Factors affecting the water extractable phosphorus from compost

M. Grigatti , L. Cavani, S. Mancarella, L, Sciubba, C. Ciavatta, C. Marzadori

Department of Agricultural Sciences

Alma Mater Studiorum – University of Bologna - Italy

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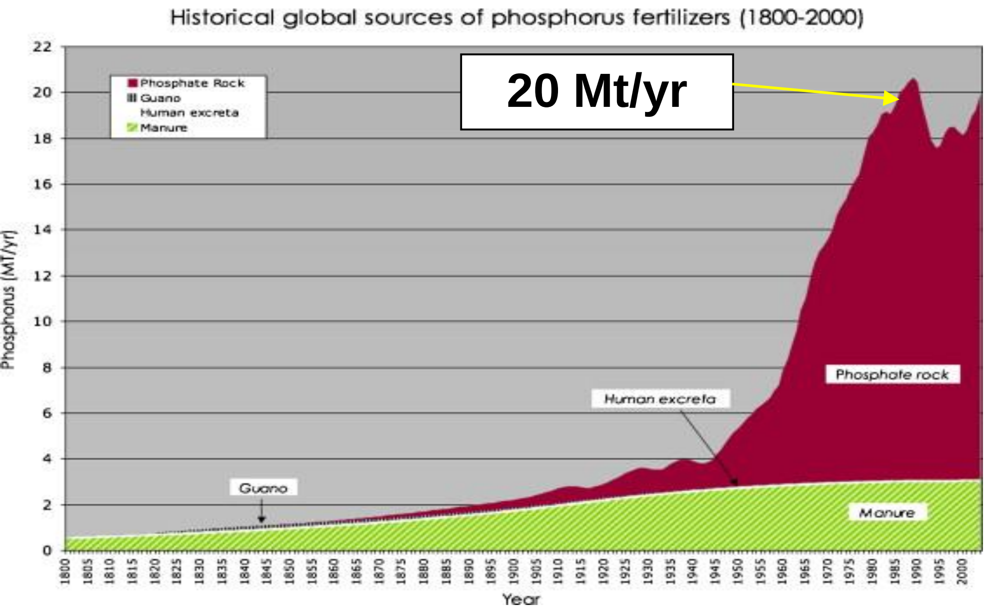
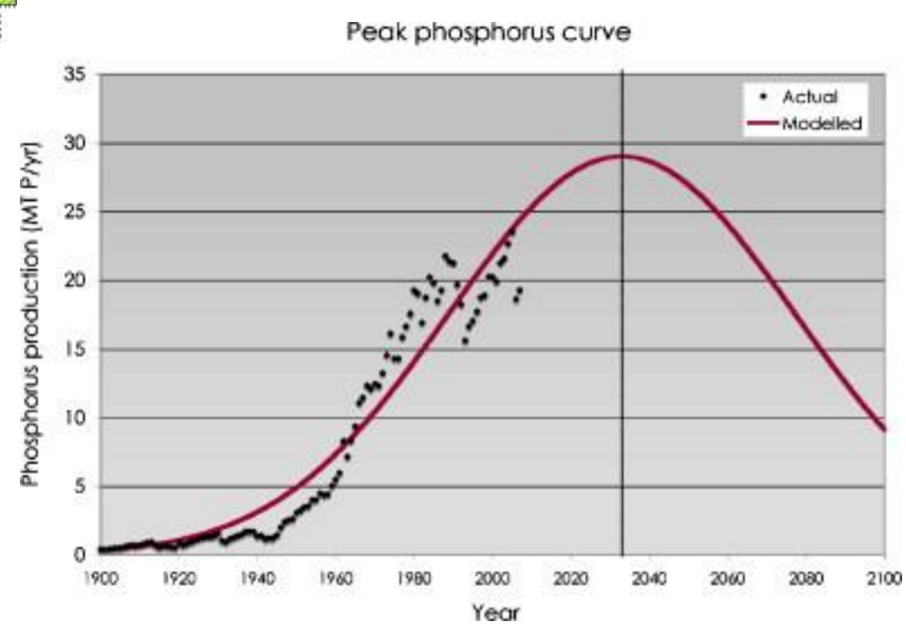
Future P lack



Phosphate rock are utilized to produce P fertilizers, (Cordell et al., 2009)

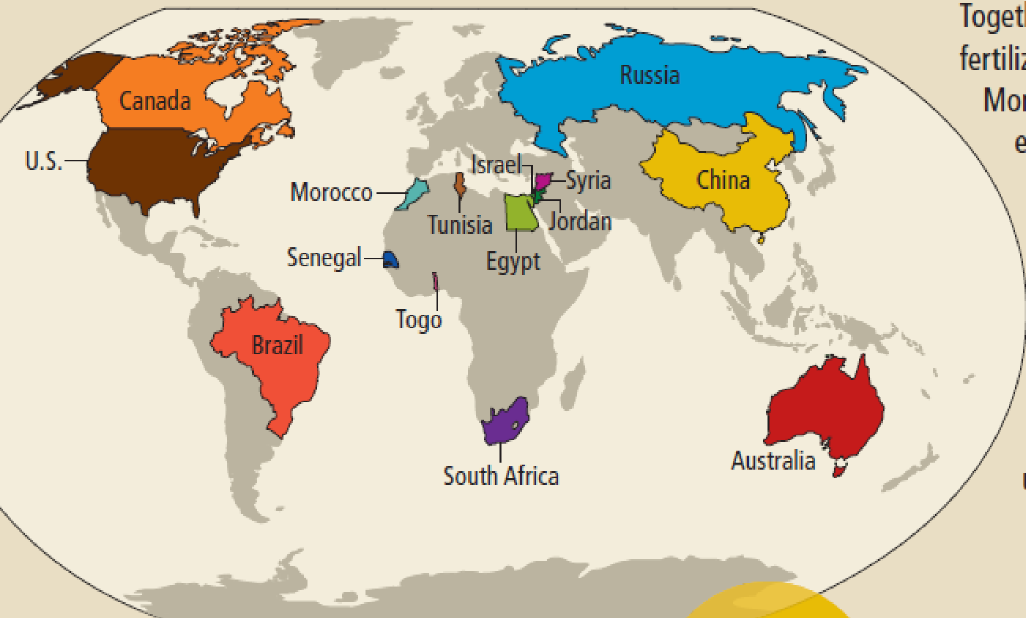
"Phosphorus Peak"
(Jasinski, 2006; EFMA, 2000)



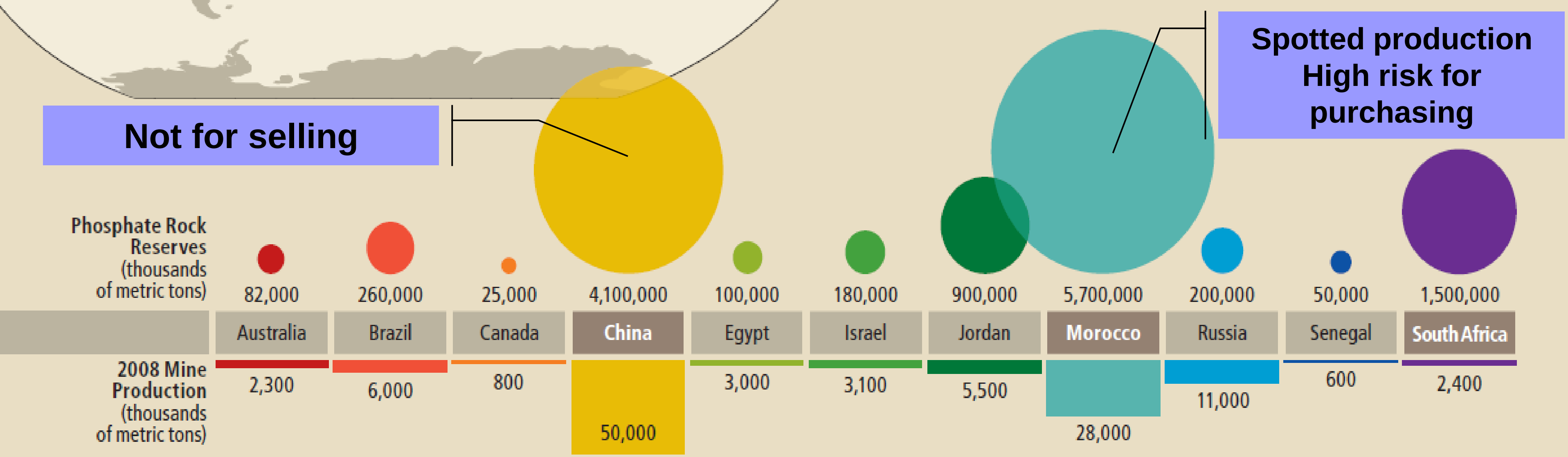
Introduction

Future P lack

CONCENTRATED RESOURCES



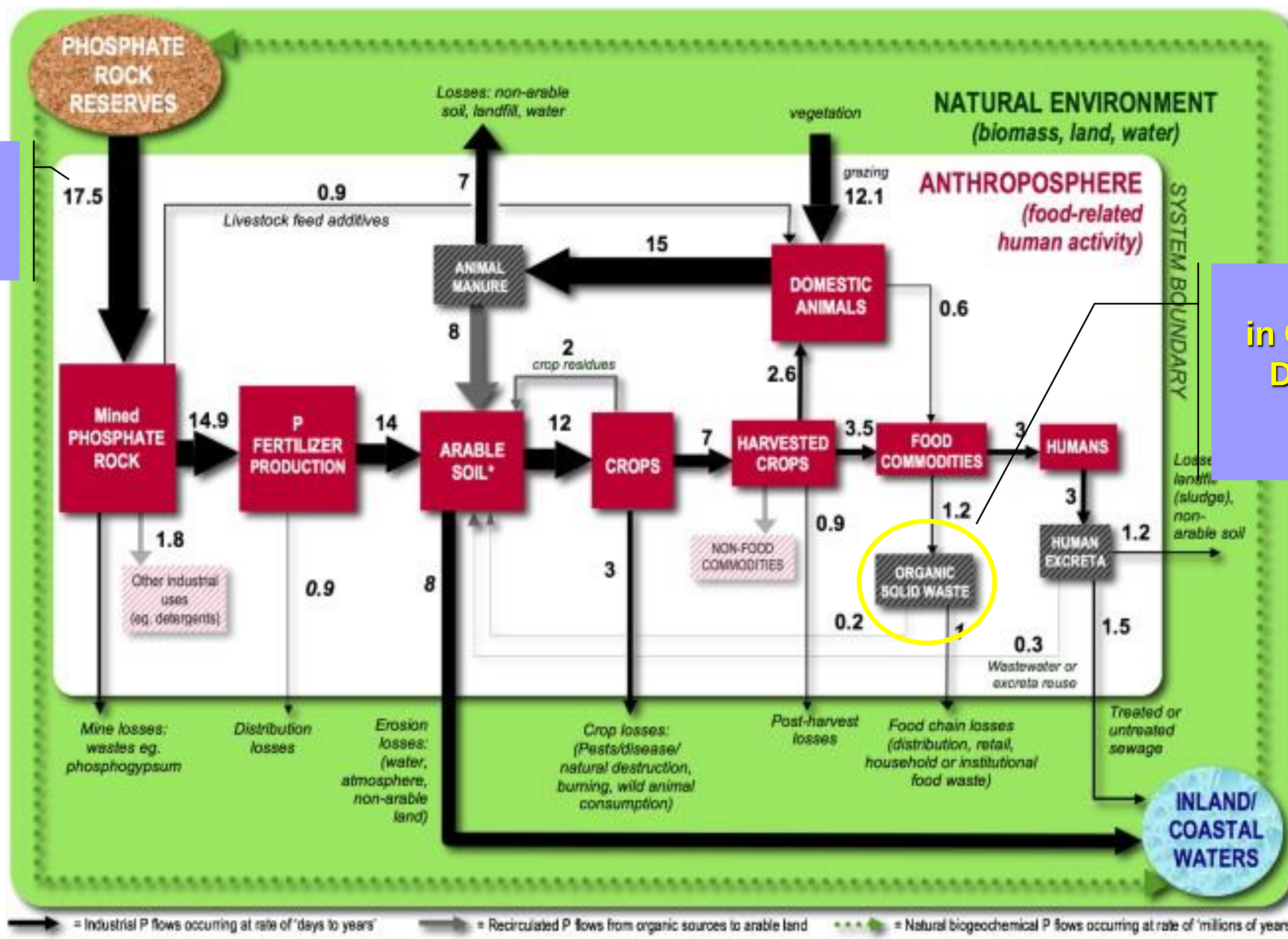
Together with nitrogen and potassium, phosphorus is a crucial ingredient in fertilizer. It is extracted from phosphorus-rich rock in the form of phosphate. Morocco, China, South Africa and the U.S. hold 83 percent of the world's easily exploitable phosphate rock and contribute two thirds of the annual phosphorus production (*circles, below*). At current rates of extraction (*bars, below*), known U.S. reserves are projected to last 40 years. Globally about 90 years' worth of phosphorus remains. Once the resource starts running out, less economical supplies may have to be tapped, which could result in higher prices and market disruptions. Already production has been declining despite the incentive of increasing prices (*graph, right*); last year the price spiked up because of tight supply and increased demand.



Introduction

P cycle in the food and non-food crop production (Cordell et al., 2009)

P total production (Mt y^{-1})



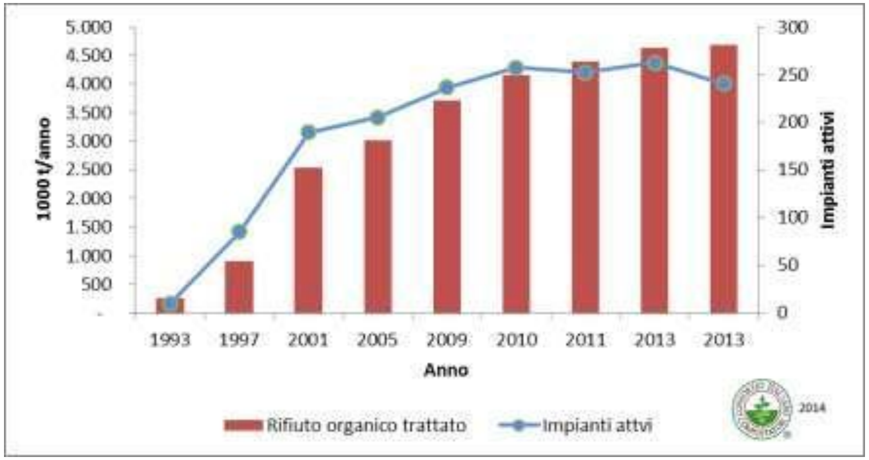
* only a fraction of applied mineral P is taken up by crops in a given year, the balance comes from the soil stocks, either from natural soil P, or build up from previous years and decades of fertilizer application.

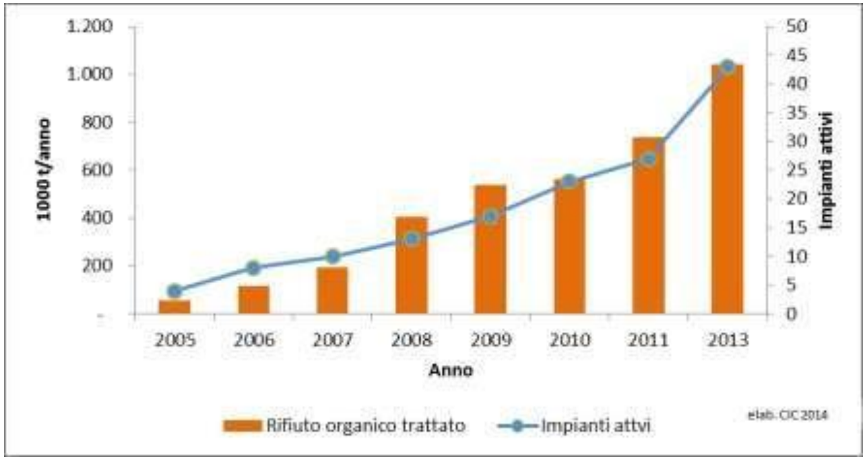
P in Compost & Digestates 1 Mt y^{-1}

Compost as possible P source

Amount of Selected Organic Waste for composting and # of operating composting plants in Italy (Consorzio Italiano Compostatori CIC, 2014).

Amount of selected organic waste for anaerobic digestion and # of operating anaerobic digestion plants in Italy (CIC, 2014).





≈5.500.000 ton of selected organic waste yr^{-1}

≈25.000 ton P yr^{-1}

Objectives

Assessment of the different P forms in compost for a better knowledge for rational agronomic re-utilization

- H_2O extractable P is recognized to be readily available for plant nutrition;
- $NaHCO_3$ extractable P is recognized to be available in the short-term;
- NaOH extractable P is recognized to be available in the long-term.

- Assess the main factors affecting the H_2O extractable P in compost beside to the study of factors affecting the midle-long term releaseble P ($NaHCO_3$ and NaOH) .

Materials & Method
Compost samples

26 compost samples from the northern-center Italy:

- **Selected organic fraction of municipal solid waste with tree pruning;**

- **Anaerobic digestate from the selected organic fraction of MSW with tree pruning (wet and dry-batch digestion);**

- **Green waste (tree pruning).**

Materials & Method

- **Assessment of the main physical chemical traits:**
  - **pH, TS, VS, C, N, C/N;**
  - **Stability: (Oxygen Uptake Rate);**
  - **Total P content and other elements: Ca, Fe, Al, Mn, Mg;**

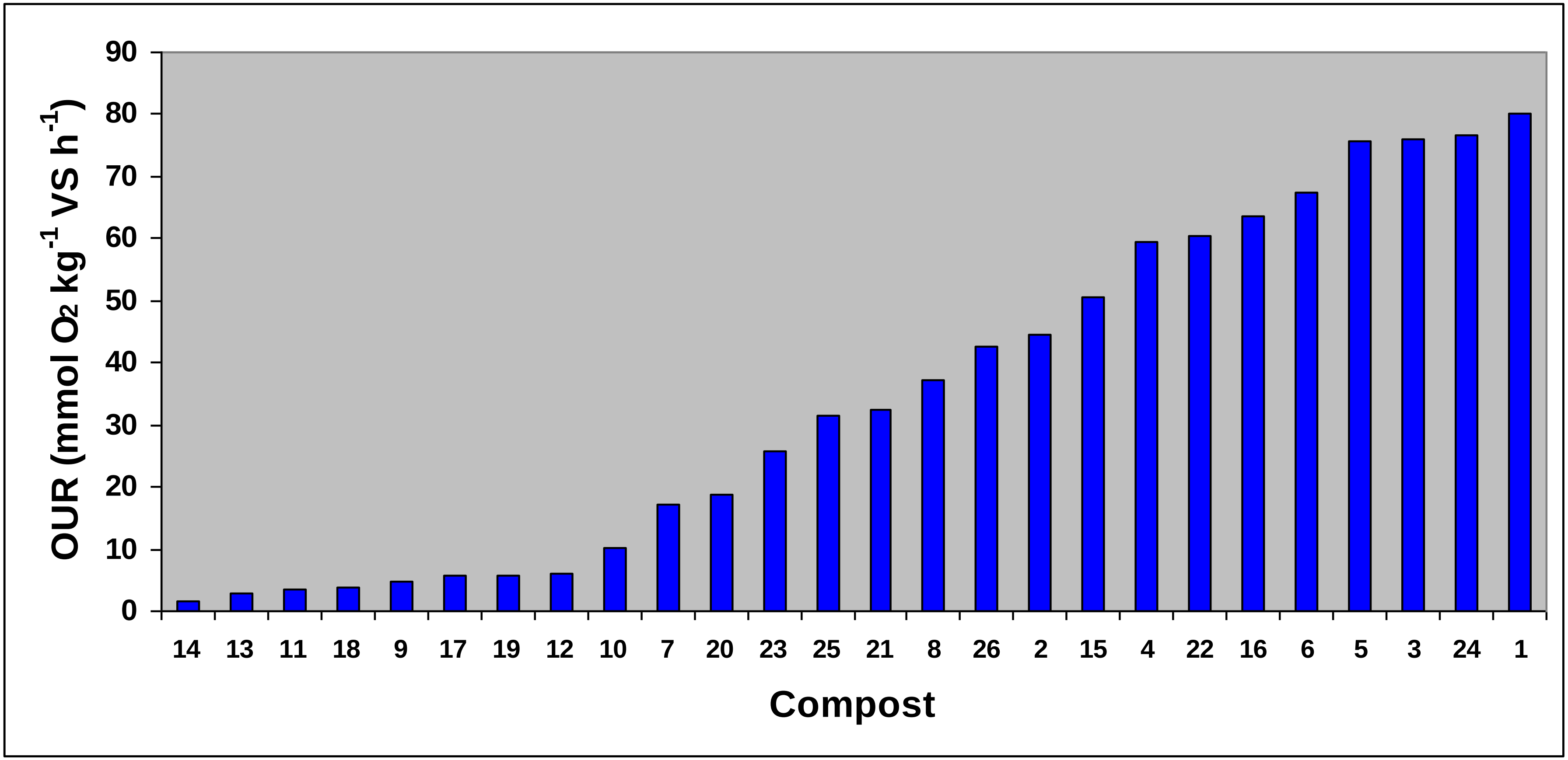
- **Assessment of the H_2O estractable P:**
  - **300 mg of sample in 30 ml H2O (2h, 25°C), centrifugation, filtration;**
  - **Total P via ICP;**
  - **Inorganic P via Murphy and Riley method;**
  - **Organic P = Total P - Inorganic P.**

- **Sequential extraction (on selected stable compost):**
  - **H_2O; $NaHCO_3$ 0.5 M pH 8.5; NaOH 0.1 M; HCl 1M; H_2SO_4 96%.**
- **Study of the relationships between those variable and P extractabilty (Principal component analysis; PCA).**

Results

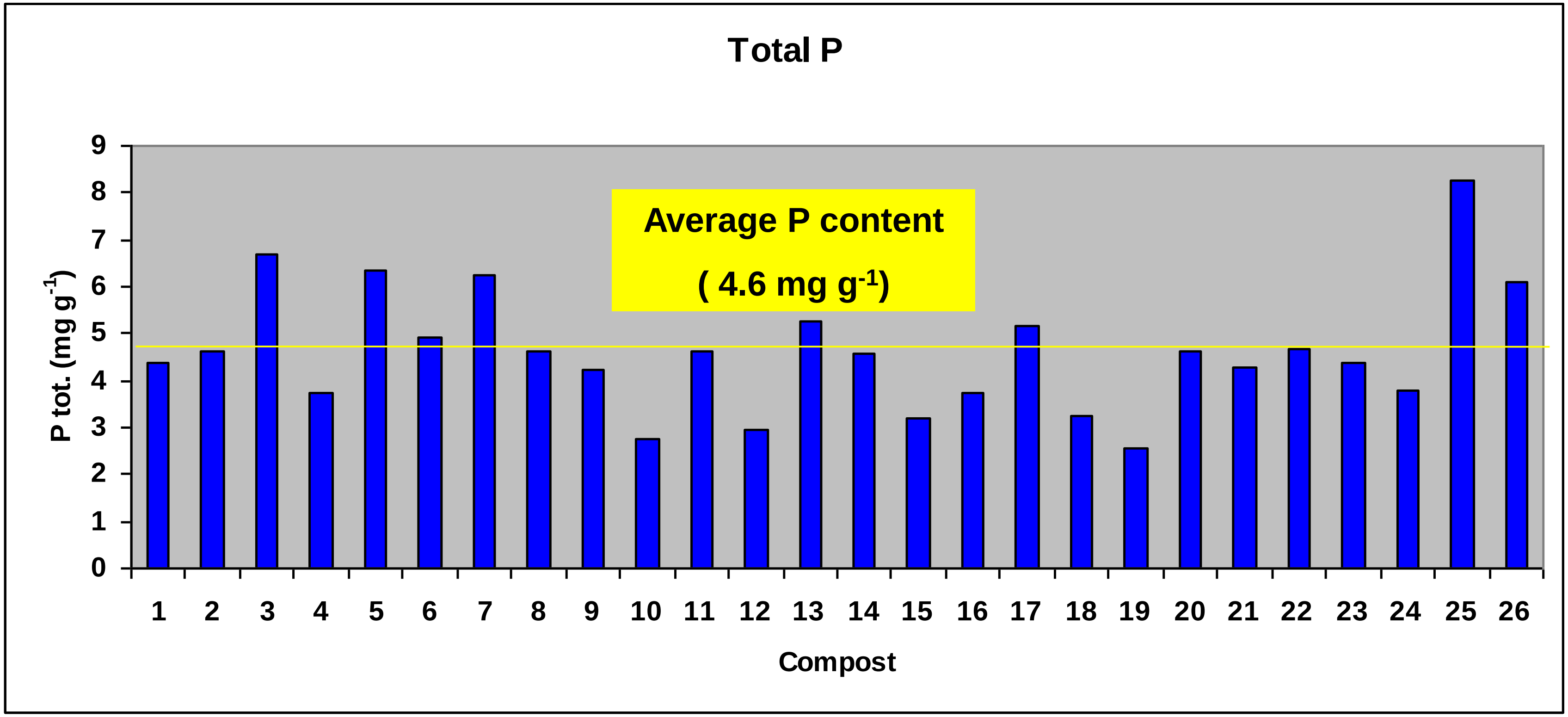
Results

Stability (OUR)

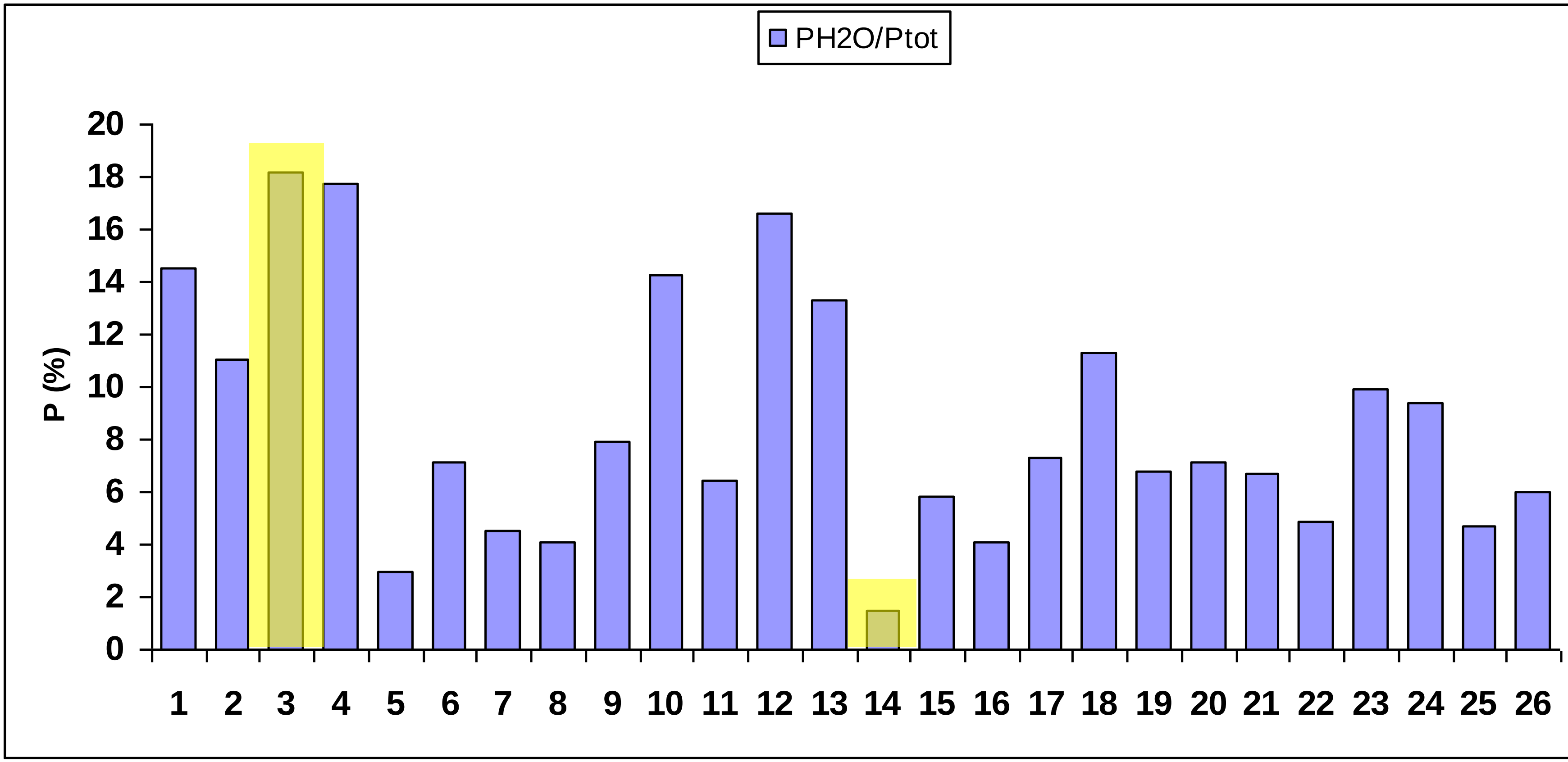


Results

Total P (aqua regia)

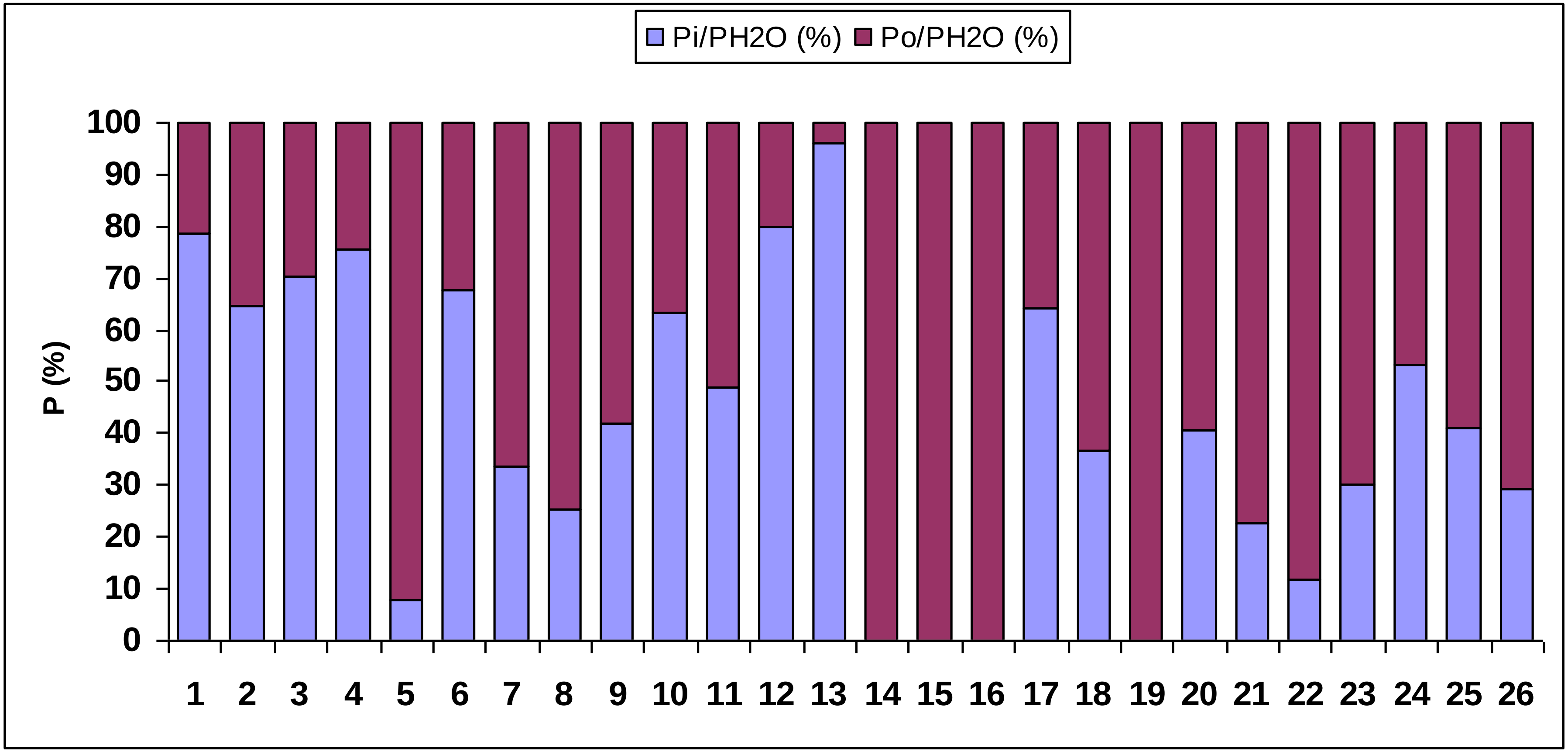


Ratios between different P forms in compost



Ratio between H_2O extractable and total P in tested compost (P_{H2O}/P_{tot})

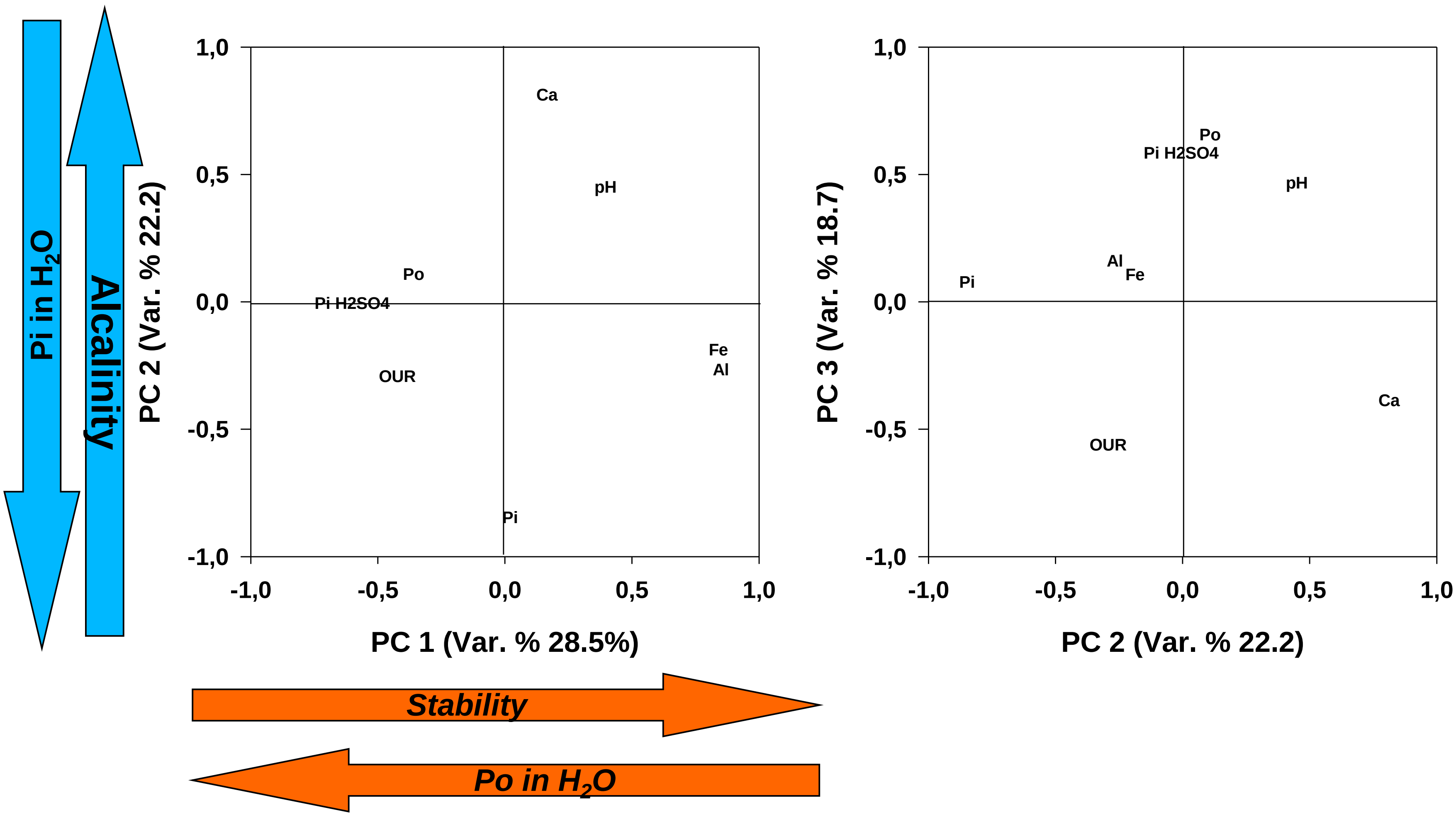
Ratio between different P forms in compost



Ratio between water soluble inorganic P and total P extractable in water (P_i/P_{H2O}) and between water soluble organic P and total P extractable in water (P_O/P_{H2O}).

Results

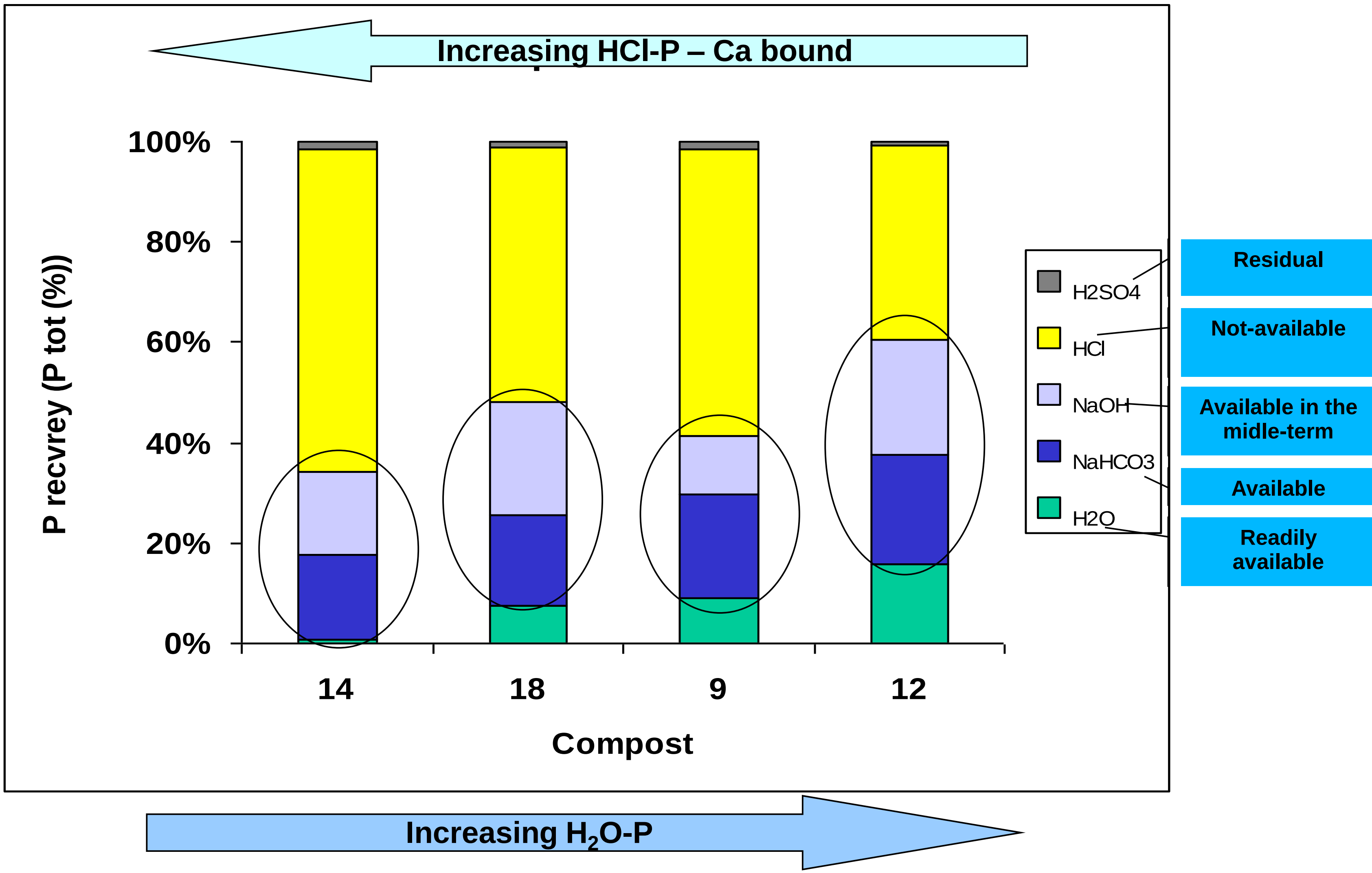
Factors affecting P extractability in water



Results

Sequential extraction on selected stable compost samples

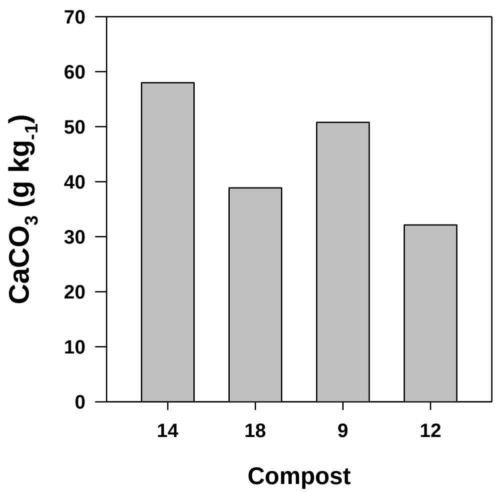
(OUR ≤5 mmol O_2 kg^{-1} VS h^{-1}) as function of P_{H2O}



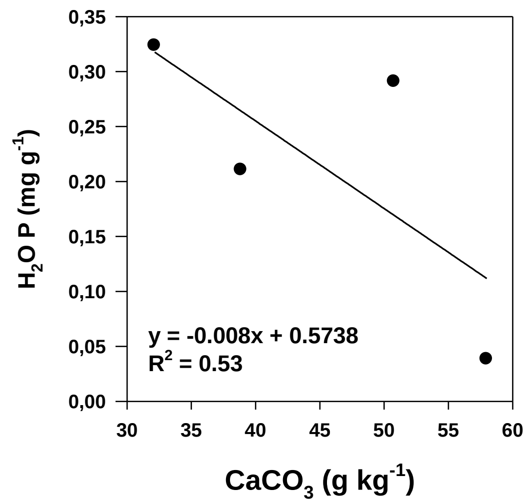
Results

Sequential extraction, relationship with total $CaCO_3$ content

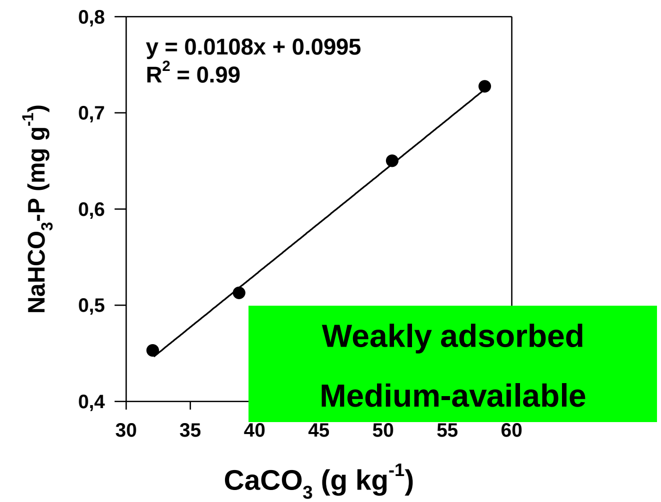
$CaCO_3$



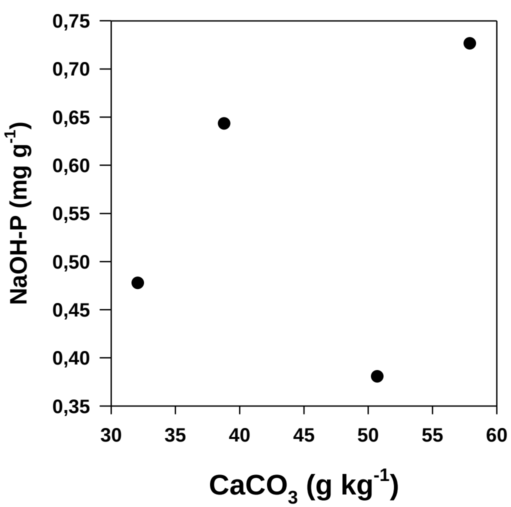
$CaCO_3$ vs H_2O-P



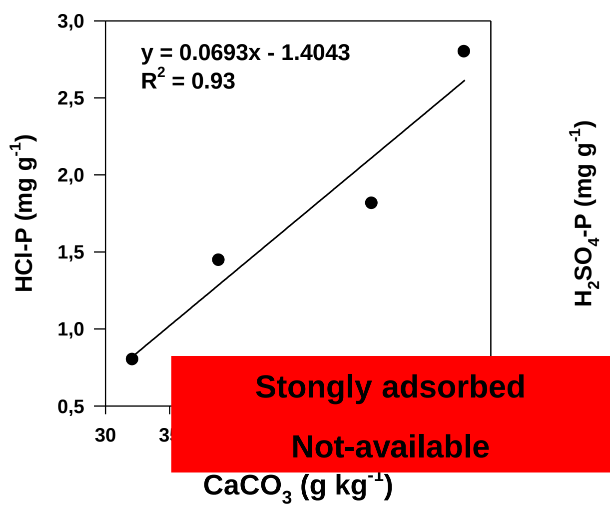
$CaCO_3$ vs $NaHCO_3$-P



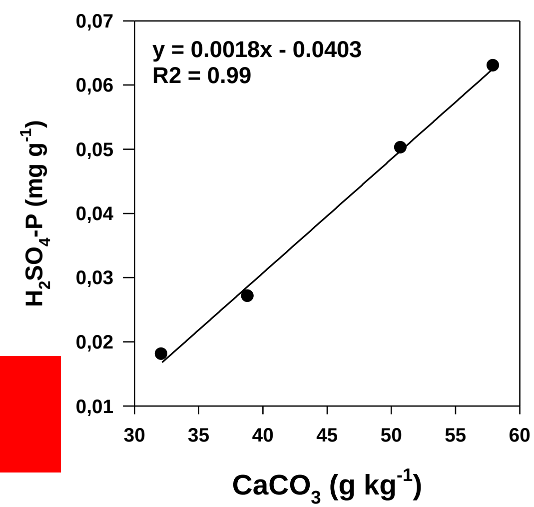
$CaCO_3$ vs NaOH-P



$CaCO_3$ vs HCl-P

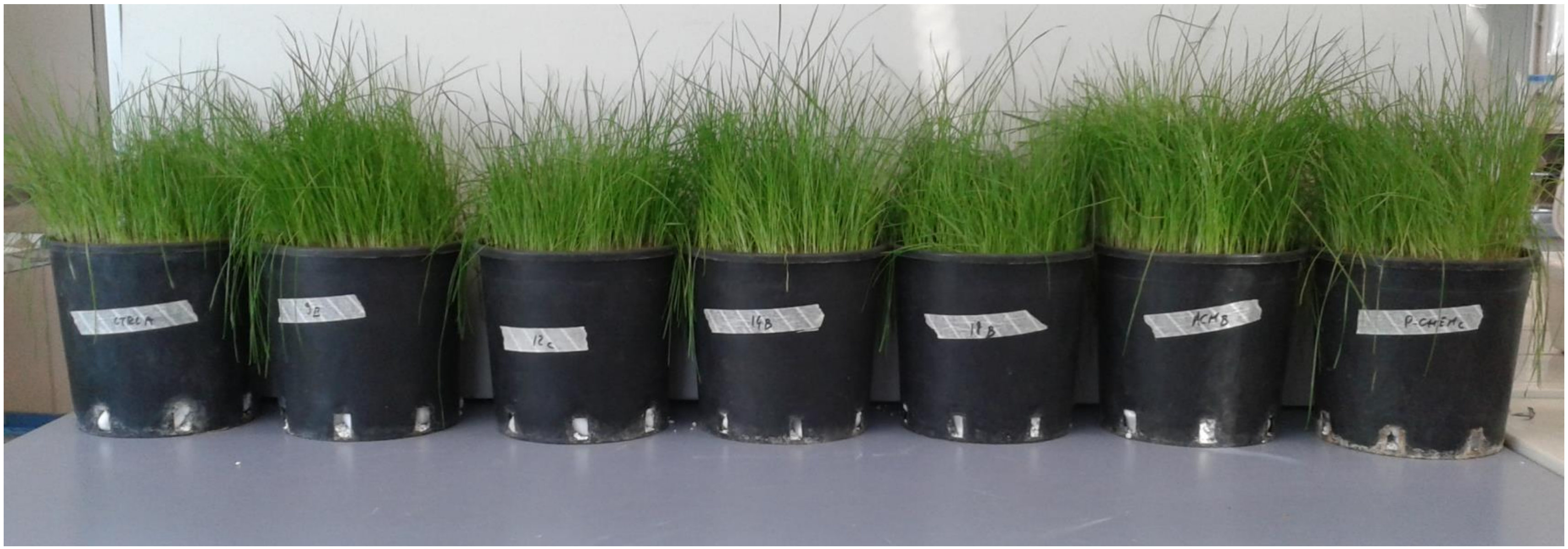


$CaCO_3$ vs H_2SO_4-P



Results

P apparent recovery fraction (ARF) on Ryegrass



Ryegrass in pot after 21 days of cultivation at 30 mg P kg^{-1} in calcareous soil.

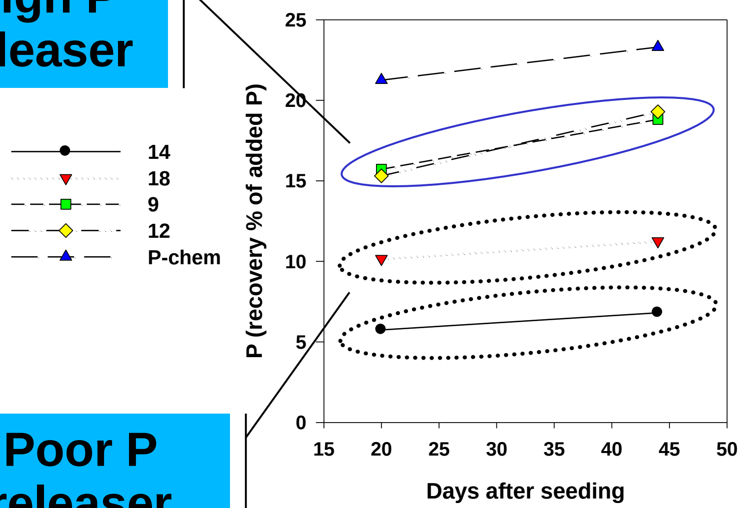
Results

Relationships between P_{H2O}; P in P_{NaHCO3} and P uptake by ryegrass

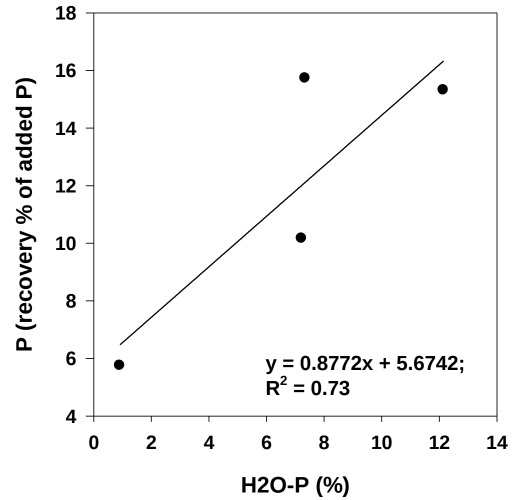
High P releaser

Poor P releaser

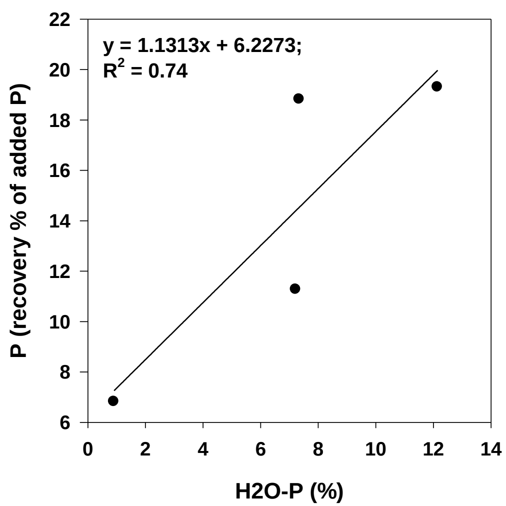
ARF (%)



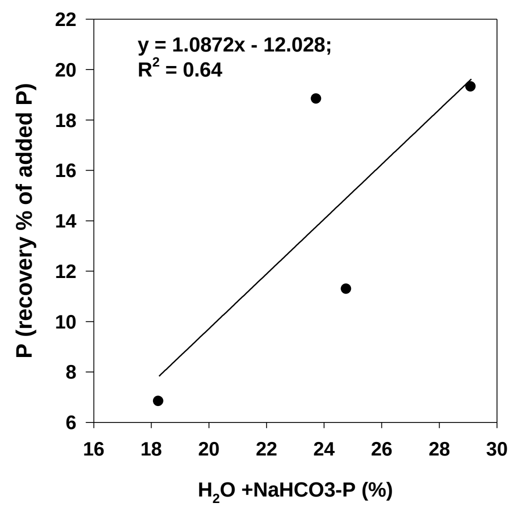
Relationship H_2O-P/ARF (3 weeks)



Relationship H_2O-P/ARF (6 weeks)



Relationship $NaHCO_3$-P/ARF (6 weeks)



Discussion

- The **26 composts** showed high variability of many traits:
    - samples representative of compost production in Italy;
- **Total P content (*P_{tot}*)** : variable but very interesting.
- Good relationship with $CaCO_3$ and P extractable in:
    - H_2O (readily available);
    - $NaHCO_3$ (available);
    - HCl (not available).
- **P availability resulted mainly $CaCO_3$ driven in tested stable compost.**

Conclusion

- **During the composting process the mineralized P-org precipitate with Ca, thus reducing plant available P;**

- **The study of (free) water soluble P beside to the labile Ca-bound ($NaHCO_3$) can reliable predict plant-available P from compost.**

- **(Stable) Compost utilization can ensure interesting amount of plant-available P this beside to the organic matter restoration, especially in mediterannean region (calcareous soils).**

- **Longer pot trial are now running to assess the role of metal-bound P (NaOH-P).**

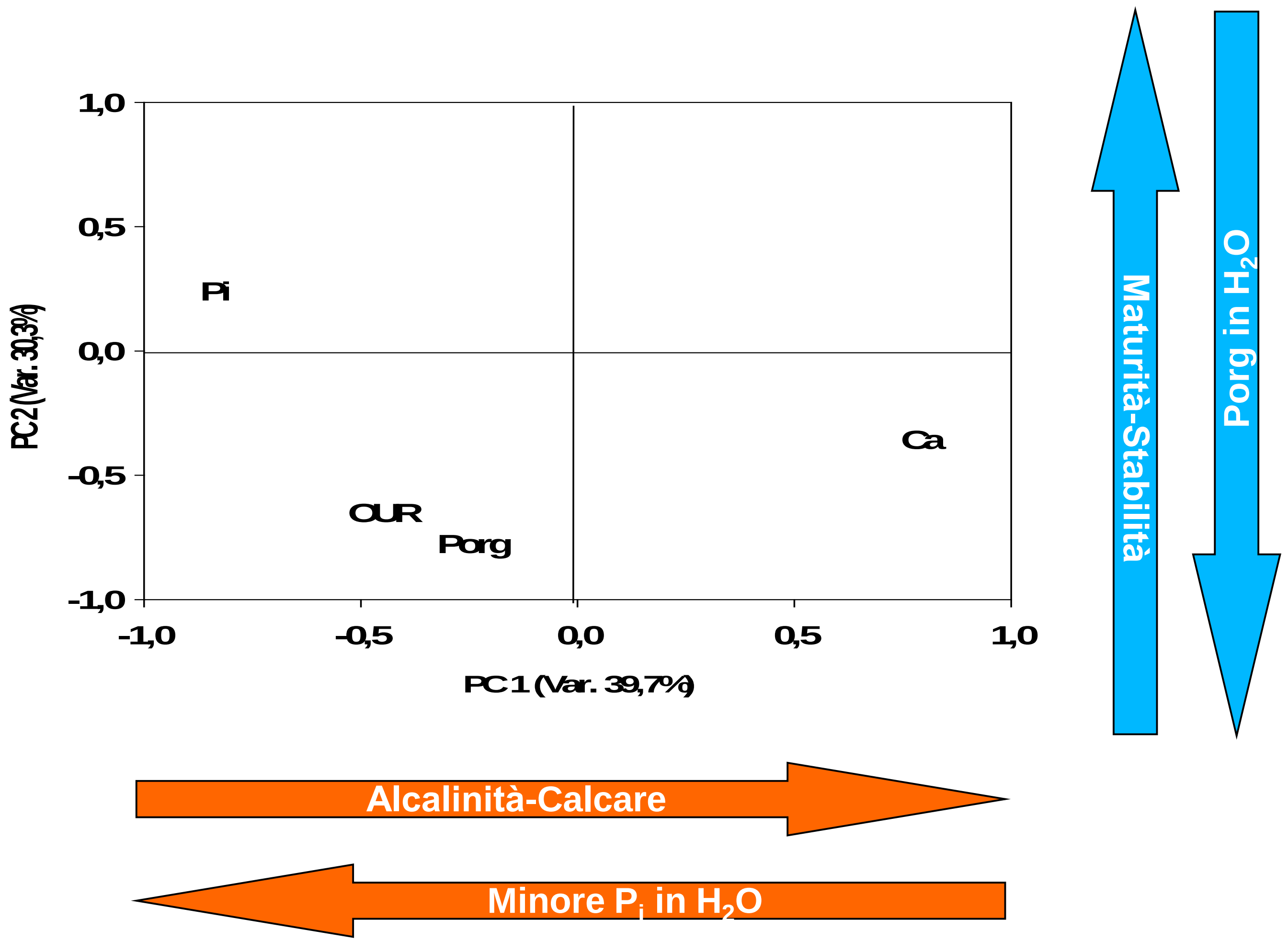
Thank you for your attention

marco.grigatti@gmail.com

Results

Fattori influenti la estraibilità del P in H_2O

Factor loadings **(PCA)**

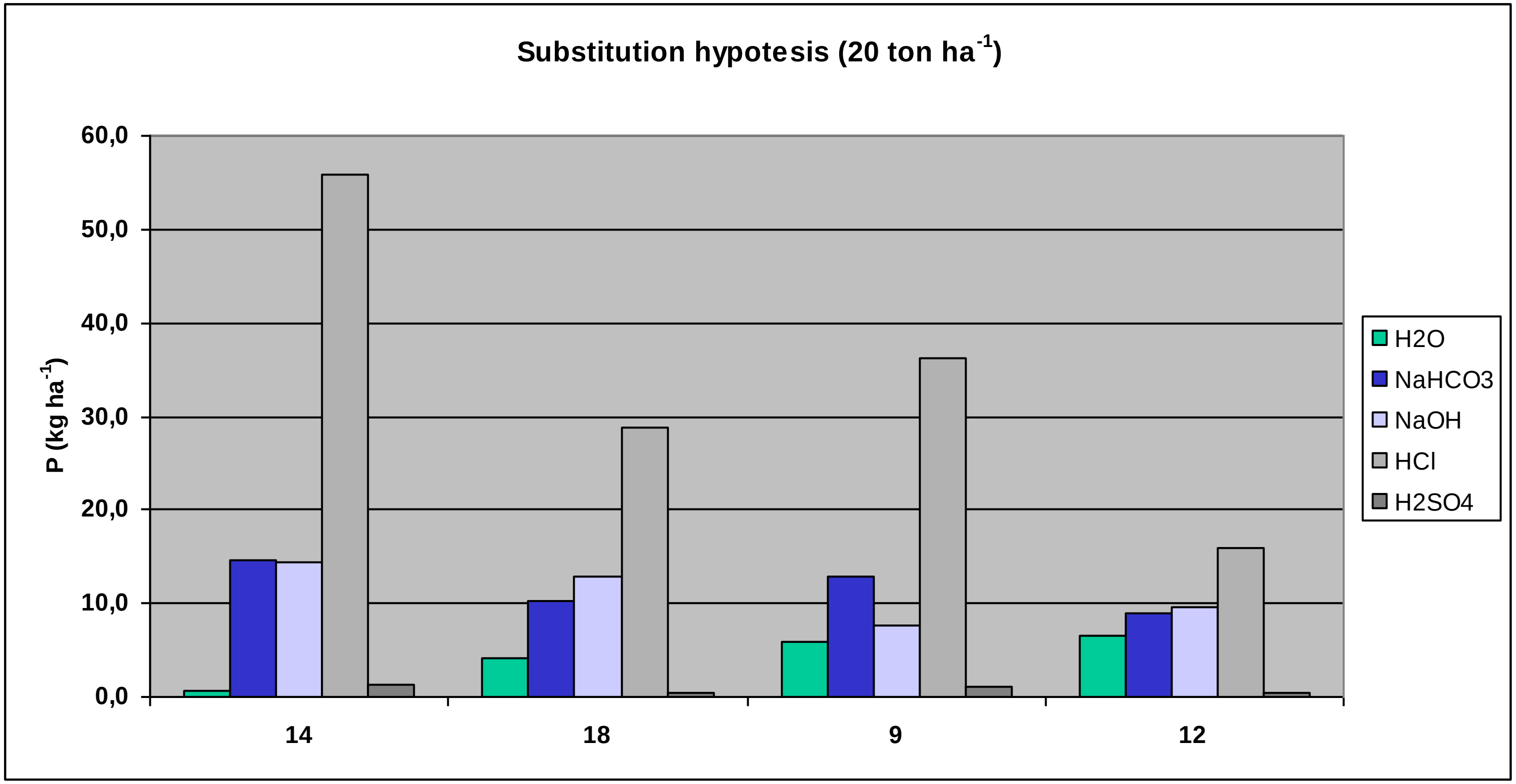


Discussion
P distributed with compost application 20 ton ha^{-1}

$PO_4(NH_4)_2$ (150 kg ha^{-1})

30,1 kg P ha^{-1}

→ Compost (20 ton ha^{-1})



Fosforo apportato con i diversi compost in un'ipotesi di distribuzione alla dose di 20 ton ha^{-1}

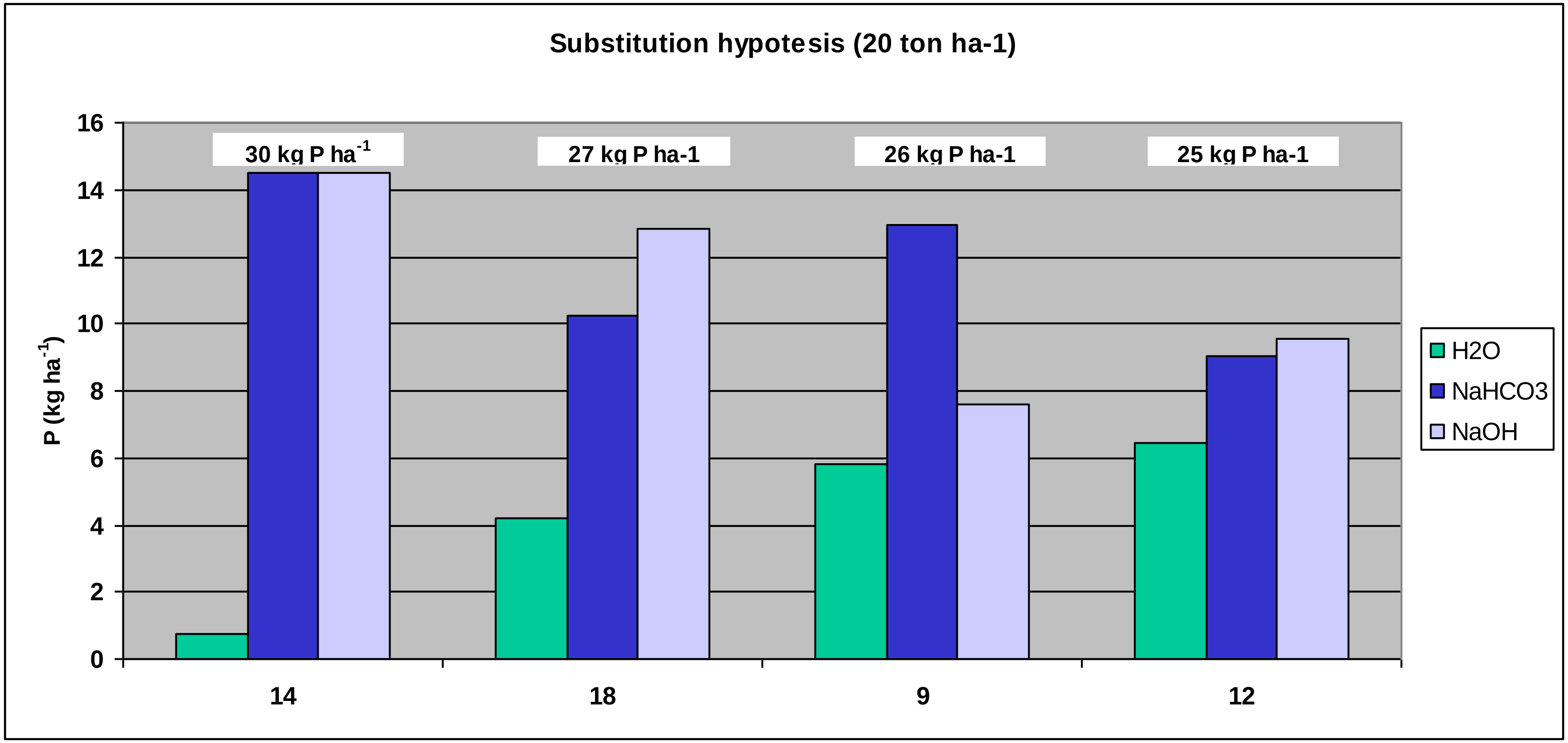
Fosfato biammonico (150 kg ha^{-1})

30,1 kg P ha^{-1}

→

Compost (20 ton ha^{-1})

25÷30 kg P prontamente e mediamente disponibile ha^{-1}



Variable	PC 1	PC 2	PC 3
OUR	-0.42		-0.56
$P_{i\ H2SO4}$	-0.60		0.58
Ca		0.81	
Fe	0.84		
Al	0.85		
pH		0.45	0.47
P_i		-0.85	
P_o			0.66
Variance (%)	28.5	22.3	18.7