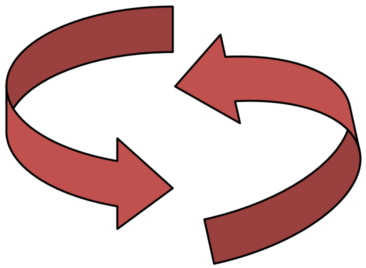
Phosphorus cycling by using biomass ashes

- a contribution to sustainable bioenergy production



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people, planet, profit

Criteria for evaluation of bioenergy must be related to social, ecological and economical aspects

Fotos, FAO

people, planet, profit

Reduced dependence from fossil fuels (oil…)

Alternative income opportunities, creation of jobs

Chances of development for rural areas

Reduction of green house gases

Diverse cropping systems

Utilization of wastes/residues

Substance and nutrient cycles

….

people, planet, profit

Food shortage

Disadvantages for developing countries

Market distortions and trading barriers

Destruction of natural habitats, Reduction of biodiversity

Reduction of water and soil quality

…..

Combustion of biomass

-Wood direct from forest (increment and residues)

-Organic wastes, wood industry residues, agricultural and food processing residues (kernels, shells), manure

- Energy crops from agriculture

Ashes contain nearly all nutrients except N

Real economical and ecological advantages
(recycling of valuable nutrients and saving limited resources)

⇕

Possible disadvantages connected with recycling.

⇕

Ashes - no declaration as a fertilizer

Heavy metal contents in biomass ashes – examples

Element mg/kg	sewage sludge*	wood (treated)	wood (natural)	wood Rostock	grain Rostock
Cu	470-1300	6914	164	90	171
Co		21	21		
As	4-40	17	4		-
Ni	40-100	180	66	21	13
Cr	60-170	470	325	43	14
Pb	80-270	2144	14	20	3
Cd	0.2 - 4	20	1	0,2	1
Hg	0.1-0.2	0.5	0.01	0.05	0.04
Zn	1540-2000	1234	432	720	750

* Average 7 ashes, Adam et al. 2007

1. **Depletion of natural resources**
2. **Closed P cycles for sustainable biomass production**
3. **P availability is considered to be low in biomass ashes**

Experiment- Utilization of P in ashes

Ashes

Poultry litter
Rape seed meal
Straw
Wood
Whole plant/grain

Soils

Loamy sand
Loamy clay

Crops

Catch crops
Main crops

Results

- Different P content levels in biomass ashes
  Generally, the rate of P soluble in citric acid is high

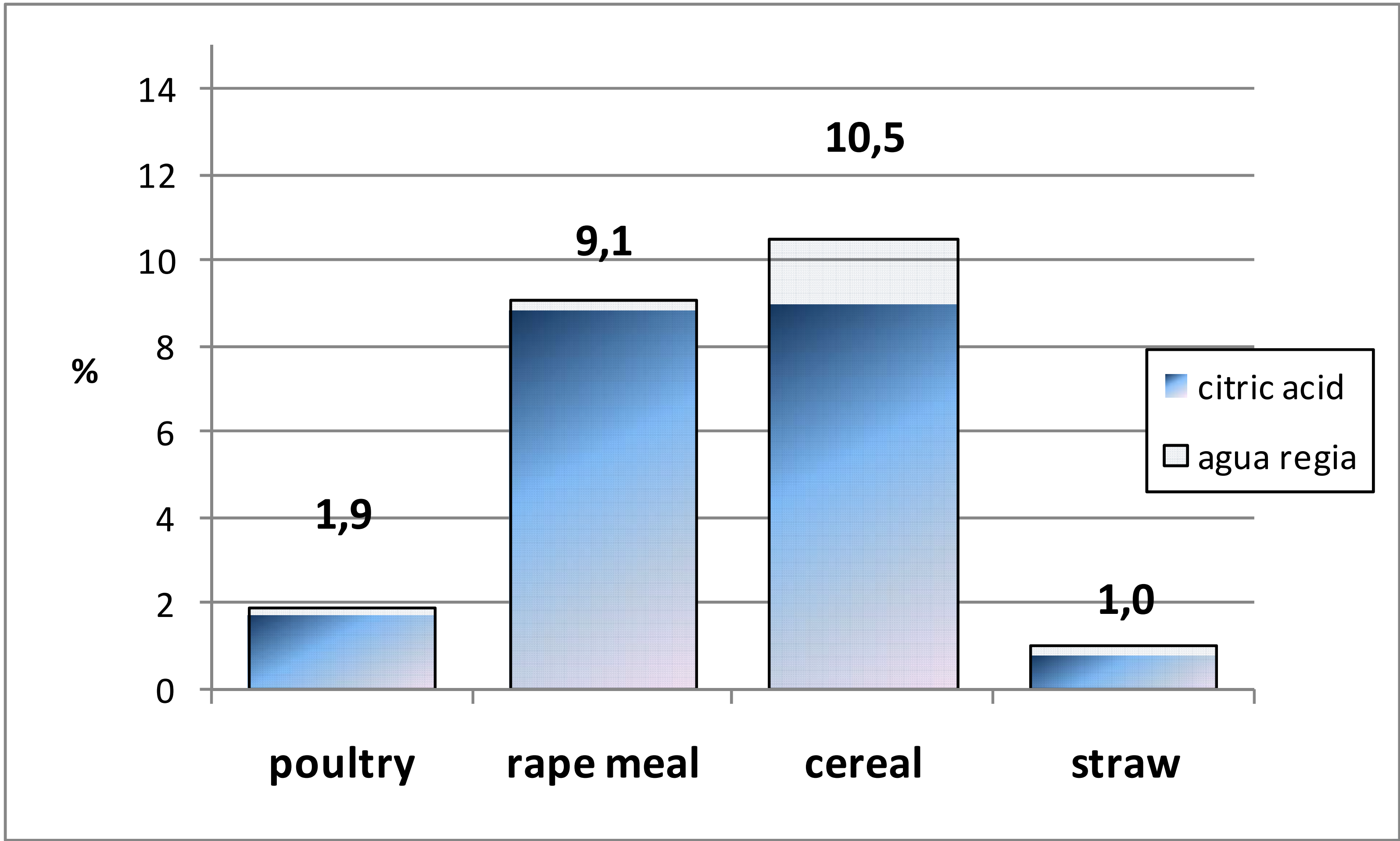
- Comparable P fertilizing effect
  biomass ashes vs. high soluble P forms (KH_2PO_4, TSP)

- Elevation of the high bio-available P pools in soil after ash application

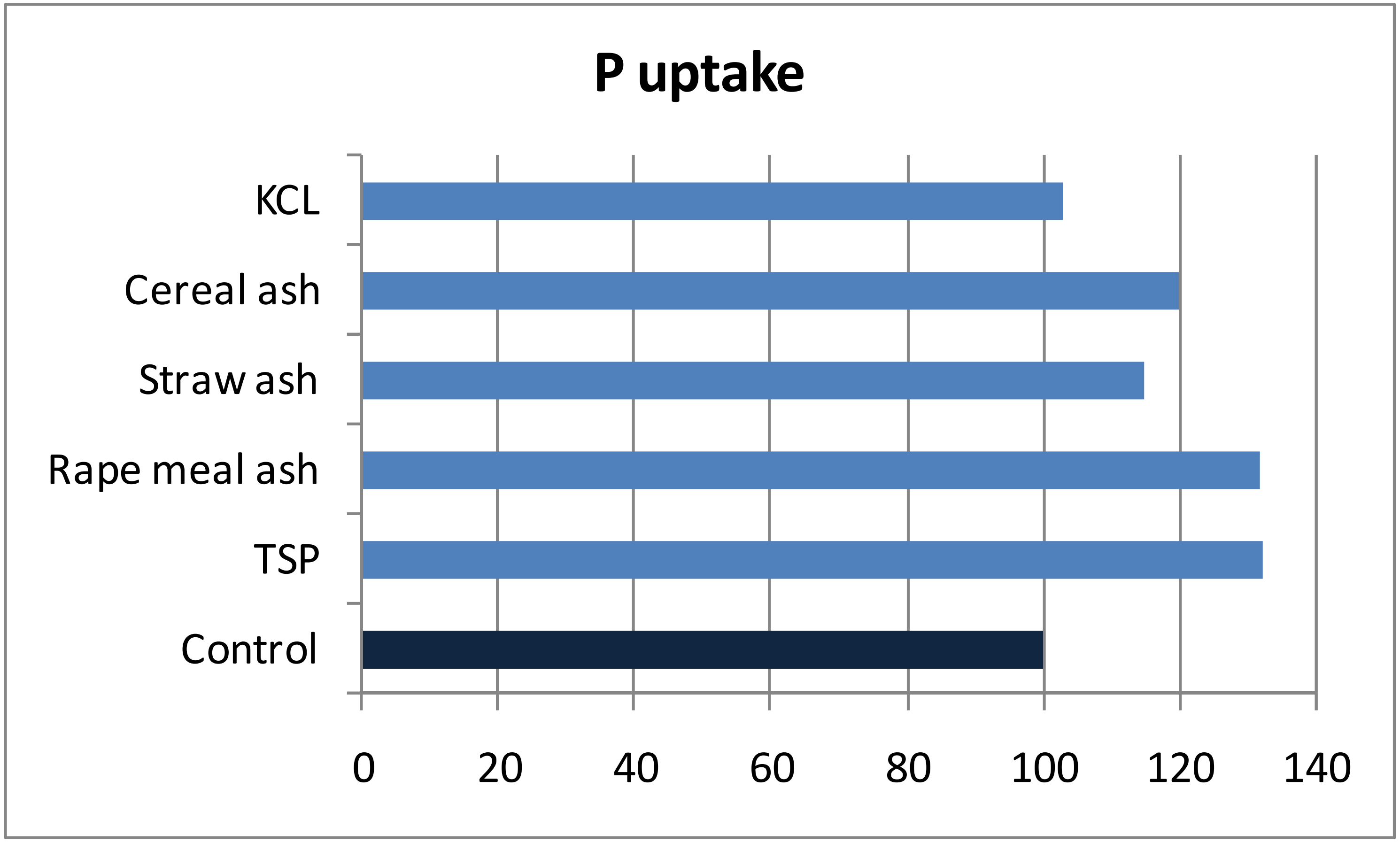
- No need for pre-treatment of ashes

Experiment- Utilization of P in ashes

P contents

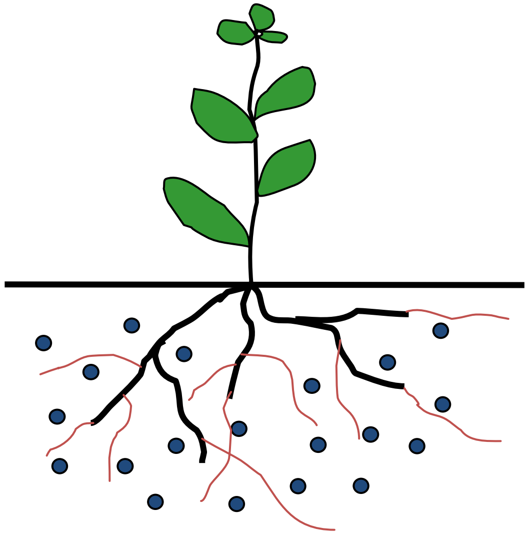


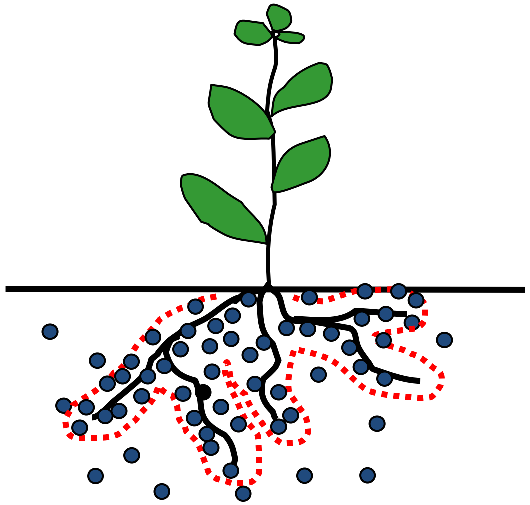
Plant P uptake



Schiemenz & Eichler, 2009

Interactions crops vs. fertilization





morphological

Enhanced spatial availability

- Enhanced root:shoot ratio
- Elongation of root hairs
- Enhanced formation of fine roots
- Enhanced mycorrhizal colonization

physiological

Enhanced chemical availability

changes in rhizosphere chemistry (pH; redox potential)

release of organic acids and enzymes

modified: Neumann & Römheld 2002, Hahn 2005

Plant P uptake

Treatment	maize	rape	rye grass	barley	lupin	phacelia	oil raddish	b.wheat
Control	100	100	100	100	100	100	100	100
TSP	146	145	141	133	131	128	120	113
Rape meal ash	133	142	141	126	142	137	116	118
Straw ash	122	129	115	117	108	136	85	109
Cereal ash	134	114	130	104	103	129	120	123
KCl	94	101	85	113	109	116	97	110
p (duncan)	0.000***	0.000***	0.000***	0.000***	n.s.	0.039*	0.004**	n.s.

rel. values, pot experiment 2007, 6 kg sandy soil,
Sign. interactions crop x fertilization, 2-factorial analyses of variance

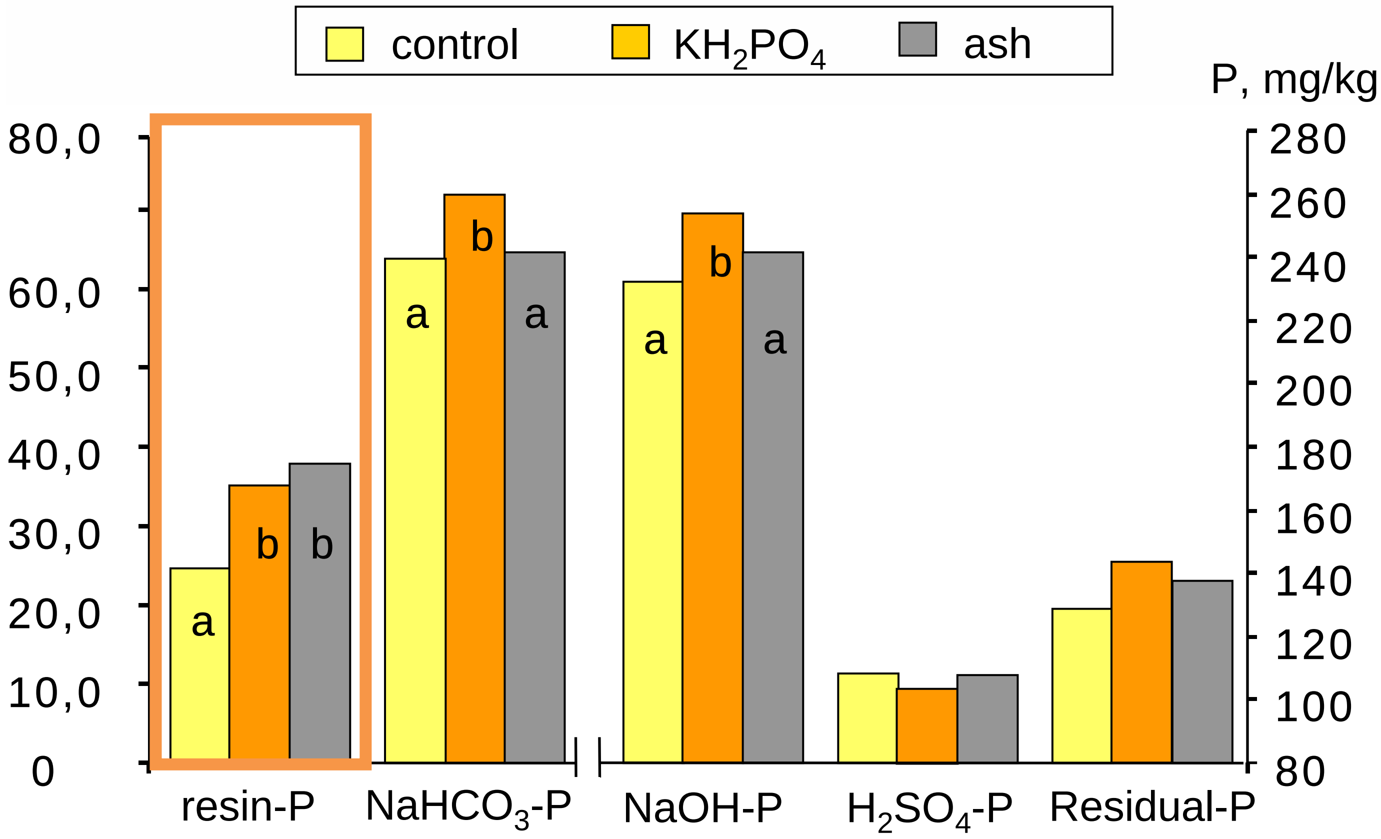
Soil P pools

Treatment	pH	Pw mg kg^{-1}	Pdl mg kg^{-1}	Pt mg kg^{-1}	Pox mmol kg^{-1}	DPS %
Control	5.31	8.59	30.3	516	11.9	40.1
TSP	5.30	12.98	39.0	533	12.6	41.8
Rape meal ash	5.41	12.53	38.8	534	12.8	42.4
Straw ash	5.52	12.84	41.6	526	12,4	41.9
Cereal ash	5.34	12.79	39.7	530	13.1	43.2
KCl	5.22	8.23	31.6	509	12.2	40.6
p	*0.024 **	*0.000****	*0.000****	*0.003***	*0.000****	*0.000****
LSD (0.05)	*0.11*	*3.01*	*6.63*	*15.0*	*0.55*	*1.20*

Pot experiment 2007, 6 kg soil per pot, after 6 weeks

Schiemenz & Eichler, 2009

Soil P pools

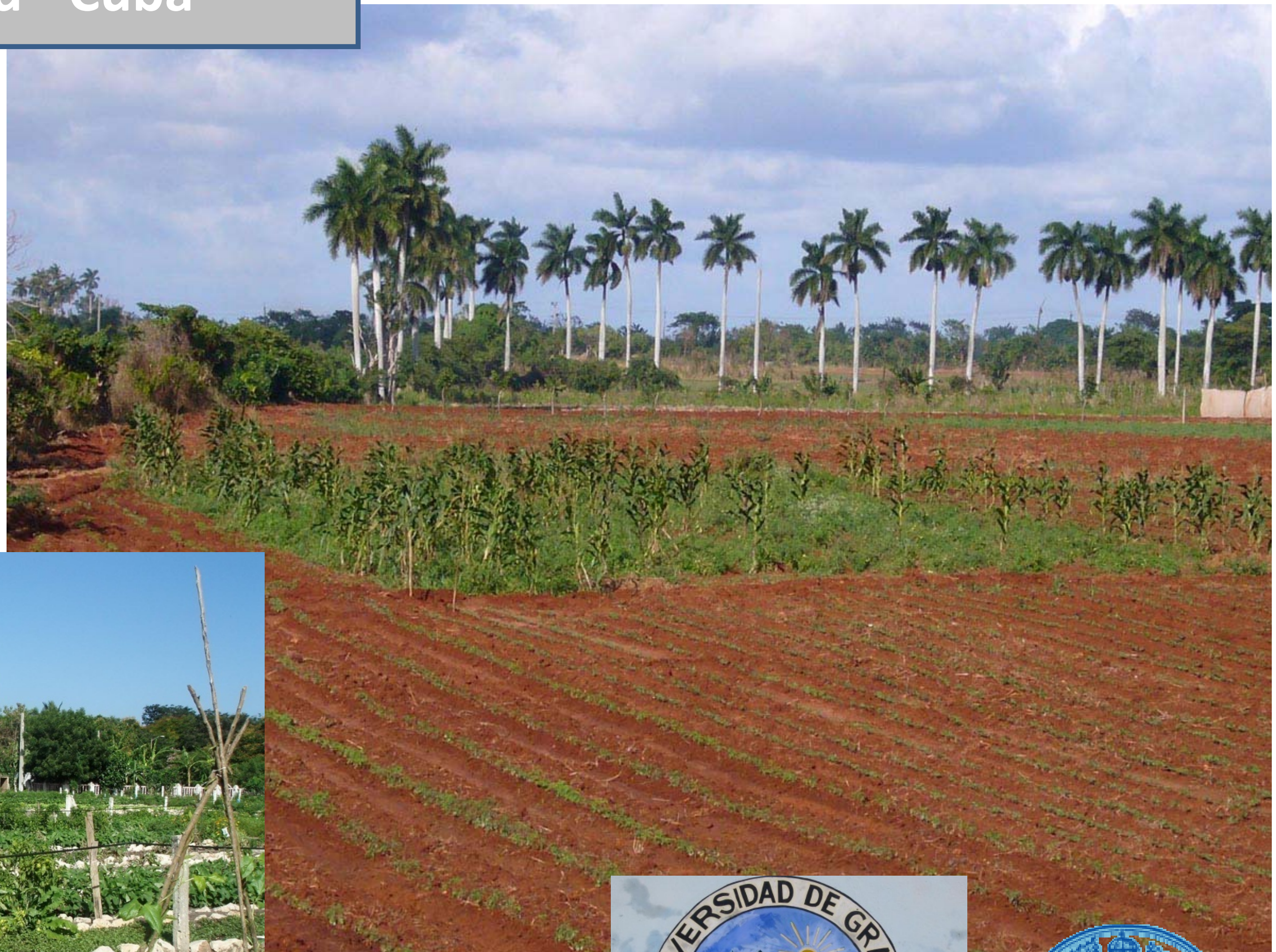


Pot experiment, 6 kg soil per pot, after 8 weeks

Bachmann & Eichler, 2008

Experiment- Utilization of P in ashes

Vegetable yield - Cuba



Vegetable yield - Cuba

Effect of sugar cane ash (SCA) on lenght, diameter of fruits (cm) yields of fruits (kg/m^2) and P uptake of shoots (g/m^2) of cucumber

	Control	SCA	Residual SCA effect
Lenght of fruits	20.33 a	29.21c	23.41 b
Diameter of fruits	5.62 a	7.87 c	6.21 b
Yield	2.10 a	3.14 c	2.70 b
P uptake (shoot)	5.66 a	13.8 c	8.64 b

different letters indicate significant statistical differences between the treatments, $p<0.005$ (Duncan)

Lopez et al., 2009

- Increasing importance of biomass as a source of energy requires sustainability criteria
- Ashes are an important nutrient source and may have a positive fertilizing effect
- P utilization depends on the kind of ash, cultivated crops and on soil parameters
- Possible risks have to be considered with respect to soil and water protection and food chain

Figure: Obernberger

Supported by
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(FNR)

Thank you for attention

Nutrient amounts fertilized

Treatment	P (g/pot)	K (g/pot)
Control	-	-
TSP	0.2	-
Rape meal ash (2.5 g)	0.2	0.2
Straw ash (9.8 g)	0.1	0.5
Cereal ash (1.9 g)	0.2	0.2
KCl	-	0.5

NH_4NO_3 – 1.4 g, $MgSO_4$ – 1.5 g

Pot experiment 2007