

CONCLUSION

On the basis of digital processing of the Special Purpose Soil Map of Croatia in ArcWiew 3.0. program, reliable data have been obtained regarding the soil areas. In the automorphic division there are 3,153,432 ha, or 56.6 percent. In the hydromorphic division there are

Table 1:The list of systematic soil units in Croatia

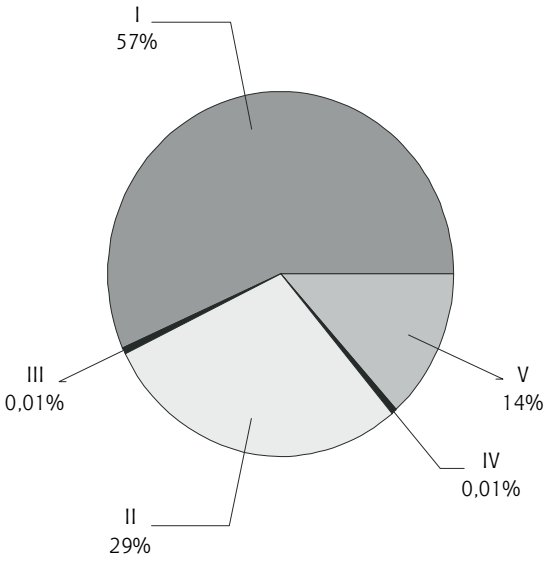
Class	Soil type	Defined lower units of soil
I. AUTOMORPHIC SOILS		
1. UNDEVELOPED SOILS (A)-R or (A)-C	1.1. Lithosol	1.1.1. on limestone and dolomite
	1.2. Arenosol	1.2.1. siliceous
		1.2.2. siliceous-calcareous
	1.3. Rhegosol	1.3.1. siliceous-calcareous on loess
		1.3.2. siliceous-calcareous on marl
		1.3.3. siliceous-calcareous on flysch
	1.4. Colluvial soil	1.4.1. with prevailing rock detritus
		1.4.2. with prevailing of soil material
		1.4.3. alluvial-colluvial
2. HUMUS ACCUMULATIVE SOILS A-C ili A-R	2.1. Calcomelanosol	2.1.1. organogenic
		2.1.2. organomineral
		2.1.3. cambic
		2.1.4. rhodo-chromic
		2.1.5. lithic
	2.2. Rendzina	2.2.1. on marl
		2.2.2. on flysch
		2.2.3. on soft limestone
		2.2.4. on gravel
		2.2.5. on worn-out limestone
		2.2.6. on dolomite
	2.3. Ranker	2.3.1. on sand
		2.3.2. on gravel
		2.3.3. on sandstones, conglomerates and schists
		2.3.4. on quartz
	2.4. Chernozem	2.4.1. on loess, calcareous
		2.4.2. on loess, noncalcareous
		2.4.3. semigleyic
	2.5. Vertisol	2.5.1. on marl
		2.5.2. on soft limestone
3. CAMBISOLS A-(B)-C ili A-(B)-R	3.1. Eutric cambisol	3.1.1. on loess
		3.1.2. on holocene sediments
		3.1.3. on sand
		3.1.4. on lacustrine sediment
		3.1.5. on pyroclastic rocks
	3.2. Distric cambisol	3.2.1. on loess
		3.2.2. on clastites
		3.2.3. on sand
		3.2.4. on relict Terra rossa
		3.2.5. on sandstones, conglomerates and schists
		3.2.6. on methamorphic rocks
		3.2.7. on pyroclastic rocks
	3.3.Terra rossa	3.3.1. shallow
		3.3.2. medium deep
		3.3.3. deep
		3.3.4. luvic
	3.4. Calcocambisol	3.4.1. on dolomite
		3.4.2. on limestone, shallow
		3.4.3. on limestone, medium deep
		3.4.4. on limestone, deep

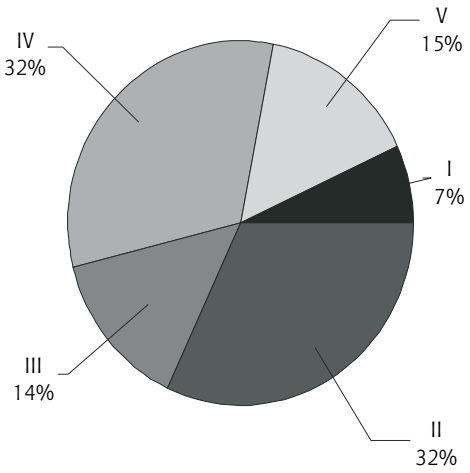
1,617,640 ha, or 29.1 percent of the total area. The halomorphic and subaquatic divisions comprise only 0.02 percent of the area.

The total rockiness of the karst part of Croatia is 796,495 ha, or 14.3 percent of the total area. Soils unsuitable for cultivation make 46.2 percent, out of which 14.4 percent are temporarily unsuitable soils, and 32 percent are permanently unsuitable. The best soils of class I constitute only 7 percent, which imposes the need of protection and prevention of wasting of the best soils in our country.

Table 1:The list of systematic soil units in Croatia

Class	Soil type	Defined lower units of soil
4. ELUVIC-ILLUVIAL SOILS	4.1. Luvisol	4.1.1. on loess, typical
		4.1.2. on loess, pseudogleyic
		4.1.3. on loos sediments
		4.1.4. on loams
		4.1.5. on limestone and dolomite
A-E-B-C or A-E-B-R	4.2. Brown podzolic soil	4.2.1. on quartz conglomerates
		4.2.2. on quartz sands
	4.3. Podzol	4.3.1. humo-ferric
		4.3.2. ferric
		4.3.3. pseudogleyic
5. ANTHROPOGENIC AUTOMORPHIC SOILS P-C	5.1. Rigosol	5.1.1. on loess
		5.1.2. on marl
		5.1.3. on colluvium
		5.1.4. on karst from Terra rossa or Calcocambisol
	5.2. Hortisol	5.2.1. loamy to loamy-clay
		5.2.2. skeletonic
II. HYDROMORPHIC SOILS		
1. SURFACE WATER GLEY SOILS A-Eg-Bg-C	1.1. Pseudogley	1.1.1. on plain
		1.1.2. on slope
2. UNDEVELOPED SOILS (A)-C	2.1. Fluvisol	2.1.1. gleyic
		2.1.2. nongleyic
3. SEMIGLEYS A-C-G	3.1. Humofluvisol	3.1.1. calcareous
		3.1.2. noncalcareous
	4.1. Pseudogley-gley	4.1.1. shallow gleyic
		4.1.2. partly ameliorated
4. GLEYS A-G	4.2. Eugley	4.2.1. hypogleyic
		4.2.2. amphigleyic
		4.2.3. epigleyic
		4.2.4. mineral
		4.2.5. vertic
	4.3. Humogley	4.3.1. noncalcereous
		4.3.2. calcareous
		4.3.3. vertic
		4.3.4. salinized
5. HISTOSOLS T-G	5.1. Low peat	5.1.1. shalow
		5.1.2. medium deep
		5.1.3. deep
6. ANTHROPOGENIC HYDROMORPHIC SOILS P-G	6.1. Hydroameliorated soil	6.1.1. drained
III. HALOMORPHIC SOILS		
1. SALINE SOILS Asa-G	1.1. Solonchak	1.1.1. surfacely salinized
		1.1.2. medium deep salinized
		1.1.3. deep salinized
2. ALKALLY SOILS A-Bt, na-C	2.1. Solonetz	2.1.1. typical
		2.1.2. luvic
		2.1.3. pseudogleyic
IV. SUBAQUATIC SOILS		
1. UNDEVELOPED SUBAQUATIC SOILS (A)-C	1.1. Protopedon	1.1.1. sandy
		1.1.2. loamy
2. HUMIC SUBAQUATIC SOILS	2.1. Gyttja	2.1.1. mineral
		2.1.2. humic



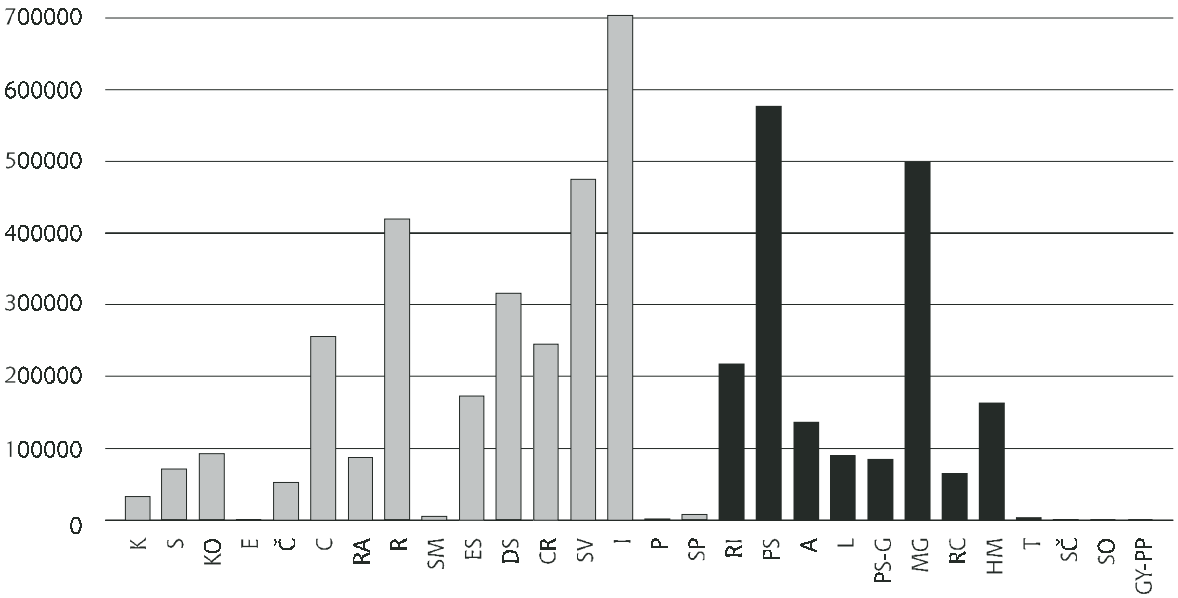


I	Automorphic soils	3153432 ha
II	Hydromorphic soils	1617640 ha
III	Halomorphic soils	532 ha
IV	Subaquatic soils	321 ha
V	Rockiness	796459 ha

Graph 1. Areas of individual soil division and rockiness in Croatia

I	Suitable - highly suitable for cultivation	313875 ha
II	Suitable - with moderate limitations	692034 ha
III	Suitable - limited suitability for cultivation	1559846 ha
IV	Unsuitable - temporarily unsuitable	688027 ha
V	Unsuitable - permanently unsuitable for cultivation	1518143 ha

Graph 3. Areas of land suitabiility classes according FAO classification



	Legend	Area (ha)	%
K	Lithosol (Kamenjar)	32703	0,587
S	Rhegosol (Silikatno karbonatni sirozem)	70698	1,270
KO	Colluvial soil (Koluvij)	91938	1,651
E	Arenosol (Eolski "živi pijesci")	667	0,012
Č	Chernozem (Černozem)	51808	0,930
C	Calcomelanosol (Vapneno dolomitna crnica)	255201	4,583
RA	Ranker (Hunusno silikstno tlo)	86944	1,561
R	Rendzina (Rendzina)	420184	7,546
SM	Vertisol (Smolnica)	5002	0,090
ES	Eutric cambisol (Eutrično smeđe tlo)	172495	3,098
DS	Distric cambisol (Distrično (kiselo) smeđe tlo)	316184	5,678
CR	Terra rossa (Crvenica)	245289	4,405
SV	Calcocambisol (Smeđe tlo na vapnencu)	474959	8,530
I	Luvisol (Lesivirano tlo)	703215	12,629
P	Podzol (Podzol)	1382	0,025
SP	Brown podzolic soil (Smeđe podzolasto tlo)	7393	0,133
RI	Anthropogenic soils (Antropogena tla)	217370	3,904

	Legend	Area (ha)	%
PS	Pseudogley (Pseudoglej)	577025	10,363
A	Fluvisol (Aluvijalno tlo)	136343	2,449
L	Humofluvisol (Aluvijalno livadno tlo)	89901	1,614
PS-G	Pseudogley - gley (Pseudoglej-glej)	84713	1,521
MG	Eugley (Močvarno glejno tlo)	499526	8,971
RC	Humogley (Ritska crnica)	64555	1,159
HM	Hydroameliorated soils	163000	2,927
T	Histosols (Tresetla tla)	2577	0,046
SČ	Solonchak (Solončak)	121	0,002
SO	Solonetz (Solonec)	411	0,007
GY-PP	Gytja and protopedon	321	0,006

Graph 2. The areas of soil types in Croatia

REFERENCES

Antonović, G., Vidaček, Ž. (1979): Osnovni principi procjene zemljišnog prostora, Zemljište i biljka, vol. 28, No 1-2, Beograd

Bogunović, M., Rapaić, M. (1993): Digitalizacija Osnovne pedološke karte R. Hrvatske. Bilt. dalj.istr. fotoint. Vol. 12, str. 45-76, Zagreb

Bogunović, M., Vidaček, Ž., Racz, Z., Husnjak, S., Sraka, M. (1996): Namjenska pedološka karta R. Hrvatske u mjerilu 1:300.000, Zavod za pedologiju Agronomskog fakulteta u Zagrebu

FAO (1976): Framework for Land Evaluation, Soil Bulletin 32, Rome

Gračanin, M. (1931): Pedološka istraživanja vriština Ličkog Polja, Zagreb

Gračanin, M. (1935): Pedološka studija otoka Paga, Glasnik za šumske pokuse, sv. 4, Zagreb

Gračanin, M. (1939): Prilog geografiji pedoloških tala Hrvatske, Hrvatski geografski glasnik, Zagreb

Gračanin, M. (1942): Tla Hrvatske, Zagreb

Jugo, B., Kovačević, P., Kurtagić, M., Mihalić, V., Hranilović, J. (1953): Ekološki uvjeti poljoprivredne proizvodnje Istočne Slavonije i Baranje, Poljoprivredno nakladni zavod, str. 120, Zagreb

Kovačević, P., Kurtagić, M., Mihalić, V., Hranilović, J. (1956): Tla Međimurja i njihovo iskorištavanje u poljoprivredi. Poljoprivredni nakladni zavod, str. 75, Zagreb

Kovačević, P. (1956): Tla Like (disertacija), str. 226, Zagreb

Kovačević, P. (1957): Tla kotara Koprivnica, Zemljište i biljka, br. 1, str. 68-87, Beograd

Kovačević, P. (1959): Tla kotara Virovitica, s pedološkom kartom 1:100.000. Zavod za agroekologiju, Zagreb

Kovačević, P., Jakšić, V. (1964): Priručnik za terenska pedološka istraživanja, str. 81, Sarajevo

Kovačević, P., Kalinić, M., Pavlić, V. (1967): Detaljna klasifikacija tala i izrada pedološke karte Posavine mjerila 1:50.000, III Kongres JDPZ, Zadar

Kovačević, P., Kalinić Mirjana, Pavlić, V., Bogunović, M. (1972): Tla gornje Posavine, Institut za pedologiju i tehnologiju tla, str. 331, Zagreb

Martinović, J. (1997): Tloznanstvo u zaštiti okoliša, Državna uprava za zaštitu okoliša, Zagreb

Šandor, F. (1911). Sammlung von Bodenkarten Kroatiens und Slavoniens und Bilder über die Kultivierung dieser Bodenarten Verhandlungen der II internat. Agrogeologenkonferenz. Stockholm

Škorić, A. i sur. (1977): Tla Slavonije i Baranje. Projektni savjet za izradu Pedološke karte R. Hrvatske, str. 256, Zagreb

Škorić, A., Filipovski, G., Ćirić, M. (1985): Klasifikacija zemljišta Jugoslavije, ANU BiH, str. 72, Sarajevo

Škorić, A. (1986): Postanak, razvoj i sistematika tla. FPZ Sveučilišta u Zagrebu, str. 172, Zagreb

Škorić, A. i sur. (1987): Pedosfera Istre. Projektni savjet za izradu Pedološke karte R. Hrvatske, str. 192, Zagreb

Škorić, A. i sur. (1991): Tla Gorske Hrvatske, Zavod za pedologiju Agronomskog fakulteta u Zagrebu (u rukopisu)