



Challenges to improve P use efficiency in agriculture

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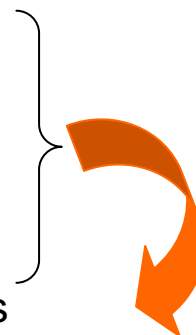
- **Background**

- Phosphorus (P) use in agriculture
- P sorption in fields
- P leaching into waters



- **Tools keep P in fields for plant use and food production?**

- Erosion control
 - Best management practises
 - Manure P control and use
 - Mineral fertiliser use
- Application methods



Challenges to improve P use efficiency in agriculture



P use in agriculture

- **Plant needs**

- “Plants take up their portion of soil P to maintain vital biological functions – und ultimately, to support entire food chains outside the soil “

(Peltovuori 2006)

Essential
macronutrient
for all plants



P deficiency symptoms



P use in agriculture

- **Annual crop uptake:**

- From Nordic fields **15 - 20 kg/ha/a is removed** by harvest

- Cereals:

- For 4000 kg/ha grain yield: ~ 20 kg/ha, P removal by harvest 15 kg/ha
 - For 6000 k/ha grain yield: ~ 30 kg/ha removal by harvest 25 kg/ha

- Forage:

- For 25 000 kg/ha silage grass yield: P removal by harvest 20 kg
 - For 5000 kg/ha dry hay yield: P removal 15 kg/ha

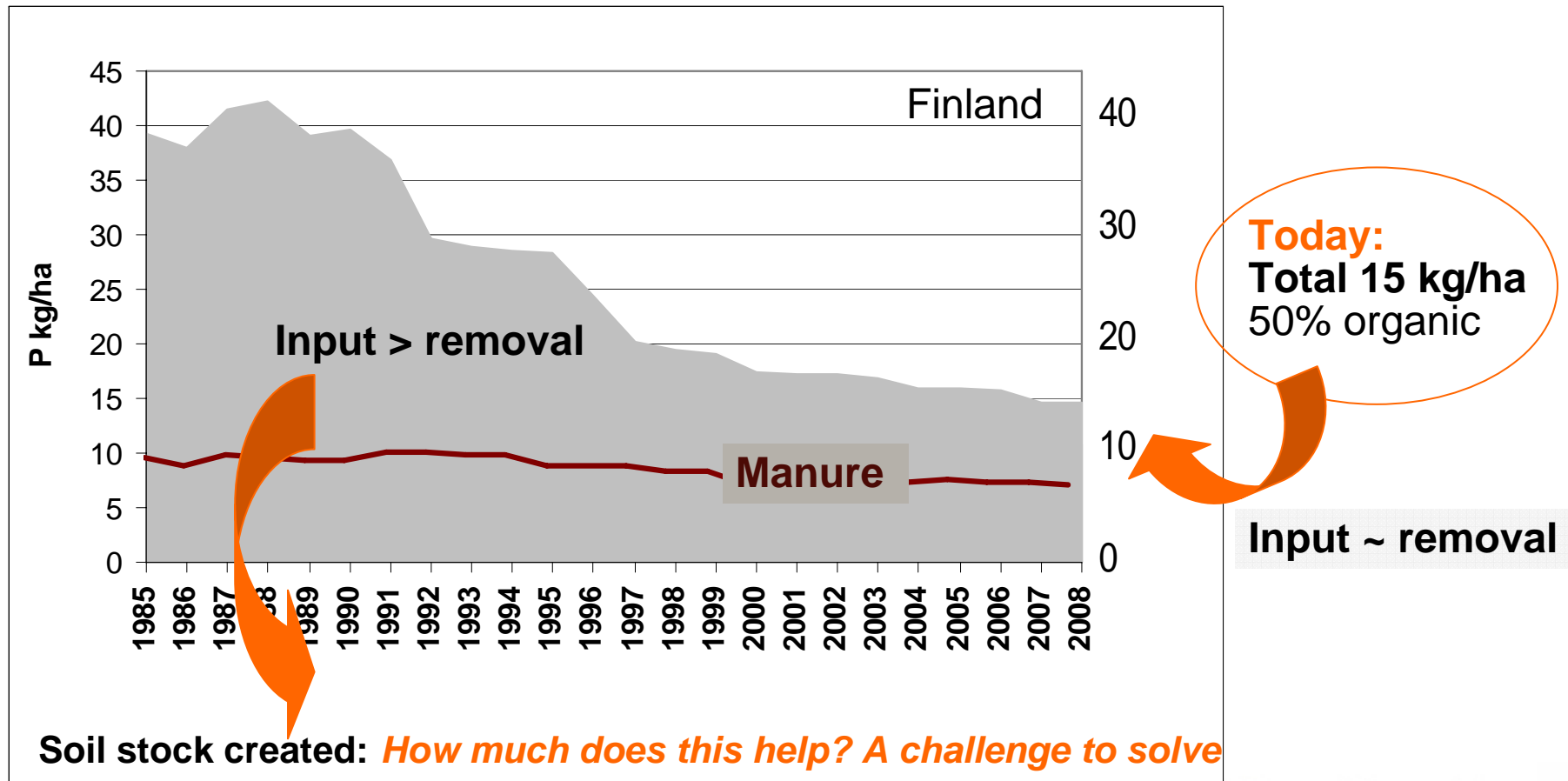
*The better the yield the higher nutrient uptake : **phosphorus, nitrogen, etc...***



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P use in agriculture

- Annual phosphorus fertilization rates (kg/ha):



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P sorption into fields

Created P stock over 300 mg/kg in Finnish surface soils (0-25 cm soil depth /plough layer)



- **Fertilizer P** sorbed to the
 - Al- and Fe-oxides (Kaila 1963- Hartikainen 1989)
 - organic forms (35%, Kaila 1963)
 - P poor sub soils (Peltovuori 2006)
- **Partly and slowly plant available:**
 - Since 1955
 - **soil P-Index** increased from **Poor** (5) to **Low- Medium** (11.5 mg/l)
(Kähäri et al. 1987, Viljavuuspalvelu 2002)

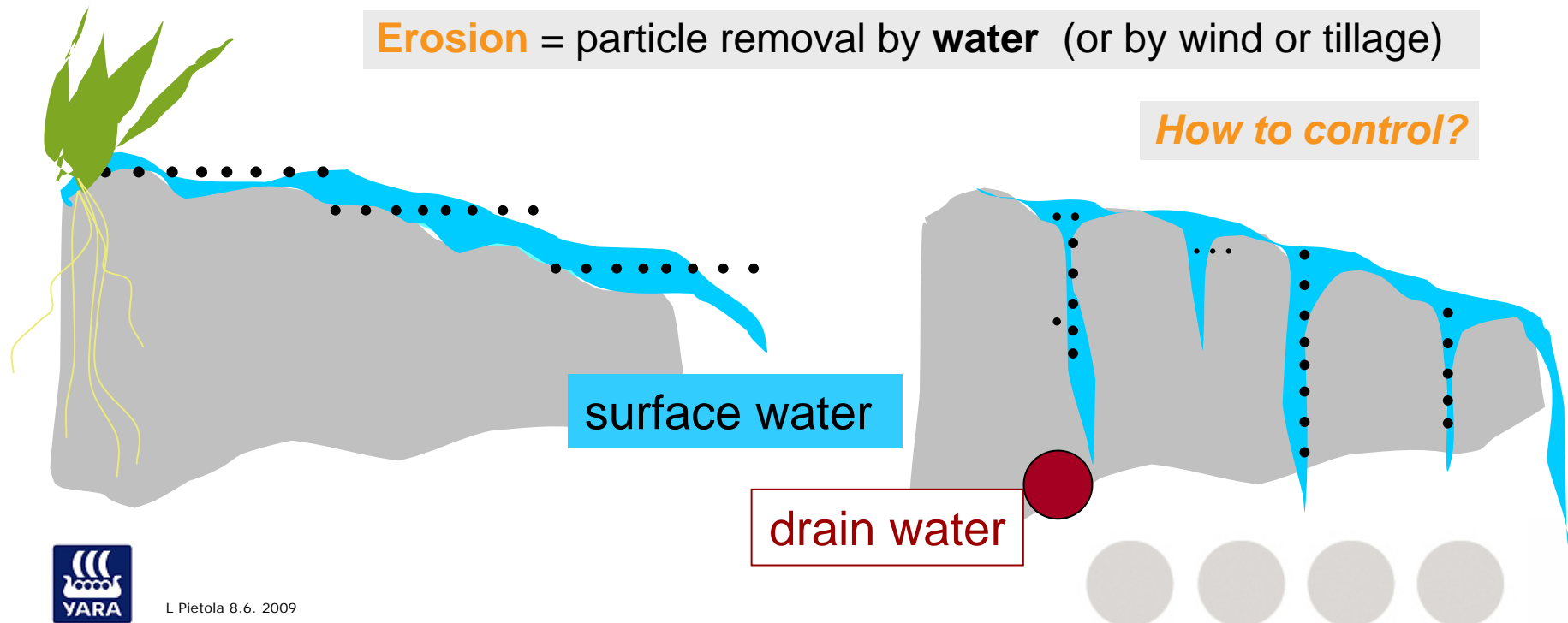
Total P of cultivated soils (mg/kg)			
	rock	570-760	(ref. Peltovuori 2006)
1940-60'	subsoils	430-920	(Salonen 1941; Kaila 1963)
1940'	plow layer	880, 1250	(Kivinen 1934; Salonen 1941)
1960'	plow layer	850-1200	(Kaila 1963) occasionally 1830
1970'	plow layer	780-1870	(Saarela et al. 2003)



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P leaching into waters

- **Transportation of P-rich soil particles**
 - Water erosion **main cause of P load** from agriculture
 - causing eutrofication (Uusitalo 2004)
- **Leaching of soluble P** 10% of the total P-load from fields



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Tools keep P in fields

Farmers need site **specific tools** to control P losses, in addition to best management practises like drainage, liming, and soil compaction control

- Reduced tillage – direct sowing
 - Constructed wetlands
 - Buffer zones
- 20-30 % reduction in P load**
(Puustinen 2008)

- **Additional innovations needed:**
 - Chemical methods for P absorption:

Focus

- **In-field – not out**
- **For crop reuse**

- **P should remain a a part of ecological cycle** for continuous use in agriculture
 - no too strong precipitation mechanisms by Al or Fe-based additives

Sustainability



Tools to keep P in fields

Focus on “Hot Spots”

➤ **Erodible clayed fields**

- With slopes
- Without slopes
 - during spring with snow melting and rains
 - soil particles escape fields transporting P to waters

➤ **Fields with high soil test P**

- Fields used for sugar beets, vegetables etc. (non-grains)
- Fields where manure has been spread for years
 - P surplus in manure use:
 - P:N in pig manure 1:3
 - P:N in cereals 1:6 or in grasses 1:9



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Tools to keep P in fields

- **Erosion control:**

- Minimum tillage, buffer zones, constructed wetlands
- Soil amendments: **Gypsum**



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- Phosphorus trapping project (TraP) tests gypsum effects on:
 - **particle P –control** via improved soil aggregation
 - **soluble P leaching control** via enhanced adsorption on particle surfaces



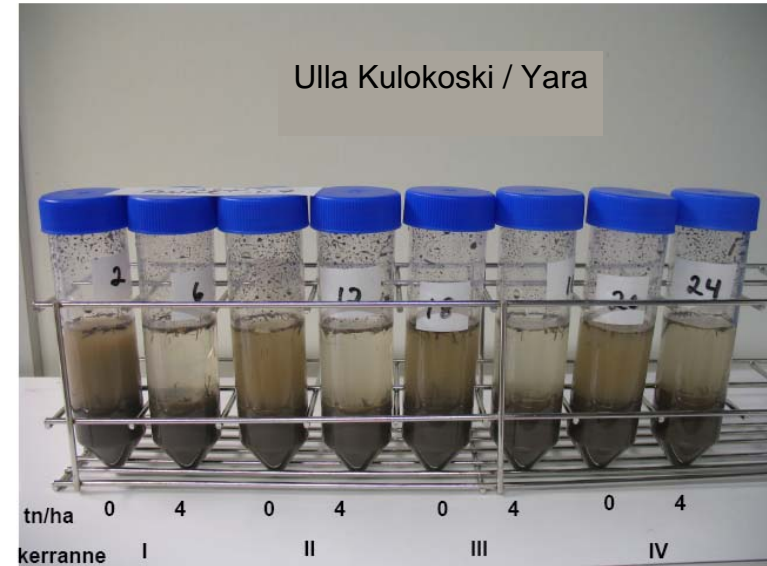
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Tools to keep P in fields

- **Erosion control:**
 - Soil amendments: **Gypsum**



No gypsum



Challenges to improve P use efficiency in agriculture

Tools to keep P in soils

1. Erosion control
2. **Manure P control**



- Manure P in fibre and party in liquid fraction
- **Before farm use, manure P should be fractionated for separate use**
 - P-free fraction for fields with high P-content
 - P-rich fraction for field poor in P
- **Specific Tools for manure management:**
 - Mechanical separation
 - and/or P precipitation by a manure/slurry treatment
 - **With Ca-based precipitation** manure P remains bio available
 - No Fe/Al –based additives

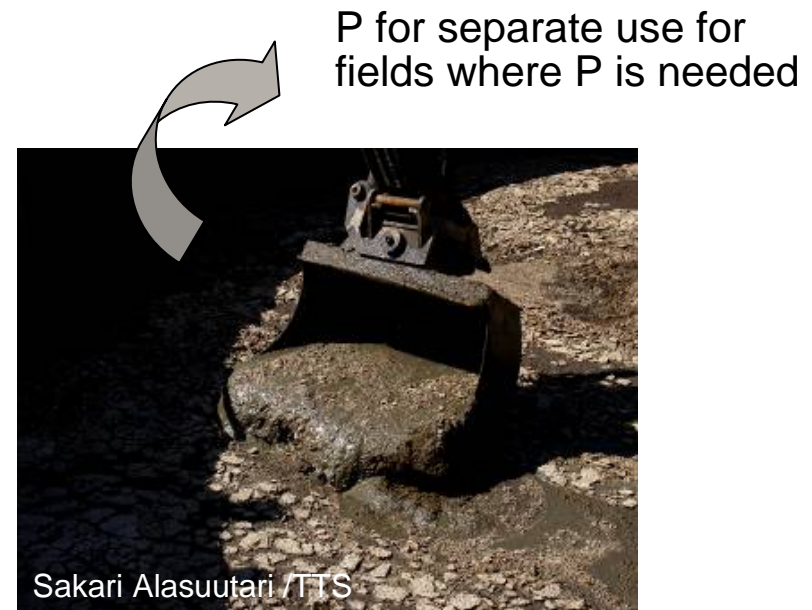
Sustainability



Challenges to improve P use efficiency in agriculture

Tools to keep P in soils

- Manure P fractioning



- Phosphorus trapping project (TraP) tests gypsum for phosphorus fractioning to:
 - **P-free effluent** after solid removal and settling of phosphates
 - **P-rich solids** at the bottom of farm pit



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Tools to keep P in soils

1. Erosion control
2. Manure P control
3. **Best management practises for fertilizer use**

- Rates close to removal
 - **Focus on application methods**
 - **P close to roots**
 - P uptake within 5 mm distance
 - **with co-nutrients**
 - P uptake needs other essential elements (nutrients)
 - **N, K, S,...** micros (e.g. Weliamama et al 2008)
 - Balanced plant nutrition according to plant needs
 - Fast nutrient release for Nordic spring-sown crops
 - **Soluble fertilizers**



P use in agriculture

- Application methods
 - Top dressing
 - Broadcast
 - Bands



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Organic fertilizers

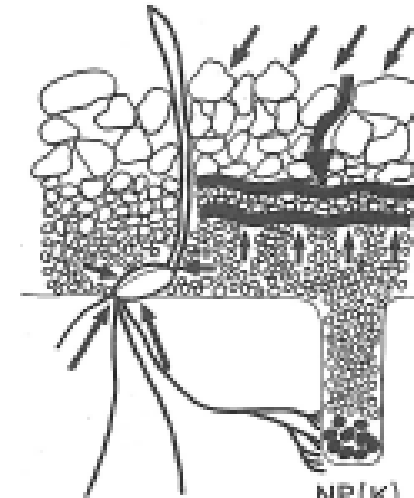


Mineral fertilizers



P use in agriculture

- Application methods
 - Placement/ Sub surface band
 - directly for root zone for plant uptake
 - applicable for granule mineral fertilizers
 - for different tillage systems



NP(K)
(Håkansson 1985)

Most efficient



Paavo Elonen



Mikko Sakala / Yara



Uneven fertiliser spreading – losses for farmer and risk for environment



Conclusions

Challenges to improve P use efficiency in agriculture:

1. **Erosion control:**
 - Minimum tillage, buffer zones, constructed wetlands
 - *More tools needed: Ca-based soil amendments*
2. **Manure P control**
 - **Ca-based precipitates for P fractioning**
3. **Best management practises for fertilization**
 - Application methods: **subsurface band placement**

Soil physical, biological and chemical care

- *vigorous crop growth*
- *high yields of best quality and high nutrient removal*



Thanks!

