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Comparison of phosphate recycling products with regard to plant availability

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Soils and tested substances

	soils	CAL-P mg P/100g	P supply level (class)	pH	
	clay	1.8	poor (A)	7.1	**field** 3 years crop rotation
pot 2 years maize	alluvial loam	2.3	poor (A)	6.8	
	decalcified loess	1.9	poor (A)	5.6	
	sand	2.4	poor (A)	5.5	

precipitated P

MAP – 1

MAP – 2

MAP – 3

Ca – P (apatite)

ashes

meat-and-bone meal ash (mb-ash)

heavy metal stripped
sewage sludge ash (ss-ash)

thermal P

sinter-P

cupola furnace slag (cupola)

controls

unfertilized

triplesuperphosphat

triplesuperphosphat (high dose)

rock phosphate

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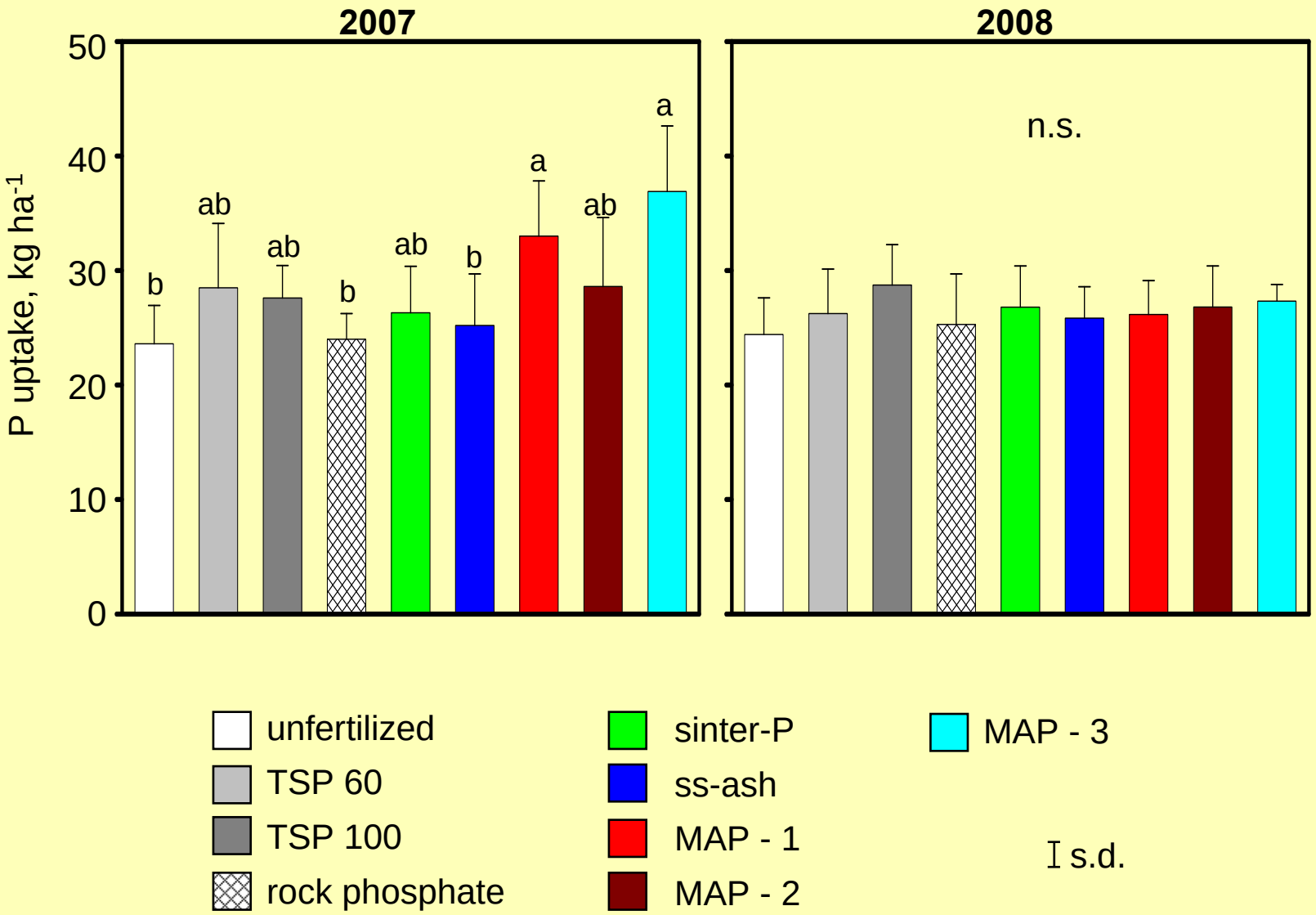
P uptake in field experiments in 2007 and 2008

average over all sites and crops



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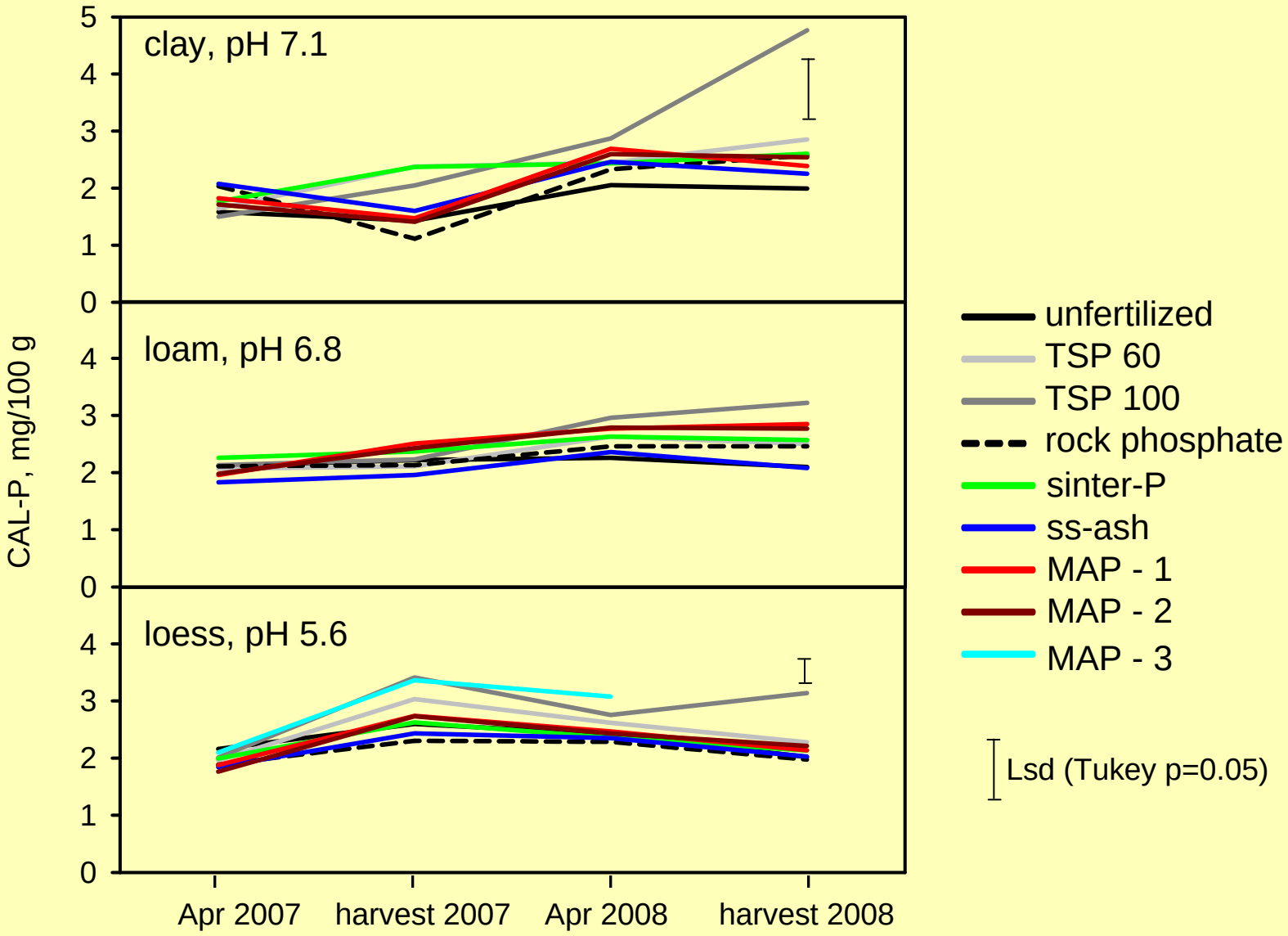
Development of the CAL extractable P over two years



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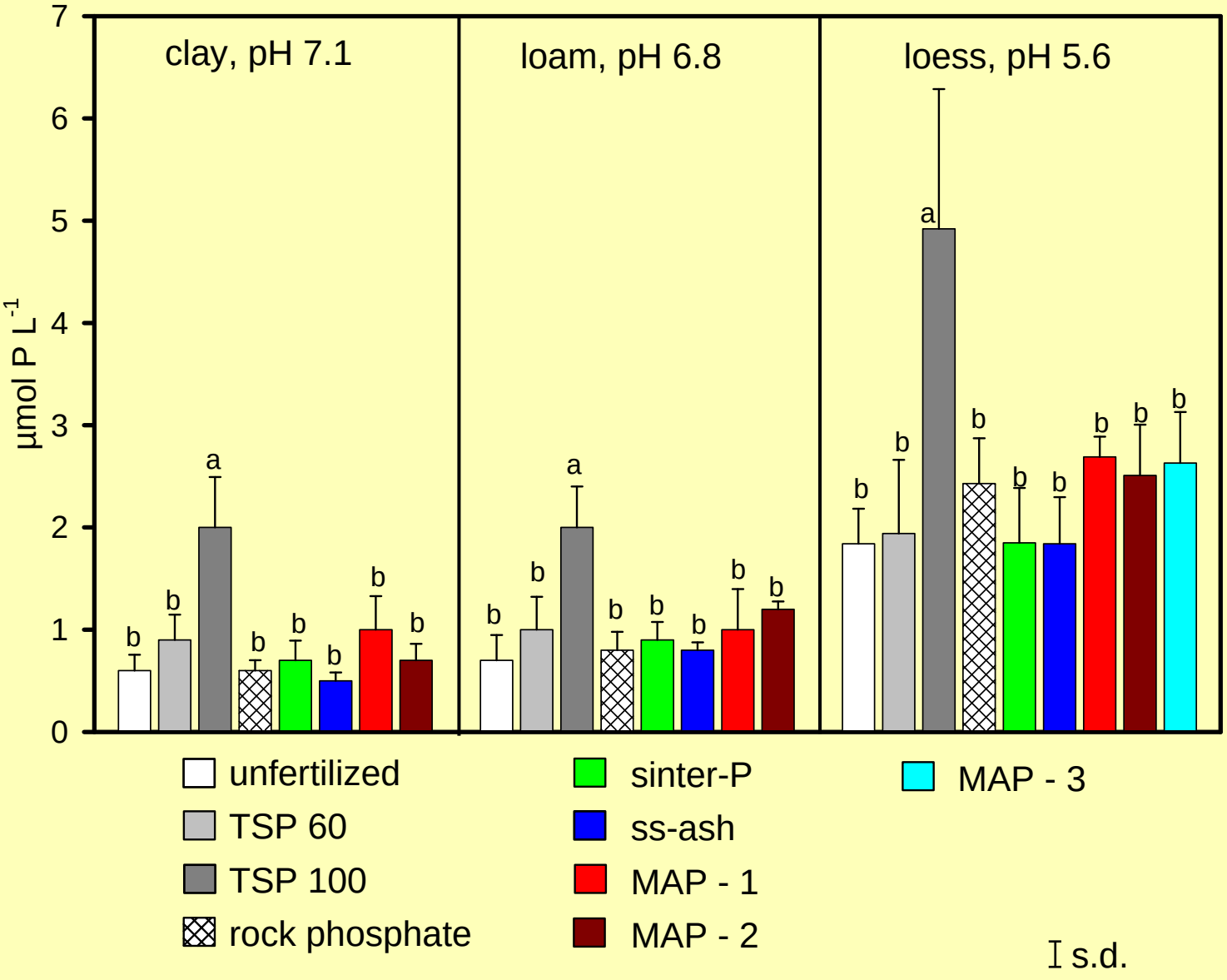
Soil solution P concentration at harvest 2009

(2.5 years after fertilization)



Intermediate results of the field experiments

- Plants were able to take up enough phosphorus despite the low supply levels of the soils.

  Therefore, a clear fertilizer effect of the used substances was not evident.

- In the first year, magnesium ammonium phosphates (MAP) seemed to perform slightly better than thermal phosphates.

- There was no visible long-term effect of the fertilizers with regard to plant availability.

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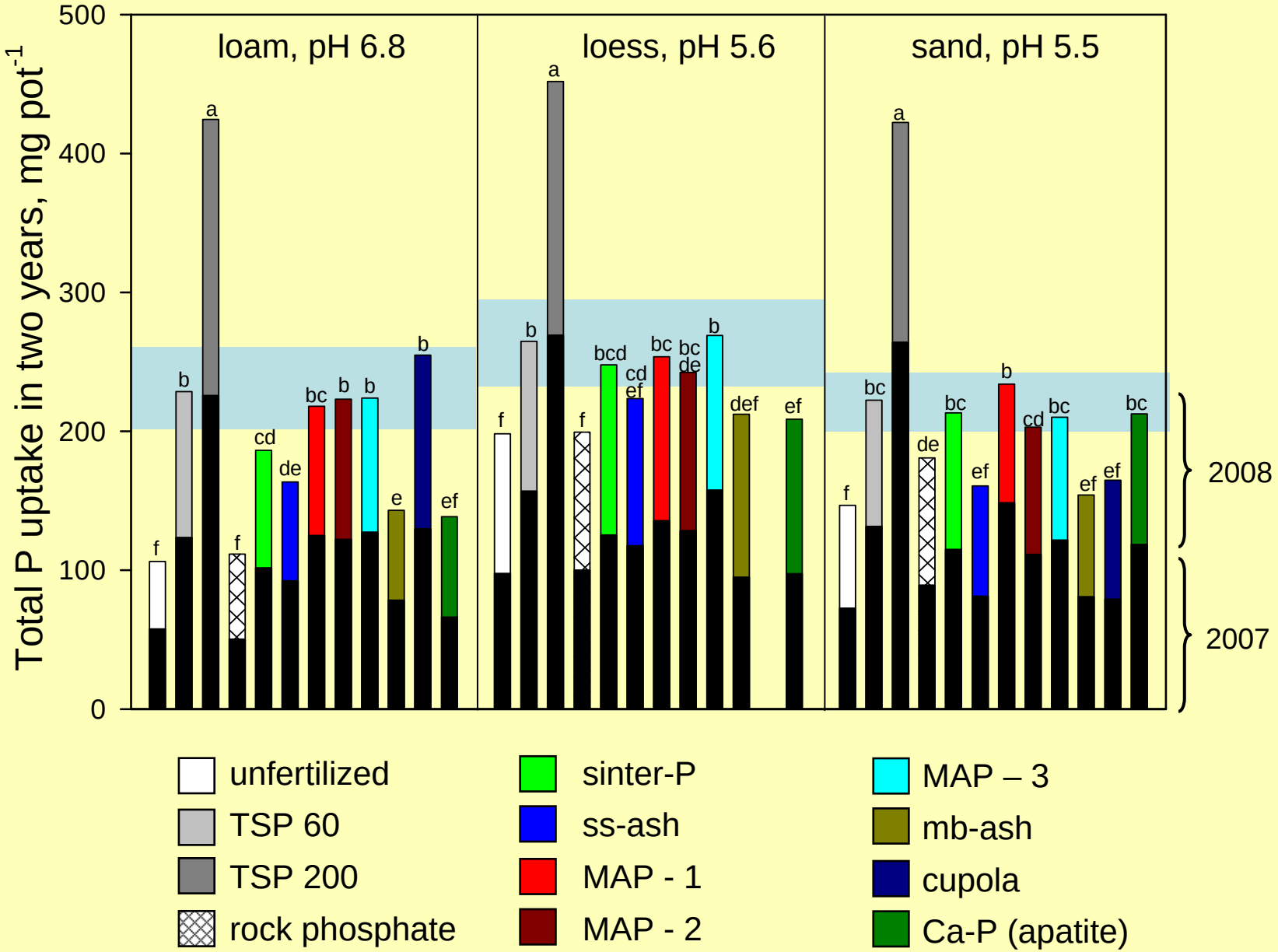
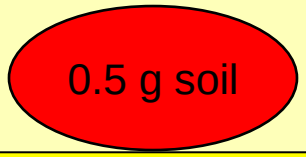
Total P uptake of maize over two years

(P-fertilization in 2007, 2 plants per pot with 5.5. kg soil)





	inorganic-P	organic-P
30 mL H_2O with resin strip (16h)	exchangeable P	
30 mL 0.5 M $NaHCO_3$ shaking for 16h	readily plant available	easily mineralizable
30 mL 0.1 M NaOH shaking for 16h	associated to amorphous and crystalline Al and Fe	slowly mineralizable
30 mL 1.0 M HCl shaking for 16h	hardly soluble Ca-phosphates	
10 mL conc. HCl 80°C für 10 min + 1h bei 20°C	stabile P	P from larger organic particles
$H_2SO_4 + H_2O_2$ 360°C	residual P	

(Tiessen und Moir, 1993)

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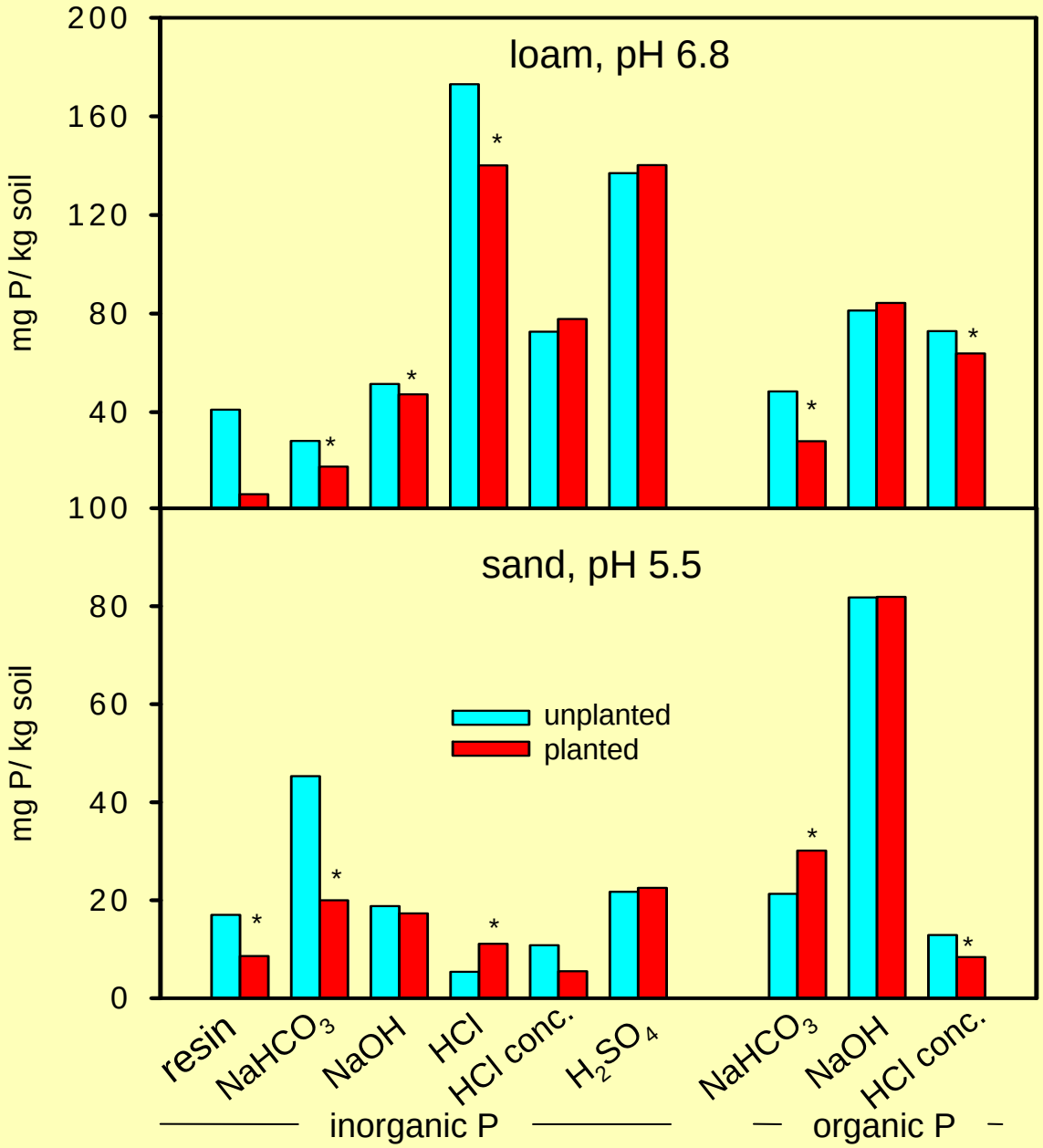
From which fraction is the phosphorus taken up by plants ?

Comparison of planted and unplanted soils without P-fertilization



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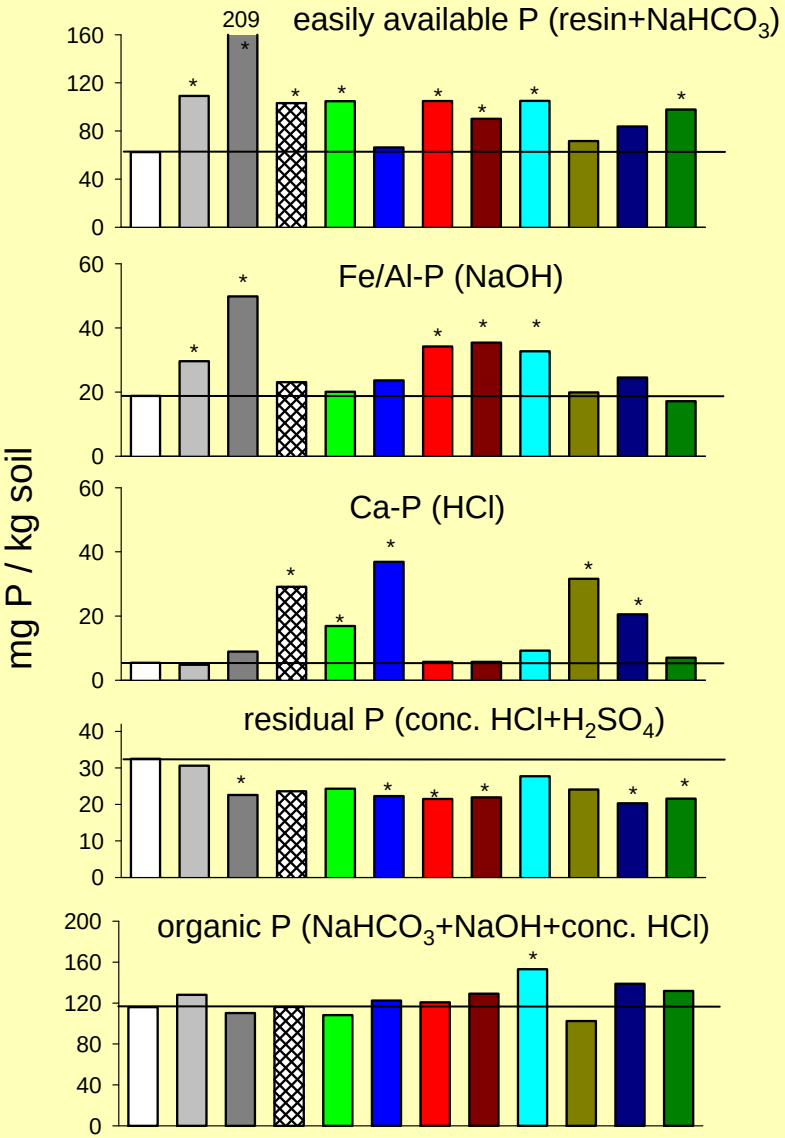
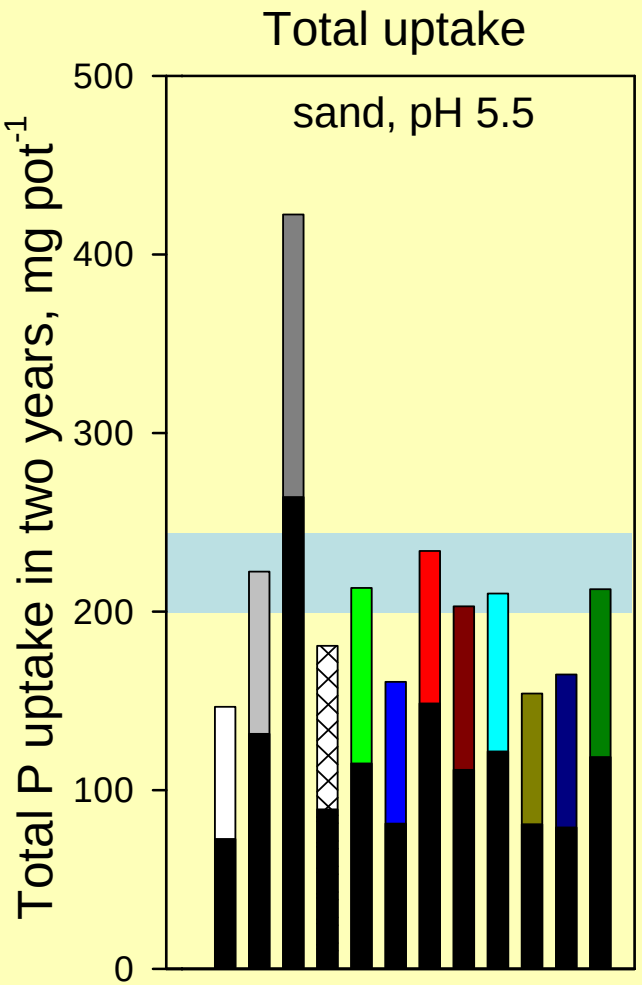
Changes in P fractions of the sandy soil due to fertilization



* significant different to unfertilized soil

unfertilized
TSP 60
TSP 100
rock phosphate
sinter-P
ss-ash
MAP-1
MAP-2
MAP -3
mb-ash
cupola
Ca-P (apatite)



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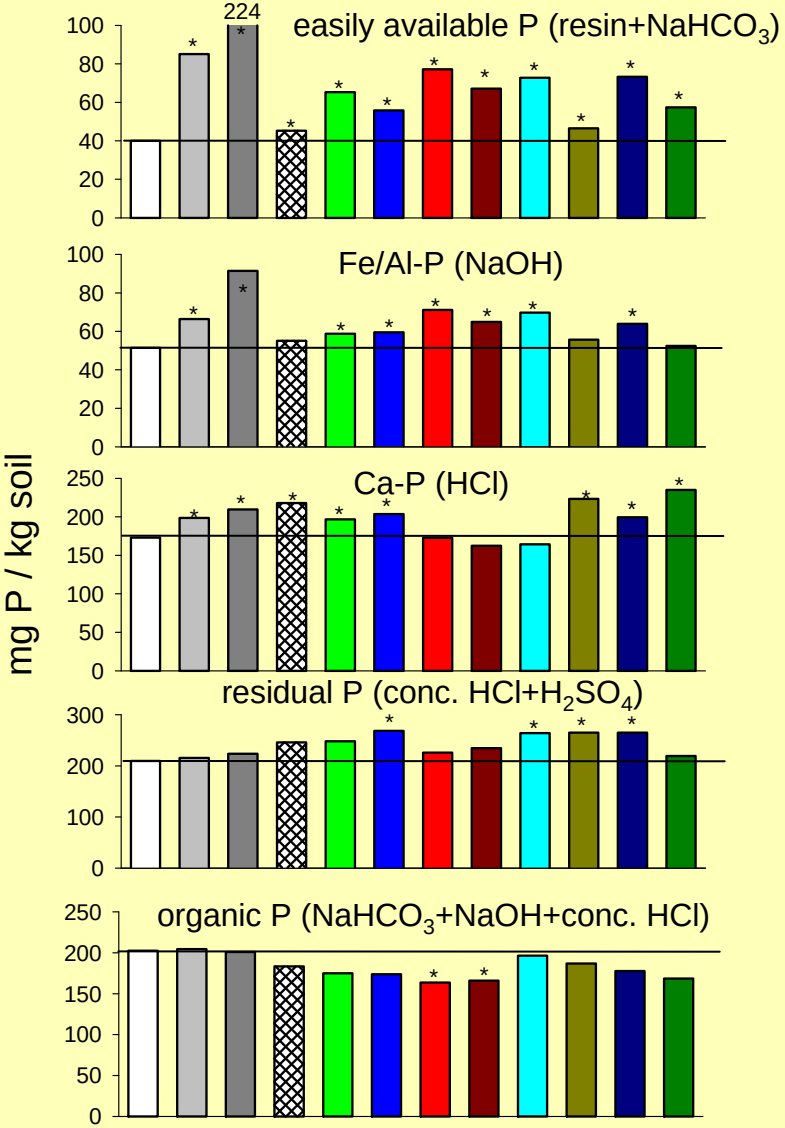
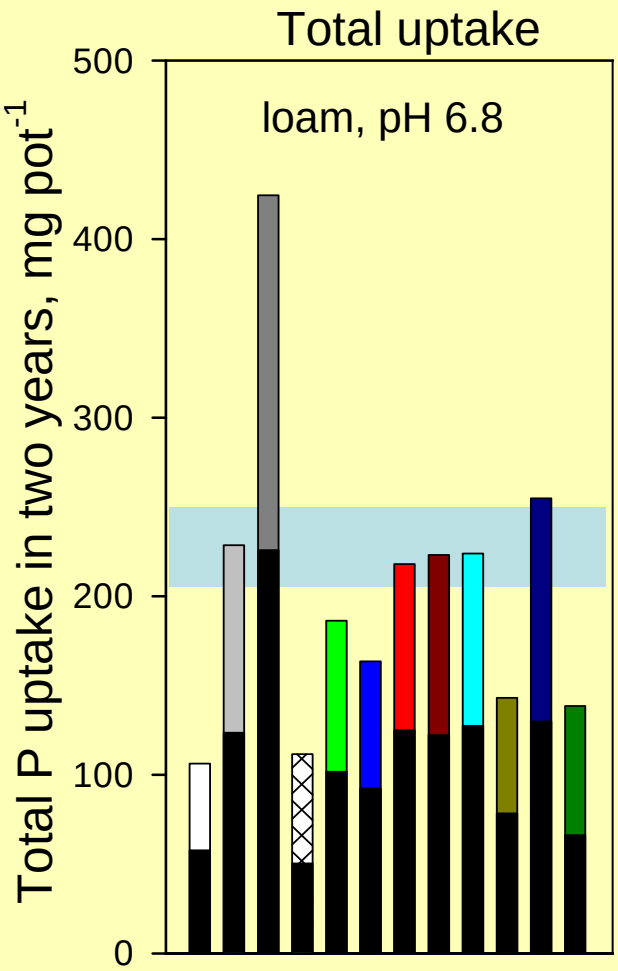
Changes in P fractions of the loamy soil due to fertilization





* significant different to unfertilized soil

unfertilized
TSP 60
TSP 100
rock phosphate
sinter-P
ss-ash
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MAP -3
mb-ash
cupola
Ca-P (apatite)

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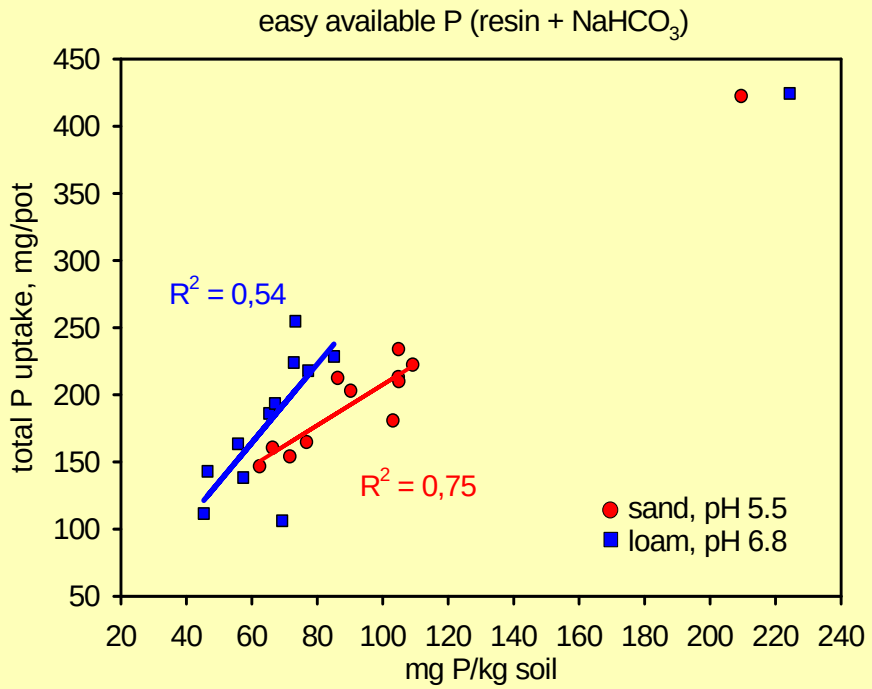
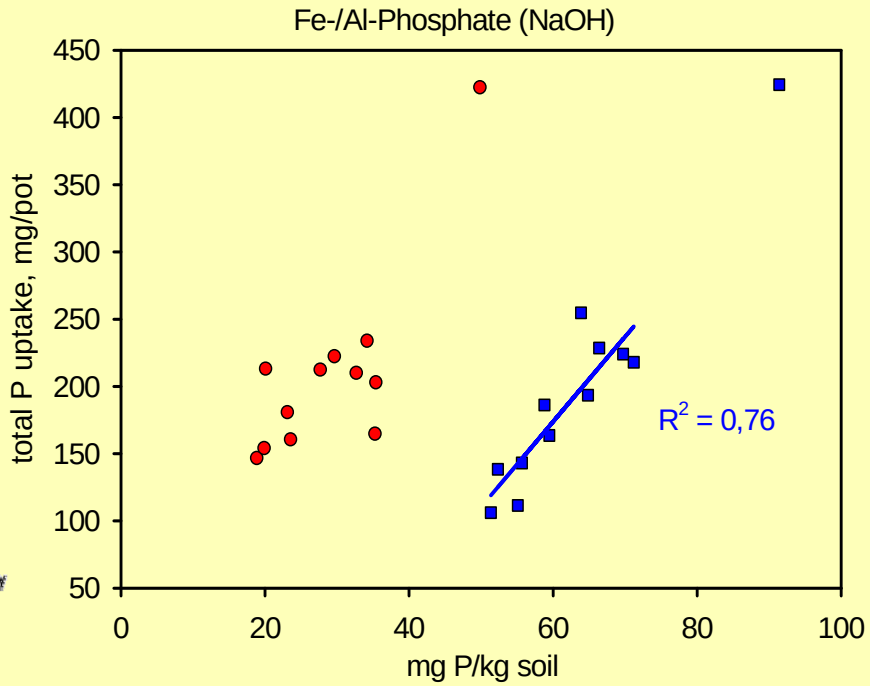
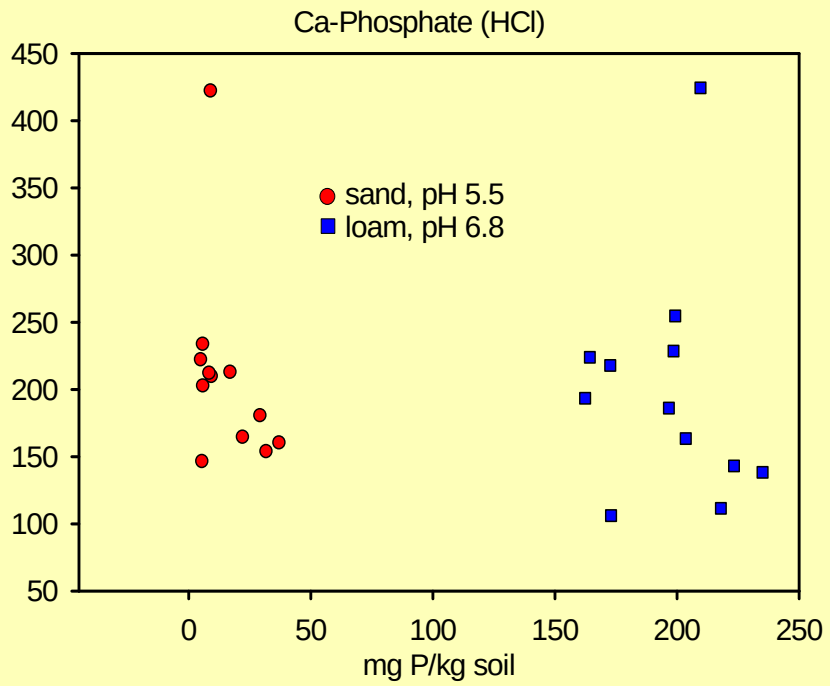
Relationship between P fractions and P uptake







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Conclusions from the pot experiments

- **The tested substances differed in their short-term plant availability:**

  TSP ≈ MAP > thermal P > ashes ≈ Ca-P ≈ rock phosphate

- **Phosphate uptake is mainly from the fractions:**

  resin (exchangeable)

  $NaHCO_3$ (easy available P, mainly Fe/Al-P)

  NaOH (stronger bound Fe/Al-P)

- **TSP and MAP showed a higher P dynamic and appeared faster and/or to a larger extent in the resin and $NaHCO_3$ fraction than the other fertilizers.**

- **Less soluble Ca-P like ashes, thermal P or apatite could not be used by the plants.**

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Thank You for Attention

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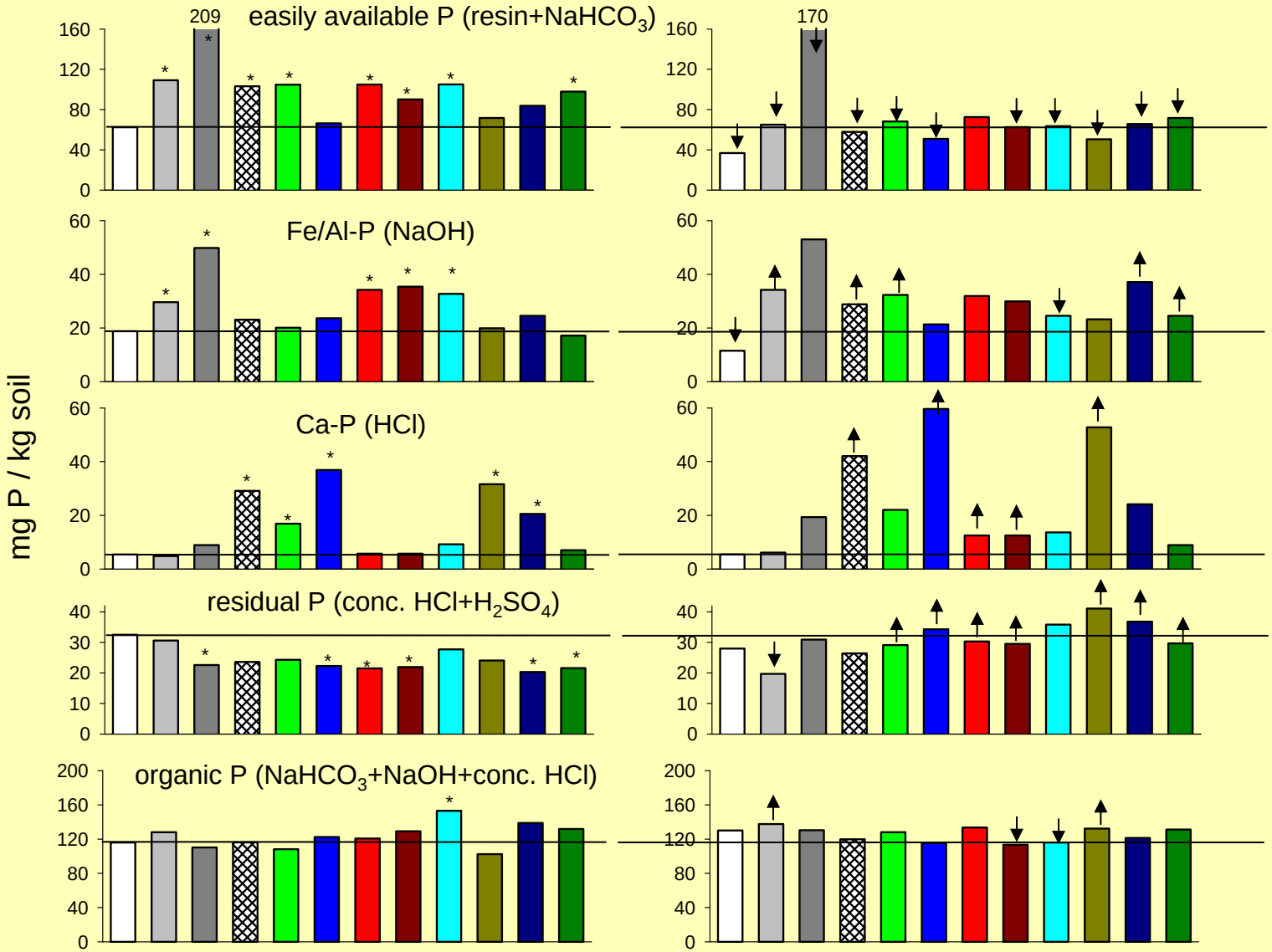
Changes in P fractions of the sandy soil due to fertilization .....and plant uptake



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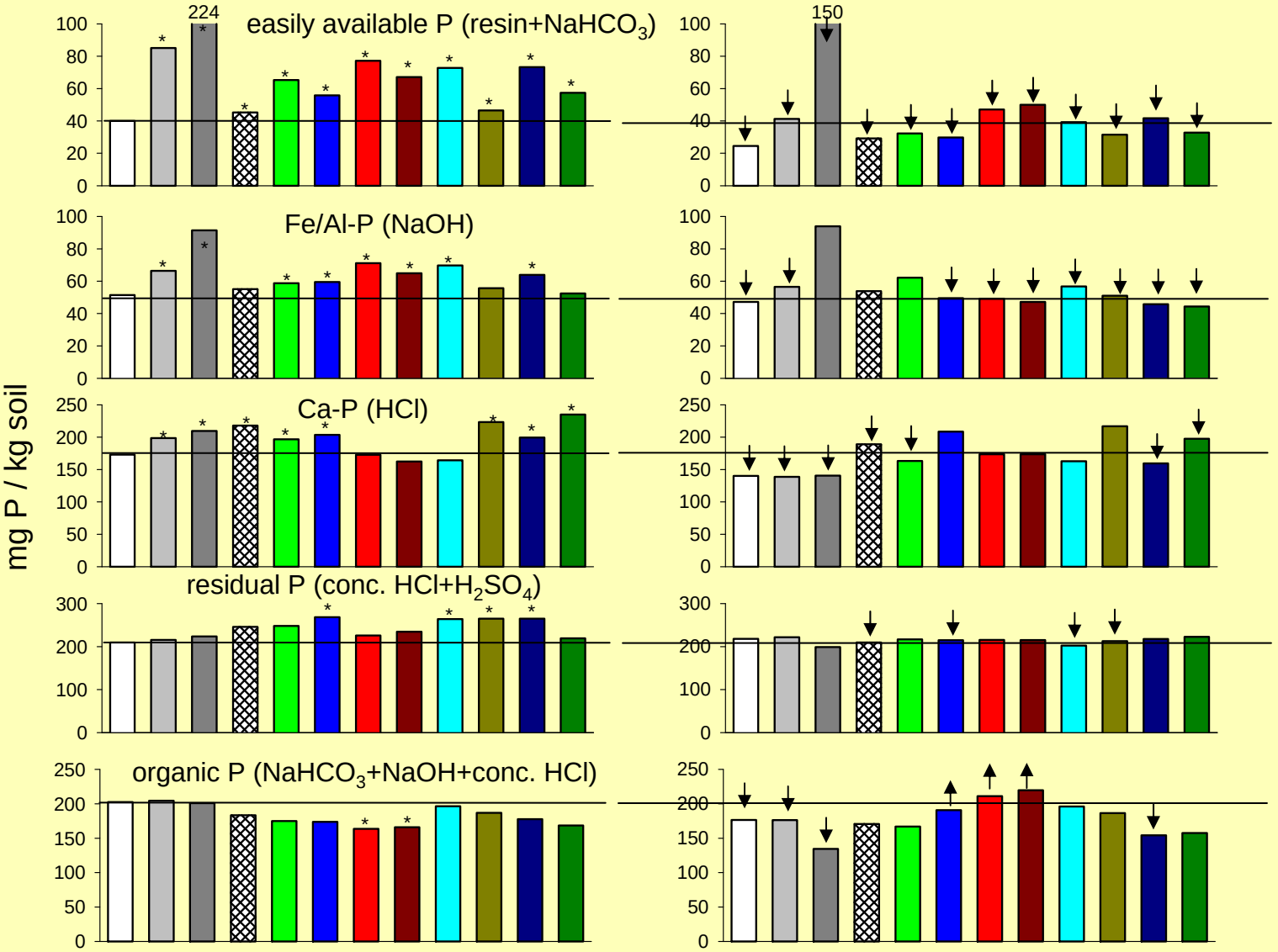
Changes in P fractions of the loamy soil due to fertilization .....and plant uptake



* significant different to unfertilized soil

↓ significantly decreased
↑ significantly increased
compared to unplanted control

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Relative P acquisition of rye seedlings

fertilizer	%P	%P water	%P citric acid	relative P acquisition
$Ca(H_2PO_4)_2$	25	95	96	100 %
apatite (Kola)	15	0	8	10 %
sinter-P (Rhenania type)	11	1	83	63 %
basic slag (Thomas-slag)	6	0	100	43 %
struvites (Ø)	12	2	100	119 %

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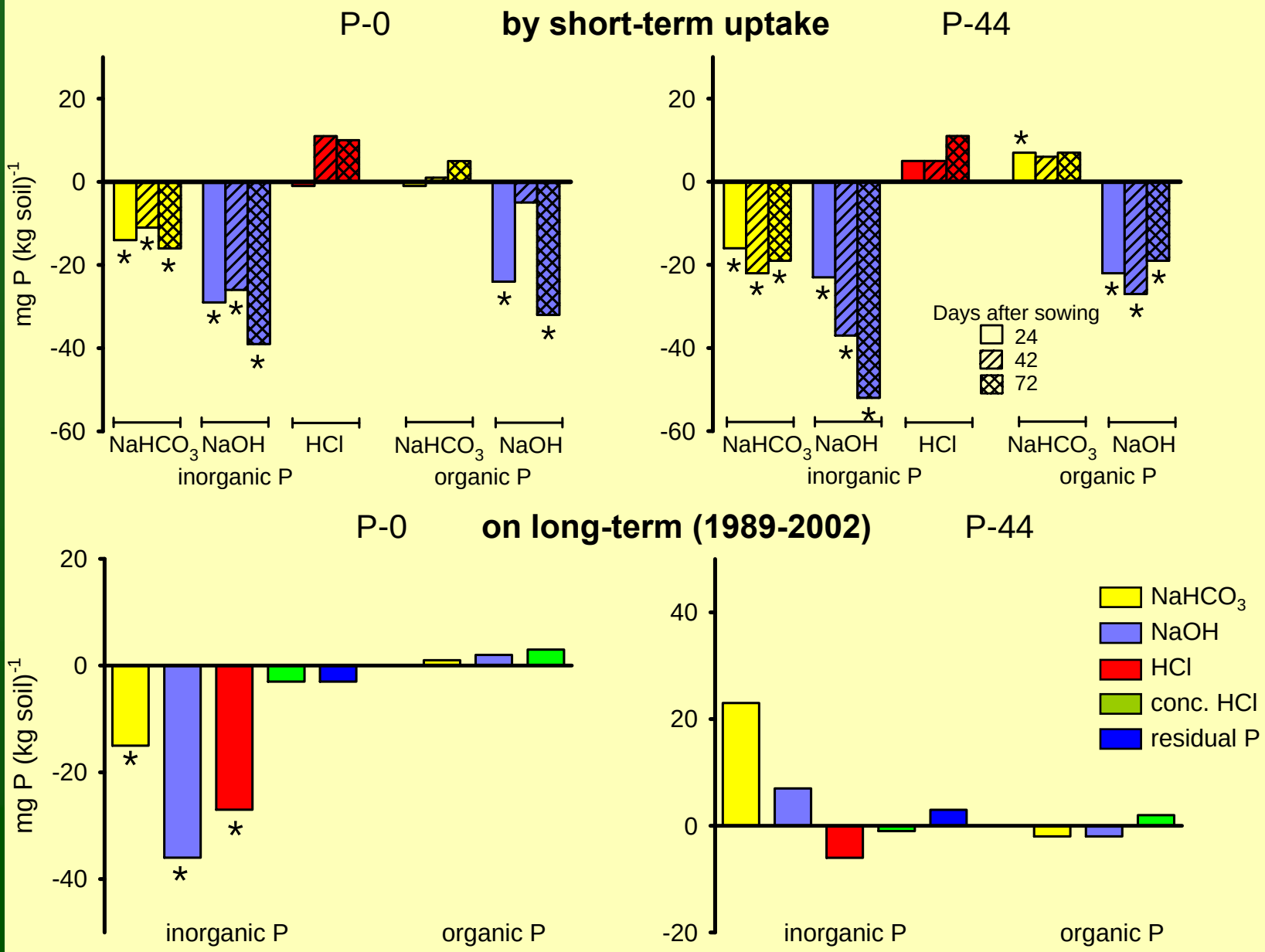
Römer (2006) J. Plant Nutr. Soil Sci. **169**, 826-832

Changes in P fractions in sand



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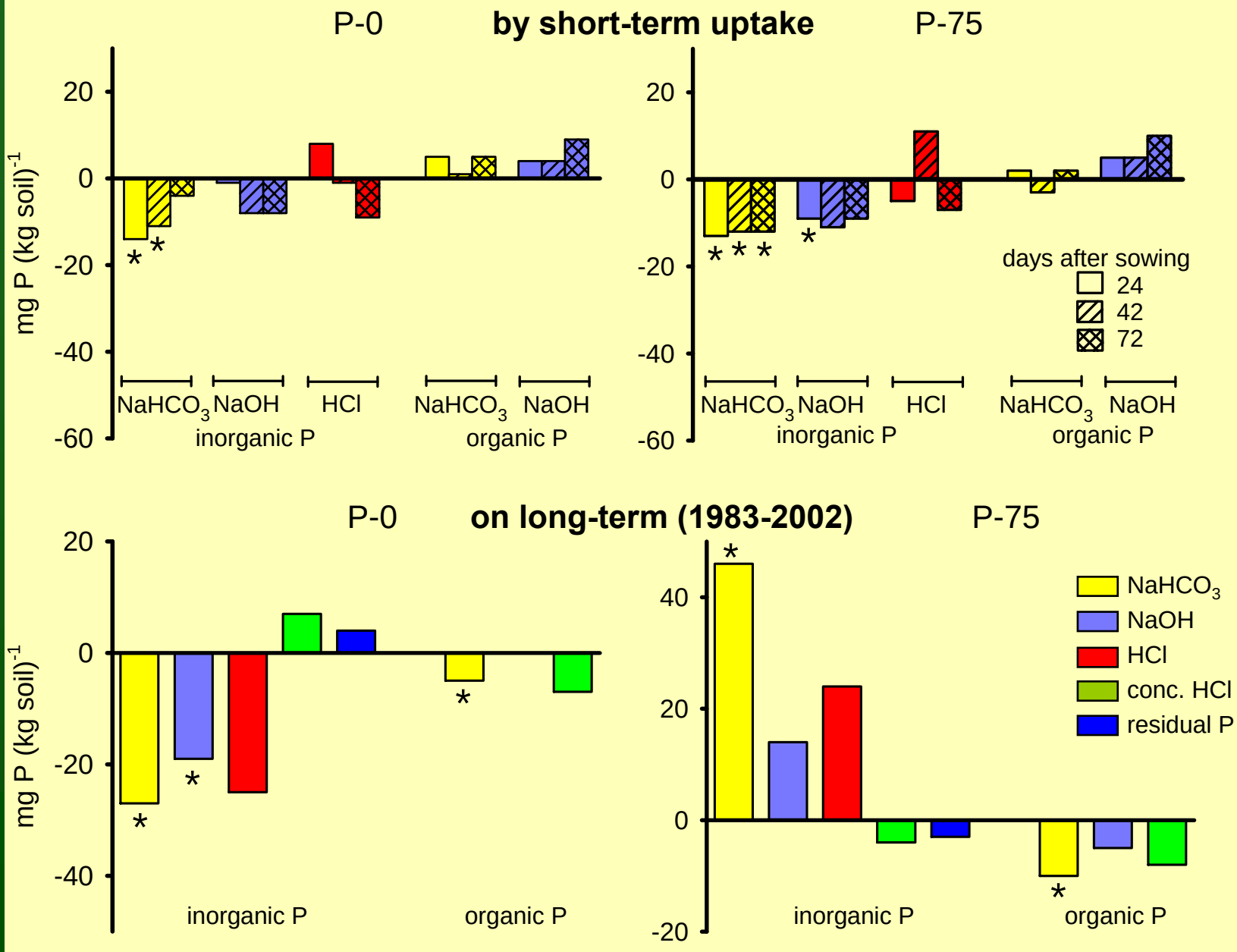
Changes in P fractions in loam



Changes in P fractions on loam at a fertilization with 75 kg P ha^{-1} yr^{-1} (3 times the P removal) as triple-superphosphate or rock phosphate (soil-pH 7,2)