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Cinnamonic Calcareous Soil Fertilizing Systems for Pastures of Akhaltsikhe District

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ABSTRACT. Fertilizing systems of cinnamonic calcareous soils, distributed in the villages of Minadze and Ghreli in Akhaltsikhe district, have been studied in 2007-2009. It was found that to improve soil fertility, the use of both organic and mineral fertilizers is required. The needed norms of nutrients for perennial pastures have been ascertained and based on that, the applicable doses of organic and mineral fertilizers and rules for their application were determined. *© 2009 Bull. Georg. Natl. Acad. Sci.*

Key words: *cinnamonic soils, cereals, legume, soil profile, soil texture.*

Introduction. Soils providing high yields from agricultural crops, have been and are the basic means for the development of mankind's civilization. The natural fertility of a soil is determined by its physical and chemical properties and is improved by an appropriate and effective use of mineral and organic fertilizers. Therefore, in this modern age of soil-agrochemical production, it is imperative that we understand the geomorphic, chemical and physical properties of soils. It is these properties coupled with the rational use of fertilizers and the proper selection of agricultural crops that can lead to improved crop yields [1, 2]. This project looked at two locations in South Georgia to characterize the soils and to determine the fertility needs of these soils for agricultural crop production.

The studied areas are located in Akhaltsikhe district of Georgia and are comprised of soils developed in a subzone of semi-arid region of the dry subtropical zone. Akhaltsikhe district is characterized by a hypsometric (topographic) "anomaly" and is located at an altitude (1000-1300 m) in the subtropical forest-steppe zone. Neogene and volcanic rocks as well as Paleocene and Oligocene sandstones and clay sediments make up the geological composition of this area. A climatic peculiarity of this subtropical forest-steppe zone assists in weathering of the rocks rich in carbonates, which significantly influences the soil formation processes and the soils' chemical composition [3].

The climatic data of this district indicates an average annual temperature of 9^0 C, the total active temperatures comprise 3029^0, and the average annual precipitation is approximately 533 mm. The area is characterized by two extremes of precipitation, with precipitation being plentiful at the end of spring and very scarce at the beginning of autumn. The annual coefficient of humidity is 0.9 (ratio of evaporation to precipitation) and indicates that the soil moisture balance is characterized by weekly deficiency [4].

The vegetation cover of Akhaltsikhe district is complex. *Carpinus spp.*, hornbeam; *Quercus spp.*, oak; *Crataegus spp.*, hawthorn and *Carpinus orientalis*, oriental hornbeam dominate the tree species, while the subforest is dominated by *Cornus spp.*, dogwood. The meadows are primarily *Onobrychis sativa*, sainfoin; *Medicago sativa*, lucerne; *Trifolium spp.*, clover; *Dactylis glomerata,* orchard grass; *Phleum pratense,* timothy; *Avena indoviciana,* wild oat; but rarely *Stipa spp.,* feather grass [5].

In accordance with the 1999 soil map (1:500 000) of Georgia, the cinnamonic calcareous soils are reflected by two names: "Calcaric Cambisols" and "Calcic Kashtanozems" [6]. With the ensuing consequences that many issues of modern soil classification still are disputable and the object of research for Georgian soil scientists, an attempt was made to relate the Akhaltsikhe region soil to one of the soil groups of modern classification. Considering the diagnostic criteria of World Reference Base for Soil Resources [7] and according to the morphological characteristics (texture, differentiation of the humic horizon in comparison with sub-horizons according to color, contents of clay etc.) and extent, the soil investigated in the Akhaltsikhe region appears to belong to the "Calcaric Cambisols" rather than to the "Calcic Kashtanozems." The "Calcaric" characteristic confirms the presence of calcium carbonate [8]. This soil does not belong to "Calcic Kashtanozems" because it does not satisfy Kashtanozems most typical diagnostic characteristic, the presence of a "mollic" horizon with 2 or less chroma in the moisten condition [9].

Cinnamonic soils in the Akhaltsikhe hollow (depressed form of relief) occupy a narrow strip of land at heights of 950-1300 m above sea level. However, the cinnamonic calcareous soils most often occur on slightly sloping elements of relief - on terraced slopes, on loops and slightly sloping plains, where a favorable environment is created for accumulation of $CaCO_3$. These soils are characterized by different levels of fertility, often requiring the addition of fertilizers to increase the soil's fertility and productivity of agricultural crops [10].

Objectives and Methods. Field investigations of soils were carried out in the villages of Minadze and Ghreli in Akhaltsikhe district. About 30 ha of agricultural land were investigated. Soil samples were collected and analyzed for various physical and chemical parameters to aid in determining the fertility needs for growing legume crops and perennial grasses.

The whole area in the village of Minadze is about 23 ha and located 3-10 km east of Akhaltsikhe, at approximately 1,300 m above sea level. Vegetation is xerophytic bushes (*Paliurus spina-christi,* Jerusalem thorn; *Rosa canina*, dog rose and *Ribes uva-crispa*, gooseberry). The soils of this area are cinnamonic calcareous, developed from carbonated clayey parent material deposits. The relief is one of complex slopes and the soils are located on 14 terraces. According to the elements of their relief, the terraces No. 3, No. 5, No. 6 are basically flat and the rest are terraced slopes, with elevated and depressed elements of relief. The main part of the area has been in long-term fallow (terraces No.1- No.8), and the remaining are arable lands on which sainfoin is grown.

The village of Ghreli is located about 7 km from Minadze and is also approximately 1,300 m above sea level. Vegetation consists of xerophytic bushes and the soil is cinnamonic calcareous, formed on carbonated clayey deposits. The total area investigated was approximately seven ha and included three terraces of nearly flat relief.

According to the topographical peculiarities of the area investigated, soil samples were collected from each slope/terrace. A minimum of 20 auger samples were collected and combined into one soil sample. In the case of the areas of flat relief, the areas were divided into two or more parts based on areas of similar characteristics. In the long-term fallow areas (most of the area was fallow) soils were sampled at the depth of 0-10 cm, while arable land, where sainfoin was grown, samples were taken at a depth of 0-20 cm. In total, 17 terraces were studied and 36 combined soil samples were taken.

The same subtype of soils (cinnamonic calcareous) exist in both areas investigated (Minadze and Ghreli villages). Owing to this reason, only one complete soil profile description (in Minadze) was made for macromorphological studies. Four soil samples were taken from this profile in order to define the soil texture. In the field, the soil profile was described by international standards ("Table 1"). The "Munsell Color Chart" [11] was used for definition of soil matrix color, and estimates were made for the contents of humus and bulk density [12].

Soil samples for laboratory analysis were prepared by grinding the soils and then sifting through 1 mm and 0.25mm sieves. The following analyses were carried out: hygroscopic water content, soil texture, pH, percent calcium carbonate, percent humus, exchangeable cations (Ca; Mg), hydrolyzed nitrogen, available phosphorus and exchangeable potassium [13, 14].

Results and Analysis. Field description of the cinnamonic calcareous soil derived from carbonated clayey deposits parent material.

Cinnamonic calcareous soils are characterized by a dark brown surface color, silt loam (upper limit clay content) or sandy clay loam texture and well expressed granular or subangular blocky structure and a prevalence of limy nodules (nerves and rings) in the middle of the soil profile, and increasing amount of clay and humus cutans in the subsoil. The entire soil profile is carbonated and does not contain skeletons. Below is shown the soil field description made according to the international code methodology. Detailed data are shown in Table 1.

Profile No. 1. Village of Minadze, Terrace # 5, (whole area) – 0.45 ha, flat slope, altitude 1190-1196 m above sea level.

A 0-20 cm Dark brown (7.5YR3.5/2), loamy texture, well-expressed granular structure, cool, sufficient amount of roots, powdery, carbonated - effervescence under influence of 10 % HCl, does not contain skeletons, gradual transition;

B 20-30 cm Brown color (7.5YR3.5/3), loamy texture, subangular blocky structure, slightly moist, roots of fine and medium sizes, clay and humus cutans, slightly solid, carbonated - effervescence under the influence of 10 % HCl, no skeletons, gradual transition;

BC_1 33-50cm Dark brown (7.5YR3/3.5), loamy texture, subangular blocky structure, few roots, slightly solid, slightly moist, with prevalence of limy nodules, clay and humus cutans, carbonated - effervescence under the influence of 10% HCl, gradual transition;

BC_2 50-80cm Dark brown (7.5YR3.5/3.5), loamy texture, subangular blocky structure, without roots, slightly solid, slightly moist, less amount of cutans, many limy nodules, no skeletons, carbonated - effervescence under the influence of 10 % HCl, gradual transition.

Laboratory data for the cinnamonic calcareous soil derived from carbonated clayey parent material deposits. Soil texture analyses of the soil profile samples indicate that the amount of physical clay ranges from 45-58 %. In the A horizon (humus horizon), the texture is silt loam which grades into sandy clay loam texture in the subsoil. The middle part of soil profile, shows an increased amount of physical clay. This well-expressed claying process is one of the typical properties of these soils, which were described by the following scientists: G.Talakhadze and K. Mindeli [15], T. Urushadze [16] et al. The claying process is a result of intersoil ("in situ") weathering [17]. In the subsoil, distribution of the silt fraction (<0.001 particles) totals 21-29 %.

Chemical composition of combined samples from the village of Minadze. The soils are characterized by alkaline or strong alkaline reaction (pH 7.35 – 8.95); with a wide range of calcium carbonates (9.04 – 37.26 %); low content of humus, with the obvious quantitative differences between long-term fallow (1.31 – 3.4 %) and arable (0.99 – 2.10 %) areas. On some terraces, the low content of humus (1.31%; 1.45%) shows that the area has been eroded. Visually, samples from the long-term fallow and the arable areas were distinguished from others by the bright color of the eroded arable areas.

For many years organic fertilizers have not been applied, which has significantly limited plant growth and the content of humus added to the soils. These soils exhibit high cation exchange capacities ranging between 48.27 – 79.90 mg.equiv/100 g soil and a high base saturation. Exchangeable calcium ranges from 72% to 84%, and accordingly the quantities of exchangeable magnesium are low (15-30 %). This high content of bivalent cation enrichment is directly due to the parent material that is caused by the climate peculiarity of the subtropical forest-steppe zone.

The high saturation of calcium on the colloid complex proves that calcium would be easily available for plants and eliminates the need for calcium to be added to the soil. However, when observing the low contents of nitrogen, phosphorus and potassium (hydrolyzed nitrogen (3.36-15.68 mg/100g soil), available phosphorus (from trace to 0.8 mg/100g soil) and exchangeable potassium (5.2-21.2 mg/100g soil) it is readily apparent that these nutrients must be added from either chemical or organic fertilizers to ensure favourable fertility for crop production.

In some terraces (terrace No. 2, 12, and left part of 3 elevated areas of terraces No. 4, 9 and 14, depressed parts of terraces No. 7, 8 and 10) soils are very poor in hydrolyzed nitrogen; however, in some areas the amounts of hydrolyzed nitrogen are medium (7.28-15, 68 mg/100g.soil) but this is only enough to produce lower than average yields for agricultural crops.

Chemical composition of combined samples from the village of Ghreli. All of the soils of this area are very similar to those discussed from the village of Minadze. These cinnamonic calcareous soils are characterized by alkaline or strongly alkaline (pH 7.95 – 8.9) reaction, are carbonated (8.47 – 37.62%), with low contents of humus (1.27 – 1.88%). Exchangeable càlcium (71-79%) prevails over exchangeable magnesium (21-29%) in the cation exchange complex. However, these

Table 1

Description of Soil Profile Using the International Code System

№ 1 1	Sakreb. Akhaltsikhe 4	X: 0340634 7	Relief SE 10	Slope (%) T/05 13
Date: 13.10.2007 2	Land use AA2 5	Y: 4611082 8	Position MS 11	Exposition SB 14
Author: Kvrivishvili T. Sanadze, E. 3	Veg/crop. HS 6	a.s.l.(m) 1195 9	Erosion WS/2/S/A 12	Human infl. VS 15

Hor. № 16	Depth (cm) Boundary 17	Texture (class) 18	Skeleton (Vol. %) 19	Humus (%) 20	Munsell color 21	Mottling (%) 22	Concentra-tions 23	Cutans 24	Carbonates. Gypsum. Salts 25	Wet-ness 26	Struc-ture (type) 27	Bulk den-sity 28	Density 29	Roots (n/dm^2) 30	Rock fragments 31	Horizon symbol 32	Remarks
1	0-20 G/S	SiLr	N	1.5-3	7.5YR 3.5/2	N	N	N	ST//	3	MS/GR /FM	1.0-1.2	powdery	C/FM	N	A	
2	20-33 G/S	SCL	N	1.5-3	7.5YR 3.5/3	N	N	C/CH/P/F	ST//	3	MO/SB /FM	1.2-1.4	slightly hard	F/FM	N	B	
3	33-50 G/S	SCL	N	1.5-3	7.5YR 3/3.5	N	N	C/CH/PV/D	ST	3	WM/SB /FM	1.2-1.4	“ - “	V/VF	N	BC_1	
4	50-80	SCL	N	0.9-1.5	7.5YR 3.5/3.5	N	N	C/CH/PV/D	ST	3	WM/SB /FM	1.2-1.4	“ – “	N	N	BC_2	

Soil type local cinnamonic calcareous 33	Parent material SO1 34	Ground water 35
WRB calcaric cambisols 36	Stratification N 37	Organic surface layers N 38

soils are characterized by a lower cation exchange capacity (45.96 – 59.30 mg eq/100g of soil) in comparison with the soils of the village of Minadze.

Soils are characterized by medium (10.64-15.68 mg/100g soil) or very low (6.16-6.72 mg/100g soil) content of hydrolyzed nitrogen. According to the amounts of mobile phosphorus and exchangeable potassium they belong to the group of very poor soils. Again, according to the analytical data, content of these cinnamonic calcareous soils is very low in nutrients and humus and their fertility must be improved. For adequate crop production, the use of both organic and mineral fertilizers is essential.

Fertilizing recommendations for growing cereal perennial and legume grasses on cinnamonic calcareous soils. Nitrogen fertilizers (Table 2). Fertilization of legume crops with ammonium nitrate or urea is recommended as a split application at a rate of 60 kg of nitrogen per ha. 30 kg of nitrogen should be applied before planting and the remaining 30 kg during the flowering phase. These recommendations translate by weight to a total of 176 kg of ammonium nitrate per ha applied in two 88 kg/ha applications, one prior to plowing and the other at the flowering phase. If urea is used, this translates by weight to a total of 130 kg of urea or 65 kg/ha during each application.

For perennial cereal grasses nitrogen should be applied at the rate of 120 kg of nitrogen per ha. This recommendation translates by weight to 353 kg/ha of ammonium nitrate or 261 kg/ha of urea. Of these amounts, 50% should be applied before planting and the other 50% in additional fertilizations. After the first mowing, 25% or 30 kg of nitrogen should be applied and the remaining 25% after the third mowing, i.e. 176.5 kg should be applied prior to planting and the remaining 176.5 kg to be divided for the application at two additional fertilizations of 88.2 kg each. In the case of application of urea, 130.5 kg should be applied prior to

Table 2

Nitrogen fertilization recommendations

	Perennial Legume Grasses		Perennial Cereal Grasses	
Ammonium Nitrate	kg/ha nitrogen	kg/ha ammonium nitrate	kg/ha nitrogen	kg/ha ammonium nitrate
Total	60	176	120	353
1st application	30	88 pre-plowing	60	176 pre-plowing
2nd application	30	88 at flowering	30	88 after 1st mowing
3rd application	0	0	30	88 after 3rd mowing
Urea	kg/ha nitrogen	kg/ha urea	kg/ha nitrogen	kg/ha urea
Total	60	130	120	260
1st application	30	65 pre-plowing	60	130 pre-plowing
2nd application	30	65 at flowering	30	65 after 1st mowing
3rd application	0	0	30	65 after 3rd mowing

Some terraces require less nitrogen, (see text) planting, and the remainder of the 130.5 kg applied at two additional applications, 65 kg/ha after the first and third mowing respectively.

In the areas of terraces (terraces No.5,.6, elevated part of terrace No.8, terraces No.11, 13, 15,16, 17) with average contents of nitrogen, fertilization of legume grasses should be carried out at the rate of only 30 kg/ha of nitrogen. This corresponds to 88 kg/ha for ammonium nitrate, and 65 kg/ha for urea, during pre-plant fertilization. On the same terraces, when growing cereal perennial grasses, the rate of application should be 90 kg/ha of nitrogen corresponding to 264 kg/ha of ammonium nitrate or 196 kg/ha of urea. Again, half of this should be applied (132 kg of ammonium nitrate or 98 kg of urea) during the pre-plant fertilizing and the remainder divided equally between two additional applications following the first and third mowing.

Phosphorus fertilizers (Table 3). When growing legume grain crops or grasses, 90kg/ha of phosphorus is recommended. In the autumn before fall plowing or before re-plowing in the spring, 70 – 80% of the above-mentioned rate of phosphorus should be applied. In weight this corresponds for simple superphosphate to 500 kg /ha, for double superphosphate 214 kg/ha. It is recommended to apply 400 kg of simple superphosphate per ha or 171.2 kg/ha of double superphosphate (80 % of rate) before fall plowing or re-plowing in the spring. After mowing, it is recommended that the remaining 100 kg/ha of simple superphosphate or 42.8 kg/ha of double super phosphate be applied.

With cereal perennial grasses the application rate for phosphoric fertilizers should be 100 kg/ha of phosphorus, which corresponds to 555 kg/ha of simple superphosphate or 238 kg/ha of the double superphosphate. Sixty percent of the phosphorus fertilizers should be applied during the fall (November) before soil cultivation. This would be 333kg/hà of simple superphosphate or 142.8 kg/ha of the double superphosphate. After mowing, additional phosphorus should be applied (simple superphosphate of 222 kg/ha or 95.2 kg/ha of double superphosphate).

Table 3

Phosphorus fertilization recommendations

Phosphorus	Perennial Legume Grasses		Perennial Cereal Grasses	
Superphosphate	k/ha phosphorus	kg/ha superphosphate	k/ha phosphorus	kg/ha superphosphate
Total	90	500	100	555
1st application	63-72	350-400 pre-plowing	50-60	278-333 pre-plowing
2nd application	27-18	150-100 after 1st mowing	50-40	277-222 after 1st mowing
Double Superphosphate	k/ha phosphorus	kg/ha double superphosphate	k/ha phosphorus	kg/ha double superphosphate
Total	90	214	100	238
1st application	63-72	150-171 pre-plowing	50-60	119-143 pre-plowing
2nd application	27-18	64-43 after 1st mowing	50-40	119-95 after 1st mowing

Superphosphate - $CaH_4 (PO^4)_2 + CaSO_4$

Double superphosphate - $CaH_4 (PO^4)_2$

Potassium fertilizers (Table 4). For legume grain crops as well as legume/grass mixtures it is recommended that 60 kg/ha of potassium be applied before fall plowing or before re-plowing in the spring. For application of potassium chloride this would be 107 kg/ha and for potassium nitrate, 150 kg/ha. For cereal perennial grasses the rate of application recommended for potassium fertilizers is 100 kg/ha of potassium. All of these fertilizers should be applied during the fall fertilization. This corresponds to 250 kg/ha of potassium nitrate or 178 kg/ha of potassium chloride.

N-P-K fertilizers. It is possible to use a fertilizer containing all three elements – “Nitroamophoska” which contains N-16 %, P-16 %, K-16 %; however, the use of this fertilizer will not result in meeting the complete recommended fertility needs. This blended fertilizer - “Nitroamophoska” - could be applied during preliminary cultivation, at a rate not to exceed the recommendation for the lowest needed nutrient. The remainder of fertility requirements would need to be met by nutrients supplied with additional simple fertilizers.

Micronutrients. Some legume grain crops respond to low solution concentrations of salts of molybdenum or nitrogen. Foliar feeding with a solution of 0.01-0.02% molybdenum acid ammonium has given good results. Under nonirrigated conditions, the recommendations for mineral fertilizers should be reduced to 30-50 %.

Organic fertilizers and micronutrients. Generally, under legume/cereal grass mixtures manure is not applied. When needed, the micronutrients should be applied before planting, especially molybdenum fertilizers, which are needed by the nitrogen-fixing bacteria and the nitrogen fixing processes.

When growing cereal perennial grasses and using manure (half burned), 10-20 t/hà of the manure should be applied. On soils with an average content of nitrogen (terraces No.5, No.6, elevated part of terrace No.8, terraces No.11, No.13, No.15, No.16, No.17) manure should be applied in the amount of 10-15 t/ha.

Summary

1. Cinnamonic calcareous soils in the villages of Minadze and Ghreli in Akhaltsikhe district have been studied. It was determined that the soils are characterized by low amounts of nutrients and humus. With the purpose of improving the soil fertility, application of organic and mineral fertilizers is required.

2. Applicable recommendations of nutrients for cereal and legume grass mixtures and rules for application have been ascertained:

a) perennial legume grass mixtures - 60kg N-90kg P-60kg K per ha;

b) perennial cereal grasses - 120 kg N-100kg P-100kg K per ha.

Table 4

Potassium fertilizing recommendations

Potassium	Perennial Legume Grasses		Perennial Cereal Grasses	
Potassium Chloride	kg/ha potassium	kg/ha potassium chloride	kg/ha potassium	kg/ha potassium chloride
Total	60	107	100	178
1st application	60	107 pre-plowing	100	178 pre-plowing
Potassium Nitrate	kg/ha potassium	kg/ha potassium nitrate	kg/ha potassium	kg/ha potassium nitrate
Total	60	150	100	250
1st application	60	150 pre-plowing	100	250 pre-plowing

3. Applicable recommendations and rules of organic fertilizer (manure) for cereal grasses and legume/grass mixtures have been ascertained:

a) under legume/grass mixtures manure, as a rule, is not used;

b) 10-15 t/ha of manure is needed under cereal perennial grasses, where the amount of soil nitrogen is at an average level.

სოფლის მეურნეობა

ახალციხის რაიონის საძოვრების ყავისფერი კარბონატული ნიადაგების განოყიერების სისტემა

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განხილულია ახალციხის რაიონის მინაძისა და ღრელის სოფლებში გავრცელებული ყავისფერი კარბონატული ნიადაგების ნაყოფიერების დონის შესწავლის შედეგები, ბიოცენოზები და სასუქებით განოყიერების სისტემების ოპტიმიზაციის გეგმა. გამოკვლეულ იქნა დაახლოებით 30 ჰექტარი სასოფლო-სამეურნეო სავარგული. აქედან სოფ. მინაძის ტერიტორიაზე საკვლევი ფართობი შეადგენდა დაახლოებით 23 ჰა და მოიცავდა 14 ტერასას. რელიეფის ელემენტების მიხედვით, ტერასები №3, №5 და №6 მოვაკებულია, ხოლო დანარჩენი კი დატერასებული ფერდობებია, რელიეფის შემაღლებული და ჩადაბლებული ელემენტებით. ტერიტორიის უმეტესი ნაწილი ნასვენია (ტერასა №1, ტერასა №8), დანარჩენი კი სახნავია, რომლებიც მრავალწლოვანი ბალახების კორდით არის დაფარული. ნიადაგის ნაყოფიერების ამაღლების მიზნით დადგინდა გამოსაყენებელი მინერალური და ორგანული სასუქების რაოდენობა, ასევე მიკროსასუქების დოზები. დადგინდა საკვები ელემენტების შესატანი ნორმები მრავალწლიან ბალახდგარში ბოტანიკური შემადგენლობის მიხედვით მათი ზედაპირული გაუმჯობესების სისტემაში, რის საფუძველზეც განისაზღვრა ორგანული და მინერალური სასუქების შეტანის ოპტიმალური ვადები და მეთოდები.

REFERENCES

1. *G. Agladze and A. Korakhashvili* (1998), In: Dry Land Pastures, Forage and Range Network News, 15: 22-24, ICARDA, Aleppo, Syria.
2. *A. Korakhashvili, G. Agladze* (2000), Grass Landraces of Georgian Arid Pastures. IPGRI, Elvas, Portugal: 96-98.
3. *A. Korakhashvili* (2001). New Growing Technologies of Grain Leguems and Treir role in Farmers Economics. Caravan., Aleppo, Syria, pp 23-29.
4. *D. Gedevanishvili, G. Talakhadze* (1961). Niadagmtsodneoba [Soil Science], Tbilisi, 370 p. (in Georgian).
5. *N. Ketskhoveli* (1959), Sakartvelos mtsenareuli sapari [Vegetation Cover of Georgia].Tbilisi, 441 p, (in Georgian).
6. World Reference Base for Soil Resources, (2006), FAO, Rome, 144 p.
7. F. Nachtergaele (2000), New Developments in Soil Classification: World Reference Base for Soil, FAO, Rome, 19 p.
8. World Reference Base for Soil Resources (2002), FAO, Rome, 88 p.

9. *A. Didebulidze and H. Plachter* (2002), In: Pasture Landscapes and Nature Conservation (B. Redecker, P. Finck, W. Hдrdtle, U. Riecken and E. Schrцder, eds.). Heidelberg, Berlin, New York: 15-23,
10. *R Munsell* (2000), Soil Color Charts, Revised washable edition, USDA
11. *H. P. Blume (*2002), Students Guide for Soil Description, Soil Classification and Site Evaluation. Halle, 358 p.
12. Prakticheskoe rukovodstvo pochvovedenia (1986), Ed. I. Kaurichev, Moscow: 28-45 (in Russion).
13. *A. Didebulidze, G. Tarkhan-Mouravi* (2009), Annals of Georgian Science, **7**, 1: 51-56.
14. *T.Urushadze* (1997), Sakartvelos dziritadi niadagebi [The Main Soils of Georgia], Tbilisi, 186 p. (in Georgian)
15. *T. Urushadze* (1999), The map of Georgian soils – 1: 500 000 scale, Tbilisi.
16 *A. Didebulidze, T. Urushadze* (2009), Schriften zur Internationalen Entwicklung- und Umweltforschung, 26: 241-263, Frankfurt am Main.
17. *D. Gedevanishvili, G. Talakhadze* (1961), Niadagmtsodneobis kursi [A Course in Soil Science], Tbilisi, 370 p (in Georgian).

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