# Management of organic matter in agricultural soils of Czech Republic

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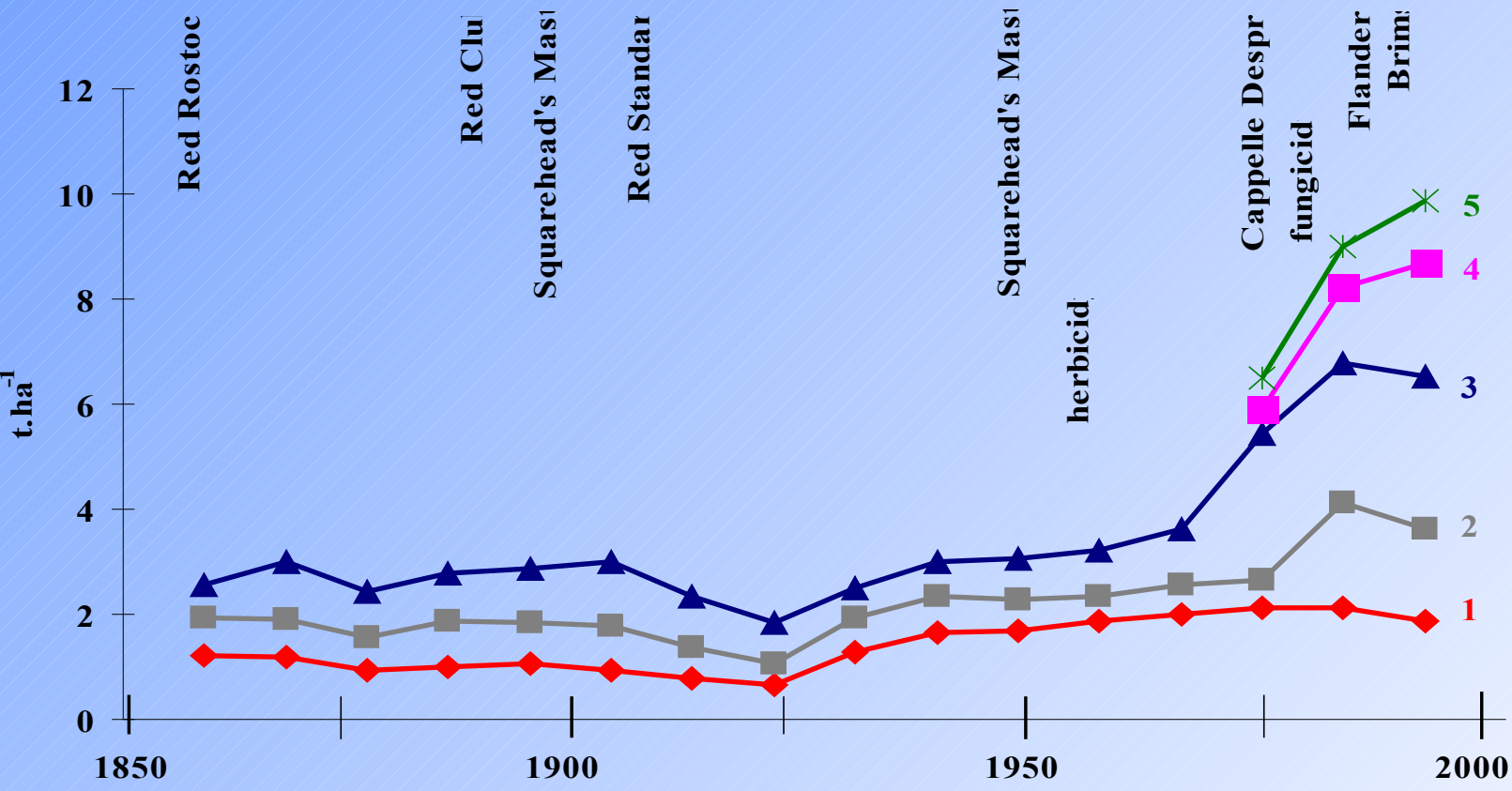
# Multifuctional role of organic matter in soil

**Organic matter can affect majority of soil properties as well plant development**

- Higher yield of growing crops
- Improvement of soil properties
- Increase of microbial activity in soils
- Higher soil water retention

# Grain yield of winter wheat in long-term experiment at unfertilized and fertilized treatment – Broadbalk, Rothamsted - England




**Explanations:**

**Monoculture**

**1 – unfertilized**

**2 – PK fertilizer + 48 kg N**

**3 – PK fertilizer + 144 kg N**

**Rotation of crops**

**4 – PK fertilizer + 144 kg N**

**5 – PK fertilizer + 96 kg N**

# Evaluation of parameters of long term experiment with rye in Halle (determination was made after 80 years from the exteriment start)

| Parametr | Treatment | | | | |
|---|---|---|---|---|---|
| | Zero | Manure | NPK | N | PK |
| Yield ($t.ha^{-1}$) | 1.20 | 2.25 | 2.19 | 1.72 | 1.46 |
| pH | 6.2 | 6.6 | 6.3 | 5.6 | 6.8 |
| CEC ($mval.kg^{-1}$) | 106 | 125 | 110 | 103 | 111 |
| $C_{ox}$ (%) | 1.20 | 1.70 | 1.28 | 1.29 | 1.26 |

**Explanation:**

$C_{ox}$ at the beginning of experiment 1.26 %

Rates of nutrients

N 40 $kg.ha^{-1}$

P 24 $kg.ha^{-1}$

K 75 $kg.ha^{-1}$

# The effect of manure and fertilizer application on soil water retention (%)

(Russell – in Baier and Baierová, 1985)

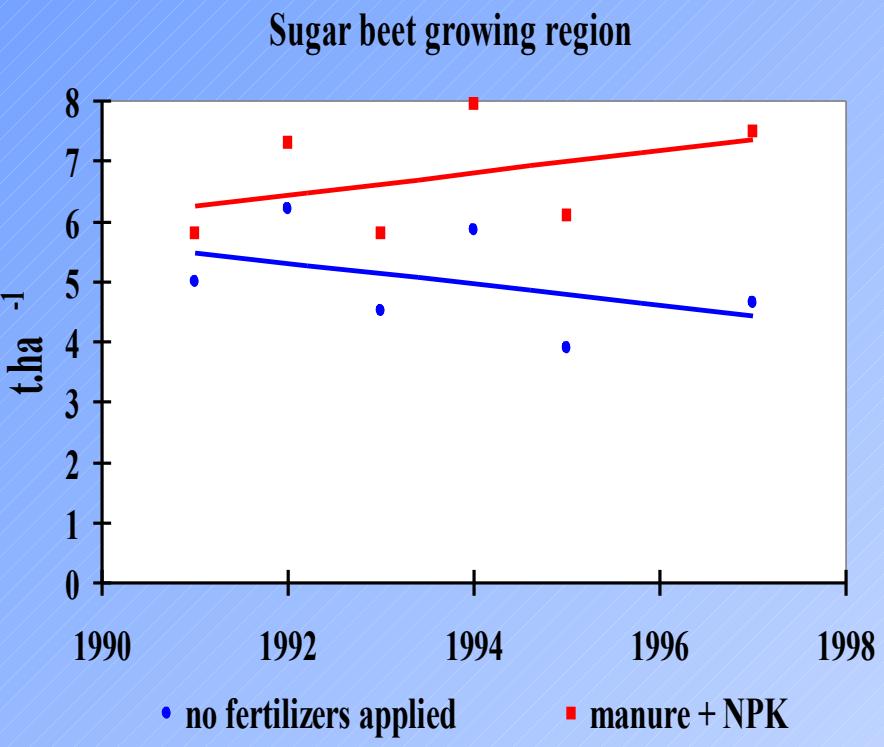
| Date | Soil water content (%) | | |
|---|---|---|---|
| | Fertilizers | Manure | Relative comparison (fertil. = 100 %) |
| 17.5. | 15.8 | 21.2 | 134 |
| 8.6. | 10.9 | 15.8 | 145 |
| 13.9. | 3.8 | 6.9 | 182 |
| 15.2. | 17.7 | 21.2 | 119 |

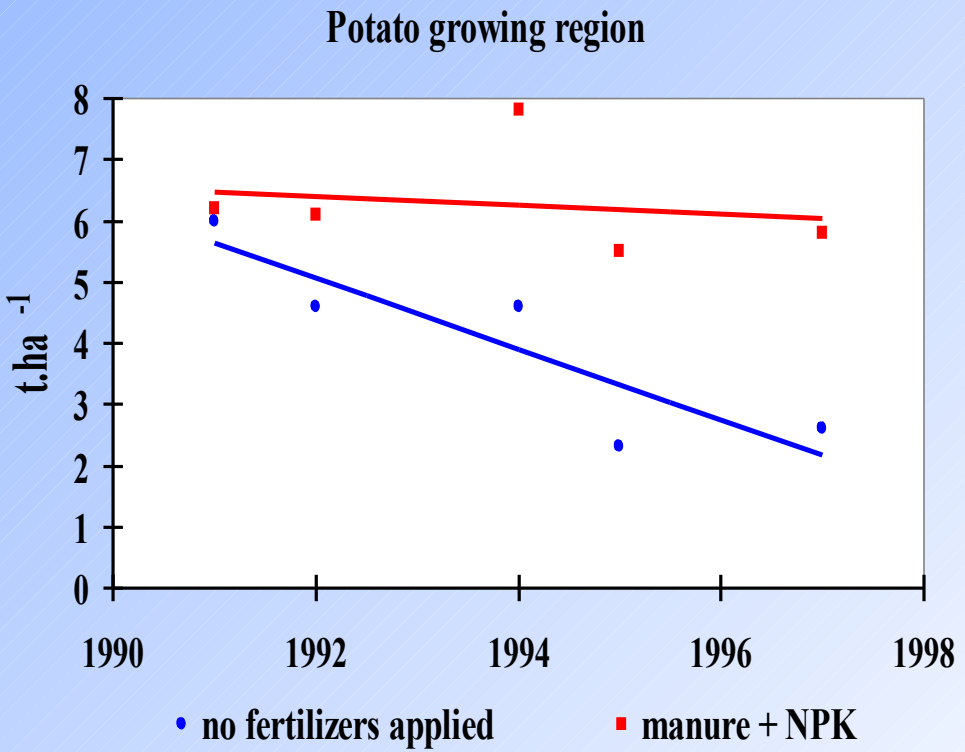
# The effect of manure and fertilizer application on soil biological activity

(Rubensam a Steinbrecher, 1961)

| Application | Relative number of bacteria (%) | | | |
|---|---|---|---|---|
| | Bacteria -total | Celulotic | Amonification | Nitrification |
| zero (from 1937) | 100 | 100 | 100 | 100 |
| NPK + Ca | 200 | 137 | 148 | 189 |
| NPK + Ca + 30 t manure | 398 | 133 | 199 | 520 |
| NPK + Ca + 60 t manure | 470 | 150 | 223 | 594 |

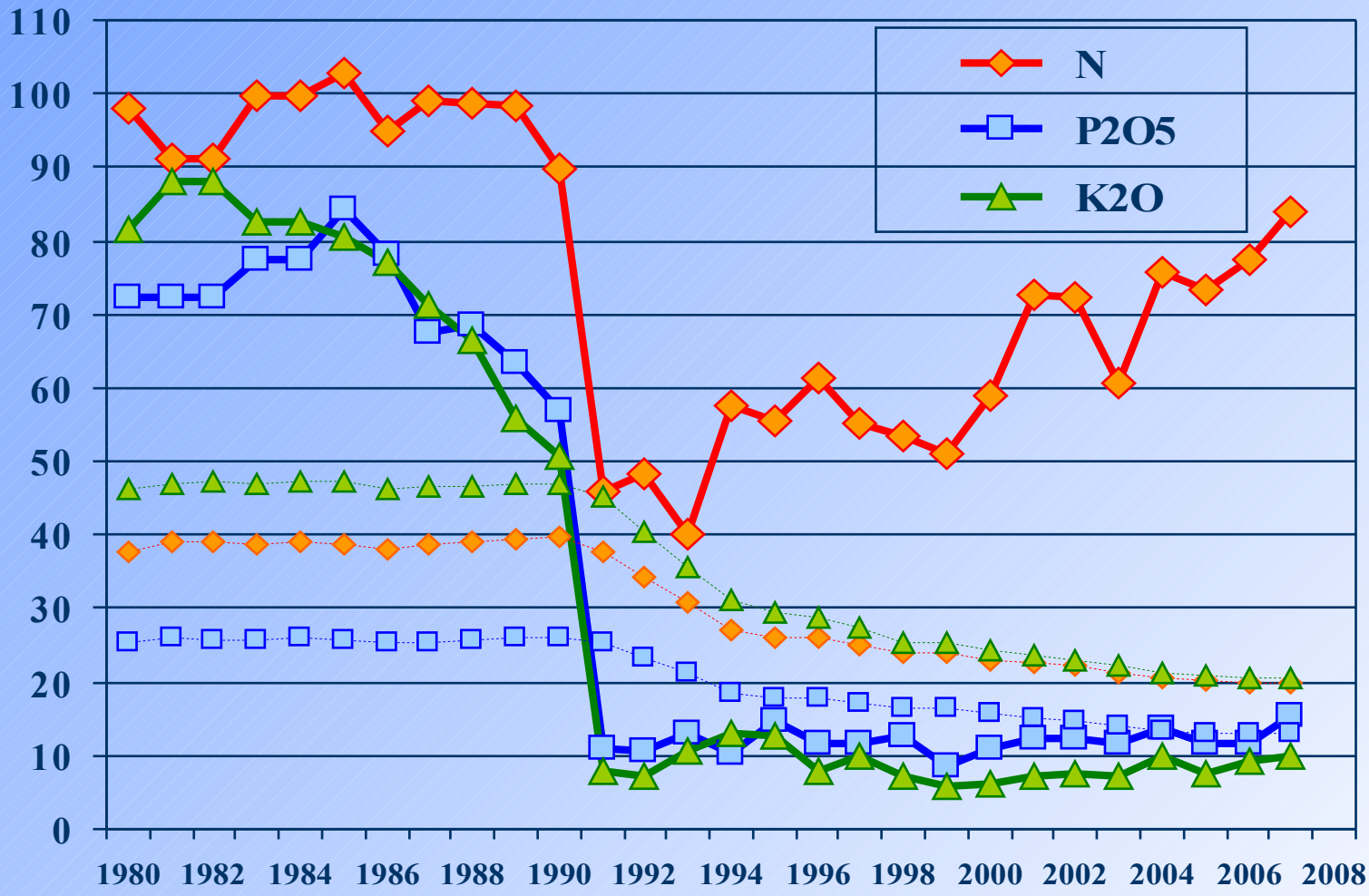
# The mean yield of grain unit of field experiments in two different growing regions



# Sources and losses of organic matter in Czech

# Mean input of nutrients in Czech by fertilizers (kg per ha agric. s.) (Klír et al. 2007)



# Normative decomposition of organic matter (OM) (tones . ha$^{-1}$ . year$^{-1}$) (Neuberg et al., 1985)

| Proportion of main crops in rotation (%) | | | OM decomposition (t.ha$^{-1}$) | |
|---|---|---|---|---|
| Cereals | Root crops + maize | Fodder crops | Sand soil | Loamy soil |
| 20 | 80 | 0 | 2.5 | 2.85 |
| 80 | 20 | 0 | 1.7 | 1.9 |
| 20 | 70 | 10 | 2.1 | 2.6 |
| 70 | 20 | 10 | 1.4 | 1.8 |
| 20 | 60 | 20 | 1.65 | 1.9 |
| 60 | 20 | 20 | 1.0 | 1.4 |
| 20 | 50 | 30 | 1.1 | 1.2 |
| 50 | 20 | 30 | 0.5 | 0.6 |
| 70 | 0 | 30 | 0 | 0 |

# Numbers of farm animals in the Czech (milions ) within period and mean intensity of livestock units (LSU/ha) per ha of agricultural soil (Klír et al. 2007)

| | 1985 | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | Relation % 2007/1990 |
|---|---|---|---|---|---|---|---|---|
| Livestock | 3.60 | 3.51 | 2.03 | 1.57 | 1.40 | 1.37 | 1.39 | 40 |
| Pigs | 4.30 | 4.79 | 3.87 | 3.69 | 2.88 | 2.84 | 2.83 | 59 |
| Poultry | 31.90 | 31.98 | 26.69 | 30.78 | 25.37 | 25.74 | 24.59 | 77 |
| Others | 0.45 | 0.50 | 0.23 | 0.14 | 0.17 | 0.19 | 0.21 | 42 |
| Acreage agric. soil (thous. ha) | 4 327 | 4 287 | 4 280 | 4 100 | 4 000 | 4 000 | 4 000 | 93 |
| LSU/ha | 0.81 | 0.81 | 0.51 | 0.44 | 0.39 | 0.38 | 0.38 | 46 |

# The estimation of organic matter (OM) production (million tones) by different farm animals according to different husbandry management and normative manure production (Klír et al. 2007)

| | 1985 | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2007 (OM/ha) |
|---|---|---|---|---|---|---|---|---|
| Manure*) | 4.54 | 4.35 | 2.65 | 2.10 | 1.85 | 1.82 | 1.83 | 0.46 |
| Dung water | 0.27 | 0.26 | 0.16 | 0.13 | 0.11 | 0.11 | 0.11 | 0.03 |
| Slurry | 0.95 | 0.99 | 0.72 | 0.65 | 0.52 | 0.50 | 0.51 | 0.13 |
| Poultry slurry | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.005 |

*) including poultry manure from bedding husbandery

# Yield, organic matter, and nutrients in different plants suitable for green manure

| Crop | Mean biomass yield | Organic matter content | Root depth | Nutrients (%) | | |
|---|---|---|---|---|---|---|
| | ($t.ha^{-1}$) | (%) | (cm) | N | P | K |
| Clover | 8-14 | 18 | 40-60 | 0.56 | 0.08 | 0.26 |
| Rape | 7-15 | 13 | 110-175 | 0.46 | 0.05 | 0.29 |
| Mustard | 10-12 | 11 | 60-120 | 0.52 | 0.02 | 0.33 |
| Sugar beet–leaves | 25-30 | 10 | x | 0.40 | 0.04 | 0.45 |
| Potatoes haulm | 7-10 | 10 | x | 0.28 | 0.02 | 0.40 |

# Evaluation of compost according organic matter and nutrient contents

| Quality | Content in dry matter (%) | | | |
|---|---|---|---|---|
| | Organic matter | N | P | K |
| Excellent | > 50 | > 2 | > 0.65 | > 1.25 |
| Good | 30 | 0.3 – 1.0 | 0.20 | 0.8 |
| Poor | 8 | 0.1 | 0.10 | 0.2 |

# Decomposition half time of main organic matter sources in soil (Novák et al. 1991)

| Source | Minimum[1)] | Maximum[1)] | Mean |
|---|---|---|---|
| Root exudates | 2 days | 5 days | 3 days |
| Thin roots | 4 days | 18 days | 7 days |
| Harvest residues[2)] | 1 month | 40 months | 16 months |
| Manure | 2 months | 20 months | 7 months |
| Slurry | 5 days | 60 days | 20 days |
| Green manure | 1 month | 4 months | 2 months |
| Compost[3)] | 20 months | 50 months | 35 months |

Notes:

[1)] Min. a max. depended mainly on soil temperature and moisture

[2)] Moist residues (leaves of beet) have short, dry residues (straw) long decomposition half time

[3)] Compost decomposition depends on stability of product

# Balance of organic matter (t OM per ha) arable soil - 2007

## Proportion of growing crops:

Cereals - 76%  Root + maize - 14%  Grasses +Legumes – 10 %

## Needs:

**- 1.70 t OM per ha arable soil**

## Sources:

| | | | |
|---|---|---|---|
| Manure + slurry | → 0.62 t OM/ha | | → 0.91 t OM per ha arable soil |
| Straw | → 4.0 mil t | → 3.2 mil t OM | → 1.22 t OM per ha arable soil |
| Green waste | → 2.1 mil t | → 0,21 mil t OM | → 0.08 t OM per ha arable soil |
| Compost + sludge | → 0.18 mil t | → 0.063 mil t OM | → 0.02 t OM per ha arable soil |

Transformed OM **+ 0.93 t OM per ha arable soil**

Primary OM **+ 1.30 t OM per ha arable soil**

# Balance of organic matter (t OM per ha) arable soil - 1985

## Proportion of growing crops:

Cereals - 56%  Root + maize - 19%  Grasses +Legumes – 25 %

## Needs:

**- 0.85 t OM per ha arable soil**

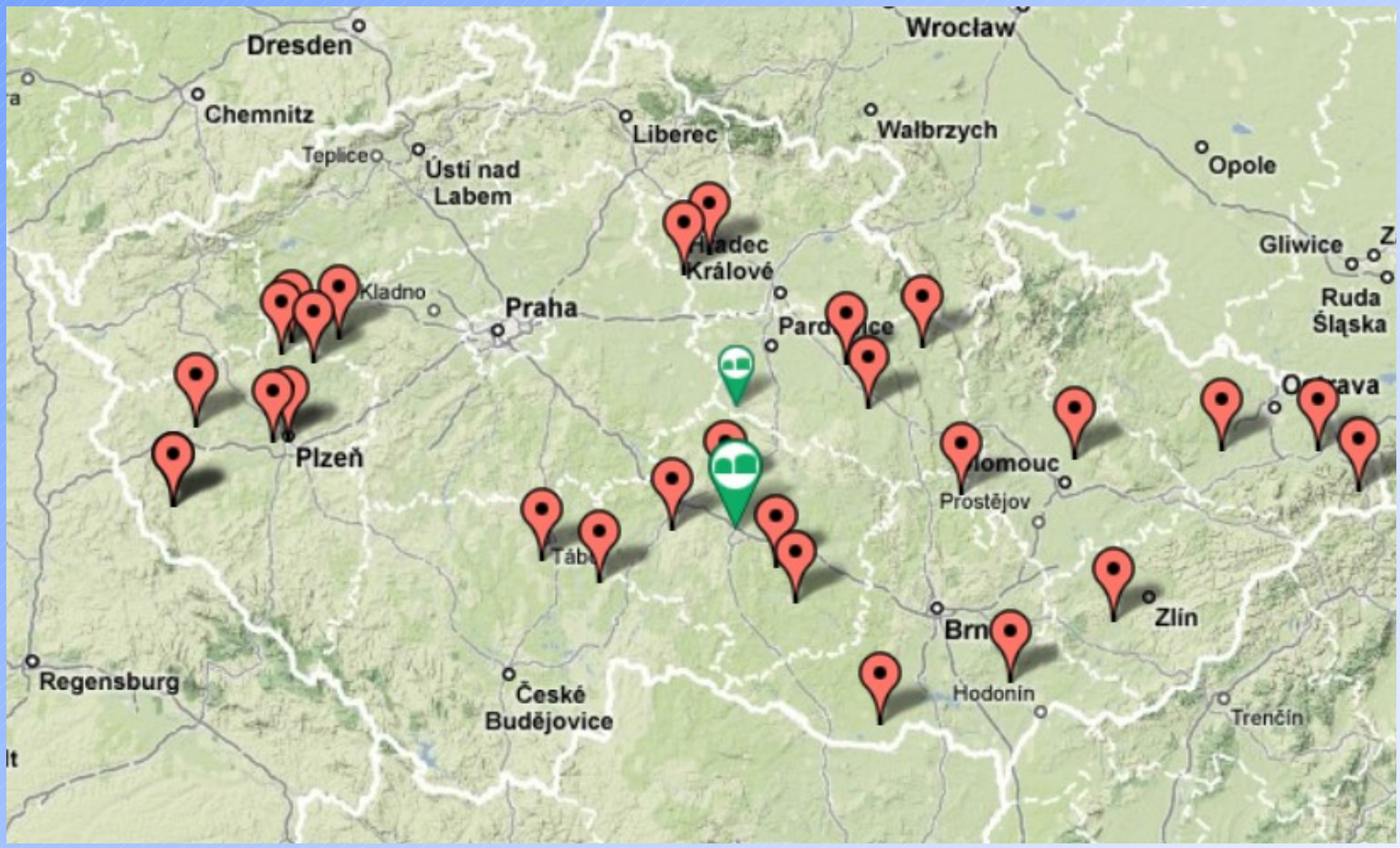
## Sources:

| | | |
|---|---|---|
| Manure + slurry | → 1.34 t OM/ha | → 1.75 t OM per ha arable soil |
| Straw | forbiden to plough in | |
| Green waste | → 3.37 mil t → 0,34 mil t OM | → 0.10 t OM per ha arable soil |
| Compost + sludge | → 0.30 mil t → 0.10 mil t OM | → 0.03 t OM per ha arable soil |

Transformed OM **+ 1.78 t OM per ha arable soil**

Primary OM **+ 0.10 t OM per ha arable soil**

# Biogas plants in Czech




not compleet, total biogas plant 45, 10 use waste products, 35 agromaterials

# Biogas production - anaerobic digestion

- In 2008 – production doubled  131 GWh
- Sources:  40 000 t biowaste
  500 000 t slurry
  400 000 t maize + grass silage
- Organic matter conversion:  40 %
  (60 %  OM remains in digestate)
- Production of biogas should increase 10 x by 2020

# Balance of organic matter (t OM per ha) arable soil – 2020

## Biogass influence

### Proportion of growing crops:

Cereals - 72%  Root + maize - 18%  Grasses +Legumes – 10 %

### Needs:

**- 1.75 t OM per ha arable soil**

### Sources:

| | | | |
|---|---|---|---|
| Manure + slurry | → 0.53 t OM/ha | | → 0.75 t OM per ha arable soil |
| Straw | → 4.0 mil t | → 3.2 mil t OM | → 1.22 t OM per ha arable soil |
| Green waste | → 2.1 mil t | → 0,21 mil t OM | → 0.08 t OM per ha arable soil |
| Compost + sludge | → 0.18 mil t | → 0.063 mil t OM | → 0.02 t OM per ha arable soil |
| Biogas slurry | | → 0.970 mil t OM | → 0.32 t OM per ha arable soil |

Transformed OM **+ 0.77 t OM per ha arable soil**

Primary OM **+ 1.62 t OM per ha arable soil**

# Proportion of three pools of C (%) (determined by acid hydrolysis) (Kolář, 2008)

| Material | Proportion (%) | | |
|---|---|---|---|
| | LP I | LP II | RP |
| Sludge + slurry (1 : 1) before anaerobic digestion | 63 | 20 | 17 |
| Sludge + slurry (1 : 1) after anaerobic digestion | 18 | 16 | 66 |

LP I – labile pool I
LP II – labile pool II
RP - residual pool

# Incubation of sludge + slurry (1: 1) mixture solids with Cambisols (3 : 1) for 20 weeks (Kolář, 2008)

| Compounds | Before digestion | | After digestion | |
|---|---|---|---|---|
| | before incubation | after incubation | before incubation | after incubation |
| Lipids (%) | 10.8 | 10.4 | 2.0 | 2.1 |
| Proteins (%) | 15.3 | 13.9 | 8.5 | 8.5 |
| Hemicellulose (%) | 3.3 | 2.9 | 0.7 | 0.7 |
| Cellulose (%) | 9.6 | 8.0 | 6.0 | 6.0 |
| Lignin (%) | 5.0 | 5.0 | 5.2 | 5.2 |
| Total N (%) | 2.3 | 2.1 | 1.1 | 1.1 |
| CEC (mval/kg) | 53 | 55 | 145 | 168 |

# Conclusions

- Soil organic matter has a possitive effect on a wide range of soil parameters causing higher soil fertility

- Reduction of animals led to lower acreage of grasses and manure production affecting OM balance

- Expected level of biomass production could affect production of transformed OM