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CORRELATIONS BETWEEN THE ZONATION OF SANDY GRASSLANDS AND THE PHYSICO-CHEMICAL CONDITION OF THEIR SOIL IN BUGAC

L. KÖRMÖCZI

Department of Botany, Attila József University, Szeged
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Abstract

Investigations were performed on the conditions of the soil of five sandy grassland communities within of the Kiskunság National Park in Bugacpuszta in 1981. The basis for comparison was the different relief conditions of the plant communities. The soil of the higher relief communities contained a higher percentage of coarse sand, in the soils closer to underground water the ratio of the colloid granules increased. Accordingly, the water balance of the colloid-rich soils was more settled, the water content was higher. The water content of the deeper layers was generally lower. The humus and nitrogen contents of the soils were lower in areas of coarser sand, in every segment showing a value wich decreased from the surface down. Their seasonal changes were in relation to the precipitation conditions and the moisture-content of the soil. The chemical reactions of the soil segments was shifted in alkaline direction by their carbonic chalk-content, and alkalinity increased with depth. Treatment with chemical fertilizer resulted in the souring of the soil and the seasonal value of the chemical reaction became more fluctuating. The higher degree of colloid fraction contributed to the improvement of the water balance and nutriment supply of the soil segments, however, due to the presence of the highly saline underground water there is also a danger of salt accumulation and alkalization.
Key words: Bugac, sandy grassland, sandy soil, alkalization.

Introduction

The aim of the investigations started in 1977 in the sandy pasture near Bugac in the Kiskunság National Park was to throw light on the relations of production and the factors influencing production of the sandy grassland communities of varying relief. The cenology of the grass associations and the physical structure of their soil was reported on by BODROGKÖZY and FARKAS (1981). The paper by KÖRMÖCZI, BODROGKÖZY and HORVÁTH (1981) discussed the productive and microclimatic conditions of these associations. SZABÓ (1975) dealt with the economy of water supplies regarding sandy soils and determined that soils with a better management of water supply and an impermeable layer are suitable for afforestation. According to the studies of SZODFRIDT and FARAGÓ (1968) the level of underground water in the sand between the Danube and Tisza is at a depth of 4—5 m on sand-hill ridges, 1.5—2.5 m between the sand-hills. Underground water is deepest in the soil of *Festucetum vaginatae*, and the soil of *Molinietum coeruleae* is water-saturated to the surface.

BODROGKÖZY (1957) and SIMON and KOVÁCS-LÁNG (1964) studied the relation between sandy soils and the series of plant associations introduced there.

The present paper also deals with the correlations between the series of sandy grassland communities and the physico-chemical characteristics of their soil.

Materials and Methods

The study area is situated in Felsőbugacpuszta in the Bócsa-Bugac region of the Kiskunság National Park. The associations studied were *Potentillo-Festucetum pseudovinae danubiale* BODROGKÖZY 59, *Molinio-Salicetum rosmarinifoliae* (SOÓ 33) 57, *Lolio-Potentilletum anserinae* KNAPP 46, *Cynodonti-Poëtum angustifoliae* (RAPAICS 26) SOÓ 57, *Achilleo-Festucetum pseudovinae* (MAGYAR 28 SOÓ 45; the cenological descriptions of wich can be found in the works of BODROGKÖZY and FARKAS (1981) and KÖRMÖCZI (1982). The difference in level between the highest and lowest points was 2.8 m (Fig. 1).

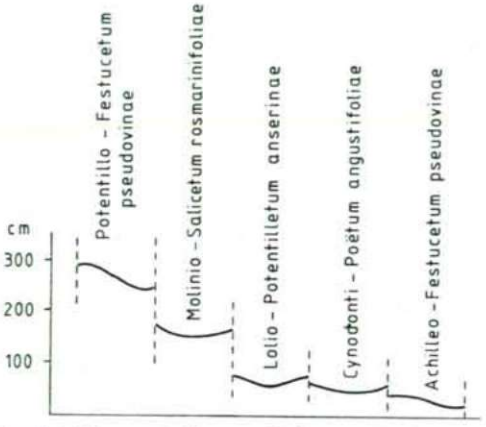

Fig. 1. Differentiation in level of the associations studied.

The meteorological data of the study year 1981 came from the measuring station in Izsák. The data are shown in a Walter-Lieth diagram (Fig. 2). Compared to the 50-year average (see KÖRMÖCZI, BODROGKÖZY and HORVÁTH, 1981. Fig. 2) the annual mean temperature was 0.5°C higher and the annual precipitation was 151 mm lower. It is characteristic of the inequality in the distribution of

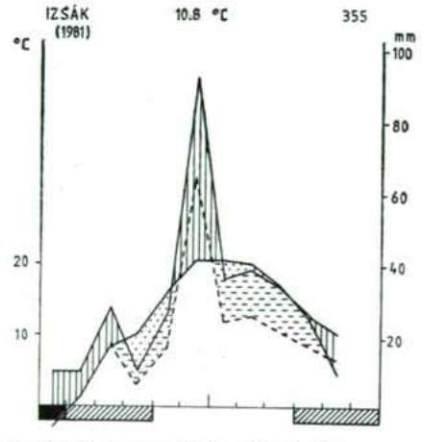

Fig. 2. Weather for the year studied shown on Walter-Lieth diagram.

precipitation that the year had meagre rainfall from March to October, with specific drought in spring and at the end of summer and a larger amount of rain (92 mm) fell only in June. The precipitation in winter was 1/3 of the average.

In 1981, from February till October samples were taken monthly from the soil of the associations with the help of an auger in layers of 10 cm.

The moisture content of the soils was calculated after drying at 95 °C and weighing the soil again. The water content was determined as a percentage of the weight of the damp soil.

The physical composition of the soil samples was measured by the sedimentation-hydrometer method, and the hygroscopy (hy) was also measured (BALLENEGGER 1953).

The $CaCO_3$ content was measured with a Scheibler apparatus. The humus-content was measured by using the permanganometric method, and the total nitrogen content was calculated with an ammonia selective electrode after Kjeldahl-destruction.

The determination of the total water soluble saline content was carried out on the basis of conductivity.

Distilled water extract was used for the hydrogen ion concentration measurements.

Results and their evaluation

Of the five associations studied the *Potentillo-Festucetum pseudovinae danubiale* BODROGKÖZY 59 pasture grass was from the areas of highest relief, the soil of wich is coarse humous sand. The ratio of granules larger than 0.4 mm was 3—4%, that of granules between 0.1—0.4 mm was 75—87%, the washable fraction was 7—15%. The hygroscopy (hy) of the soil varied between 0.64—0.15 according to the depth. The higher value at the surface was a result of the humus content. The $CaCO_3$ content of this soil was low, in the 0—30 cm surface layer no chalk content was demonstrable and even in the deeper layers it was only between 3—7%. Accordingly, the chemical reaction of the diluted extract was also low.

The water content of the association's soil showed inordinate fluctuation. The water content in the surface 10 cm layer expressed in a percentage of wet weight varied between 3—25%, being dampest at the end of winter, drying out gradually by August, and again becoming higher in water content by autumn. The higher precipitation in June (92 mm) only increased the water content of the deeper layers to a small extent, and only delayed the fast drying up of the surface layer. The water content of the deeper layers was lower than that of the surface layer, the effect of the summer precipitation prevailed downwards, with a shift in time.

The humus content of the upper 20 cm soil layer was relatively high (3—4.5% and 1.5—3%, respectively), that of the lower layers did not reach 1%. The rather high value measured in February (7.4%) was obtained from the phytomass of the previous year, which later decomposed rapidly with the drying of the soil. The decomposition of the humus material was rather fast; the humus content in the surface soil layer showed rather great fluctuation, which was caused by the continuous replacement of leaf-mould. A more intensive summer humus-formation was observable in the 10—20 cm layers, which coincided with the period when there was a lack in precipitation.

The seasonal changes in the total nitrogen content were similar to those of the humus content. It showed a gradual decrease throughout the whole vegetative period, with a slight increase in the middle of summer. Its value in the surface layer ranged from 0.8—2.0 mg/g, and was 6.2 mg/g at the beginning of the vegetative period.

The chemical reaction of the soil showed great fluctuation, shifting to alkaline from the surface down. The chemical reaction of the surface layer decreased from 7.8 to 5.6 pH by the middle of the summer, then rose gradually until it became neutral. The chemical reaction of the deeper layers varied from 7—9 pH, their course differed, being the reverse in the middle of the vegetative period, as in the surface layers. The souring of the soil was presumably due to the vegetative period (ALMÁSSY et al. 1968).

Water soluble salt was not measurable in the soil of the *Potentillo-Festucetum pseudovinae* association.

The *Molinio-Salicetum rosmarinifoliae* (Soó 33) 57 is an association of higher situated wind furrows, probably developed from the association of *Schoenetum nigri-*

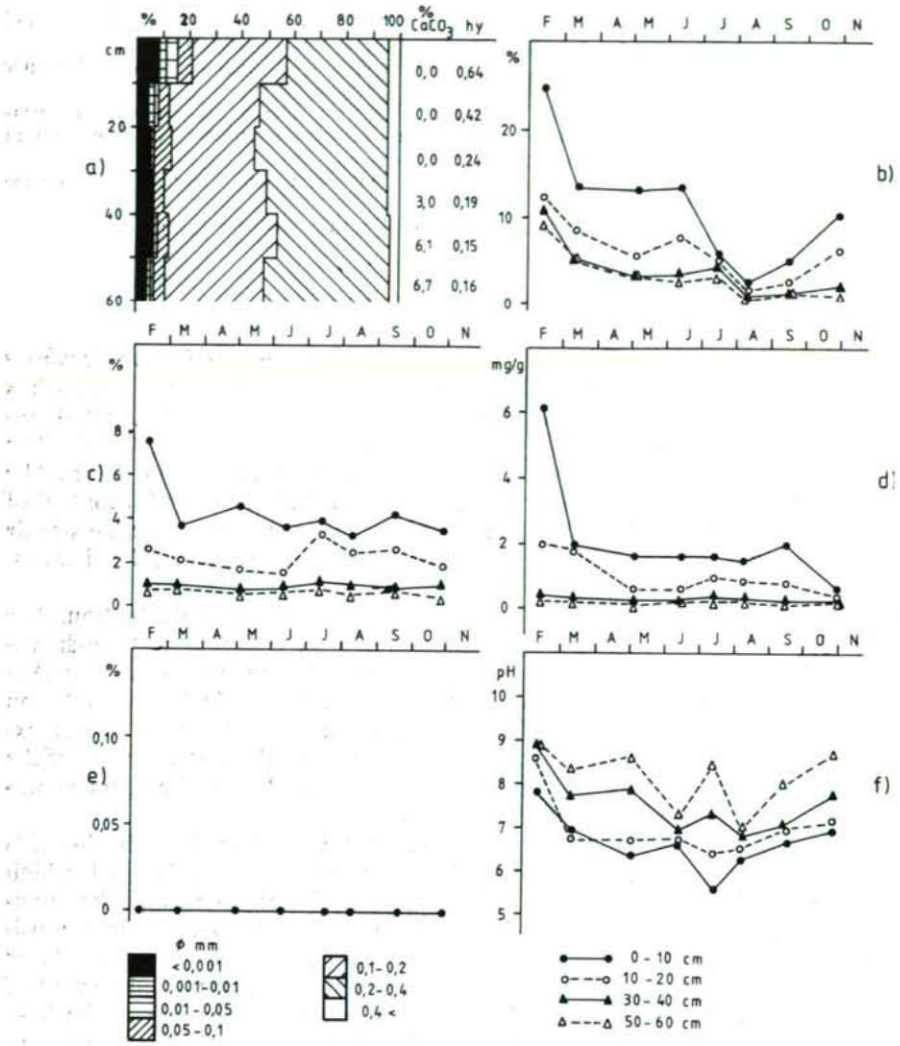

Fig. 3. Results of analysis in the *Potentillo-Festucetum pseudovinae* association. Physical composition of the segment, $CaCO_3$ content and hygroscopy (a); moisture content (b); humus content (c); total nitrogen content (d); water soluble salinity (e); and hydrogen ion concentration (f.)

cantis (ALL. 22) W. KOCH 26 from a damper site, as a consequence of the gradual drying up of the area (BODROGKÖZY and FARKAS, 1981).

The association has fine granular soil, made up of averagely humous sand, in the granular composition of which granules having diameters of 0.1—0.4 mm dominate. The ratio of the granules with diameters of 0.2—0.4 mm was 25—35%, the 0.1—0.2 mm granules had a ratio of 37—48%. The washable fraction was between 2—7%. The hygroscopy (hy) of the soil segment varied from 0.52—0.17. The $CaCO_3$ value measurable in the soil segment decreased from the surface to 40 cm, then greatly increased, being 16.1% at 60 cm and 20.6% at 70 cm. The moisture content of the soil

was low throughout the whole study period, its value decreased downwards from the surface, not even reaching 15% in the dampest upper layer. The fluctuation of the water content was the greatest in this layer, ranging from 3—13%. Due to the proximity of the underground water level the water content was again higher in the 50—60 cm layer, showing a value of about 10%, with only slight fluctuation.

Excluding the upper 10 cm layer, the organic matter content of the soil segment was low, having a value under 1%. Fluctuation was slight, showing a small rise at the beginning of the vegetative period. The humus content of the upper 10 cm layer varied from 1.8—3.7%, gradually increased in spring, fell back when the soil layer dried out and increased again in the second half of the vegetative period.

The seasonal dynamics of the nitrogen content was similar, however, the second maximum value was observed later and the decreases were steeper. The double maximum of the nitrogen content was observable in the whole soil segment. Its value ranged from 0.7—1.5 mg/g on the surface, and from 0.1—0.4 mg/g in the lower layers.

The chemical reaction of the segment was neutral-slightly alkaline during the whole vegetative period, its hydrogen ion concentration varied between 7.2—8.8 pH. The fluctuation of the chemical reaction was slight in the whole soil fragment, within 0.3 pH, and the changes occured in parallel. The hydrogen ion concentration of the upper 10 cm layer was more acidic than that of the lower layers, and its fluctuation reached a value of 1 pH.

Water-soluble salts were not demonstrable from this segment either.

In the spaces between the sand hills, which are damper and closer to the underground water level, is situated the association of *Lolio-Potentilletum anserinae* KNAPP 46, the soil structure of which significantly differs from that of the previous association; it has a better management of water supply, therefore making possible the establishment of more particular species, too (KÖRMÖCZI, 1982).

The physical composition of the soil segment is characteristic of the fact that in the upper 30 cm layer the ratio of the washable fraction is high (33—41%), but is only 15% in the layers between 30—40 cm. This latter layer is a transition towards the skeleton soil of the lower level, which is coarse sand with a washable faction of 8%. The ratio of granules larger than 0.1 mm was 47—57% in the upper layer, 76% in the transitional layer and 89% in the lower ones. In compliance with the physical structure the hygroscopy of the upper level of the segment was also high (hy 1.88—0.54), but was low in the deeper layers (0.19—0.10).

The segment could be devided into the afore-mentioned two levels also on the basis of the $CaCO_3$ content, which was 20—22% the upper level and 3—7% in the lower one. The water retaining capacity of the upper soil level was rather good, ensuring an appropriate water supply for the plants all through the year. The initial 43% water content did not fall below 25% even in the drought period. The subsoil moisture content of the coarse sand was also high, nearing a value of 20%, however, this was a result of the proximity of the underground water level. With the decrease in the level of underground water, the water content of the lower layers also decreased gradually, reaching 8% by the end of the study period.

The humus and total nitrogen contents of the soil segment were high. The humus content varied from 4—10% in the upper level, but was around 1% also in the deeper layers. In the early summer period when there was a lack of precipitation there was a significant decrease in the humus content, nevertheless, it was gradually replaced by autumn from the large quantity of phytobio-mass. In the 10—20 cm layer the organic matter content decreased further, but was of a lesser degree. This change in the humus content of the deeper layers was not similar to that of the upper layers.

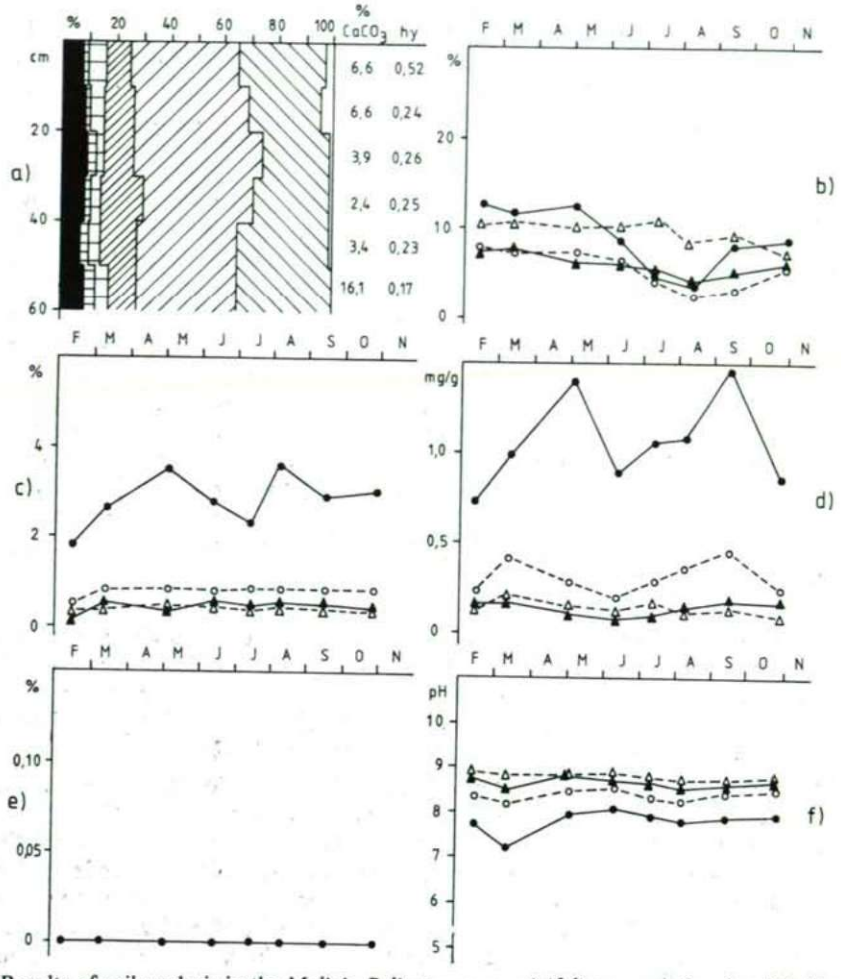

Fig. 4. Results of soil analysis in the *Molinio-Salicetum rosmarinifoliae* association (see labellings for Fig. 3).

The value of the total nitrogen content was 3—5 mg/g in the 0—10 cm layer, 2—3 mg/g in the 10—20 cm layer and under 1 mg/g in the deeper layers. Its change in the upper 10 cm layer was similar to that of the humus content, decreasing significantly in the period when there was a lack of precipitation by 1.3 mg/g, and rising by the same amount gradually by autumn. The chemical reaction of the soil segment was slightly alkaline, with values between 7.5—8.5 pH. Going downwards the alkalinity increased. The pH value did not show significant seasonal changes.

A large amount of water soluble salt was measurable in the upper 40 cm layer of the soil segment. Here the Na salts dissolved in underground water accumulated due to the upward flow of the underground water and the higher colloid granule content of the upper soil layer, involving a danger of alkalization. The highest salt content was observable throughout in the uppermost soil layer, moving within the limits of the saline value (0.1 %). In the period lacking precipitation the salt content of the soil increased, showed a decrease in the second half of the vegetative period, and was

completely washed out of the 30—40 cm layer by the end of the period, falling beneath the saline value even in the upper layer. Water soluble salt was not detectable in the subsoli (40—60 cm).

In one part of the area of the previous association the upper soil level was disrupted and removed to a depth of 25 cm. With the reestablishment of the plants an association of *Cynodonti-Poëtum angustifoliae* (RAPAICS 26) SOÓ 57 developed in this area, the soil of which had a bad water and nutriment supply despite the proximity of the underground water level, as a consequence of the small basal area of the vegetation.

The soil of the association was coarse sand, where the ratio of granules with diameters of 0.2—0.4 mm was 28—55%, that of granules having diameters of 0.1—0.2 mm was 37—48%, and the ratio of washable areas was 9—11%. Going downwards the ratio of coarse granules showed an increase. The hygroscopy of the soil segment varied between 0.14—0.09.

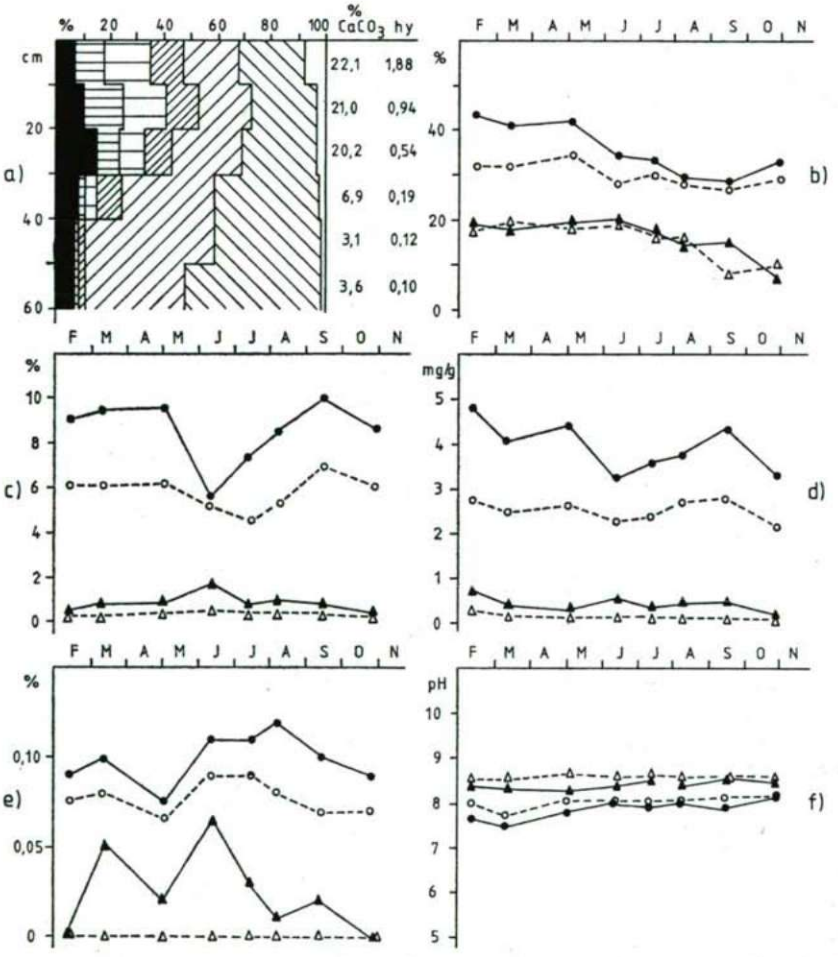

Fig. 5. Results of soil analysis in the *Lolio-Potentilletum anserinae* association (see labellings for Fig. 3).

The $CaCO_3$ content of the soil segment was found to be higher than the value measured in the lower level of the soil of the previous association, but that of the upper layer was lower. This can be explained by the washing away of the $CaCO_3$ from the upper level, since the degree of eluviation increased after the removal of the upper level rich in colloids (STEFANOVITS, 1981). The $CaCO_3$ content ranged from 8.3— 11.2%.

The water balance of the soil segment was bad, as consequence of the decrease in the underground water level the whole segment gradually dried out, the moisture content decreased to 1% by the middle of summer in the upper layers and that of the deeper layers also fell beneath 5%. By the end of autumn a moisture content of about 5% was measured in the whole segment.

The humus content was low during the whole period, not reaching 1% in the 0—10 cm layer, and being under 0.5% in the lower layers; ranging from 0.2—0.5%. By August a slight increase could be experienced in regard of the humus content. The total nitrogen content developed similarly to that of the humus; the nitrogen content of the layers under 10 cm varied only slightly, and that of the 0—10 cm layer was twice that of the lower ones. Its value was rather low, 0.18—0.34 mg/g in the upper layer and between 0.04—0.17 mg/g in the deeper ones. A slight increase could also be experienced in this respect by the end of summer.

The hydrogen ion concentration of the soil segment was slightly alkaline, falling between 8.2—9.1 pH and becoming slightly more alkaline further down. The pH-fluctuation of the various layers was within 0.3. No water soluble salts were demonstrable from the segment.

Of the associations studied the *Achilleo-Festucetum pseudovinae* (MAGYAR 28) SOÓ 45 was situated at the lowest relief, where the process of alkalization was detectable. The upper part of the soil of this association (till 50 cm) was sandy adobe, turning to coarse sandy subsoil in the lower layers. The ratio of granules with diameters of 0.2—0.4 mm was 21—30%, that of granules with diameters of 0.1—0.2 mm was 26—35%. The ratio of washable areas was 21—37%. The hygroscopy of the segment ranged from 0.60—0.11. The $CaCO_3$ content was found to be rather high; between 20.8—34.4%. Because of this the colour of the soil was whitelight grey. This also significantly shifted the chemical reaction in an alkaline direction; values of about 10 pH were measurable. (The hydrogen ion concentration varied from 8.3 to 10.4 pH). The $CaCO_3$ content increased from the surface to a depth of 40 cm, and below from this it decreased again. The chalk-content of the different layers had a positive correlation with the ratio of colloid granules.

The changes in the moisture content of the various layers showed variability. In the surface layer of 10 cm the water content stayed at the same level till the middle of summer — at a value of 17—18% —, then it suddenly decreased to 7% and gradually increased again by autumn. The water content of the 10—20 cm layer gradually decreased from 20% to 8% from spring till the end of summer, and the increase following this was also gradual. The value and change of the water content was slighter, too, in the lower layers; values of 8—12% were measured in the 30—40 cm layer. In conformity with the gradual decrease in the level of underground water, the water content of the lower levels also showed a constant decrease. The upper part of the soil segment was rich in humus. A gradually increasing humus content between the values of 1.9—4.7% was measurable in the 0—10 cm layer. The humus content of the 10—20 cm layer ranged from 0.8—3.1%, showing great fluctuation. In the lower sites the humus content did not reach the value of 1%. As in the humus the value of the total nitrogen content increased slightly until autumn from 0.9 mg/g to 1.9 mg/g, however, its va-

lue fell to half in the 0—10 cm layer at the end of autumn. The nitrogen content also showed great fluctuation in the 10—20 cm layer, being between 0.3—1.2 mg/g.

A high, water soluble total sa linity, well above the saline value, was measured in the soil of the *Achilleo-Festucetum pseudovinae* association. The total salinity of the whole segment was above 0.1 % till the middle of summer. The highest value was measured in spring — 0.38 % — rom which value it gradually decreased till the end of the study period. By the time of the last sampling soluble salt could not be demonstrated at all in the whole segment. The soluble salt content of the segment decreased together with that of the underground water level, and the salts were gradually washed out with the precipitation. Due to the coarse sand composition of the subsoil there was no possibility for the replacement of the salts from the underground water, therefore the salt content was probably washed out completely from the segment.

The correlations between the humus- and salt content need further study.

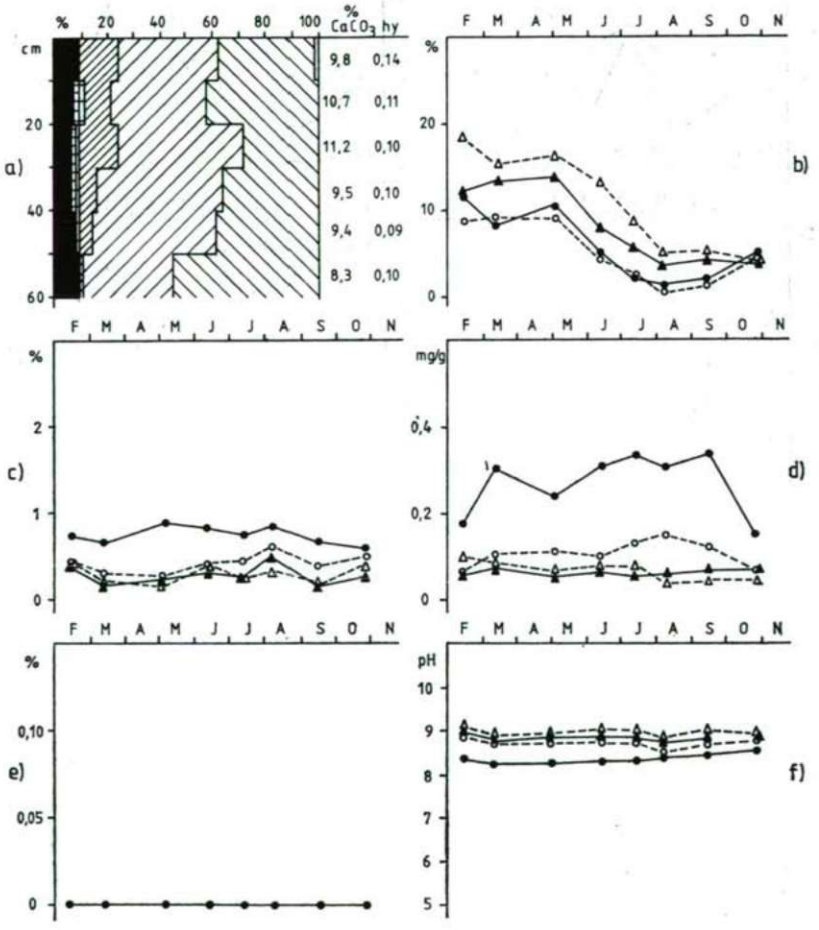

Fig. 6. Results of soil analysis in the *Cynodonti-Poëtum angustifoliae* association (see labellings for Fig. 3).

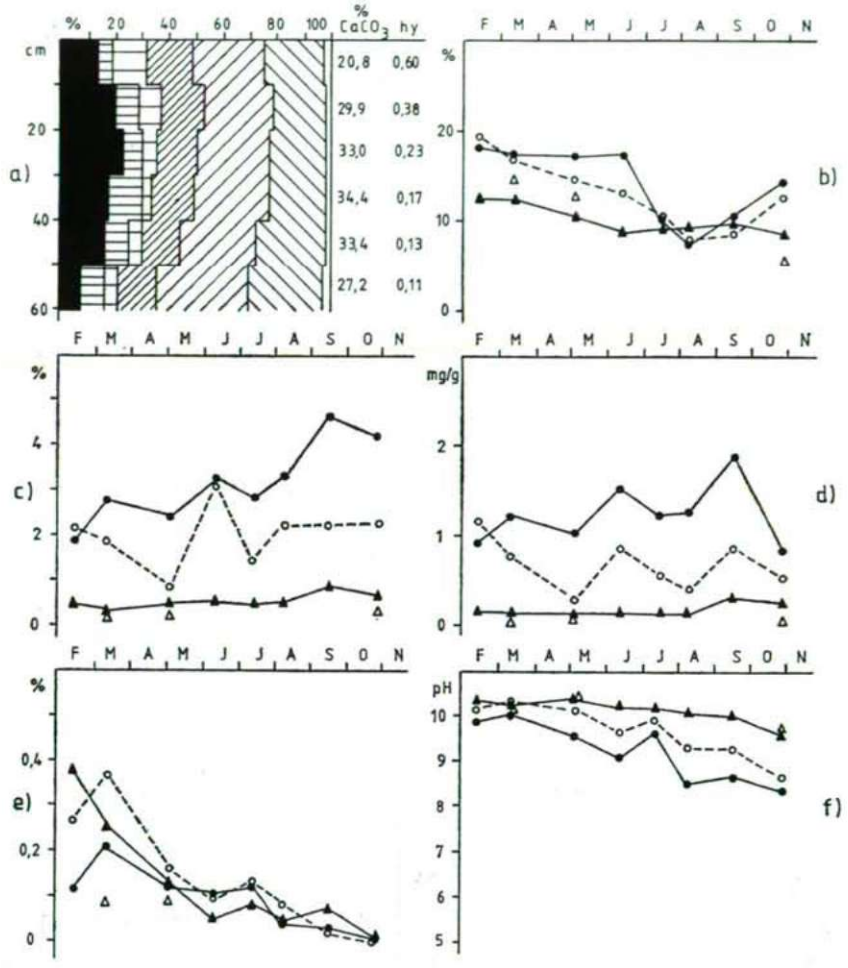

Fig. 7. Results of soil analysis in the *Achilleo-Festucetum pseudovinae* association (see labellings for Fig. 3).

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Address of the author:
DR. L. KÖRMÖCZI
Department of Botany, A. J. University
H-6701 Szeged, P.O. Box 657.
Hungary