# Soil organic matter and stability of soil aggregates

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# Material and methods

- ***Soil texture*** - pipet method
- ***Hydrophysical properties:*** bulk density (ρd=BD), porosity (P), air capacity (VA)
- „**packing density**“ PD = BD + (0.009 x CC)
- *Soil reaction - pH*
- $CaCO_3$ content
- ***Parameters of soil sorption complex*** – hydrolytic acidity (H), sum of exchangeable cations (S), sorption capacity (T=H+S) and base of saturation (V= S.100/T)
- ***Organic carbon content*** *($C_{OX}$)* – by Tyurin method
- ***labile organic carbon content*** *($C_L$)* (Loginov et al., 1993)
- ***Hot water soluble carbon*** *($C_{hws}$)* (Körschens et al., 1990)
- calculation - lability of carbon (L) (Blair et al., 1995)
  - carbon pool index (CPI)
  - lability index of carbon (LI)
  - carbon management index (CMI)
- **Soil structure** by dry siewing (fractions : **>7**, **5-7**, **3-5**, **1-3**, **0.5-1**, **0.25-0.5**, **<0.25 mm**)

- fractions (>5 , 3–5 , 2–3 , 1–2 , 0.5–1 , 0.25–0.5 , <0.25 mm) waterstabile macroaggregates (WSA) – Bakshajev´s method (Hraško et al., 1962)
- Coefficient of structure ability (K) (Revut, 1964)
- Mean weight diameter of macroaggregates – dry siewing method - (MWDd)
- Mean weight diameter of macroaggregates – wet siewing method - (MWDw)
- Coefficient of vulnerability (Kv) macroagregates
- Indice of structural stability Sw (Henin et al., 1969)
- Stability of waterstabile aggregates ($S_{WSA}$) modificated method Kemper and Rosenau (1986)
- SAS method of stability WSA (Kemper a Rosenau, 1986)
- USAS method of stability WSA (Mayer et al., 2002; Mentler et al., 2004)
- Contents C and N in aggregates (Baccanti, Colombo, 1988) by Carlo Erba NA 1500
- Determination of dimetylsulfoxid reduction (DMSO) (Alef, Kleiner, 1989)
- Determination of biomass production by substrate inducated respiration (SIR) (Anderson, Domsch, 1978).



# Vígľaš – Fertilization and soil properties

Soil samples from 50 years trial

## 1.Control (021)

## 2.Applicated FYM (011)

## 3.Fertilized by NPK (016)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $N_1$ **022** | $N_3$ **024** | $N_2K$ **026** | d | $N_2PK$ **014** | PK **012** | $N_4PK$ **016** |
| | **021 kontrol a** | $N_2$ **023** | $N_2P$ **025** | | $N_1PK$ **013** | FYM **011** | $N_3PK$ **015** |
| | $N_4PK$ **016** | PK **012** | $N_2PK$ **014** | c | $N_1$ **022** | $N_2K$ **026** | $N_3$ **024** |
| | $N_3PK$ **015** | FYM **011** | $N_1PK$ **013** | | **021 kontrol a** | $N_2P$ **025** | $N_2$ **023** |
| | $N_3$ **024** | $N_2K$ **026** | $N_1$ **022** | b | $N_4PK$ **016** | $N_2PK$ **014** | PK **012** |
| | $N_2$ **023** | $N_2P$ **025** | **021 kontrol a** | | $N_3PK$ **015** | $N_1PK$ **013** | FYM **011** |
| | PK **012** | $N_2PK$ **014** | $N_4PK$ **016** | | $N_2K$ **026** | $N_3$ **024** | $N_1$ **022** |
| | FYM **011** | $N_1PK$ **013** | $N_3PK$ **015** | a | $N_2P$ **025** | $N_2$ **023** | **021 kontrol a** |

particles <0.01mm


***Year 2006 „a“***

Control = 37.0 %

FYM = 38.5 %

NPK = 26.5 %

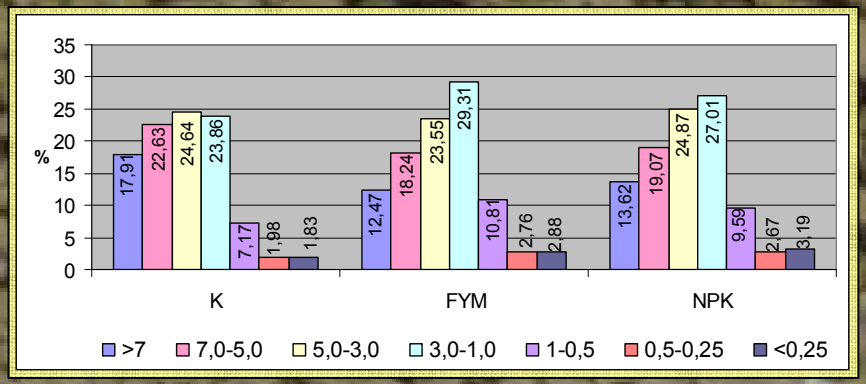
***Year 2007 „d“***

Control = 40.2 %

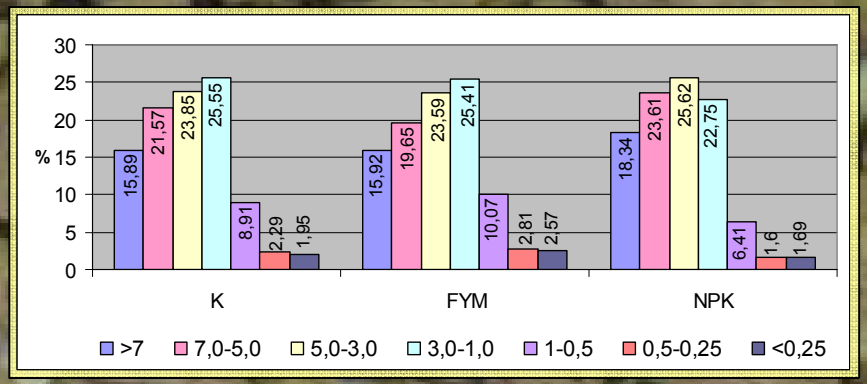
FYM = 38.9 %

NPK = 39.6 %

# Soil structure




Soil aggregates Vígľaš 2006 repetition „a“

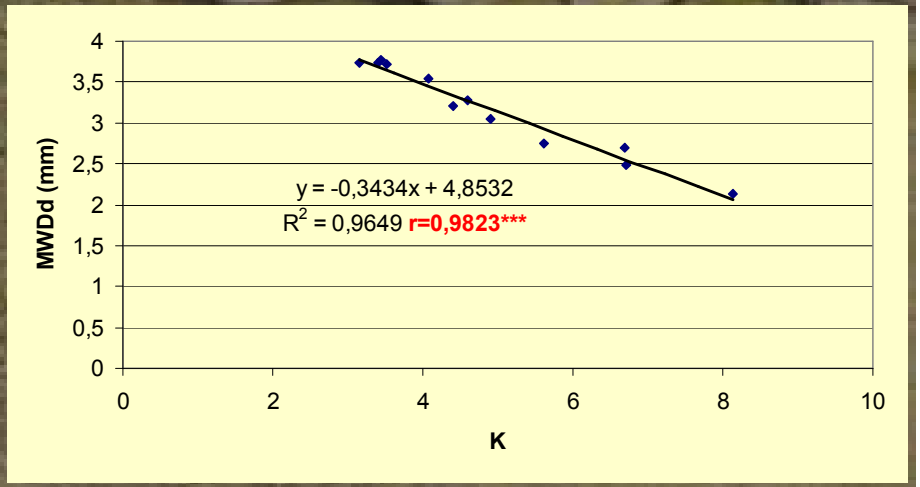



Soil aggregates Vígľaš 2007 repetition „d“

Values of Revut coefficient of structural stability (K)

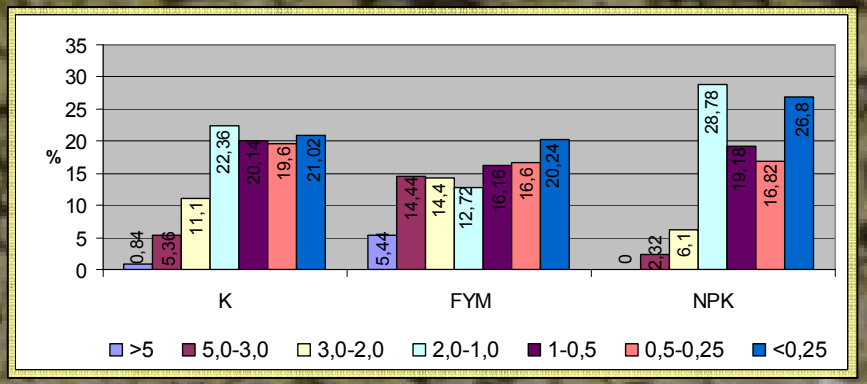
| variant | depth (m) | K („a“2006) | K („d“2007) |
|---|---|---|---|
| control | 0-0.15 | 4.90 | 6.70 |
| | 0.15-0.3 | 3.44 | 3.41 |
| FYM | 0-0.15 | 8.13 | 6.71 |
| | 0.15-0.3 | 4.07 | 3.16 |
| NPK | 0-0.15 | 5.62 | 4.59 |
| | 0.15-0.3 | 4.40 | 3.52 |

**K-value (Revut) were higher significant to depth of soil samples (P<0.0024**).**

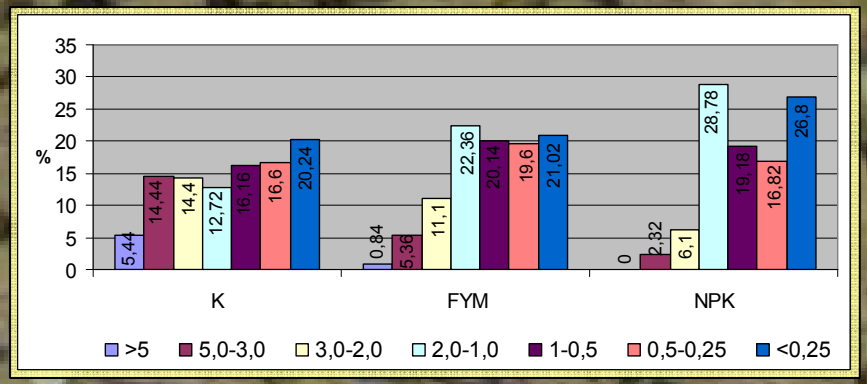



Linear correlation between K-values and MWDd

# Waterstabile aggregates - WSA




WSA Vígľaš 2006 repetition „a“



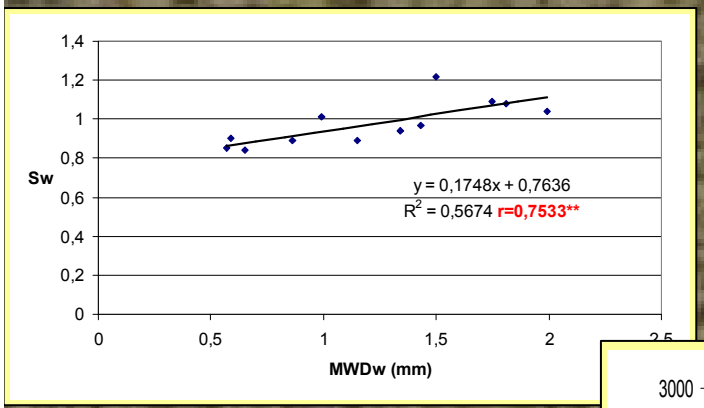

WSA Vígľaš 2007 repetition „d“

## Parameters of soil structure

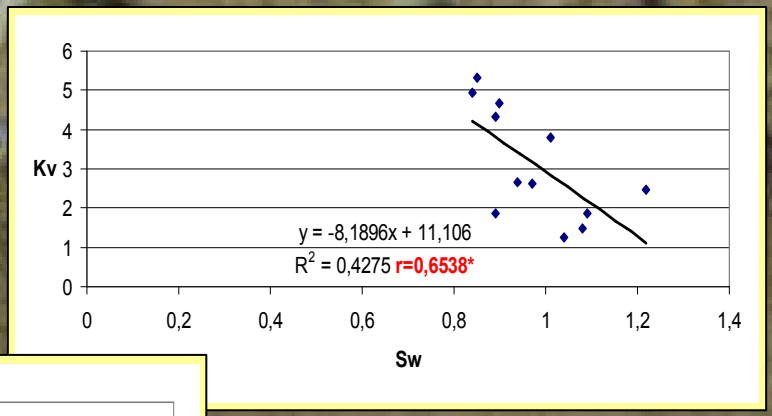
| variant | depth (m) | %WSA („a“2006) | %WSA („d“2007) | Sw („a“2006) | Sw („d“2007) | Kv („a“2006) | Kv („d“2007) |
|---|---|---|---|---|---|---|---|
| control | 0-0.15 | 72.2 | 89.4 | 0.85 | 1.08 | 5.33 | 1.49 |
| | 0.15-0.3 | 85.8 | 78.5 | 1.01 | 0.89 | 3.81 | 4.34 |
| FYM | 0-0.15 | 77.6 | 88.2 | 0.89 | 1.04 | 1.86 | 1.25 |
| | 0.15-0.3 | 81.9 | 79.4 | 0.94 | 0.97 | 2.65 | 2.62 |
| NPK | 0-0.15 | **75.8** | **89.4** | **0.90** | **1.09** | **4.66** | **1.87** |
| | 0.15-0.3 | **70.6** | **83.6** | **0.84** | **1.22** | **4.94** | **2.47** |

## Interrelation between parameters of soil structure and SOC

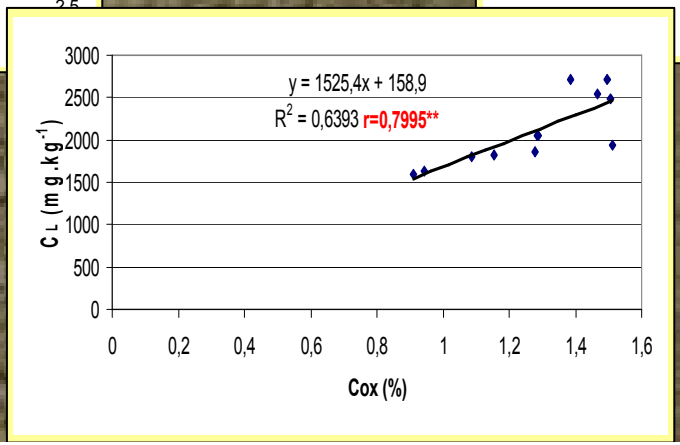
| | K | MWDd | MWDw | Sw | Kv | TOC | $C_L$ | $C_{hw}d$ |
|---|---|---|---|---|---|---|---|---|
| K | 1.0 | -0.982 | 0.222 | -0.107 | -0.417 | 0.250 | -0.045 | 0.078 |
| MWDd | *** | 1.0 | -0.124 | 0.196 | 0.300 | -0.266 | -0.044 | -0.201 |
| MWDw | | | 1.0 | 0.753 | -0.941 | 0.245 | -0.053 | -0.388 |
| Sw | | | ** | 1.0 | -0.654 | 0.197 | 0.159 | -0.428 |
| Kv | | | | * | 1.0 | -0.365 | 0.067 | 0.398 |
| TOC | | | | | | 1.0 | 0.800 | 0.265 |
| $C_L$ | | | | | | ** | 1.0 | 0.470 |
| $C_{hwd}$ | | | | | | | | 1.0 |




Linear correlation between Sw and MWDw




Linear correlation between Sw a Kv




Linear correlation - Cox and $C_L$

# Locality Borovce – the influence of crop rotations and monocultural growing cereals on soil structure

- S1 – **winter wheat** (WW) – **control**
- S2 – **winter wheat** with **application straw**
- S3 – **winter wheat** with **application straw and org. fertilizer Veget**
- S11 – **crop rotation** with 40 % WW and fertilizing on level H1
- S12 – crop rotation with 40 % WW and fertilizing on level H2- org.+min. fert.
- S13 – **crop rotation** with 60 % spring barley (SB) and fertilizing on level H1
- S14 – crop rotation with 60 % spring barley (SB) and fertilizing on level H2 - org.+min. fert.
- S15 – **crop rotation** with 80 % WW and fertilizing on level H1
- S16 – crop rotation with 80 % WW and fertilizing on level H2- org.+min. fert.

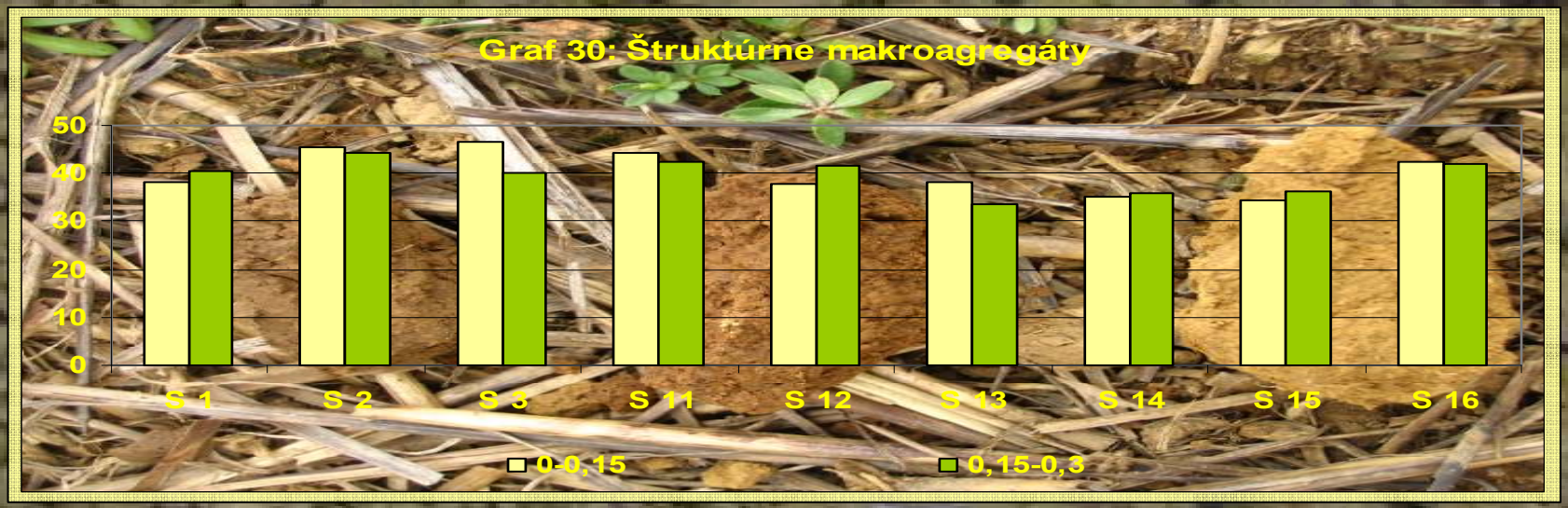
-Loamy soil,

Textural differences between variants has been inconsiderable

Contents of silt fraction have been high..

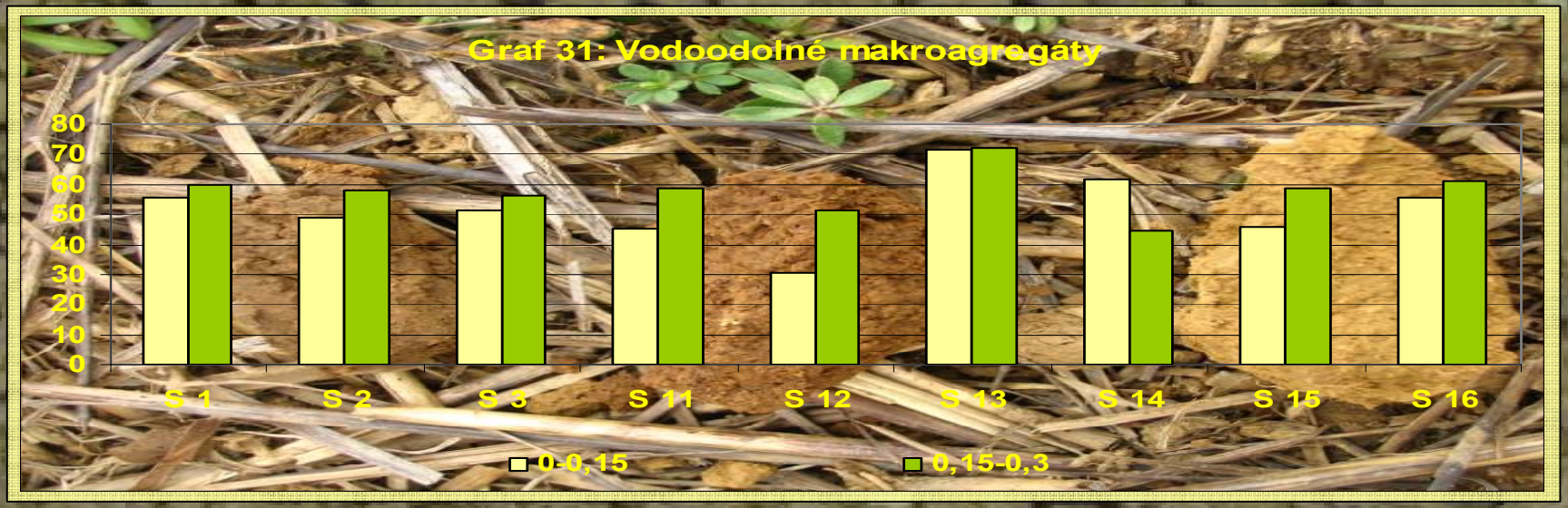
# Aggregate contents – Borovce

## Borovce 2007 - dry sieving aggregates contents in variants and layers

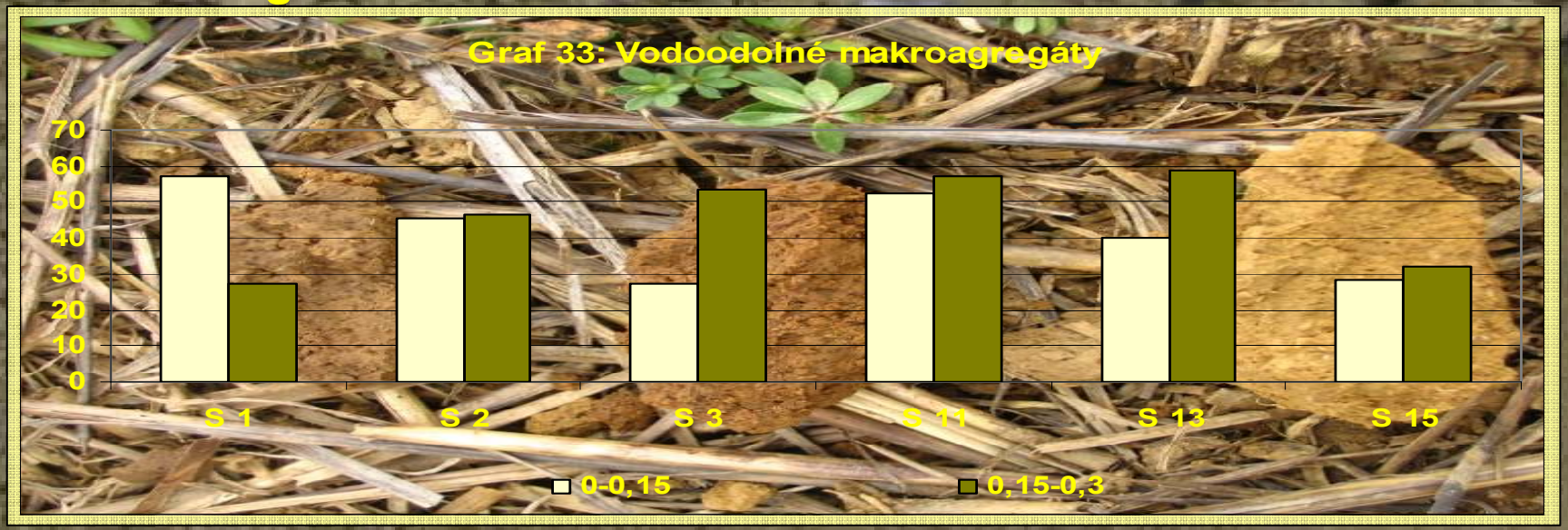



## Borovce 2008 -

# Wet sieving – 2007 – contents of WSA in variants and layers




# Wet sieving – 2008



# Parameters of soil structure - quality

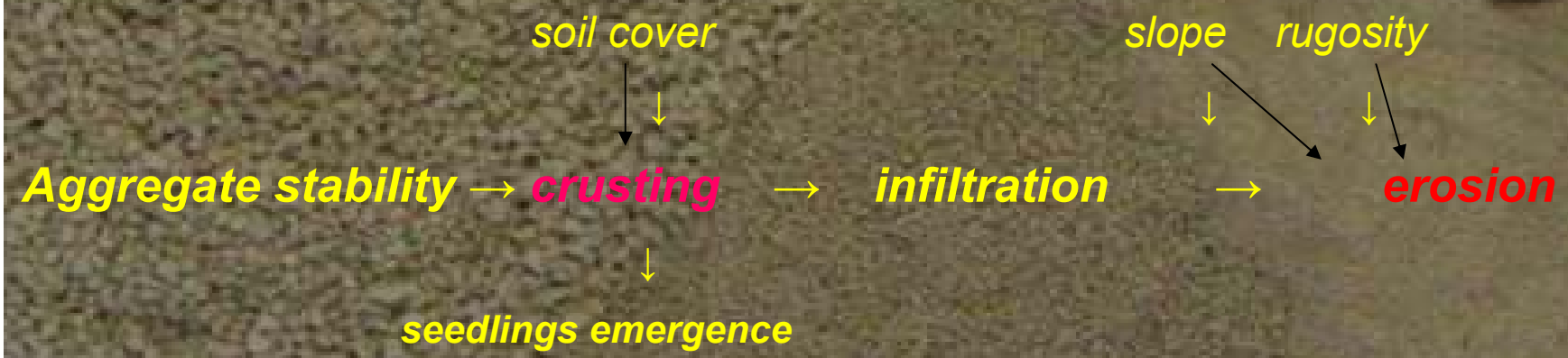
| Parameters 2007 | minimum | maximum | mean | std. deviation |
|---|---|---|---|---|
| %WSA>0.25mm | 51.8 | 86.2 | 75.0 | ± 9.38 |
| MWDd | 2.08 | 3.34 | 2.75 | ± 0.34 |
| MWDw | 0.27 | 1.31 | 0.75 | ± 0.33 |
| Kv | 1.59 | 10.44 | 4.64 | ± 2.68 |
| Sw | 0.69 | 1.26 | 1.01 | ± 0.14 |
| K | 3.47 | 6.82 | 4.96 | ± 0.91 |

| Parameters 2008 | minimum | maximum | mean | std. deviation |
|---|---|---|---|---|
| %WSA>0.25mm | 47.6 | 76.7 | 68.1 | ± 9.42 |
| MWDd | 2.42 | 3.78 | 3.19 | ± 0.42 |
| MWDw | 0.25 | 0.73 | 0.48 | ± 0.13 |
| Kv | 4.38 | 12.8 | 7.23 | ± 2.45 |
| Sw | 0.60 | 1.20 | 0.93 | ± 0.15 |
| K | 3.21 | 10.0 | 4.65 | ± 2.12 |

# From property to others and to function

| MWD (mm) | Aggregate stability | Crust formation | Risk of erosion |
|---|---|---|---|
| < 0.4 | Very unstable | always | Important, any topography |
| 0.4 – 0.8 | unstable | frequent | Frequent |
| 0.8 – 1.3 | Medium stability | moderate | Variable, depends on topography and climate |
| 1.3 - 2 | stable | rare | Limited |
| > 2 | Very stable | never | Very small |

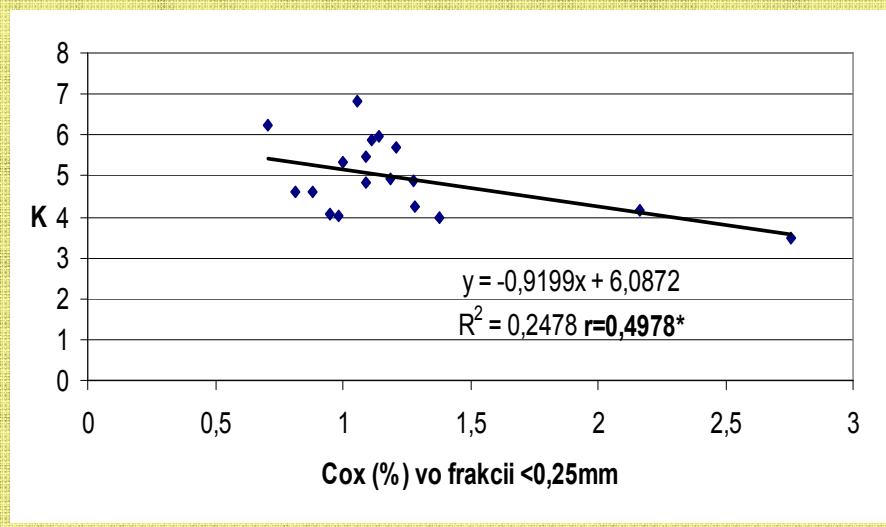
Le Bissonnais and Le Souder, 1995



# Influence SOM on aggregate stability

Between parameters of soil structure and TOC in macroaggregates were not confirmed statistically linear regression conections

Linear regression connecion was determined between contents TOC in microaggregates (<0,25 mm) and coefficients od soil strukture (K).




Linear dependence between TOC and K

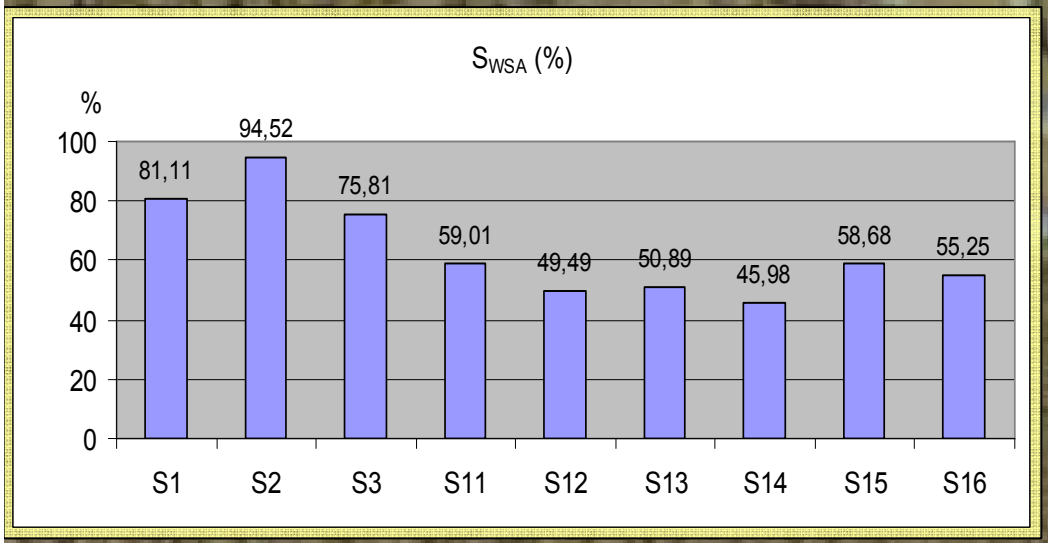
# Content of TOC (%) in fractions of soil aggregates

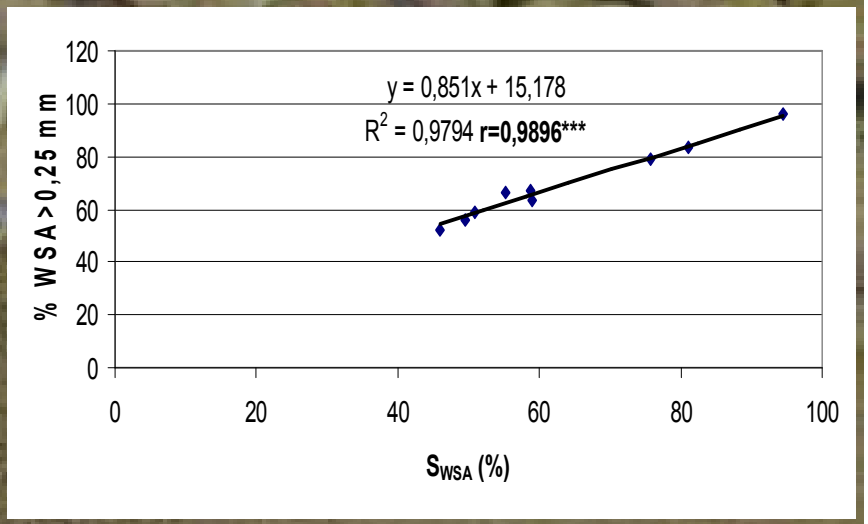
| variant | Depth | >7mm | 7-5 | 5-3 | 3-1 | 1-0,5 | 0,5-0,25 | <0,25 |
|---|---|---|---|---|---|---|---|---|
| monoculture | 0-0.15 | 1.08 | 1.06 | 1.04 | 1.01 | 1.07 | **1.17** | 1.10 |
| S 1, 2, 3 | 0.15-0.3 | 1.11 | 0.90 | 1.02 | 1.01 | 1.05 | **1.16** | 1.19 |
| Level H1 | 0-0.15 | 0.97 | 1.02 | 0.97 | 0.94 | 1.03 | **1.12** | 1.16 |
| S 11, 13, 15 | 0.15-0.3 | 0.96 | 0.95 | 0.96 | 0.98 | 1.00 | **1.13** | 1.12 |
| Level H2 | 0-0.15 | 0.97 | 1.08 | 1.08 | 1.01 | 1.13 | **1.25** | 1.51 |
| S 12, 14, 16 | 0.15-0.3 | 1.07 | 0.96 | 1.04 | 0.94 | 0.98 | **1.10** | 1.29 |

# Stability of soil aggegates

Modificated method by Kemper a Rosenau (1986) (**Swsa**)

| metóda | S1 | S2 | S3 | S11 | S12 | S13 | S14 | S15 | S16 |
|---|---|---|---|---|---|---|---|---|---|
| Swsa | 81.1 | 94.5 | 75.8 | 59.0 | 49.5 | 50.9 | 46.0 | 58.7 | 55.3 |
| WSA | 79.8 | 77.6 | 75.9 | 79.6 | 51.8 | 82.4 | 82.8 | 59.5 | 76.6 |



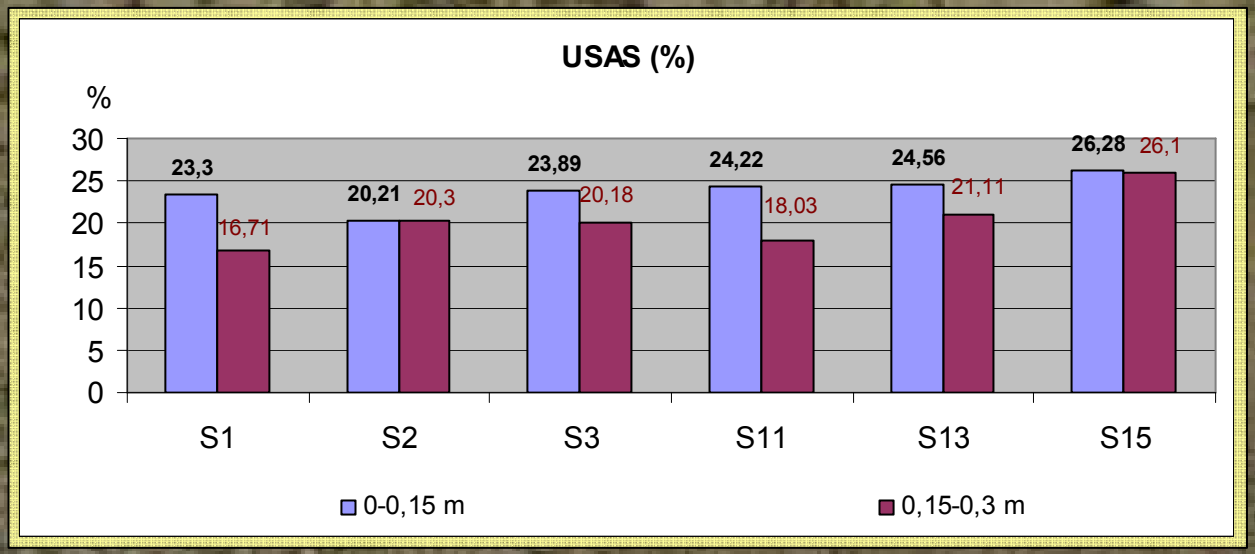




monoculture = 83.8±9.6 %

Fertilizing rate H1 = 56.2±4.6 %

Fertilizing rate H2 = 50.2±4.7 %

# Ultrasonic method - USAS




**Stability of soil aggregates, measured by USAS method and evaluated by analyse of variation, was significantly dependent to farming systems (P>0.0258) and high dependent to soil depth (P>0.0015).**

Stability of macroaggregates - USAS method

Contents of C a N determined by Carlo Erba NA 1500

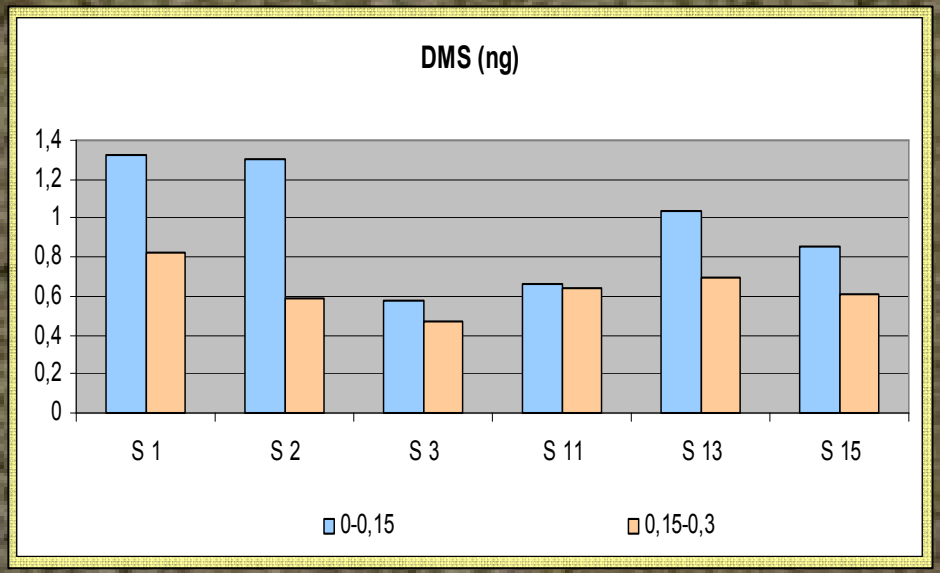
| variant | hĺbka | C | | N | | C:N | |
|---|---|---|---|---|---|---|---|
| | | 630-250µm | 250-63µm | 630-250µm | 250-63µm | 630-250µm | 250-63µm |
| S 1 | 0-0.15 | 2.19 | 1.07 | 0.15 | 0.10 | 14.6 | 10.7 |
| | 0.15-0.3 | 3.29 | 1.08 | 0.16 | 0.10 | 20.6 | 10.8 |
| S 2 | 0-0.15 | 2.00 | 1.06 | 0.14 | 0.09 | 14.3 | 11.8 |
| | 0.15-0.3 | 2.08 | 0.90 | 0.15 | 0.07 | 13.9 | 12.9 |
| S 3 | 0-0.15 | 1.68 | 0.98 | 0.14 | 0.10 | 12.0 | 9.8 |
| | 0.15-0.3 | 2.25 | 0.91 | 0.15 | 0.08 | 15.0 | 11.4 |
| S 11 | 0-0.15 | 2.12 | 1.15 | 0.16 | 0.12 | 13.3 | 9.6 |
| | 0.15-0.3 | 1.85 | 1.35 | 0.16 | 0.12 | 11.6 | 11.3 |
| S 13 | 0-0.15 | 1,94 | 1.25 | 0.16 | 0.12 | 12.1 | 10.4 |
| | 0.15-0.3 | 2.66 | 1.39 | 0.20 | 0.12 | 13.3 | 11.6 |
| S 15 | 0-0.15 | 2.06 | 1.02 | 0.20 | 0.08 | 10.3 | 12.8 |
| | 0.15-0.3 | 2.07 | 1.29 | 0.14 | 0.14 | 14.8 | 9.2 |

# BIOLOGICAL ACTIVITY OF SOIL

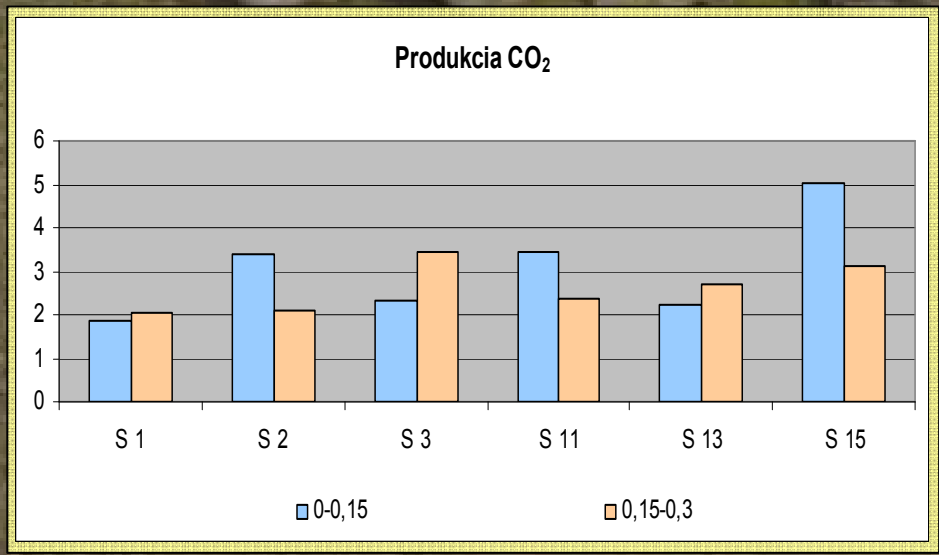
Results of DMS a SIR methods

| Met. | DEPTH | S1 | S2 | S3 | S11 | S13 | S15 |
|---|---|---|---|---|---|---|---|
| DMS | 0-0.15 | 1.32 | 1.31 | 0.58 | 0.66 | 1.04 | 0.86 |
| | 0.15-0.3 | 0.83 | 0.58 | 0.47 | 0.64 | 0.70 | 0.61 |
| SIR | 0-0.15 | 1.87 | 3.39 | 2.35 | 3.44 | 2.25 | 5.04 |
| | 0.15-0.3 | 2.02 | 2.12 | 3.43 | 2.37 | 2.69 | 3.10 |


**dimetylsulfoxid (DMSO) reduction value**




**Biomass production by substrate inducated respiration (SIR)**



# Locality Báb – Land use – forest and arable soil

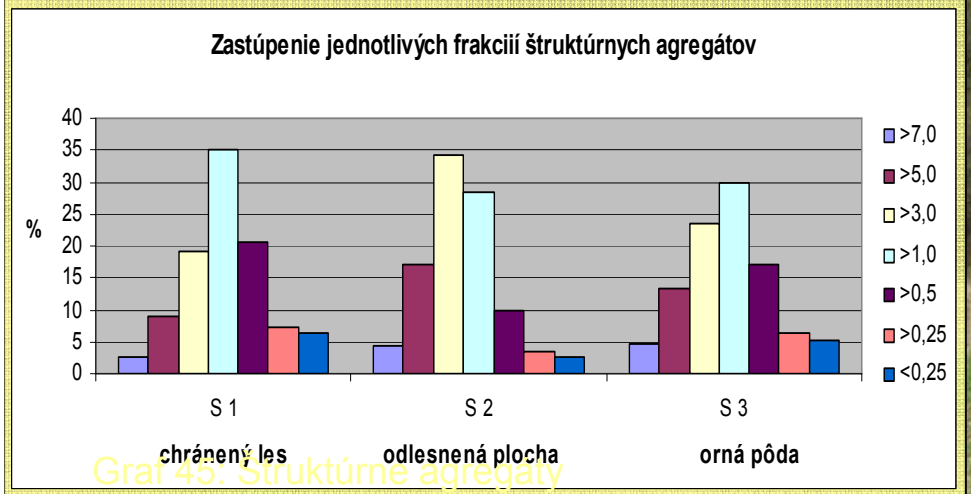
Soil samples:

1. Natural forest – S1
2. Deforested area – S2
3. **arable soil** (winter wheat) – S3

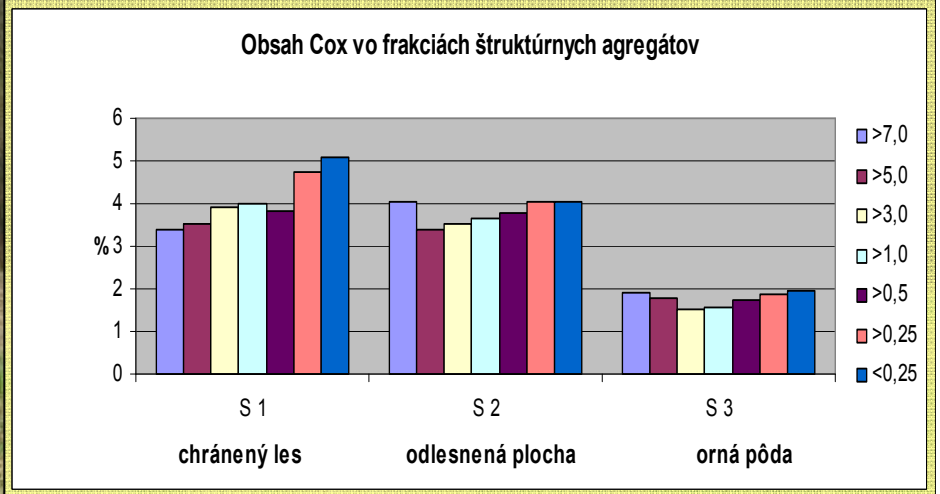
***Soil texture is loamy, with content of particles <0.01 mm :***

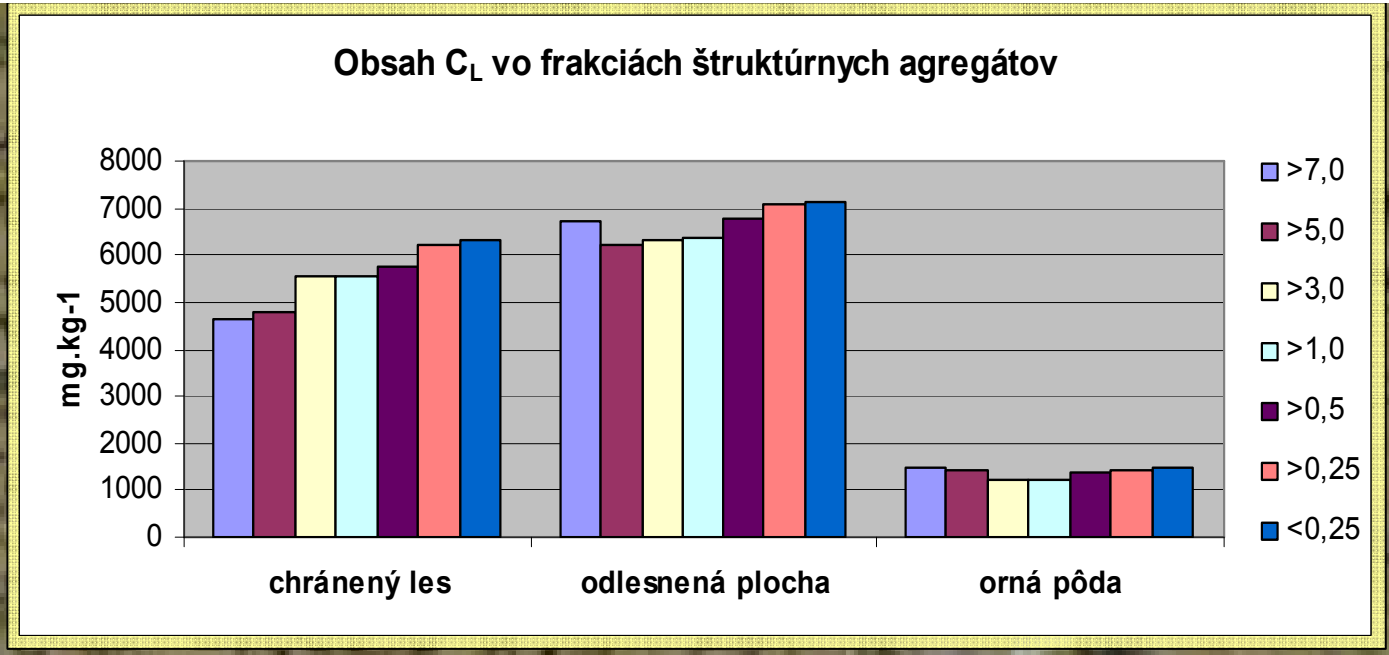
***natural forest (38.4%) > deforested area (37.7%) > arable soil (34.8%).***

***We obtained high significant dependence between contents of particles <0,01 mm and MWDw and also by values of coefficient vulnerability Kv***

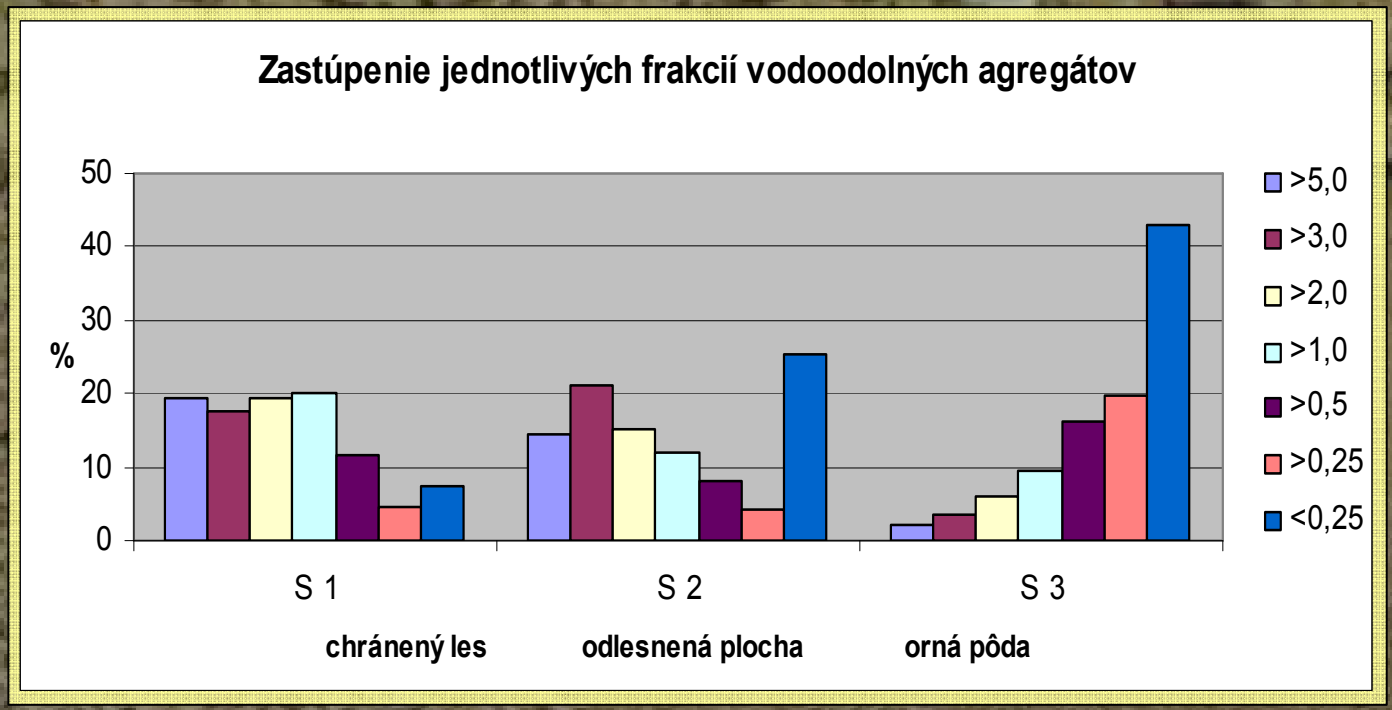



Graf 45: Štruktúrne agregáty





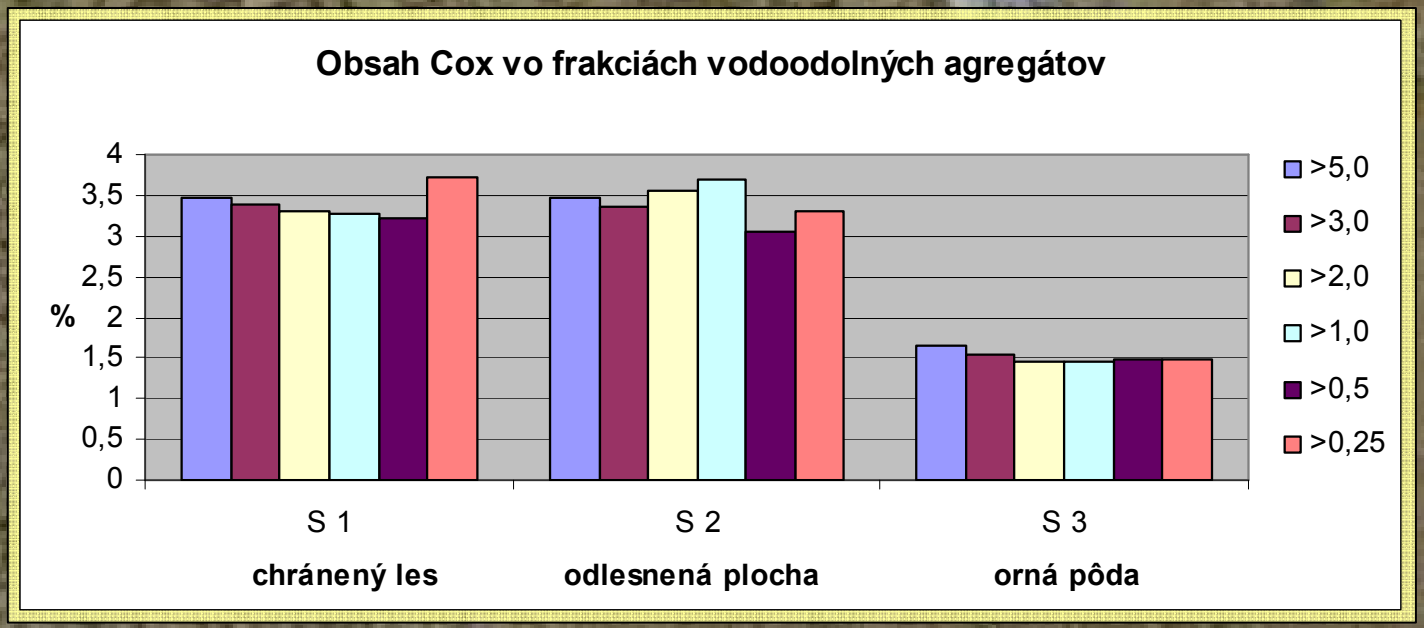

Content labile carbon - CL in fractions of soil aggregates




Waterstabile Macroaggregates contents - WSA

# Parameters of quality of soil structure

| ecosystem | %WSA | Swsa | MWDd | MWDw | Sw | K | Kv |
|---|---|---|---|---|---|---|---|
| Natural forest | 92.4 | 95.9 | 1.67 | 2.15 | 1.17 | 10.3 | 0.78 |
| Deforest area | 74.7 | 61.8 | 2.54 | 1.82 | 0.96 | 13.3 | 1.40 |
| Arable soil | 57.0 | 59.1 | 2.10 | 0.55 | 0.70 | 9.12 | 3.82 |




Content of total organic carbon in WSA

**Chernozems of Danube lowland**

**year 2002:**

**-Svätoplukovo** (district Nitra)

**year 2003:**

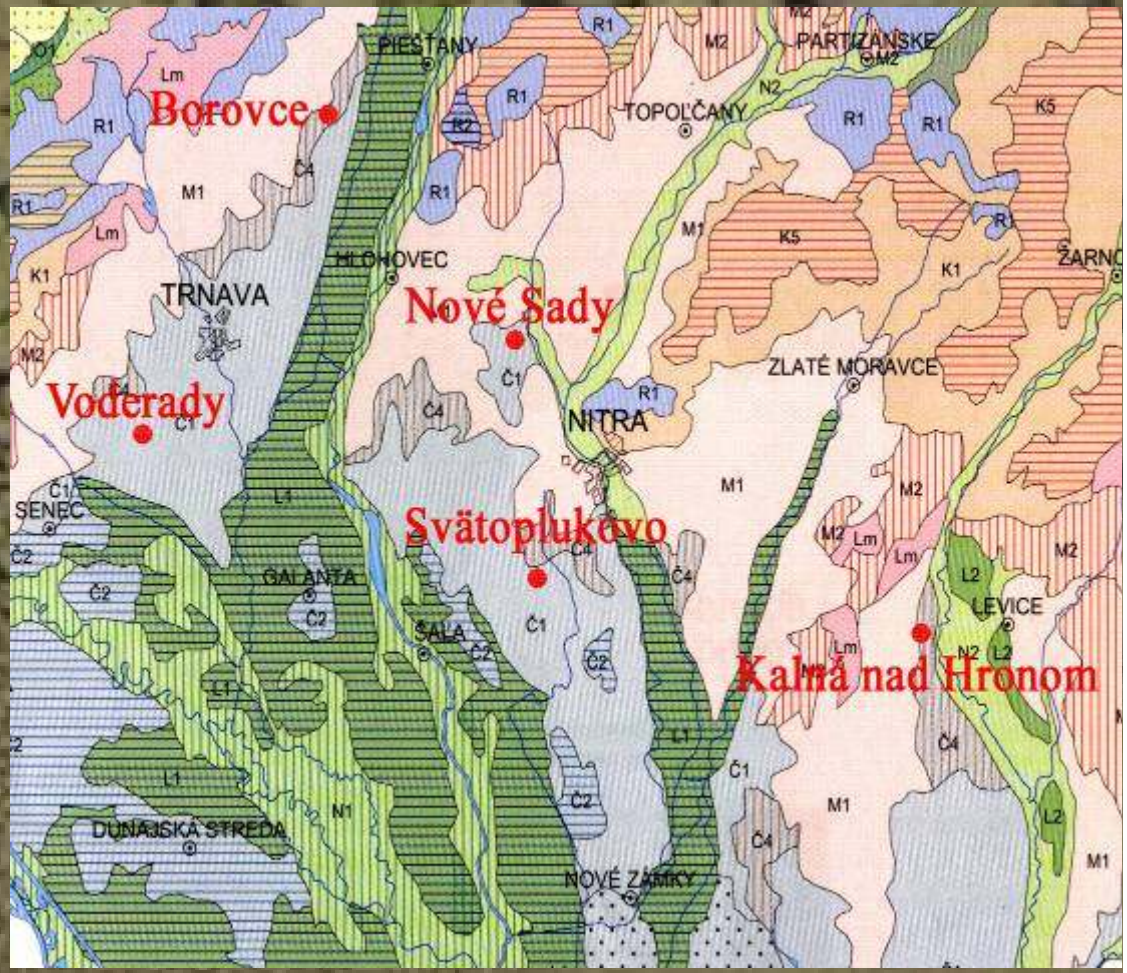
**-Nové Sady** (dist. Nitra)
**-Voderady** (dist. Trnava)

**year 2004:**

**-Kalná nad Hronom** (dist. Levice)
1. no tillage
2. conventianal tillage (ploughing)

**year 2005:**

**-Borovce** (dist. Piešťany) -
1. no tillage
2. protective belt
3. conventional management (ploughing)



# Basic chemical properties of chernozems of southwestern Slovakia

| locality | pH | | $C_{ox}$ | $C_L$ | $N_t$ | $N_{pot}$ | $C_{HK}:C_{FK}$ |
|---|---|---|---|---|---|---|---|
| | $H_2O$ | KCl | % | $mg.kg^{-1}$ | | | |
| Svätoplukovo | 7.85 | 6.99 | 1.96 | 3796 | 2470 | 128 | 0.85 |
| Nové Sady | 8.19 | 7.31 | 1.56 | 1913 | 1945 | 93 | 0.73 |
| Voderady | 7.85 | 6.89 | 2.17 | 2273 | 2505 | 150 | 0.68 |
| Kalná nad Hronom (no tillage) | 6.38 | 6.28 | 1.56 | 1879 | 1452 | 137 | 1.58 |
| Kalná nad Hronom (tillage) | 6.65 | 6.23 | 1.37 | 1822 | 1422 | 151 | 1.30 |
| Borovce (no tillage) | 7.14 | 6.17 | 1.36 | 2610 | 1239 | 126 | 0.94 |
| Borovce (protective belt) | 7.77 | 6.58 | 1.39 | 2452 | 1232 | 118 | 0.98 |
| Borovce (tillage) | 8.20 | 7.42 | 1.30 | 1688 | 1400 | 112 | 1.45 |

# Aggregates composition of chernozems

| *lokality* | *Kv* | *Aggregates – dry siewing* | | | *WSA aggregates* | | |
|---|---|---|---|---|---|---|---|
| | | *K* | *$MWD_{250}$* | *$MWD_{250}k$* | *Sw* | *$MWD_{250}$* | *$MWD_{250}k$* |
| Svätoplukovo | 3.76 | 1.14 | 3.99 | 4.26 | 0.96 | 1.06 | 1.43 |
| Nové Sady | 6.75 | 8.11 | 2.62 | 2.69 | 0.91 | 0.42 | 0.60 |
| Voderady | 3.72 | 7.43 | 2.73 | 2.81 | 1.09 | 0.75 | 0.92 |
| Kalná nad Hronom (no tillage) | 8.84 | 4.49 | 3.42 | 3.45 | 0.74 | 0.39 | 0.66 |
| Kalná nad Hronom (tillage) | 4.53 | 3.52 | 3.80 | 3.84 | 1.18 | 0.84 | 0.96 |
| Borovce (no tillage) | 5.26 | 13.0 | 2.52 | 2.56 | 0.73 | 0.50 | 0.84 |
| Borovce (protective belt) | 4.62 | 6.61 | 2.68 | 2.81 | 0.94 | 0.61 | 0.86 |
| Borovce (tillage) | 3.95 | 14.4 | 2.28 | 2.33 | 1.01 | 0.58 | 0.76 |
| mean | **5.23** | **7.22** | **3.01** | **3.09** | **0.95** | **0.64** | **0.88** |

- macroaggregate – dry siewing 25.5-47.4% (36.2± 8.0)
- WSA 30.0-59.2% (43.8± 10.8)

# Content of total soil organic carbon in WSA fractions

| *lokacity* | *TOC (%)* | | | | |
|---|---|---|---|---|---|
| | *0.25-0.5* | *0.5-1* | *1-2* | *2-3* | *>3mm* |
| **Svätoplukovo** | 2.28 | 2.08 | 2.07 | 2.03 | 2.18 |
| **Nové Sady** | 1.17 | 1.24 | 1.23 | 1.23 | - |
| **Voderady** | 1.99 | 1.82 | 1.89 | 1.86 | - |
| **Kalná nad Hronom (no-tillage)** | 1.58 | 1.53 | 1.71 | 1.66 | 1.85 |
| **Kalná nad Hronom (tillage)** | 1.68 | 1.69 | 1.55 | 1.69 | 1.88 |
| **Borovce (no tillage)** | 1.59 | 1.58 | 1.65 | 1.68 | 1.77 |
| **Borovce (protective belt)** | 1.60 | 1.64 | 1.68 | 1.67 | 1.73 |
| **Borovce (tillage)** | 1.28 | 1.48 | 1.35 | 1.33 | 1.46 |
| **mean** | **1.65±0.36** | **1.63±0.25** | **1.64±0.27** | **1.64±0.26** | **1.81±0.23** |

# Content of labile soil organic carbon in WSA fractions

| *locality* | $C_L$ *(mg.kg$^{-1}$)* | | | | |
|---|---|---|---|---|---|
| | ***0,25-0.5*** | ***0,5-1*** | ***1-2*** | ***2-3*** | ***>3mm*** |
| **Svätoplukovo** | 3149 | 3001 | 3116 | 3027 | 3105 |
| **Nové Sady** | 1378 | 1440 | 1457 | 1468 | - |
| **Voderady** | 2048 | 1980 | 2093 | 2003 | - |
| **Kalná nad Hronom (no tillage)** | 2295 | 2278 | 2321 | 2320 | 2329 |
| **Kalná nad Hronom (tillage)** | 2115 | 2093 | 2132 | 2081 | 1958 |
| **Borovce (no tillage)** | 2424 | 2419 | 2453 | 2490 | 2582 |
| **Borovce (protective belt)** | 2273 | 2289 | 2278 | 2337 | 2104 |
| **Borovce (no tillage)** | 1547 | 1553 | 1564 | 1575 | 1676 |
| **mean** | **2153±545** | **2132±496** | **2177±520** | **2163±503** | **2292±505** |

# Conclusions

- Soil organic mater play key role in processes forming and stabilizing soil structure,
- In microaggegates were determined lower contents C and N, but with smaller C:N ratios than in macroaggregate,
- Higher content SOM in forest soil, higher content TOC and labile C supports their high soil structural stability,
- Deforestation cause degradation of soil struture,
- The highest content **TOC** and **labile C** were in chernozems in fraction ***>3mm aggregates***
- *Optimal soil structure can be achieved only with annual inputs fresh organic matter in sufficiency quantity and quality*

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Thank you for your attention