Czech University of Life Sciences Prague

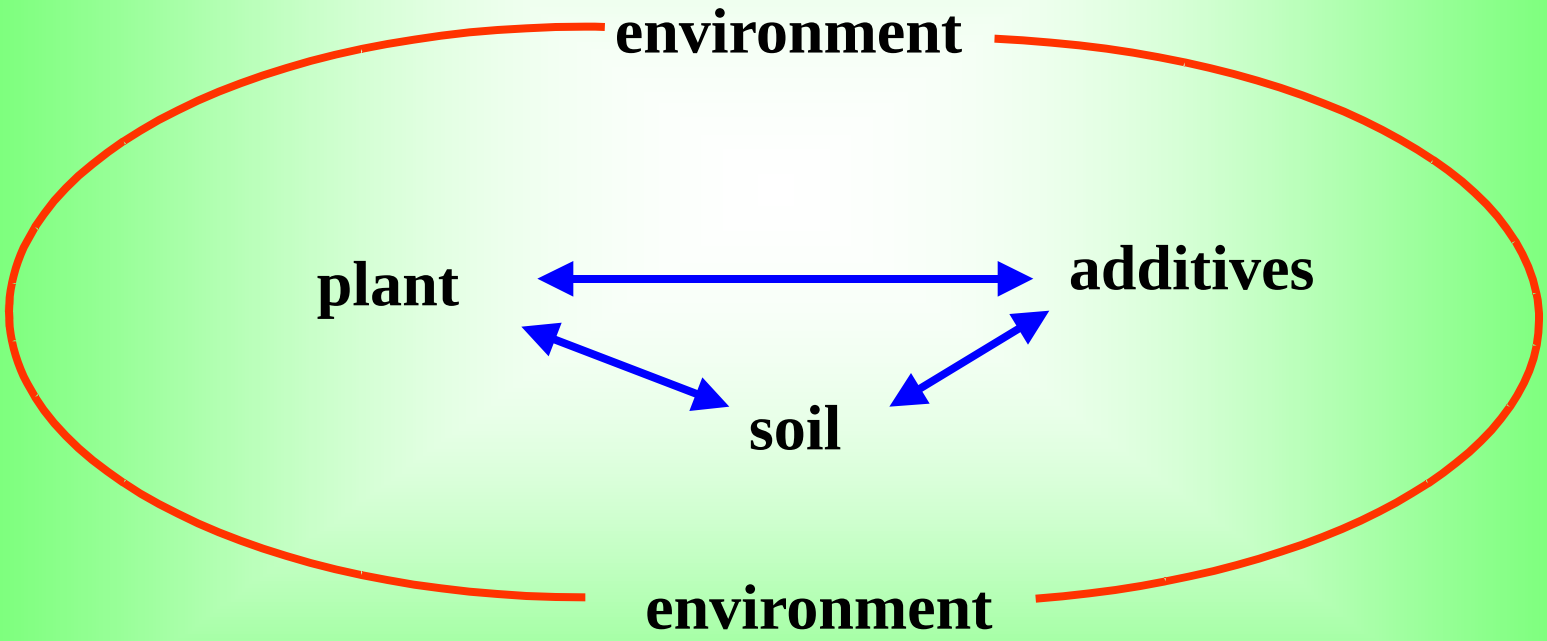
Faculty of Agrobiology, Food and Natural Resouces

Soil and Plant

Jiří Balík, Pavel Tlustoš,

CULS Prague, Czech Republic

Definition of Subject



Soil functions:

- Food and other biomass production
- Storing, filtering and transformation
- Microbial and gene pool
- Physical and cultural environment for humans
- Source of raw materials

Soil threats:

- Erosion
- Decline in organic matter
- Soil contamination (local and diffusive)
- Soil compaction
- Decline in soil biodiversity
- Salinisation

Soil fertility

- *The ability of soil to create optimum conditions for plant development and growth and to help realise their yield potential*

- **Complicated complex of soil properties with mutual relationship giving plants optimum conditions for their development and growth (Wohlrab, 1963)**

- **Quality of processes in biological cycle and not the yield (Rusch, 1985)**

Factors of soil fertility (Wohlrabe, 1963)

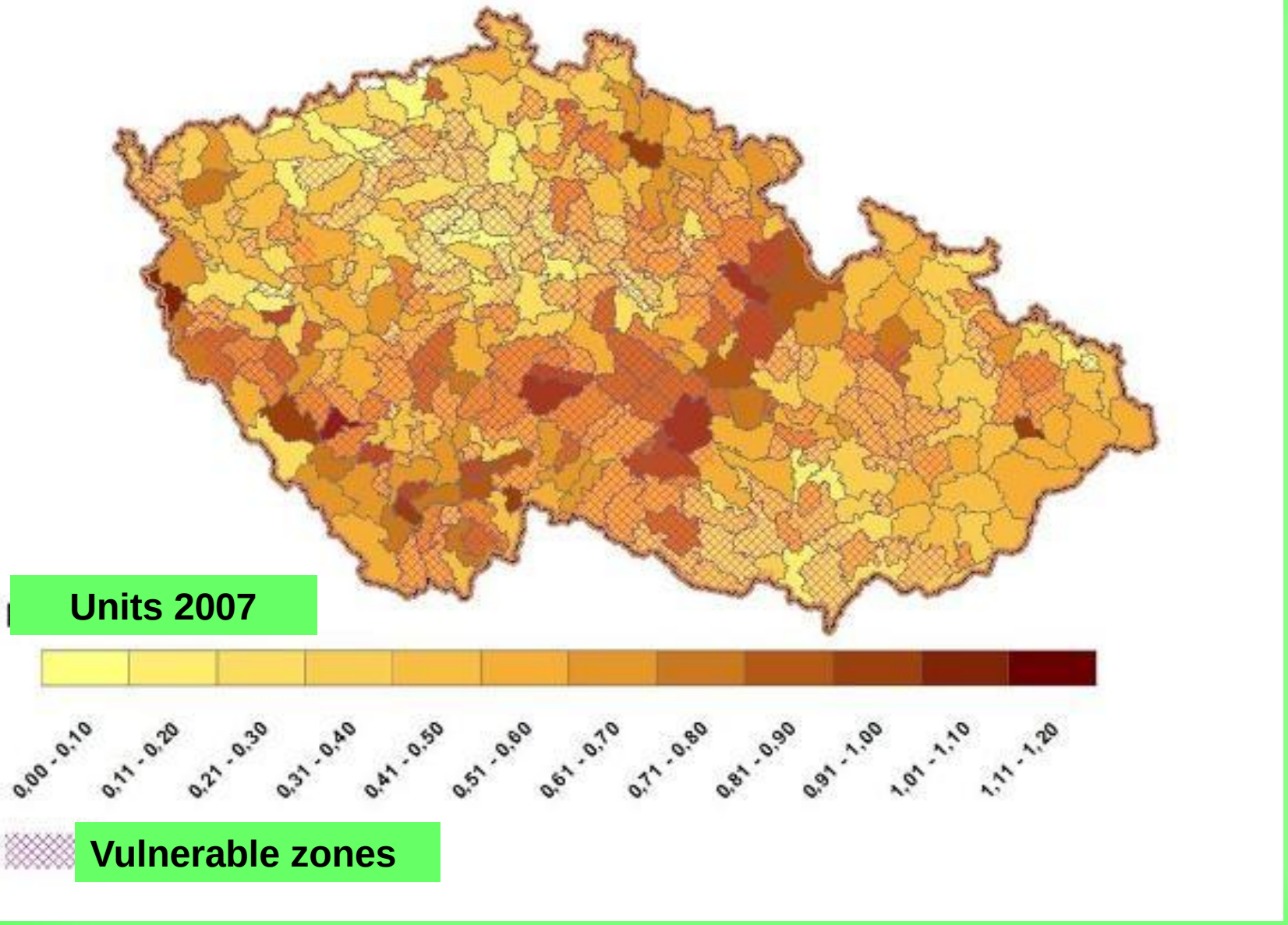
- **Physical factors:**
  - ✓ Soil structure and texture
  - ✓ Soil porosity
  - ✓ Soil temperature
  - ✓ Risk of soil erosion
- **Water regime in soil:**
  - ✓ Water movement
  - ✓ Water retention in soil
  - ✓ Water content in soil
- **Organic matter:**
  - ✓ Organic residues
  - ✓ Humic substances
  - ✓ Soil organisms
- **Agrochemical factors:**
  - ✓ Sorption capacity of soil
  - ✓ Soil pH
  - ✓ Content and availability of macro and micro nutrients

Number of farm animals in CR (milions)

Year /animal	1989	1994	1999	2004	2007	2008	*1989= 100 %*
Livestock	3,51	2,03	1,57	1,40	1,40	1,36	*39 %*
Pigs	4,79	3,87	3,69	2,88	2,43	1,97	*41 %*
Poultry	31,98	26,69	30,78	25,37	27,32	26,49	*83 %*

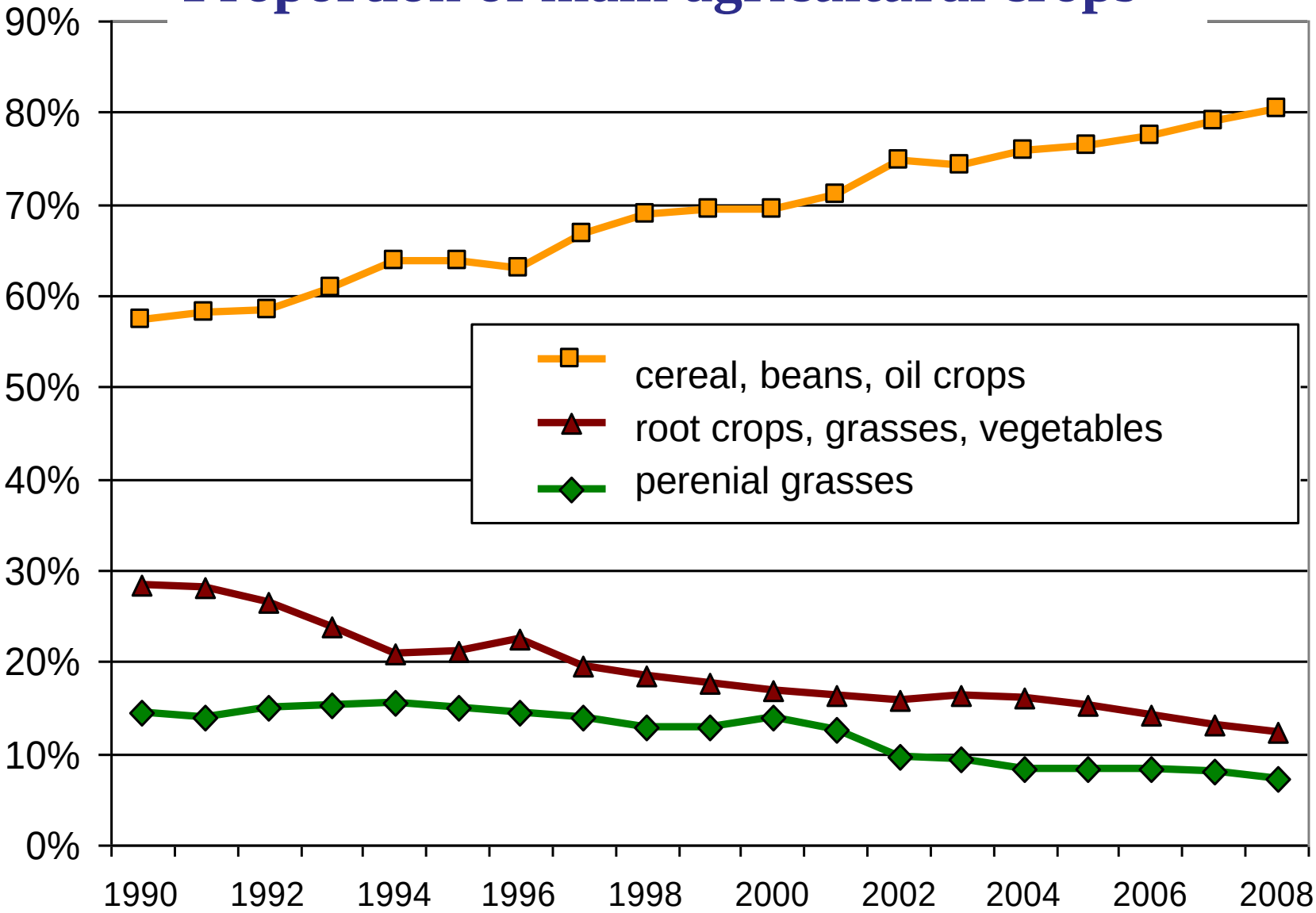
Source: (CSO; from 2001 without „hoby“ animals

Density of animals in 2007 (Unit/ha)

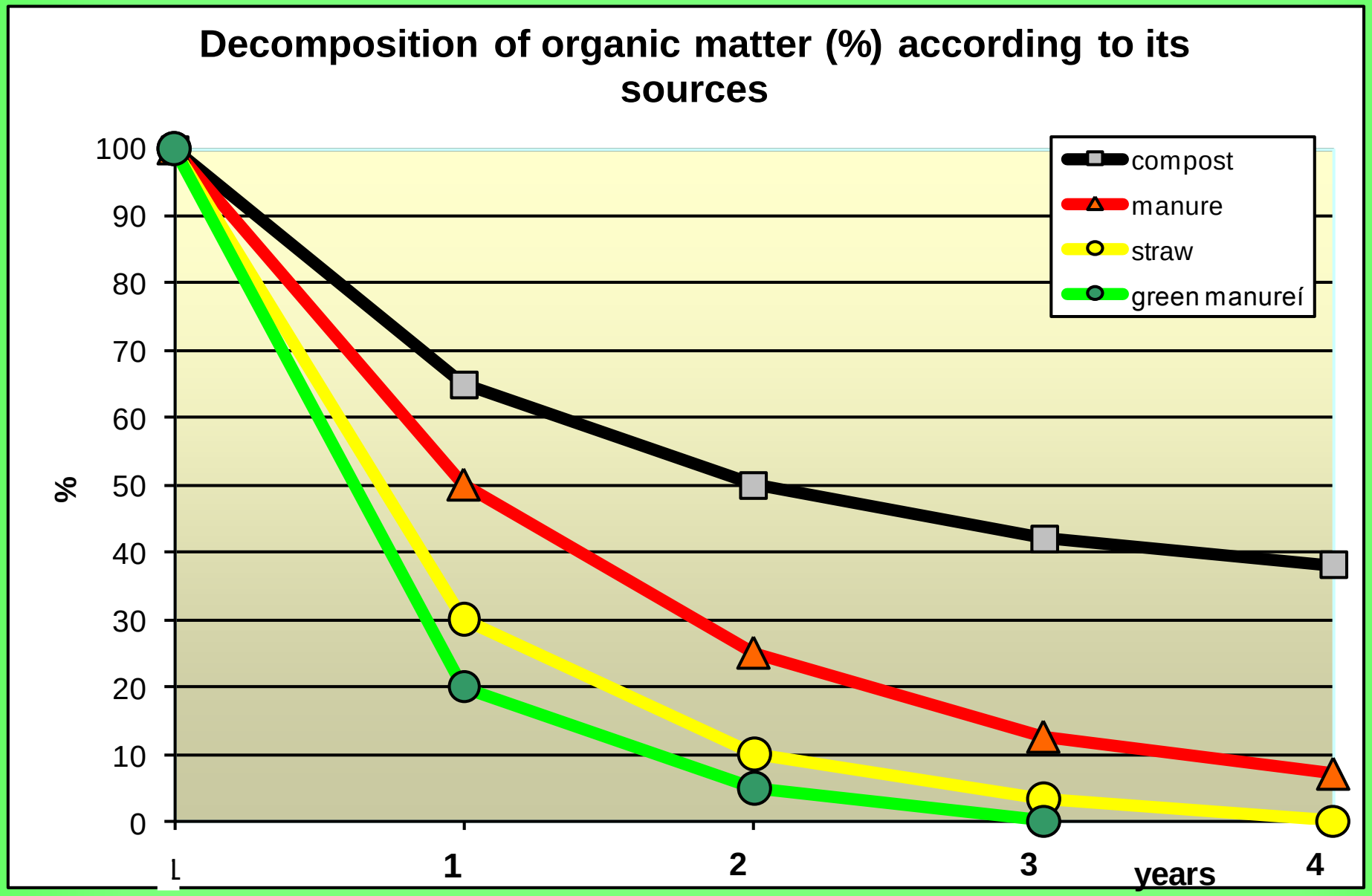


Source: Register MA CR

Proportion of main agricultural crops



Source:CSO


Decomposition of organic matter (%) according to its sources
100
90
80
70
60
50
40
30
20
10
0
%
1
2
3
4
years
compost
manure
straw
green manureí

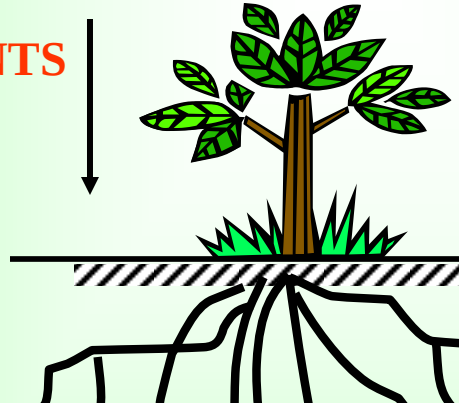
Changes in the organic matter supply into Czech soils

- **Organic fertilizers – dramatic decline**
- **Post harvest residues – increased**
- **Root biomass – slight decrease**

  - slow decrease in above ground biomass / root production

  - lower acreage of crops with high root biomass
- **Root exudates microorganisms – without change**

Soil plant interactions in nutrient uptake



INPUT OF NUTRIENTS

CO_2

NUTRIENT UPTAKE BY PLANT

SOIL AIR

SOLID SOIL PHASE

Exchangeable sorption at soil surface Ca^{2+}, Mg^{2+}, K^+, NH_4^+, ….

root exudates of ionic properties

(H^+, HCO_3^-, anions)

SOIL SOLUTION

Chemical sorption PO_4^{3-} (Ca, Al, Fe), SO_4^{2-} (Ca), $CaCO_3$

NO_3^-
NH_4^+
Ca^{2+}
Mg^{2+}
K^+
Cl^-
SO_4^{2-}
$H_2PO_4^-$
HCO_3^-
Na^+

Root exudates – organic acids

Solubilization, chelatization

BOUND NUTRIENTS

Nonexchangeable sorption – fixation
K^+, NH_4^+

MOBILE NUTRIENTS

Nutrient immobilization

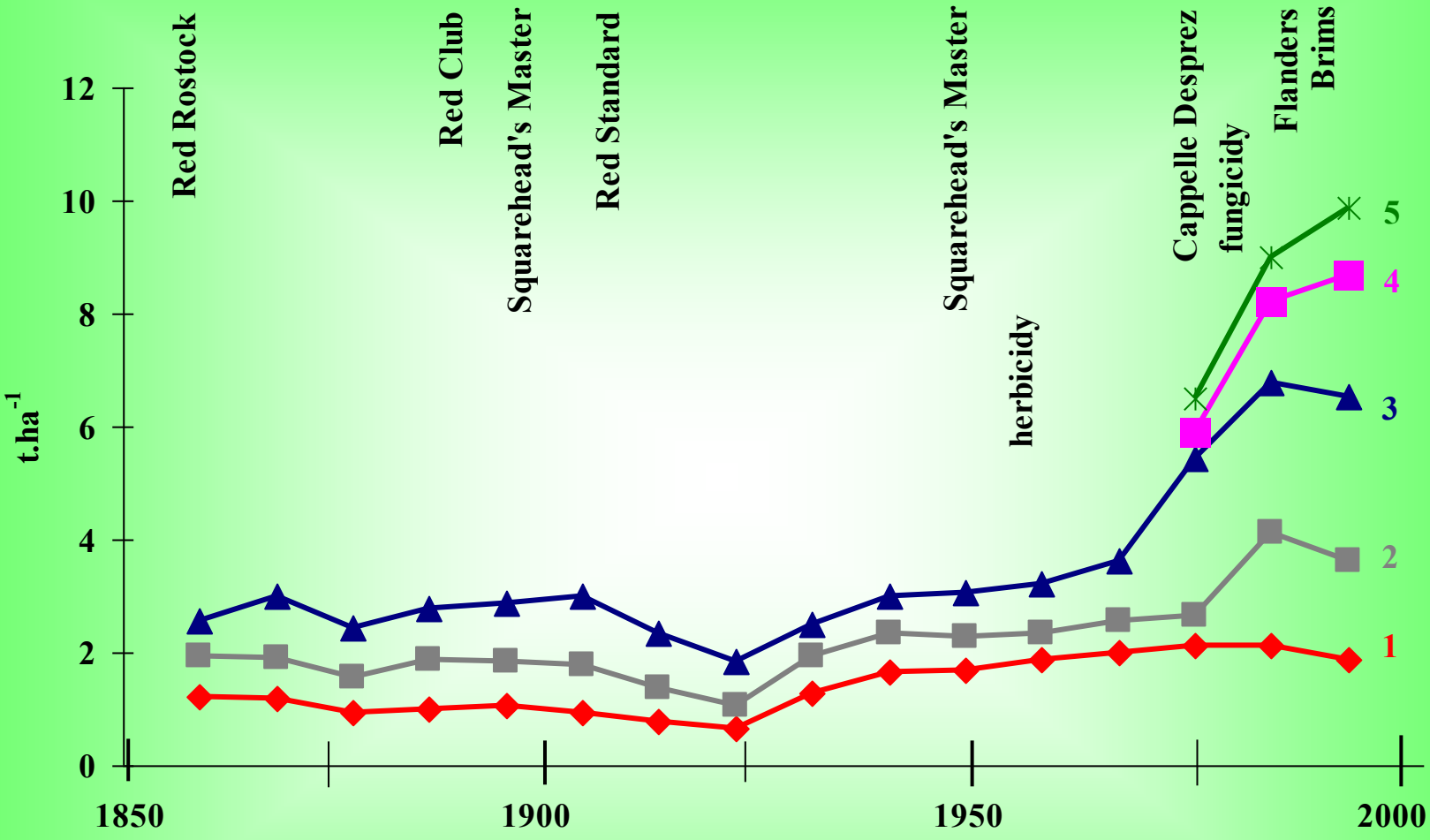
Biological sorption
N, P, S

microorganisms

mineralization

DYNAMIC EQUILIBRIUM

Grain yield of winter wheat in long-term experiment at unfertilized and fertilized treatments – 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 experiment started)

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 $kg.ha^{-1}$

Influence of fertilizers and crop rotation on the rye grain yield in long term „Ewiger Roggenbau „ experiment (Stumpfe-Hagedorn in Tesař – Vaněk, 1992)

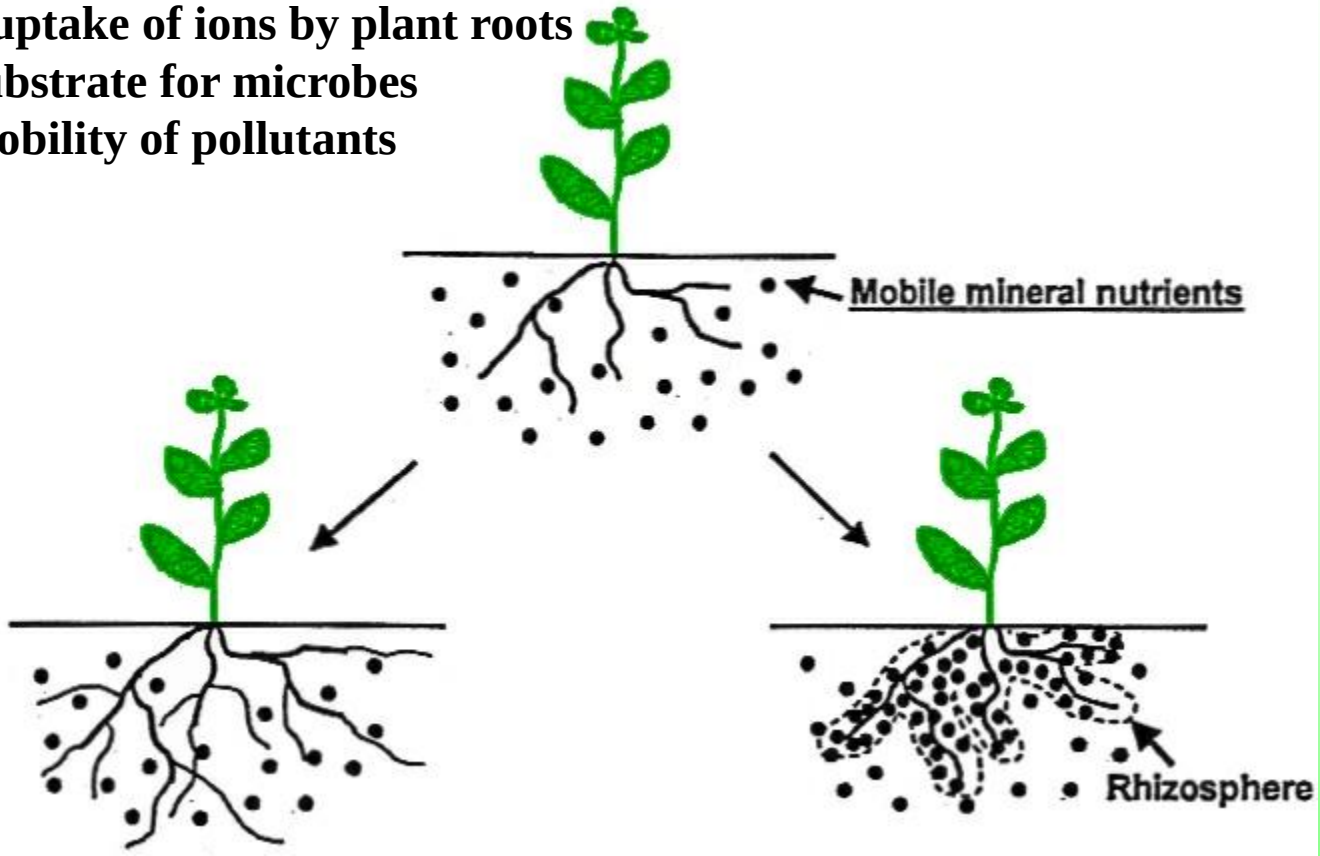
Treatment	Yield ($t.ha^{-1}$) (mean 1962/1977)	
	monoculture	rotation with potatoes
Control (0)	1.24	2.39
Manure (65-9-50)	3.03	3.96
NPK (40-11-62)	2.80	3.99
N (40-0-0)	1.92	3.31
PK (0-11-62)	2.08	3.27

Rhizosphere

Thin layer of the soil surrounding plant roots

Specific environment

Supporting uptake of ions by plant roots
Providing substrate for microbes
Changing mobility of pollutants



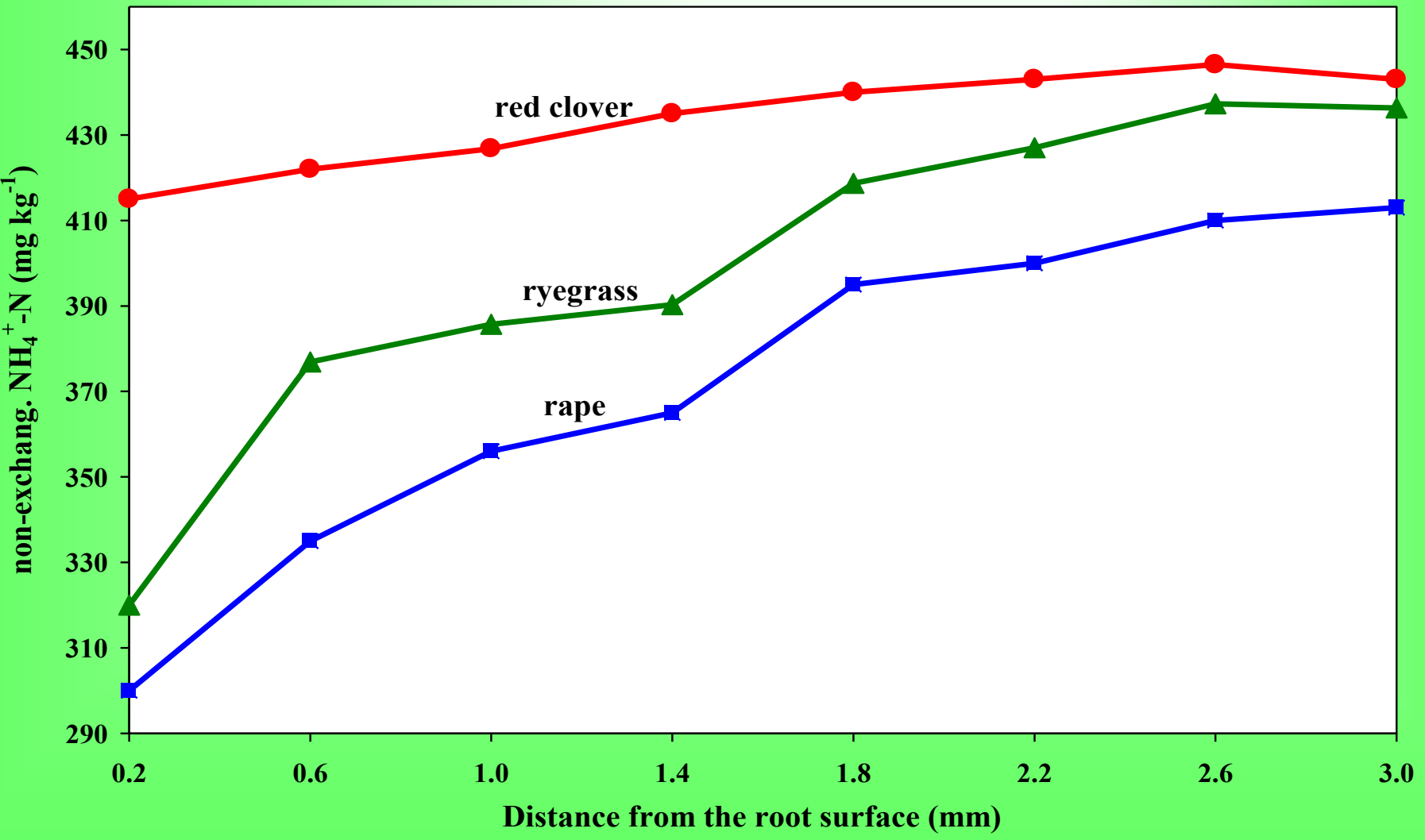
Enhanced spatial availability

stimulation of root growth
elongation and proliferation of root hairs
enhanced formation of fine roots
enhanced mycorrhizal colonization

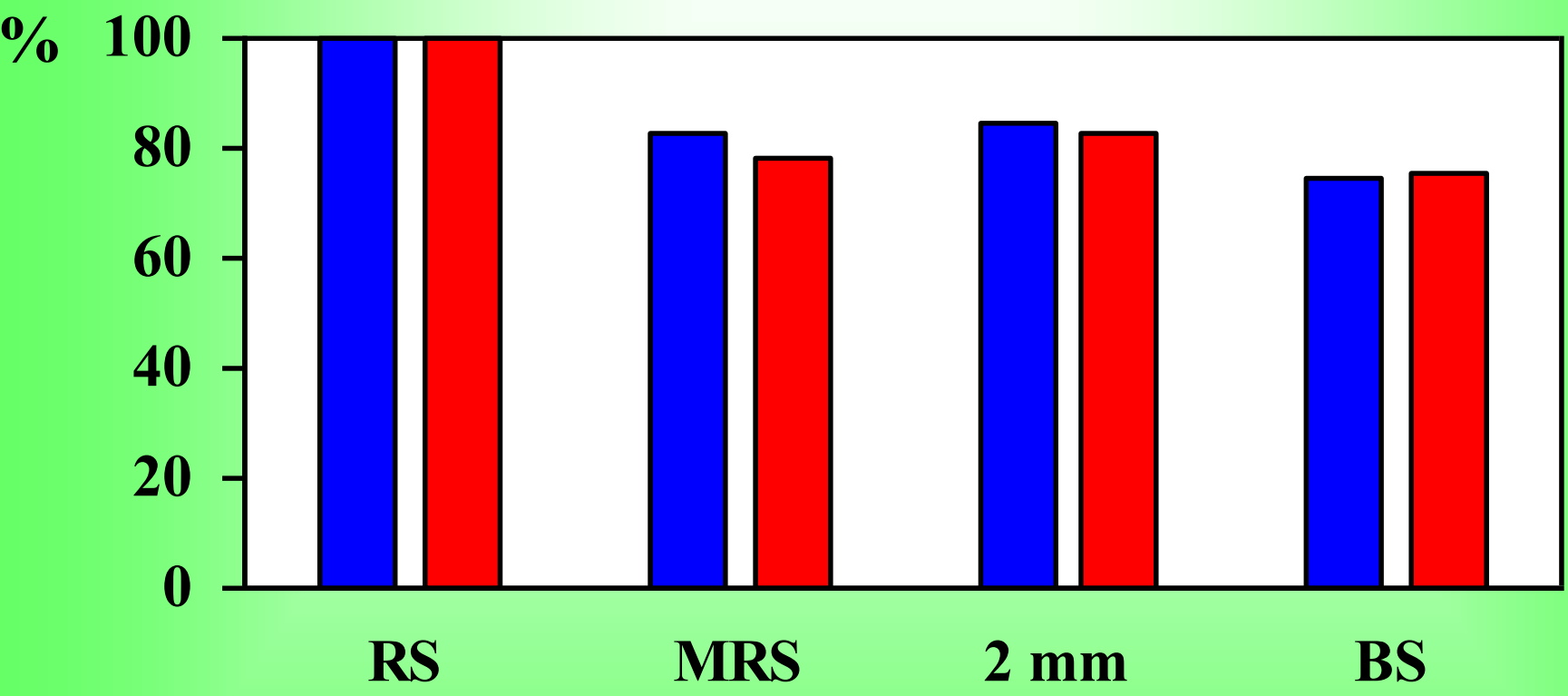
Enhanced chemical availability

Modifications in:	**pH**
	redox potential
	microbial activity
Release of:	**chelators**
	enzymes

Influence of the plant species on the depletion on non-exchangeable NH_4^+-N in the rhizosphere in a soil with high amounts of smectites and vermiculite (Scherer, Ahrens, 1996)

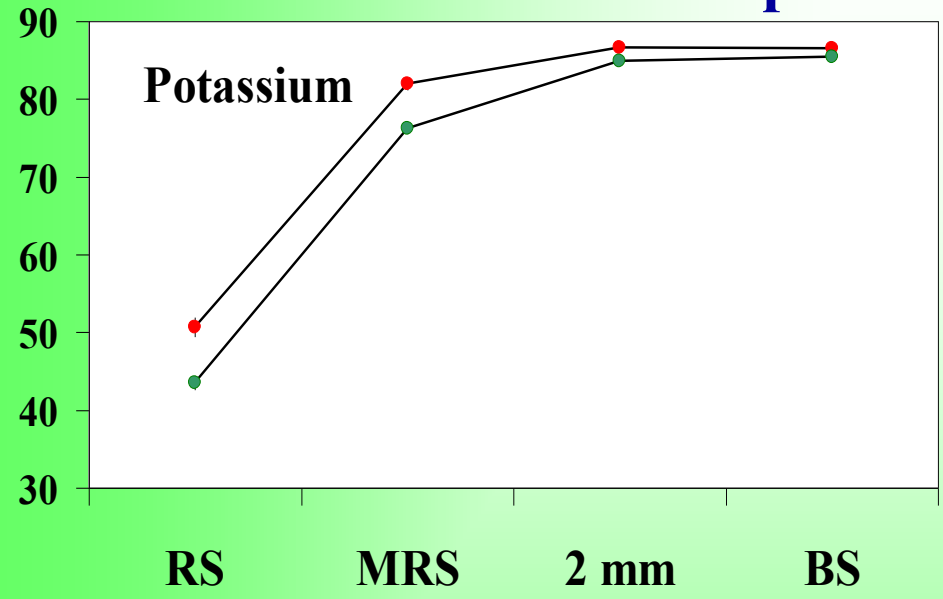


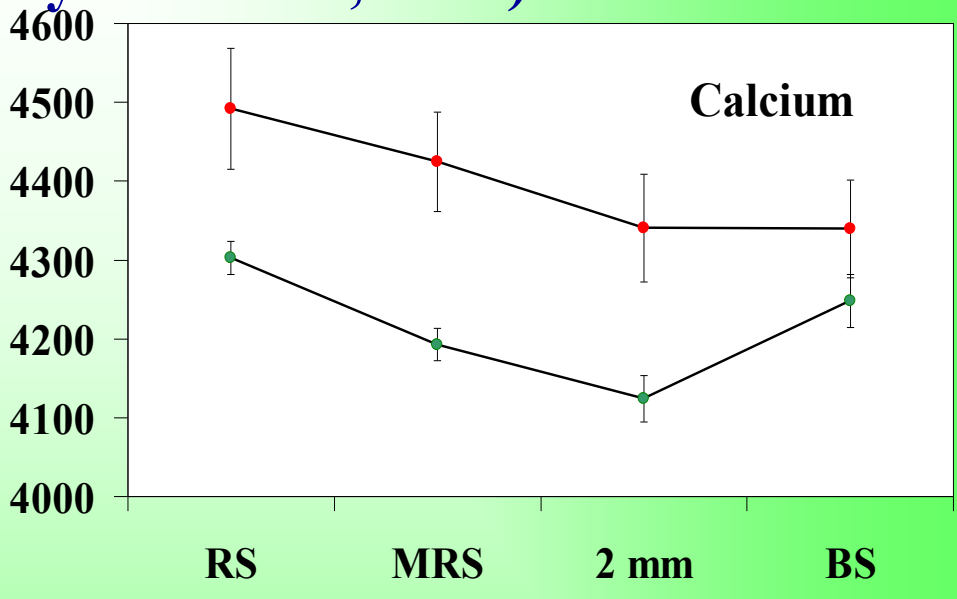
Content of water soluble carbon (mg.l^{-1}) in soil from soil rhizobox compartments after harvest of two willow species (Vysloužilová, 2003)

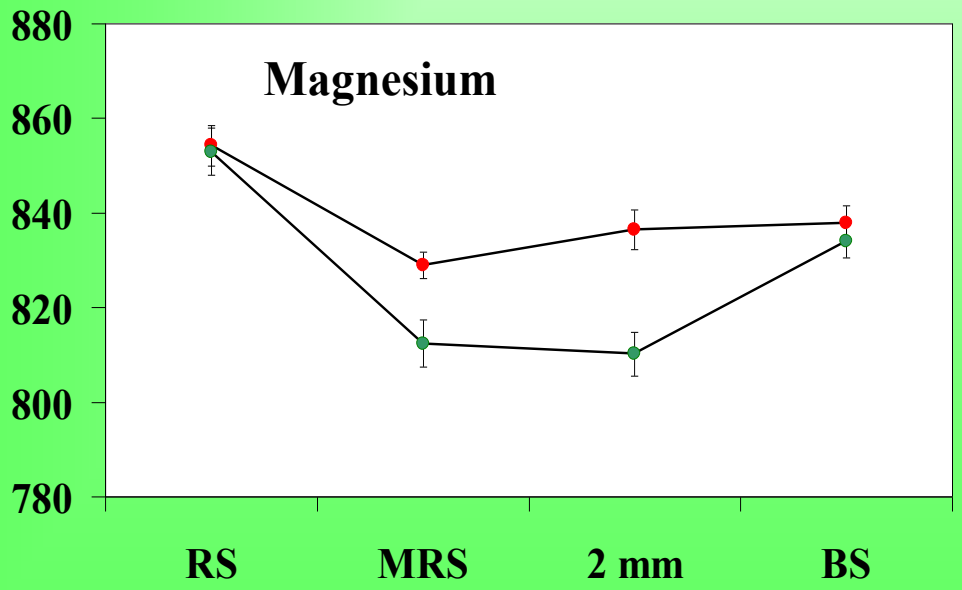


RS – rhizosphere
MRS – mycorhizosphere
2 mm – MRS mediated
BS – soil without root and mycorhiza influence

The content of elements (ppm) extracted by 1 mol.l^{-1} NH_4NO_3 from individual soil rhizobox compartments after harvest of two willow species (Vysloužilová, 2003)



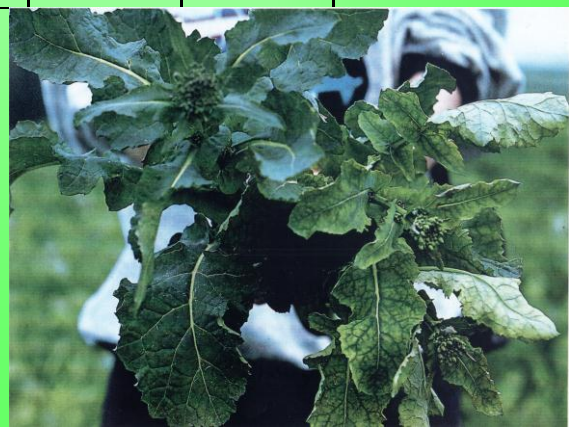




RS – rhizosphere
MRS – mycorhizosphere
2 mm – MRS mediated
BS – soil without root and mycorhiza influence

Removal of nutrients by agricultural crops and vegetables (kg.ha^{-1})

Plant		Yield (t.ha^{-1})	N	P	K	Ca	Mg
Wheat	total	5	125	26	100	21	12
	grain		95	20	25	-	6
Sugar beet	total	40	176	28	188	40	34
	roots		64	12	84	8	12
Potatoes	total	30	150	26	198	108	27
	tubers		75	14	105	63	7
White cabbage		70	238	42	266	196	21
Lettuce		10	23	5	35	14	2



Willows –remediation factor (%) per annum

Willow clone	Cd		Pb		Zn	
	pot	field	pot	field	pot	field
S. alba	7,2	3,6	0,012	0,05	1,73	2,04
S. smithiana	5,2	2,9	0,010	0,05	1,50	1,83
S. dasyclados	6,5	6,5	0,013	0,28	1,62	2,66
S. rubens	9,4	0,9	0,014	0,01	2,47	0,39

Conclusions

- **Soil has to be protected due to several very important functions**
- **Organic matter is an universal material improving soil properties**
- **Replacement of soil organic matter can be done by stable organic materials best are compost and manure.**
- **Rhizosfera is the most important inteface between soil and plant responsible for several unique processes,**
- **Plant can consume sufficient amount of nutrients depending on the ability to deplete soils.**
- **Several plants confirmed great ability to accunulate toxic compounds in their body helping with the cleaning of soil**

Thank you for your attention.