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SOIL BASAL RESPIRATION AND DEHYDROGENASE ACTIVITY OF AGGREGATES: A STUDY IN A TOPOSEQUENCE OF PASTURE SOILS

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Abstract

The objective of this study was to determine changes in soil basal respiration (BR) and dehydrogenase activity (DHA) in soil aggregates along a pasture slope. Soil samples from 0–50 mm depth were taken from three landscape positions (crest, midslope and footslope) of a pasture in Samsun, Turkey. For each landscape position, soil aggregates were separated into eight aggregate size classes using a dry sieving method and then microbiological properties and organic carbon content (C_{org}) were analysed. At all positions, the contents of macroaggregates (especially 841–1190 μm and 1190–1680 μm) were higher than microaggregates. The contents of C_{org} varied between 0.65–2.08%. The highest C_{org} contents were found in footslope positions, and the lowest in midslope. All microbiological properties were higher at footslope position than at the other positions. Generally, BR and DHA were higher in microaggregates < 250 μm, in macroaggregates of 250–420, 420–841, 841–1190 μm than in the other aggregate size classes at all positions, whereas C_{org}:C_{mic}, BR:C_{mic} and DHA:C_{mic} ratios were higher in macroaggregates of 1190–1680, 1680–2380, 2380–4760 μm than the other macro- and microaggregate size. Consequently, macroaggregates had relatively more C_{org} than the microaggregates, even if the absolute values of BR and DHA were the lower.

Key words: pasture, soil aggregates, microbial biomass carbon, soil basal respiration, organic carbon, landscape position.

Introduction

Soil aggregates are one component of soil structure and are important for maintaining soil porosity and aeration, favourable for plant and microbial growth, infiltration of water, and stability against erosion /Oades, 1984; Dexter, 1988/. Boehm and Anderson (1997) demonstrated that aggregate size and stability can indicate change in soil quality as a result of soil management. Aggregate formation and stabilization are affected by several factors, including organic materials, clay content, iron- and aluminum oxides, and microbiological activity /Degens, 1997; Castro Filho et al., 2002/. Also, it is well known that the soil organic matter and microbial activity is one of the most relevant factors affecting soil structure /Tisdall, Oades, 1982; Degens, 1997/.

The effects of topography on aggregate size distribution have long been known. The relationships between aggregation and landscape position may be affected by soil

organic matter (SOM) and microbiological properties in pasture soils. Many earlier researchers focused on microbial biomass (C_{mic}), soil basal respiration (BR), dehydrogenase activity (DHA) and organic carbon content for monitoring and evaluating the microbiological properties of soil aggregates /Casida, 1977; Trevors, 1984; Powlson et al., 1987; Camińa et al., 1998; Aşkın, Kızılkaya, 2006/.

Generally, pastures have a single management history in Turkey. Grazing is generally considered to be the most economic way of utilizing rangeland vegetation. But, overgrazing or uncontrolled grazing always reduces plant cover and thus diminishes the protection afforded to the soil and generally results in soil erosion and compaction. Soil erosion, which is a serious problem in many countries, removes > 500 million tonnes of productive soil and large amounts of plant nutrients every year in Turkey /Öztaş et al., 2003/. Soil microbiological properties and vegetation can also be altered over time under different land use and management systems. Turkey's grazing lands are subject to quite heavy, uncontrolled grazing pressure and the forage production capacities of these lands are gradually decreasing, reflecting typical examples of land degradation all over Turkey /Türkeli, Hatipoglu, 1996; Öztaş et al., 2003/. In the same way, pasture areas in the research area face degradation problems. Few studies have addressed this issue and scant attention has focused on microbiological characteristics of pasture soils associated with landscape position in the research area.

In this study we measured selected microbiological characteristics, such as microbial biomass carbon, soil basal respiration and dehydrogenase activity in different aggregate sizes gathered from pasture soils, in order to investigate relationships between microbiological properties and aggregation dependent on landscape position. The specific objectives of this research were: 1) to characterize aggregates of pasture soils in terms of aggregate size distribution and organic carbon content; 2) to observe microbiological properties of aggregates at crest, midslope and footslope positions; and 3) to determine the relationship between microbiological properties and organic carbon contents in pasture soils.

Materials and methods

Study sites. The study area is located in the Black Sea Region of northern Turkey (41°21'N; 36°15'W). The sampling area has a typical Black Sea climate (Sub-humid, R_f = 47.21). Average monthly temperature (1974–2001) varies from 6.6 °C (February) to 23 °C (August). Mean annual precipitation is 670.4 mm /Anon, 2002 a,b/. The annual average temperature is 15.6 °C and the precipitation was 648.6 mm in the sampling year. The study area was defined as pasture of Kalkanca that has relatively homogeneous vegetation and was dominated by grasses (*Plantago lanceolata* L., *Bellardia* sp., *Bellis perennis* L., *Circium arvense* L., *Bromus squarrosus* L., *Taraxacum* sp., *Stellaria* sp., *Trifolium resupinatum*, *Medicago arabica* L., *Medicago scutellata* L. and *Poa* sp.).

Soil sampling. Soil sampling was completed in May 2002; soil samples (~500 g) were taken from the top 50 mm using a sterile soil corer (sterilized with 95% ethanol before use). Soil samples were taken from different landscape positions across the slope; crest, midslope and footslope (Figure 1). Thirty soil samples were randomly collected from each landscape position in order to make three composite samples (each sample composed from 10 replicates). The samples were transported to the laboratory the same

day. The soil samples were crumbled gently by hand and sieved (< 8 mm aperture), removing root material. Soil aggregates were separated from these samples. These samples were used to determine physical (separation of aggregates) and chemical (organic C) soil properties. Also each sample was stored in polyethylene bags at 4 ^{o}C in the refrigerator for ≤ 72 h prior to analysis. These samples were used to determine microbiological (C_{mic}, BR and DHA) properties of soils at field moisture condition.

Soil properties. Some soil physico-chemical analyses were conducted on samples from which crop residues, root fragments and stones >2 mm had been removed. Selected soil physico-chemical properties were determined by means of appropriate methods: particle size distribution by hydrometer method /Bouyoucos, 1951/, pH and electrical conductivity (EC) in 1:2.5 (w/v) in soil:water suspension by pH-meter and EC-meter /U.S. Salinity Laboratory Staff, 1954/. The soil organic carbon content was measured using a modified Walkley-Black method /Rowell, 1996/.

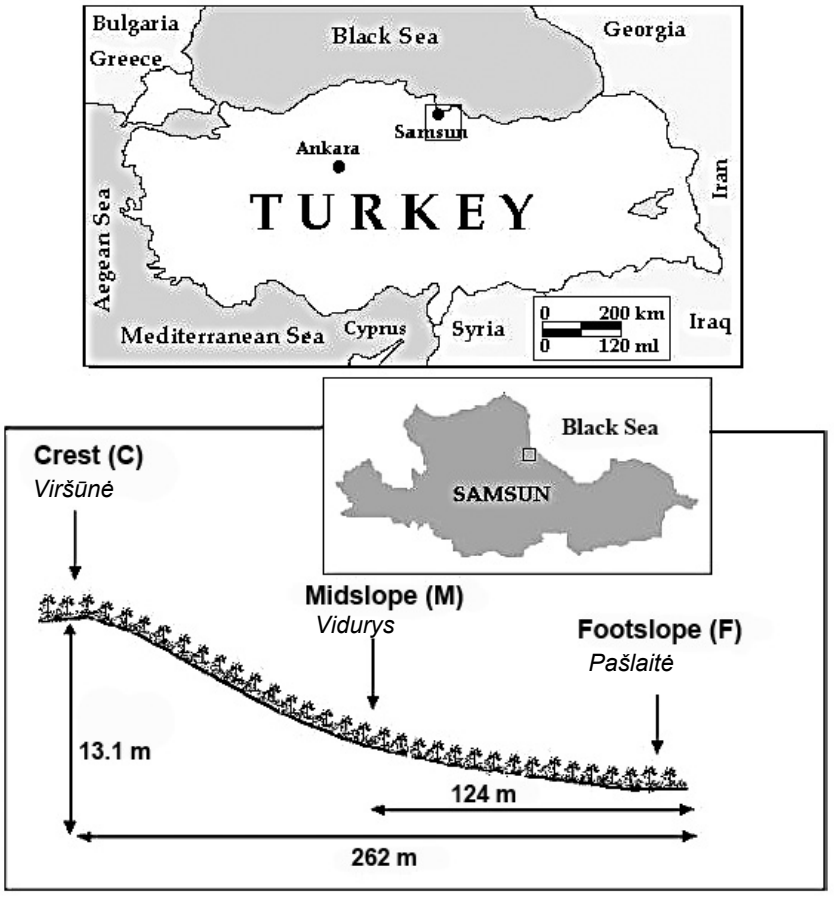


Figure 1. Location map of the study area
1 paveikslas. *Tyrimų vietovės žemėlapis*

Separation of aggregates. The initial aggregate size distribution was determined by sieving 5000 g soil for 2 minutes on a stack of sieves with openings 4760, 2380, 1680, 1190, 841, 420 and 250 μm, from the top to the bottom of the stack, using an automatic sieve shaker (speed and time of shaker were constant), manufactured by ELE International. Each size fraction was weighed, and eight size classes were obtained: (I) >4760 (II) 4760–2380, (III) 2380–1680, (IV) 1680–1190, (V) 1190–841, (VI) 841–420, (VII) 420–250 and (VIII) < 250 μm, adopting the procedure of Nearing (1995). Weighed size fractions were regrouped into two main size classes: macroaggregates (>250 μm) and microaggregates (< 250 μm), according to Tisdall and Oades (1982).

Microbiological properties. The C_{mic}, BR and DHA were determined for the each field-moist aggregate. The soil moisture content was determined after drying at 105°C for 48 h. All results on microbiological properties were expressed on the basis of moisture-free weights.

Microbial biomass carbon (C_{mic}). Microbial biomass carbon was determined according to the substrate-induced respiration method /Anderson and Domsch, 1978/. A field moist soil sample nearly equivalent to 50 g oven-dry soil (stored at 22 °C for 1 week) was amended with a powder mixture containing 150 mg glucose and 500 mg talcum. The CO_2 evolution rate was measured hourly using the method described by Anderson (1982). Microbial biomass carbon (C_{mic}) was calculated from the maximum initial respiratory response in terms of mg C g^{-1} soil as 40.04 mg CO_2 g^{-1} + 3.75. Data are expressed as μg microbial C g^{-1} dry soil.

Soil basal respiration (BR). Soil basal respiration was measured by the method described by Anderson (1982); by alkali ($Ba(OH)_2.8H_2O$ + $BaCI_2$) absorption of the CO_2 developed during the incubation period (24 hours), followed by titrating the residual OH^- with a standardized hydrochloric acid. Data are expressed as μg CO_2 g^{-1} dry soil 24 h^{-1}.

Dehydrogenase activity (DHA). Dehydrogenase activity was determined using the classical TTC method /Trevors, 1984/. Field moist soil was weighted (5 g) into a glass tube and treated with 2,3,5-triphenyltetrazolium chloride (TTC). The tubes were purged with N_2 and sealed with a rubber plug. The tubes were mixed and incubated for 24 h at 30 C in the dark. After incubation the red triphenylformazan (TPF) formed by reduction of TTC was extracted and determined at 485 nm in a spectrophotometer. Data are expressed as μg TPF g^{-1} dry soil 24 h^{-1}.

Statistical analysis. The variance analysis (*Anova*) was mainly carried out using two factors (slope x aggregate size distribution). Least Significant Difference test (LSD) and correlation analysis were performed to determine the differences and association among variables using the Statistical Package for Social Science (SPSS 10.0) program. The asterisks, *, ** and *** indicate significance at $P < 0.05$, $P < 0.01$ and $P < 0.001$, respectively.

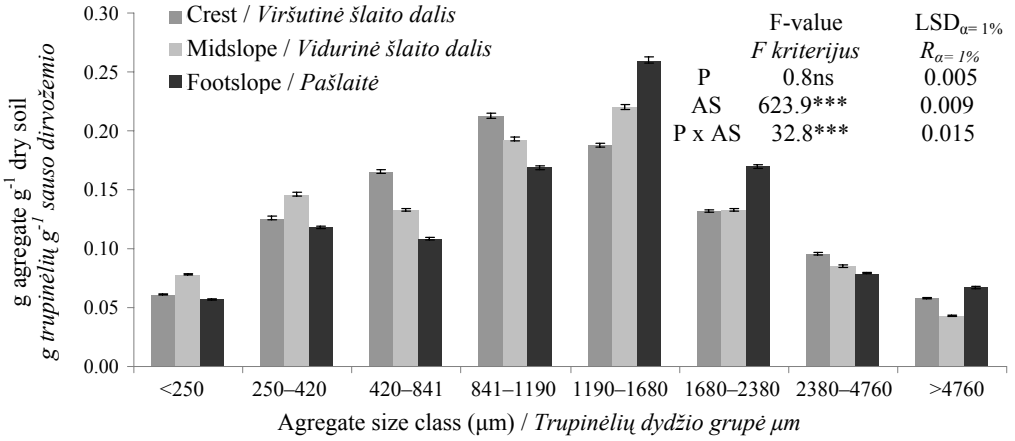
Results

Soil properties. The pasture soils were moderately low in total organic carbon content (C_{org}), low in electrical conductivity (<0.98 dS m^{-1}), non-saline, and neutral (pH 6.7–7.3). Soil texture was sandy loam and sandy clay loam. The soils had the lowest clay content at the crest position. In footslope positions, soils had generally higher clay

and silt contents than in other positions. Similarly, organic carbon content was the highest in footslope positions. Thus, clays and organic matter were probably eroded, which occurred at more severe rates on the crest and midslope positions (Table 1).

Table 1. Selected soil properties at selected landscape positions within a toposequence (n = 30 soil samples ± SE)
1 lentelė. *Dirvožemio granuliometrinė sudėtis kalvos dalyse (n = 30 dirvožemio bandinių ± SE)*

Soil property *Dirvožemio savybė*	Landscape position / *Kalvos dalis*		
	Crest *Viršūnė*	Midslope *Šlaito vidurys*	Footslope *Pašlaitė*
Sand (%) *Smėlis*	74.57 ± 1.64	77.54 ± 1.31	61.02 ± 1.72
Silt (%) *Dumblas*	11.42 ± 0.81	8.79 ± 0.97	15.06 ± 0.86
Clay (%) *Molis*	14.01 ± 0.59	13.67 ± 1.94	23.92 ± 1.47
Texture class *Granuliometrinė sudėtis*	Sandy Loam *Smėlingas lengvas priemolis*	Sandy Loam *Smėlingas lengvas priemolis*	Sandy Clay Loam *Smėlingas vidutinio sunkumo priemolis*
pH (H_2O)	6.83 ± 0.09	6.75 ± 0.06	6.90 ± 0.11
Organic carbon content (%) *Organinės anglies kiekis*	1.16 ± 0.04	1.25 ± 0.04	1.72 ± 0.07
Electrical conductivity (dS m^{-1}) *Elektrinis laidumas*	0.143 ± 0.004	0.138 ± 0.003	0.145 ± 0.006

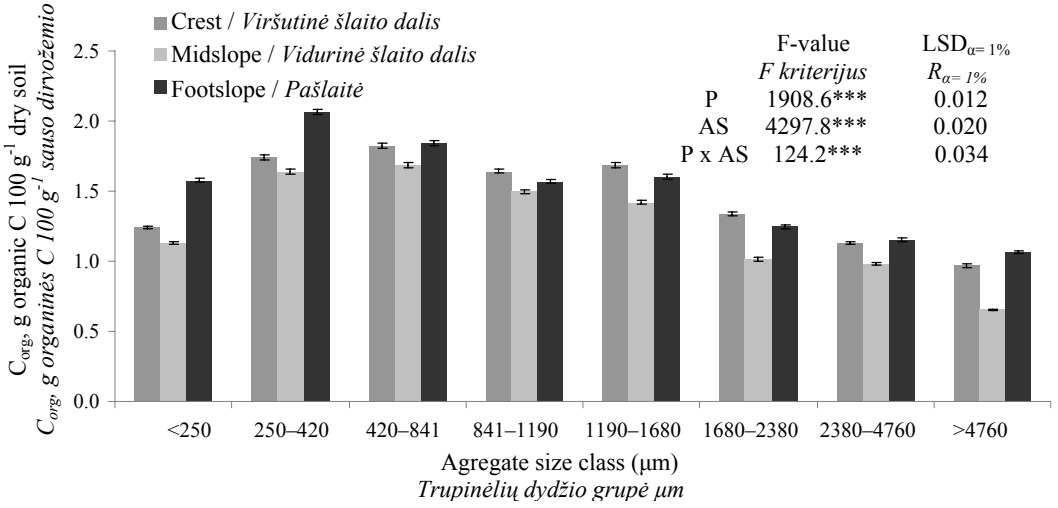


Note / *Pastaba*. P – landscape position / *kalvos dalis*, AS – aggregate size class / *trupinėlių dydžio grupė.*

Figure 2. Distribution of aggregates by landscape position. Vertical bars indicate standard error of mean of three replicates at 95% confidence level
2 paveikslas. *Dirvožemio trupinėlių pasiskirstymas skirtingose kalvos dalyse. Vertikalūs stulpeliai rodo trijų pakartojimų vidutinę standartinę paklaidą esant 95 % tikimybės lygiui*

Aggregate size distribution. Based on all positions, aggregate size was confined to two major classes 841–1190 and 1190–1680 μm which represent 41% in all size classes of the soil aggregates (Figure 2). The proportion of macroaggregates was highest at the footslope position (especially 1190–1680, 1680–2380 and > 4760 μm size classes) ($P < 0.01$). But the smallest aggregate sizes (< 250 and 250–420 μm) were highest in the crest position.

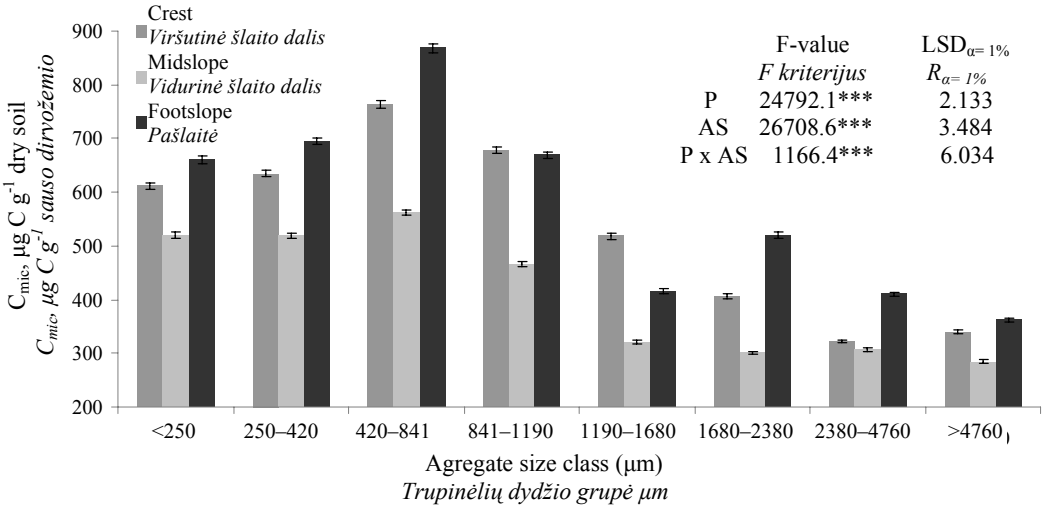
Organic carbon **(C_{org})** ***distribution.*** C_{org} content changed depending on aggregate sizes and landscape positions along the slope (Figure 3). In the midslope position, the organic carbon contents were less than the other positions ($P < 0.01$). In addition, the C_{org} contents decreased with slope (except the < 250 μm size class).



Note / *Pastaba.* P – landscape position / *kalvos dalis*, AS – aggregate size class / *trupinėlių dydžio grupė.*

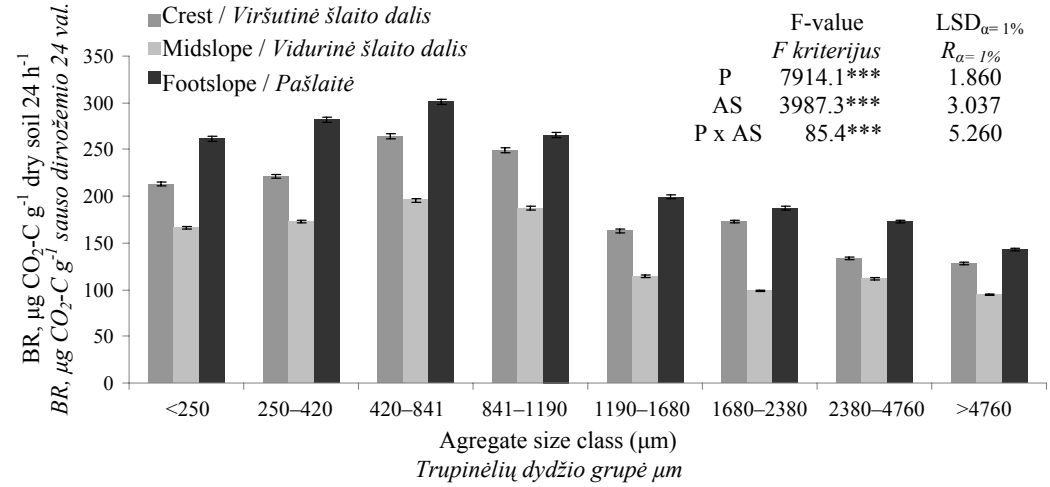
Figure 3. Organic carbon (C_{org}) distribution in soil aggregates by landscape position. Vertical bars indicate standard error of mean of three replicates at 95% confidence level
3 paveikslas. *Organinės anglies (C_{org}) kiekio pasiskirstymas skirtingose kavos dalyse. Vertikalūs stulpeliai rodo trijų pakartojimų vidutinę standartinę paklaidą esant 95 % tikimybės lygiui*

Microbiological properties. The microbiological properties are presented in Figures 4, 5 and 6 for each position and aggregate size class.



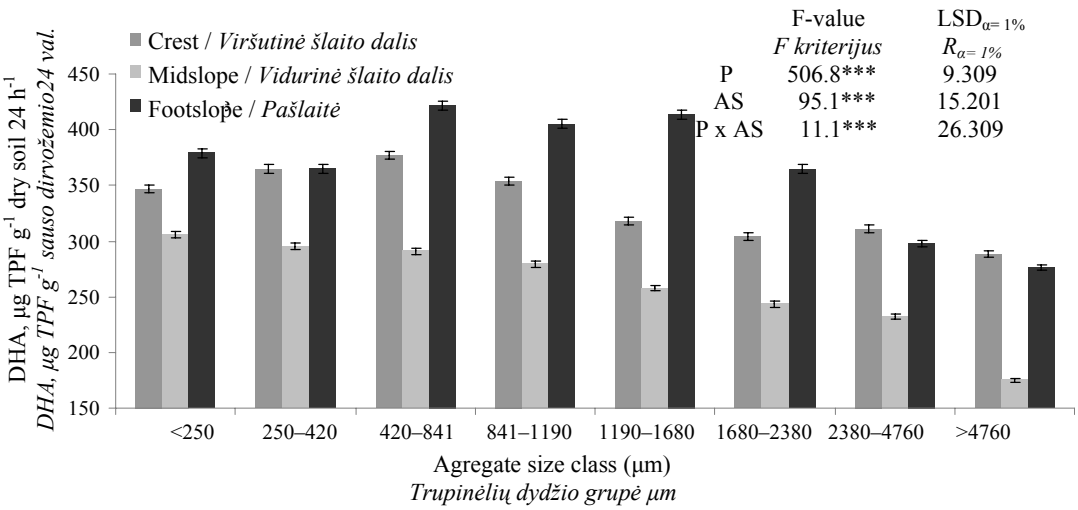
Note / *Pastaba*. P – landscape position / *kalvos dalis*, AS – aggregate size class / *trupinėlių dydžio grupė.*

Figure 4. Microbial biomass carbon (C_{mic}) in soil aggregates by landscape position. Vertical bars indicate standard error of mean of three replicates at 95% confidence level
4 paveikslas. *Dirvožemio trupinėliuose esančių mikroorganizmų biomasės anglis (C_{mic}) skirtingose kalvos dalyse. Vertikalūs stulpeliai rodo trijų pakartojimų vidutinę standartinę paklaidą esant 95 % tikimybės lygiui*



Note / *Pastaba*. P – landscape position / *kalvos dalis*, AS – aggregate size class / *trupinėlių dydžio grupė.*

Figure 5. Soil basal respiration (BR) in natural soil aggregates by landscape position. Vertical bars indicate standard error of mean of three replicates at 95% confidence level
5 paveikslas. *Dirvožemio bazinė respiracija (BR) natūraliuose dirvožemio trupinėliuose skirtingose kalvos dalyse. Vertikalūs stulpeliai rodo trijų pakartojimų vidutinę standartinę paklaidą esant 95 % tikimybės lygiui*



Note / *Pastaba*. P – landscape position / *kalvos dalis*, AS – aggregate size class / *trupinėlių dydžio grupė.*

Figure 6. Dehydrogenase activity (DHA) in soil aggregates by landscape position. Vertical bars indicate standard error of mean of three replicates at 95% confidence level
6 paveikslas. *Dehidrogenazės veikla (DHA) dirvožemio trupinėliuose skirtingose kalvos dalyse. Vertikalūs stulpeliai rodo trijų pakartojimų vidutinę standartinę paklaidą esant 95 % tikimybės lygiui*

Microbial biomass C **(C_{mic}).** In the crest position, C_{mic} ranged from 322.7–763.7 µg C g^{-1} dry soil in all size of aggregates (mean 543.6). In the midslope position, values ranged from 285.0–562.0 µg C g^{-1} dry soil in all size of aggregates (mean 416.8). In the footslope position, values ranged from 362.0–868.7 µg C g^{-1} dry soil in all size of aggregates (mean value 586.8) (Figure 4). On average, it was the lowest on midslope and highest on footslope positions ($P < 0.01$).

Soil basal respiration **(BR).** On all aggregate sizes, BR ranged from 127.7–264.0 µg CO_2-C g^{-1} dry soil (mean 194.5 µg CO_2-C g^{-1} dry soil) in the crest position, 95.7–196.0 CO_2-C g^{-1} dry soil (mean 142.3) in the midslope position, and 144.7–300.7 CO_2-C g^{-1} dry soil in the footslope position (Figure 5). The highest BR values were obtained from the footslope position, but the lowest values from midslope ($P < 0.01$). This is the same trend shown as C_{mic}.

Dehydrogenase activity **(DHA).** In all aggregate sizes, DHA was a mean of 331.3 µg TPF g^{-1} dry soil in the crest (range 288.0–377.0 µg TPF g^{-1} dry soil), 256.8 µg TPF g^{-1} dry soil in the backslope (range 175.0–306.0 µg TPF g^{-1} dry soil), and 364.5 µg TPF g^{-1} dry soil (range 276.3–422.0 µg TPF g^{-1} dry soil) in the footslope position (Figure 6). It was relatively higher in footslope positions ($P < 0.01$).

C_{mic}, BR and DHA relationships with aggregate size were similar at all positions. Generally, BR and C_{mic} concentrations were greater in microaggregates < 250 µm and in macroaggregates of 250–420, 420–841 and 841–1190 µm than in the other aggregate sizes (Figures 4, 5). However, DHA was lower in macroaggregates of 2380–4760 and > 4760 µm, than in other aggregates (Figure 6). C_{org}:C_{mic}, BR:C_{mic} and DHA:C_{mic} ratios

were calculated as the ratios of C_{org} and BR over C_{mic} (Table 3). C_{org}:C_{mic} ratio was 27.67 (range 20.50–34.83) in the crest, 30.65 (range 21.23–43.83) in the midslope, and 26.82 (range 21.37–37.70) in the footslope positions. Mean BR:C_{mic} ratio in the crest was 3.64 (range 3.10–4.19) and was 3.40 (range 3.16–3.91) in the midslope, was 3.96 (range 3.46–4.76) in the footslope position. DHA:C_{mic} ratio was 6.52 (range 4.93–9.58) in the crest, 6.39 (range 5.14–7.96) in the backslope, and 6.56 (range 4.86–9.65) in the footslope position. Based on means, BR:C_{mic} and DHA:C_{mic} ratio was higher on the footslope; whereas the C_{org}:C_{mic}, ratio was the higher on the midslope position ($P < 0.01$).

Table 2. C_{mic}:C_{org}, BR:C_{mic} and DHA:C_{mic} in soil aggregate sizes by landscape position (C = crest, M= midslope, F= Footslope)
2 lentelė. *C_{mic}:C_{org}, BR:C_{mic} ir DHA:C_{mic} dirvožemio trupinėliuose skirtingose kalvos dalyse (C = viršūnė, M= šlaito vidurys, F= pašlaitė)*

Aggregate size classes *Trupinėlių skersmuo* μm	C_{mic}:C_{org}			BR: C_{mic}			DHA: C_{mic}		
	C	M	F	C	M	F	C	M	F
< 250	4.89	4.71	4.28	3.53	3.16	3.93	5.64	5.74	5.59
250–420	3.71	3.22	3.46	3.44	3.30	3.98	5.59	5.50	5.08
420–841	4.17	3.33	4.68	3.46	3.49	3.46	4.93	5.14	4.86
841–1190	4.25	3.19	4.38	3.58	3.91	3.90	5.02	5.58	5.87
1190–1680	3.16	2.28	2.65	3.10	3.52	4.76	5.89	7.76	9.65
1680–2380	3.12	2.98	4.25	4.15	3.16	3.52	7.22	7.96	6.82
2380–4760	2.87	3.21	3.66	4.19	3.60	4.12	9.58	7.30	6.99
>4760	3.62	4.37	3.39	3.66	3.08	4.00	8.26	6.14	7.63
	F-value *Fišerio kriterijus*		LSD $_{\alpha=1\%}$ $R_{\alpha=1\%}$	F-value *Fišerio kriterijus*		LSD $_{\alpha=1\%}$ $R_{\alpha=1\%}$	F-value *Fišerio kriterijus*		LSD $_{\alpha=1\%}$ $R_{\alpha=1\%}$
Landscape position (P) *Kalvos dalis (P)*	776.952***		0.030	537.953***		0.046	3.684***		0.177
Aggregate size class (AS) *Trupinėlių skersmuo (AS)*	1998.672***		0.050	73.595***		0.075	257.840***		0.288
P x AS	489.747***		0.086	124.046***		0.130	60.039***		0.500

Note. Means are calculated based on C_{mic}:C_{org}, (BR: C_{mic}) x 10 and (DHA: C_{mic}) x 100.
Pastaba. Viduriai apskaičiuoti taip: C_{mic}:C_{org}, (BR: C_{mic}) x 10 ir (DHA: C_{mic}) x 100.

Correlation analysis. The C_{org} gave significant correlations with C_{mic}, BR, DHA and DHA:C_{mic}. The C_{mic} was significantly correlated with BR, DHA, C_{mic}:C_{org} and DHA:C_{mic}. The relationships between C_{mic} and C_{org} suggest that C_{org} and C_{mic} should be good indicator for monitoring soil fertility. Also the C_{mic}:C_{org} ratio is a more sensitive indicator than SOM dynamics and this ratio may also help explain soil aggregation (Table 3).

Table 3. Correlation matrix among the microbiological properties and C_{org} in aggregates ($n = 30$)

3 lentelė. *Mikrobiologinių savybių ir C_{org} koreliacija dirvožemio trupinėliuose*

	C_{org}	C_{mic}	BR	DHA	C_{mic}:C_{org}	BR:C_{mic}	DHA:C_{mic}
C_{org}	1						
C_{mic}	0.779 **	1					
BR	0.812 **	0.950 **	1				
DHA	0.699 **	0.785 **	0.859 **	1			
C_{mic}:C_{org}	0.007	−0.582 **	−0.483 **	−0.321 **	1		
BR:C_{mic}	0.118	−0.085	0.221	0.341 **	0.305 **	1	
DHA:C_{mic}	−0.525 **	−0.757 **	−0.606 **	−0.213	0.622 **	0.479 **	1

Discussion

At all landscape positions, macroaggregates (>250 μm) (especially two major classes 841–1190 μm and 1190–1680 μm) constituted more soil mass than microaggregates (< 250 μm) in pasture soils (Figure 2). Macroaggregates readily form under pasture or forage grasses (dense, fibrous root mass). Macroaggregates are more sensitive to changes in management than microaggregates and thus, are considered a better indicator for changes in soil quality. Macroaggregate stability depends on management, because of the transient nature of binding agents /Soil Quality Test Kit Guide, 1999/. Tisdall and Oades (1982) formulated an aggregate hierarchy theory, which explains a gradual break down of macroaggregates into microaggregates, preceding complete dissociation into primary particles. Another consequence of this principle is that younger and the more labile SOM is contained in macroaggregates than microaggregates.

Generally, C_{org} level increased with increasing aggregate size ($P < 0.01$), reaching a maximum in the > 250 μm size at all landscape positions (Figure 3). Similar observations have been reported by Tisdall and Oades (1982), suggesting the presence of partially decomposed roots and hyphae within macroaggregates increasing the C concentrations and contributing to aggregate formation. The high C_{org} content of the > 250 μm soil fraction can be explained by the local use of no-till. The relatively high C_{org} concentration in the >250μm fraction compared with the microaggregates suggests the presence of much fresh and partially decomposed organic matter /Elliott and Coleman, 1988/. In agreement with in this, Elliott (1986) found in a temperate grassland soil that organic matter associated with macroaggregates was more labile than organic matter in microaggregates. Similar results have been reported by Puget et al. (1999) and Oades et al. (1987). In the crest position, the organic carbon content of aggregates was the less than the other positions ($P < 0.01$). In addition, C_{org} contents of aggregates (except < 250 μm) decreased depending on slope. Walker et al. (1968) reported that midslope soils were most affected by erosion and footslope had higher clay and organic matter contents. Because of the low soluble salt contents (EC) and the absence of free carbonates, it was assumed that free $CaCO_3$ content and EC might be affect of cloud the C_{org} content of aggregates. Generally, C_{mic}, BR and DHA concentrations were greater in microaggregates. In addition, it is possible to state that all microbiological properties had higher values in all aggregates at footslopes compared with other landscape positions

(Figure 4, 5 and 6). The soil organic C contents significantly correlateds with C_{mic}, BR and DHA at $P < 0.01$. Similarly, other studies /De Luca and Keeney, 1993/ showed organic C content significantly correlated C_{mic}.

The C_{mic}:C_{org} ratio reflect the physiological level of a soil ecosystem and appears to be a much more sensitive indicator for soil quality than either C_{org} or C_{mic} alone /Wu and Brookes, 1988/. The total C_{org} percent presented as C_{mic} in a soil over long-term treatment was thought to represent C equilibrium in oil /Anderson and Domsch, 1989/. Insam et al. (1989) proposed the relations between C_{mic} and C_{org} in soil might serve as a quantitative indicator for carbon dynamics. At all positions, the C_{mic} percentage of total C_{org} in macroaggregates was relatively consistent, suggesting near C equilibrium status and aggregation. However, a consistent trend was not found among macroaggregates, suggesting that aggregation may be affected by microbial biomass. Except for large macroaggregate (>4760 μm), the percentage of total C_{org} presented as C_{mic} increased with increasing aggregate size at the crest position. On the contrary, the higher C_{mic}:C_{org} ratios were in the 190–1680 μm size class than the other macroaggregates at the crest and footslope positions (Table 3). This situation may be arisen by water erosion and differences of organic carbon deposition in the footslope position. Footslope position influences water movement and the nature and extent of erosion or deposition. Although no universal equilibrium constant was found after surveying 129 permanent monoculture plots, Anderson and Domsch (1989) showed that the average percentage of C_{mic} in C_{org} was ~ 2.3% in 34 soils under long-term continuous monoculture with inorganic fertiliser treatment and 2.57% in 15 soils with straw or farmyard manure treatments. The percentages obtained from this study were generally higher than reported by Anderson and Domsch (1989).

DHA has been used to assess microbial activity, although some authors have criticized this. Benefield et al. (1977) indicated that DHA is not on accurate parameter for determining the electron flow rate to O_2, because electron acceptors used in DHA assays are less efficient than O_2. However, Garcia et al. (1997) found that DHA is a good index of the status of soil microbial activity. Soil enzymes involved in the DHA assay are mainly intracellular, so that correlation between DHA and oxygen uptake or CO_2 release (BR) by bacterial population is expected. BR is a useful index for measuring soil microbial activity /Wardle and Ghani, 1995/ and relates both the size and activity of soil microbial populations /Anderson and Domsch, 1993/. In fact, DHA and BR have been widely used to measure catabolic activities in soil, which are correlated with microbial activity /Skujins, 1973; von Mersi and Schinner, 1991/. BR is the higher in the size classes > 1190 μm for all three positions, with the crest having the lowest values and footslope was the highest. DHA are highest in the lower size classes (< 250 to 420–841 μm) in the crest and midslope positions, while the highest are in the middle classes (420–841 to 1190–1680 μm in footslope positions). The BR:C_{mic} and DHA:C_{mic} ratios reflect the physiologically active soil microbial biomass and oxidation SOC. Many substances on aggregates and some products of microorganisms are later destroyed by other microorganisms low in C_{org} content in soils. If these ratios decrease, soil aggregation may increase. In all positions, BR:C_{mic} and DHA:C_{mic} ratios were the highest in macroaggregates (1190–1680, 1680–2380, 2380–4760 μm) (Table 2). For the footslope position, C_{mic}:C_{org}, BR:C_{mic} and DHA:C_{mic} ratios showed similar trends in all aggregate

sizes. In the crest position, BR:C_{mic} and DHA:C_{mic} ratios were highest in aggregate sizes of 2380–4760 μm. These differences may be based on erosion and SOC deposition at footslopes.

Significant relationships among the microbiological properties were found (Table 3) and exist between the microbiological properties and C_{mic}:C_{org} , BR:C_{mic}, DHA:C_{mic} ratios. It was likely that C_{mic}, DHA and BR increased depending on the C_{org} derived from plant residues, as reported by Tisdall (1991), Franzluebber and Arshad (1997) and Chantigny et al. (1997). Franzluebber and Arshad (1997) assumed that positive relationships among soil microbiological properties were due to the fact that the level of C_{mic} and BR associated with C_{org} content in the water-stable aggregates. In this study, the ratios of C_{mic}:C_{org} and DHA:C_{mic} decreased, depending on increasing C_{mic}, However, C_{mic} contents of aggregates increased C_{org} content. Consequently, in macro-aggregates (especially the three major classes of 1190–1680, 1680–2380 and 2380–4760 μm) there was relatively more C_{org} than in the microaggregates, even if the absolute values of C_{mic}, BR and DHA resembled microaggregates. A large component of this may come from the roots of plants.

Conclusions

Results indicated that the aggregate size distribution and microbiological properties of aggregates along a hillslope varied considerably on a pasture soil in Turkey. Footslope positions have greater clay and C_{org} compared with other landscape positions, because the higher concentrations in fine particles and C_{org} content clearly imply erosional deposition at the footslope and denudation at the slope crest. The larger coarse particle composition in midslope positions denote increasing the intense selective fine particles compared with the other positions. In general, soils from crest to footslope positions become deeper.

Soil aggregates, macroaggregates (especially two major classes 841–1190 μm and 1190–1680 μm size class) were higher than microaggregates in all landscape positions. Generally the mid-sized macroaggregates had enhanced microbiological properties and C_{org} contents. Especially three major classes: 1190–1680, 1680–2380 and 2380–4760 μm, consumed relatively the lower C_{org} than microaggregates. The main effects of the macroaggregates on the microbiological properties may be arisen by the accumulation or decomposition of organic matter and erosion and deposition. C_{org} strongly correlated with C_{mic}, BR, DHA and DHA:C_{mic} ratios, suggesting that the number and activity of soil micro-organisms mainly depend on mineralizable substrates.

Our results demonstrated that changes of aggregate size distribution can alter the soil microbiological status and soil organic carbon content within aggregates. Soil microbiological properties responded to landscape position and aggregate sizes.

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DIRVOŽEMIO TRUPINĖLIŲ BAZINĖ RESPIRACIJA IR DEHIDROGENAZĖS VEIKLA KALVOTO RELJEFO GANYKLOJE

T. Aşkin, R. Kizilkaya

S a n t r a u k a

Šio tyrimo tikslas buvo nustatyti dirvožemio bazinės respiracijos pokyčius (BR) ir trupinėlių dehirogenazės aktyvumą (DHA) ganyklos skirtingose kalvos elementuose. Ganykla įrengta Samsune, Turkijoje. Dirvožemio ėminiai buvo paimti iš 0–50 mm gylio trijose kalvos elementuose – viršūnė, vidurys bei pašlaitė. Taikant sijojimo metodą, kalvos elementų dirvožemio trupinėliai buvo suskirstyti į 8 dydžių grupes. Juose buvo nustatomos mikrobiologinės dirvožemio savybės ir organinės anglies kiekis (C_{org}). Iš visų kalvos elementų vietų paimtuose bandiniuose dirvožemio makroagregatų kiekiai (ypač 841–1190 μm ir 1190–1680 μm skersmens) buvo didesni negu mikroagregatų. C_{org} kiekiai svyravo tarp 0,65 ir 2,08 %. Didžiausias C_{org} kiekis buvo rastas pašlaitės dirvožemyje, o mažiausias – vidurinėje šlaito dalyje. Visos mikrobiologinės savybės buvo ryškesnės pašlaitėje negu kitose kalvos dalyse. BR ir DHA buvo didesni mikroagregatuose (< 250 μm), makroagregatuose (250–420, 420–841, 841–1190 μm) negu kitose trupinėlių dydžio klasėse visose kalvos elementuose, o štai C_{org}:C_{mic}, BR:C_{mic} ir DHA:C_{mic} santykiai buvo didesni makroagregatuose (1190–1680, 1680–2380, 2380–4760 μm) negu kitų dydžių makro- ir mikroagregatuose. Todėl makroagregatai turėjo santykinai daugiau C_{org} negu mikroagregatai, nors ir absoliučios BR ir DHA vertės buvo mažesnės.

Reikšminiai žodžiai: ganykla, dirvožemio trupinėliai, mikroorganizmų biomasės anglis, dirvožemio bazinė respiracija, organinė anglis, kalvos dalys.