Fertilization and fertilizers use in the Netherlands

Presentation for Stanley Company

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Program

1. Introduction Wageningen UR
2. Introduction Dutch agriculture
3. Fertilization advisory systems in the Netherlands
   - Recommendations fertilizer rates
   - Guided fertilization systems & application techniques

Break

4. Organic fertilizer use
5. Legislation and market requirements
6. Overview of trends and developments
7. Difference China and the Netherlands (discussion)

1. Wageningen UR

Mission

'to explore the potential of nature to improve the quality of life'

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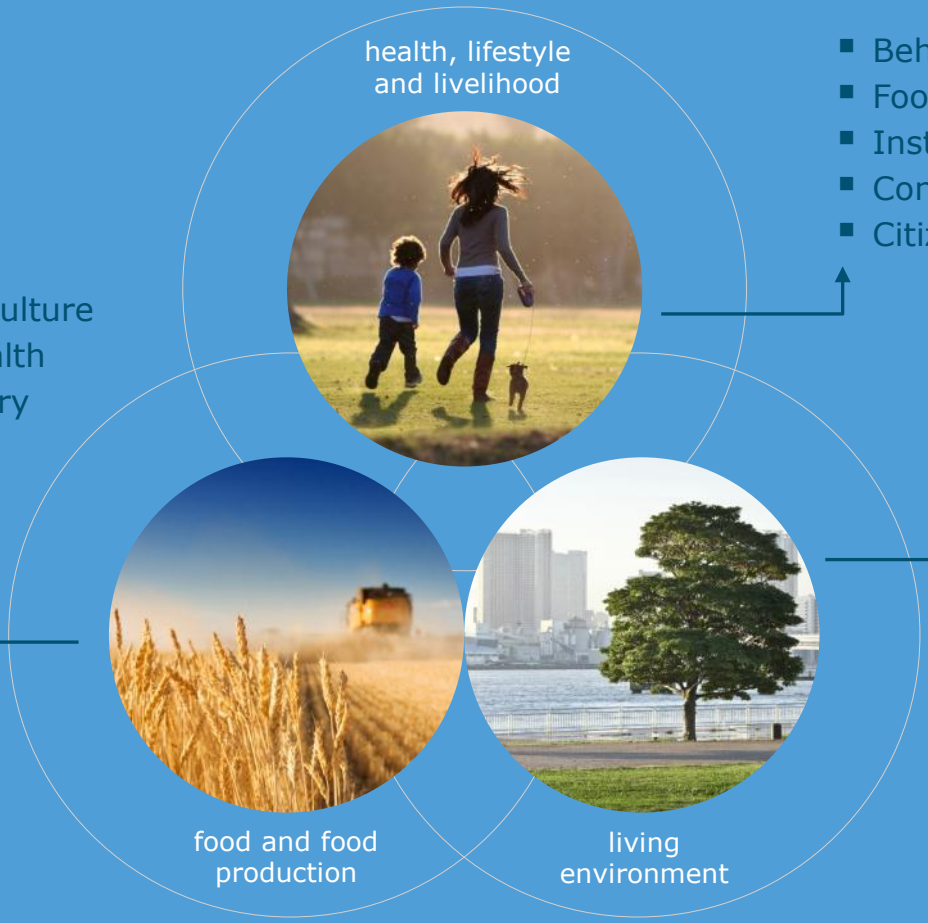
The Wageningen UR domain: healthy food and living environment



- Behaviour and perception
- Food security
- Institutions
- Consumer
- Citizen

- Sustainable agriculture
- Nutrition and health
- Sustainable fishery
- Biomass
- Chains

- Marine resource management
- Landscape and land use
- Nature & Biodiversity
- Water management
- Competing claims

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Wageningen UR

Research

- Top 3 in our domains
- Top 100 worldwide in university ranking
- Exploitation and valorisation of research

Education

- > 11,000 students
- > 6,000 faculty and staff
- Turnover € 710 million

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Two partners

Wageningen University

9 applied research institutes

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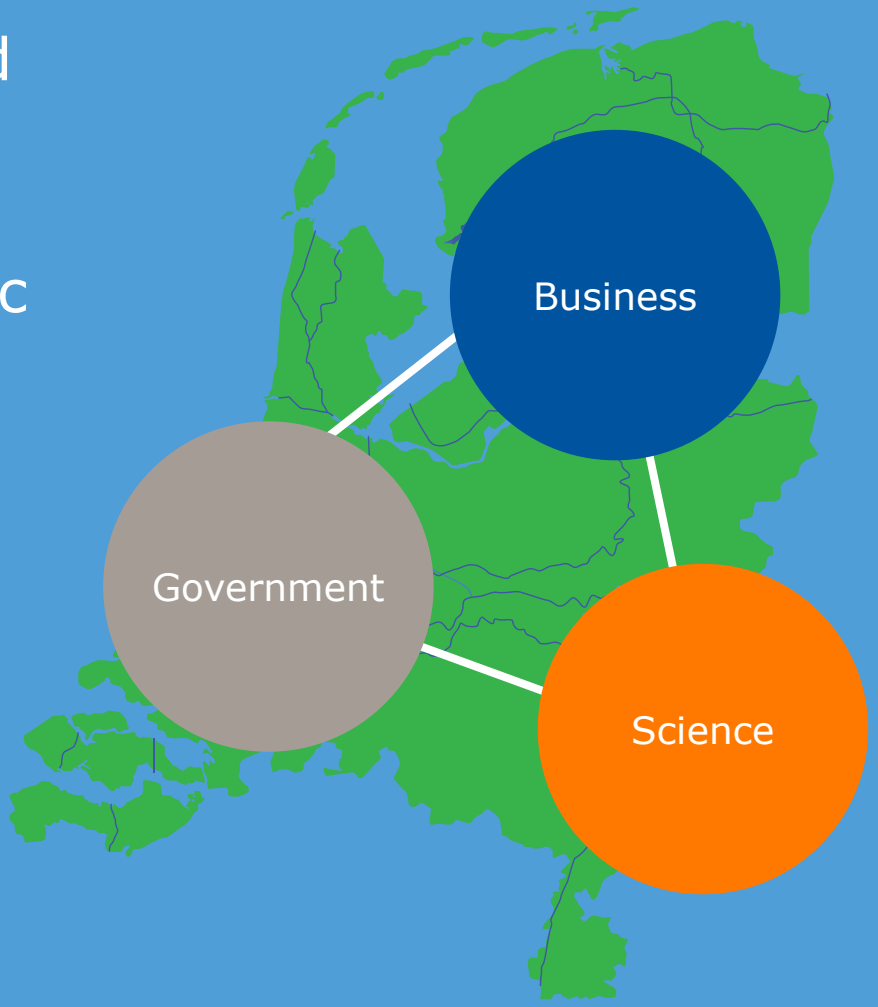
Our strengths

- Combination of university and market-oriented research institutes
- Cooperation between scientific and social science disciplines
- Connecting knowledge at various scale levels
- Strong international position
- Strong cooperation in the ‘Golden Triangle’
- Wageningen Campus



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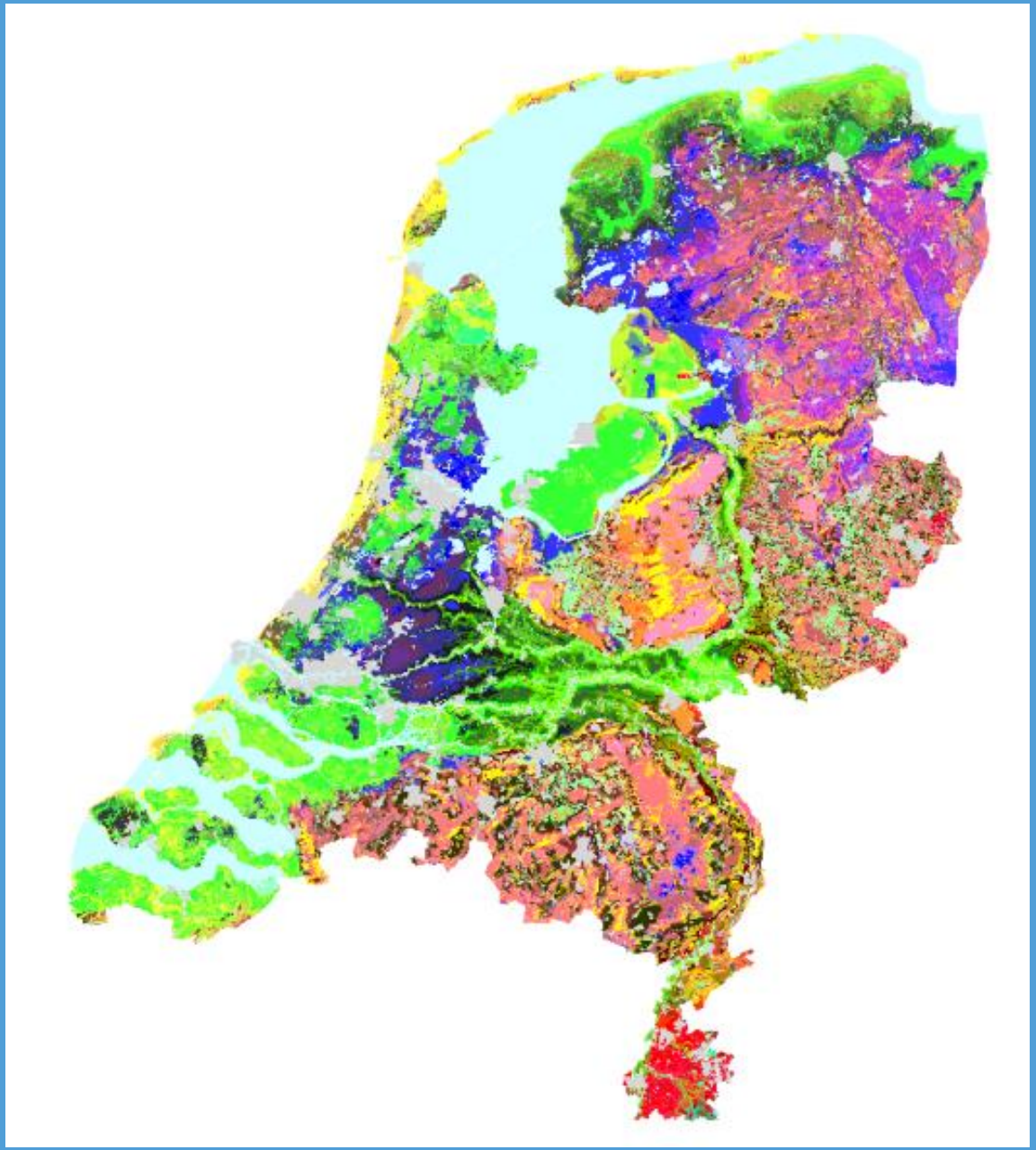
2. Dutch agriculture

Soil types in the Netherlands



Key figures Dutch agriculture

Share per sector	Area (x1000 ha)	Economic value (x10^9 €)	Labour years (x1000)	Number of farms (x1000)
Live stock farms	1 225		69	41.5
Arable farms	517	2.4	16	12.1
Field horticultural farms	87		28	6.8
Greenhouse farms	10		41	3.8
Mixed farms			7	3.3
Total	**1 839**	**26.5 (52)**	**161**	**67.5**

- Agro complex is 10% of Gross National Product
- 2nd largest exporter of agricultural products in the world

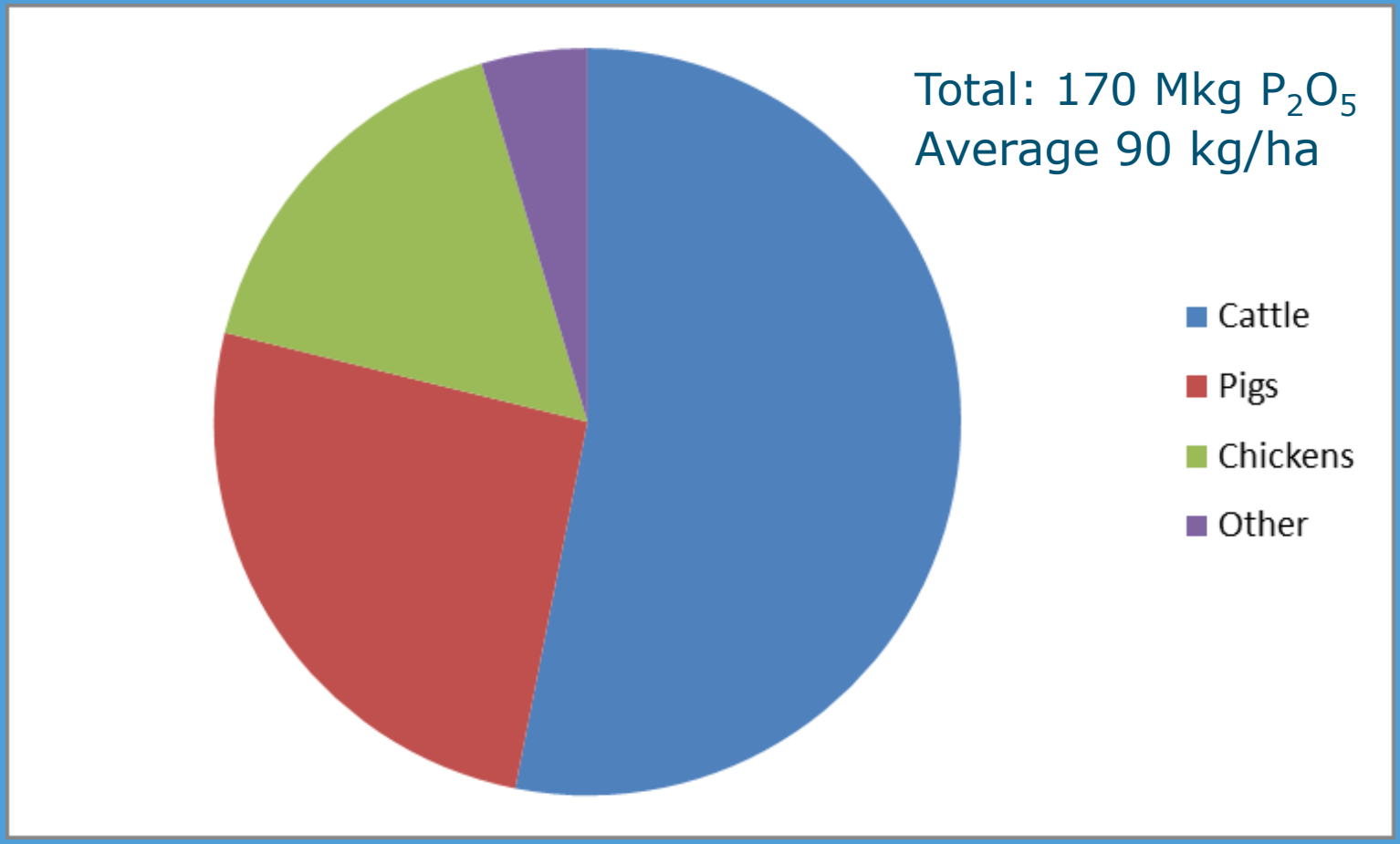
Plant production

(acreage x 1000 ha)

- Farm size 30-100 ha
- High yield levels
- High inputs
  - Nutrients
  - Pesticides
- Highly mechanized
- Large use of animal manure
- Environmental problems

Dairy farming	1,225
Grassland	993
Maize	226
Arable farming	517
Cereals	193
Potatoes	156
Sugar beets	75
Horticulture	87
Field production of vegetables	25
Flower bulbs	24
Tree nursery and perennials	17
Gardening (fruits)	19

Total phosphate production in manure
The Netherlands, 2011



3. Fertiliser recommendations

- Organisation
- Recommendations
    - Nitrogen
    - Phosphorus and potassium
    - Other nutrients
        - Magnesium and sulphur
        - Micronutrients

Fertilization Committees NL

- Main task: assessing fertilizer recommendations
  - Most recommendations developed in 1970-80
- Representatives
  - Farmers organization (chair)
  - Research institutes
  - Laboratories
  - Extension service
- Sectors
  - Forage crops
  - Arable and horticultural crops

Fixed and guided fertiliser recommendations

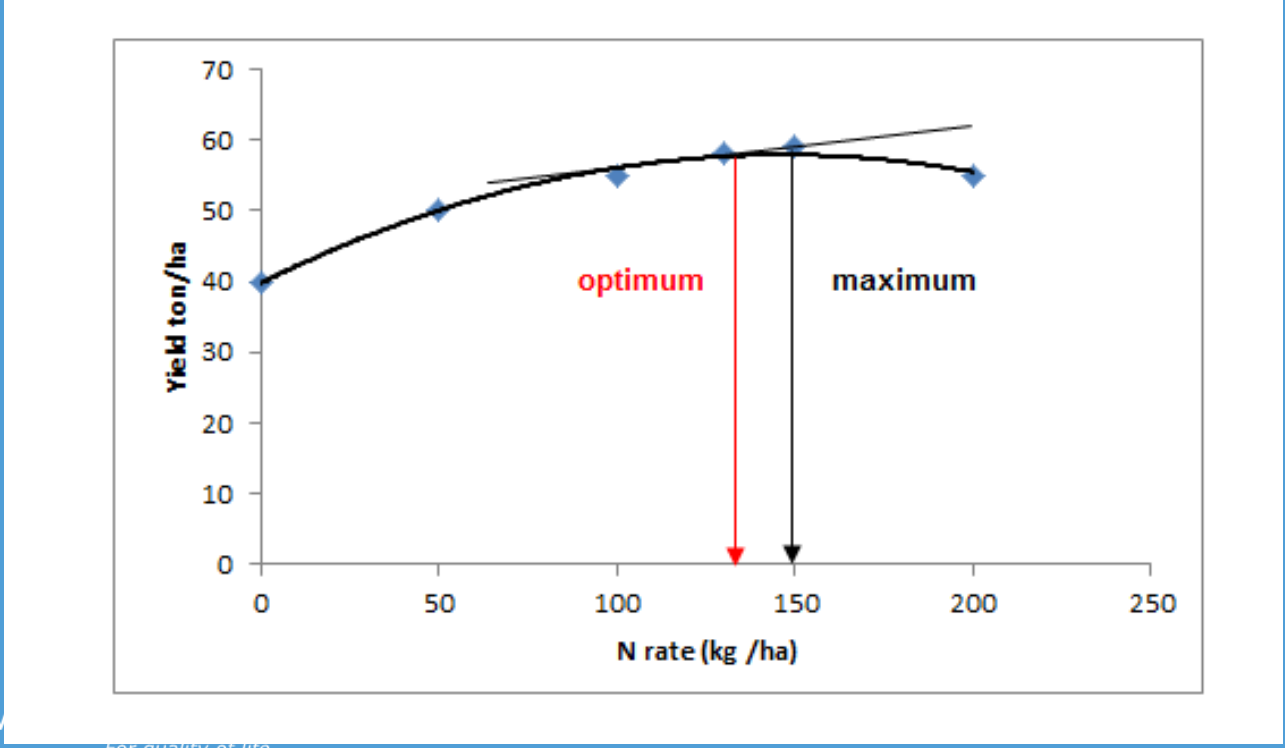
- Fixed
  - Crop demand assesses in advance
  - Based on measurement of soil nutrient status at the start of the growing season
  - Applied at once or in split applications
- Guided (nitrogen)
  - Basis fertilisation
  - Supplementary dressings based on measurement of nutrient status during the growing season

Fixed nitrogen recommendations

- Economic optimal N rate (Nopt) derived from several dose-response trials
- Taking into account soil mineral nitrogen (SMN) in spring
- Depending on: crop (type) and variety
  soil type
- Regarding: yield and quality of the product
  market price
  fertilizer price

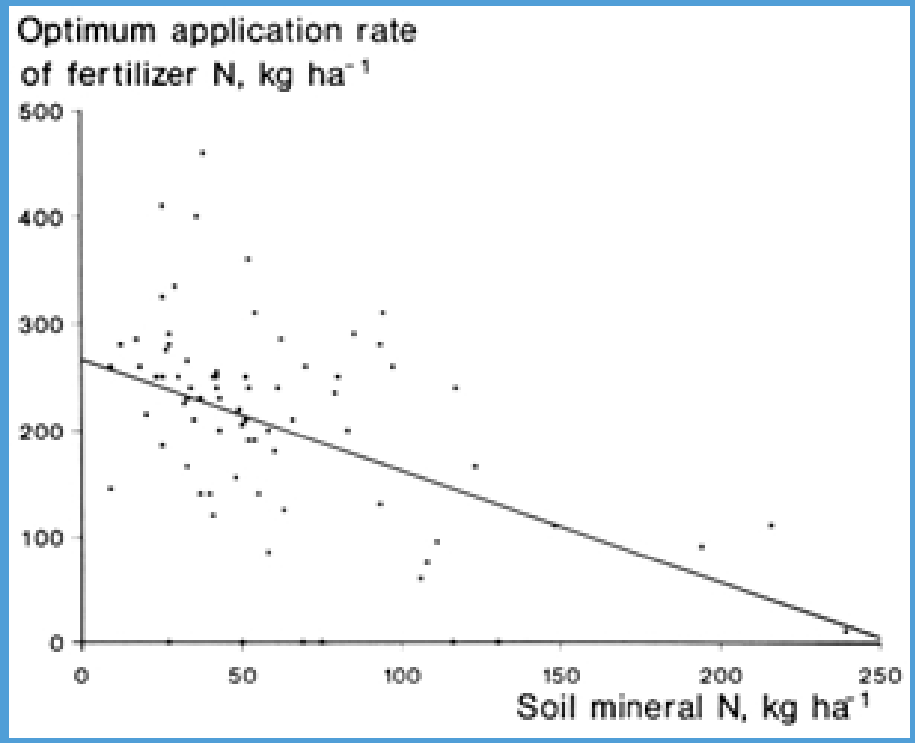
Deriving nitrogen recommendations

- Dose-response trials
  - Series of trials
    - $Nopt_{1...n}$
    - Recommendation: average of $Nopt_{1...n}$



Deriving of the recommendation

- Optimal nitrogen rate from several dose-response trials plotted against soil mineral nitrogen content
- Fitting a linear relationship → recommendation
- For example potato on clay soil (figure): 285 – 1.1 * SMN



Examples of fixed nitrogen recommendations

Cultivation	Nitrogen rate (kg/ha)
Ware potatoes, clay / loess soil	285 – 1.1 * SMN (0-60 cm)
Ware potatoes, sandy soil	300 – 1.8 * SMN (0-30 cm)
Starch potatoes, sandy soil	275 – 1.8 * SMN (0-30 cm)
Winter wheat, feed, clay soil	140 – SMN (0-100 cm) + 90 + 40
Winter wheat, bread, clay soil	140 – SMN (0-100 cm) + 80 + 80
Winter wheat, feed, sand soil	140 – SMN (0-100 cm) + 90
Sugar beets	200 – 1.7 * SMN (0-60)
Maize (all soil types)	205 – SMN (0-30 cm)

Corrections to recommended N rate

	Correction (kg N/ha)
Incorported crop residues	
Green manure	- 20 to 60
Grassland	- 100
Differences in soil mineralization	-50 to +30
Poor soil structure	+30 to 50
Yield level (wheat)	20 kg N/ton grain

Adjustment of the N rate during the season

- Splitting the N rate
  1. fixed basis rate
  2. adjust top-dressing(s) to growth conditions


crop conditions


soil conditions


weather conditions

Guided nitrogen fertilization systems

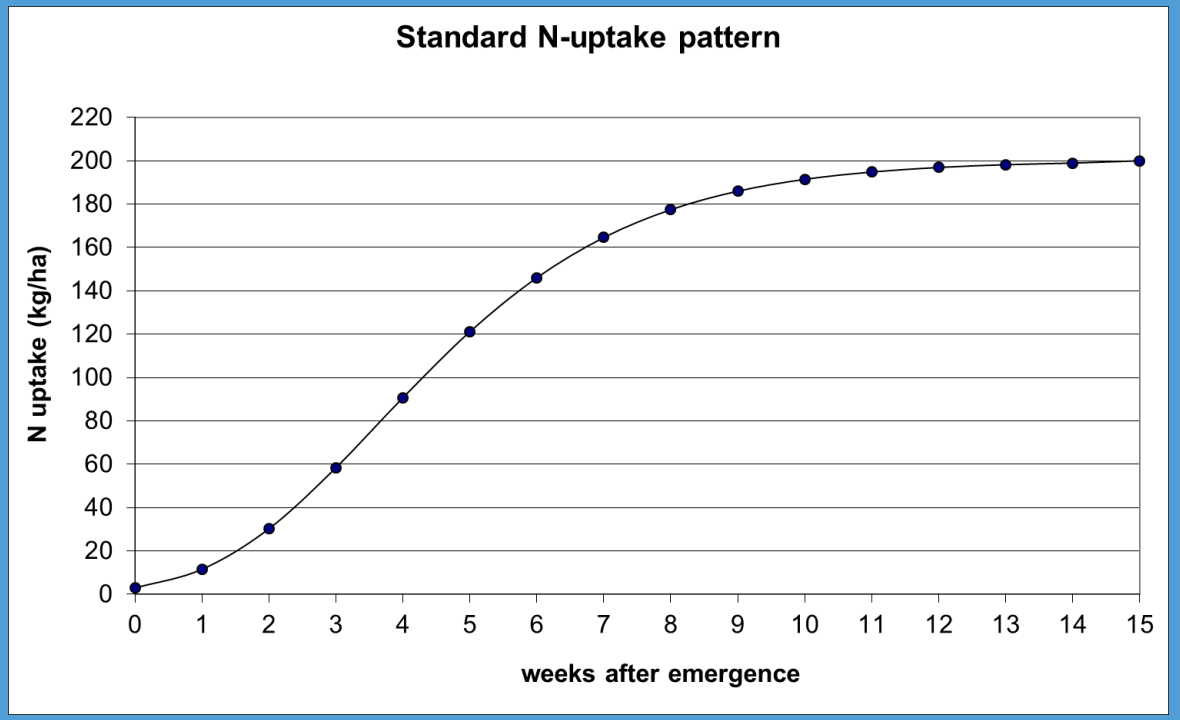
- Before planting 65% of the fixed rate (50%-80%)
- Additional top dressings based on growth conditions
- Indicators:
  - soil mineral N
  - nitrate concentration in the petioles
  - fresh biomass of the foliar
  - radiation reflection characteristic of the crop ~ N uptake, biomass

When is control and adjustment useful?

- Uncertainty about the N mineralization
- Risk of leaching
- If a high N mineralization is expected
- After application of manure
- At heterogeneous fields

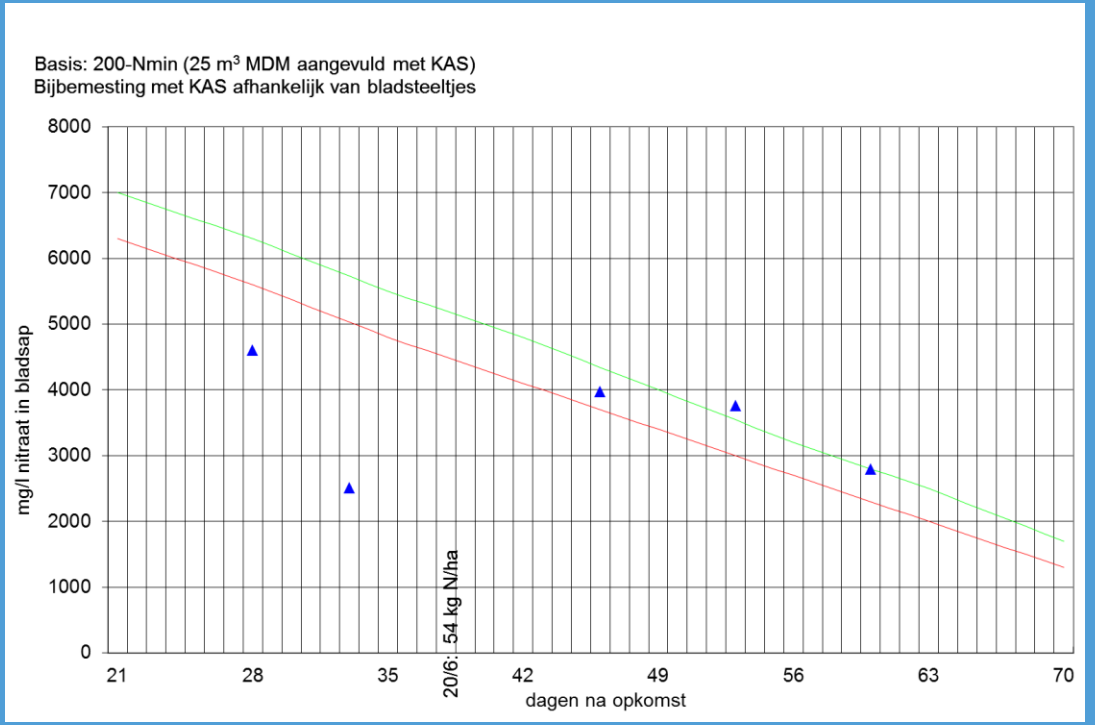
Indicator: soil mineral N (SMN)

- N balance method
- Global N uptake pattern potato
- SMN determination during growth periode (sampling)
- Additional N rate = forthcoming N uptake + margin – SMN – expected mineralization
- Potato and vegetable crops



Petiole method potato

- Sampling petioles and analyses of nitrate content, 4-5 times
- Compare nitrate content to target value (depending on variety)
- Measured value
  < target value
  → 30-50 kg/ha N top-dressing



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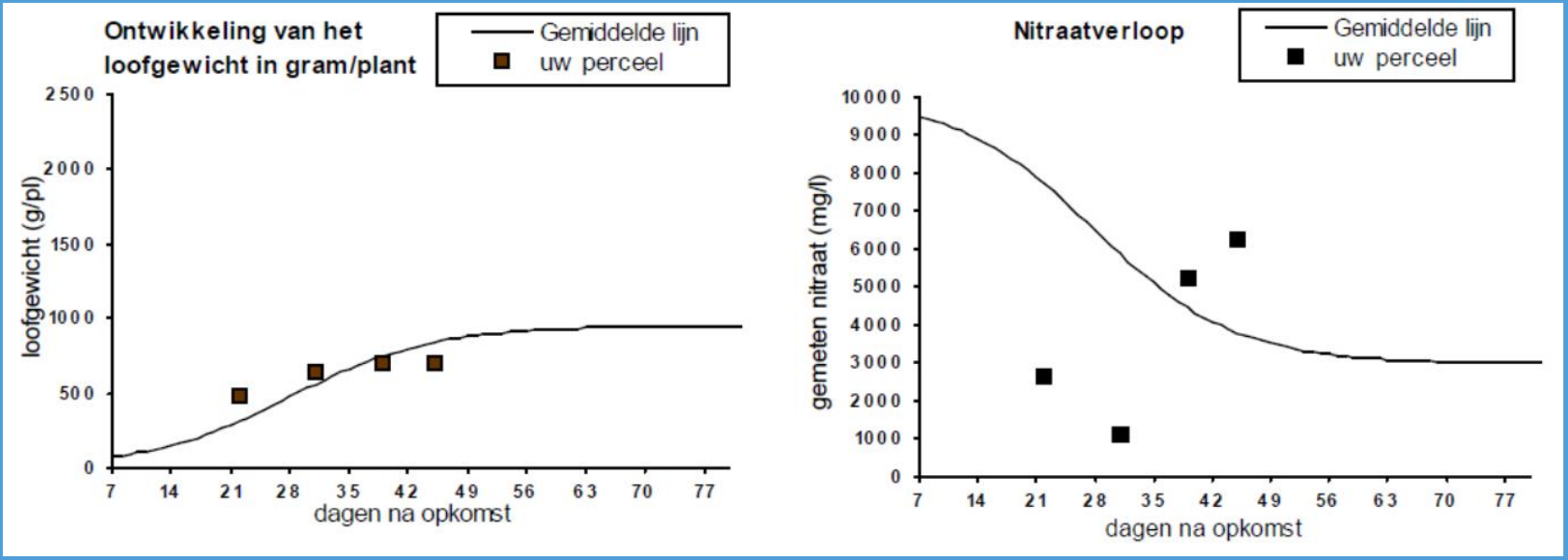
Potato monitoring

- Nitrate content petioles + foliar weight of 5 plants, 4 times during the growing season
- Comparisson to target values (depending on variety)
- Calculation additional N top-dressing



Top-dressing: 70 kg/ha N, 3-4 weeks after emergence

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Crop sensing (Remote sensing)

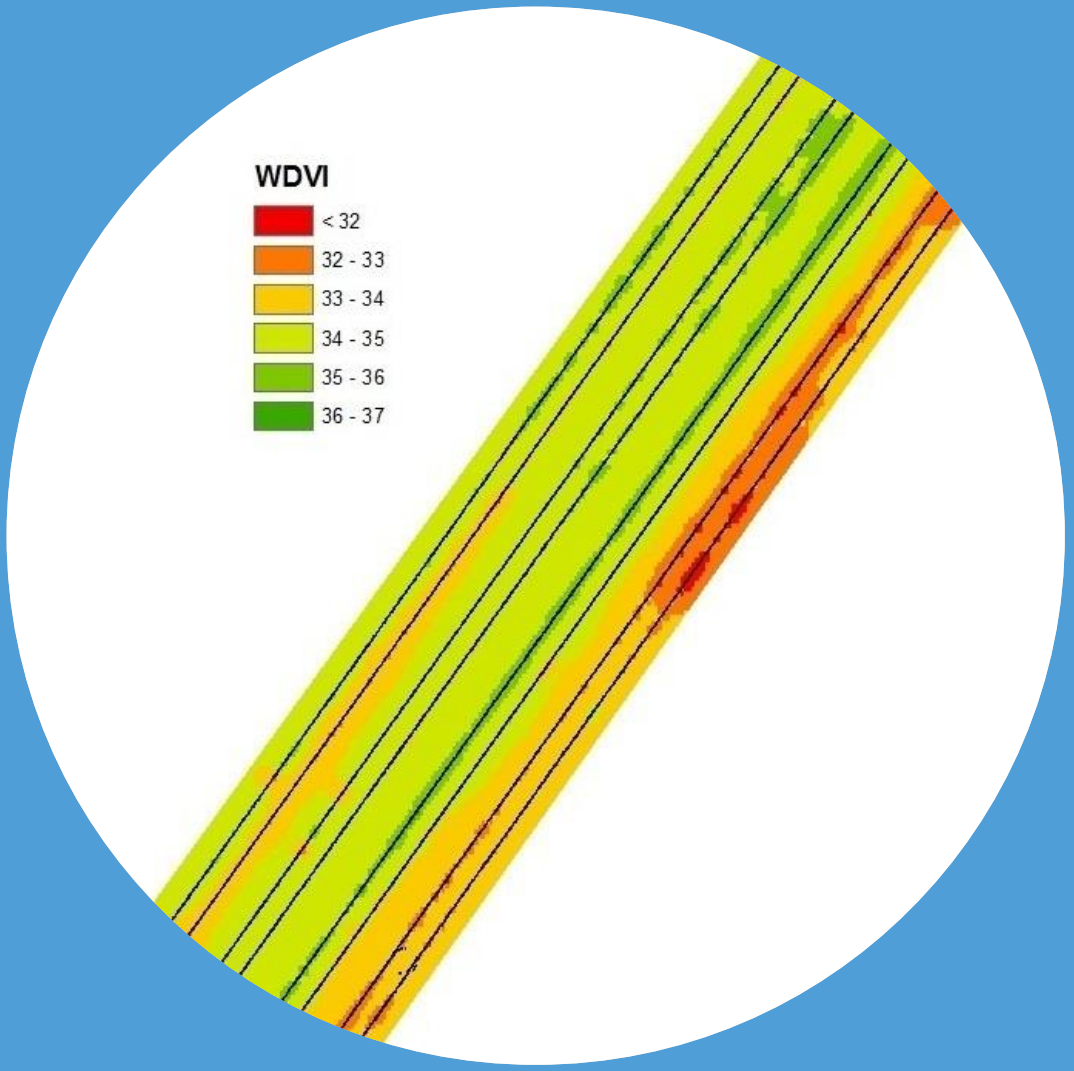
Crop sensing (Near Sensing)

Sensing of the crop

Determination of differences:

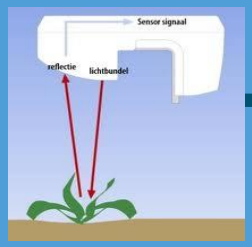
- biomass
- N uptake

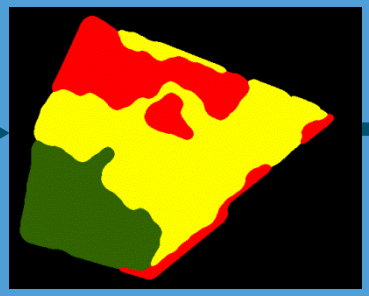
Between fields or within a field



What do crop sensors observe ?

- Crop sensor:





reflection of radiation

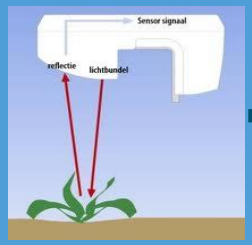
calculation vegetation index

interpretation

- Sensor data indicate relative differences
- Additional sampling to determine absolute level

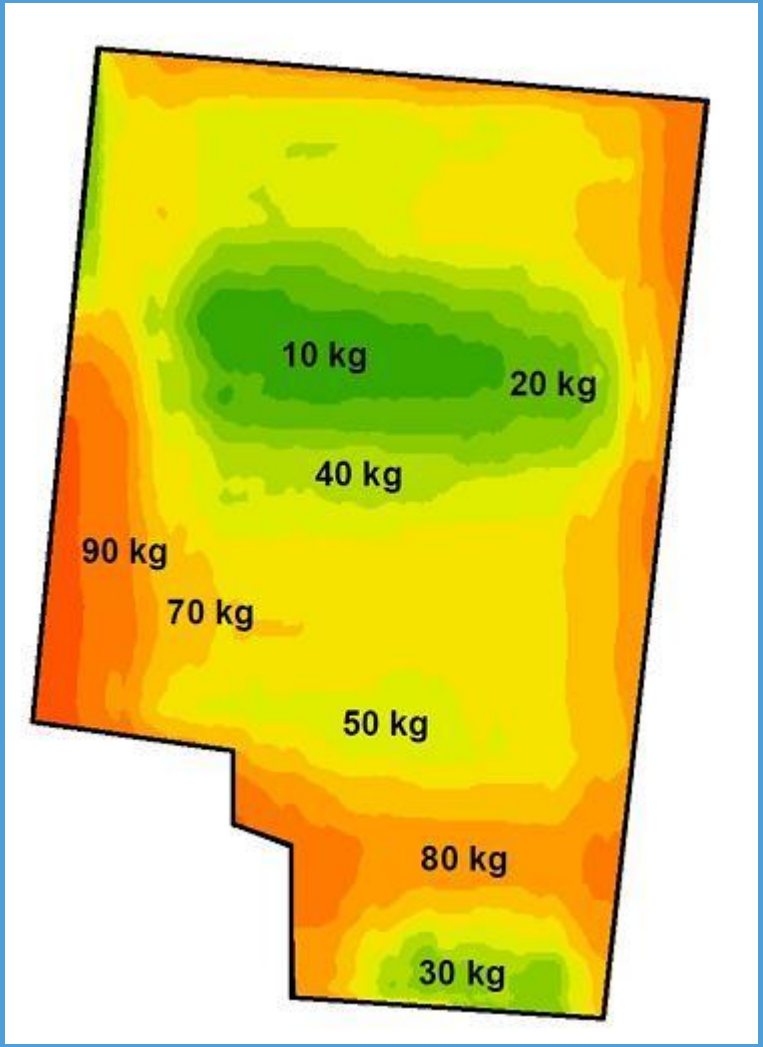
From sensing to N recommendation

- Derive N uptake of the crop from it’s radiation reflection
- Compare to target value
- Calculate additional N rate



Variability within a field

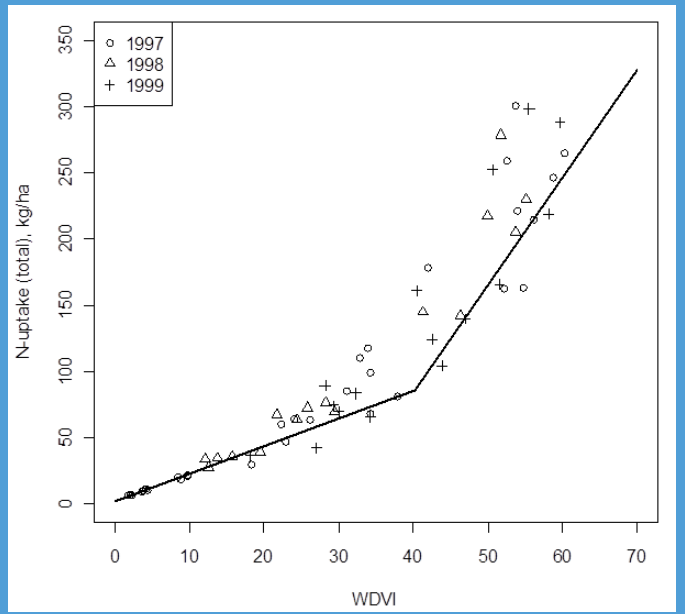
How to deal with it?



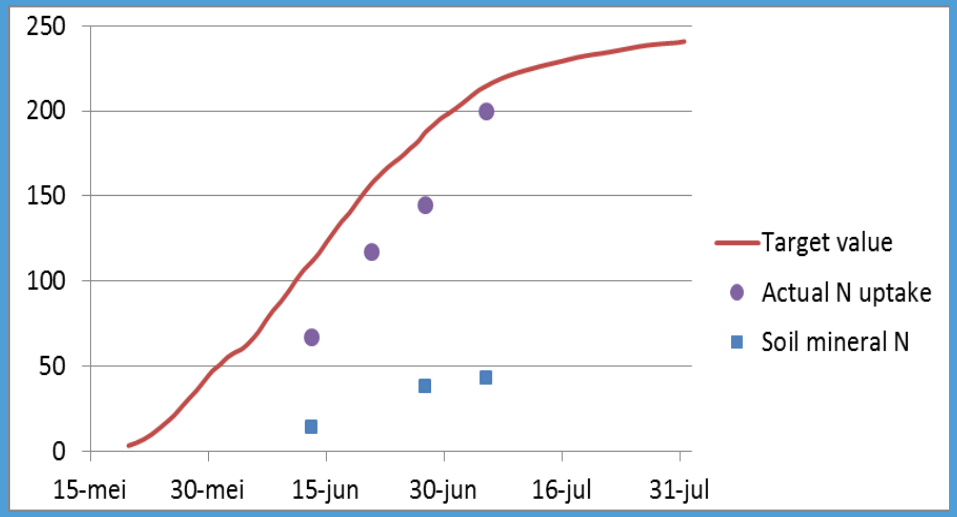
Guided N rate systems based on crop sensing of potato

Procedure:

1. Measuring radiation reflection of the canopy
2. Calculation vegetation index
3. Derivation N uptake by the crop
4. Comparison to target value
5. Calculation of additional N top-dressing (different ways)



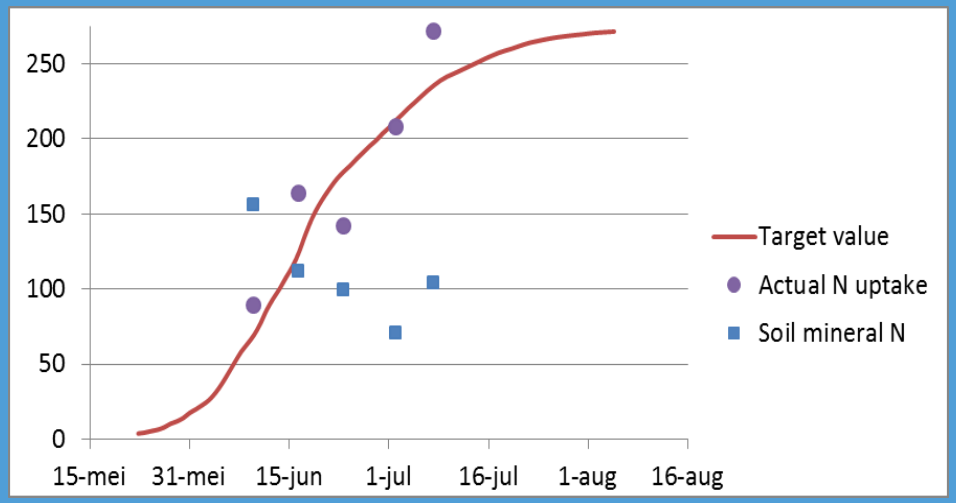
Example crop sensing + N-balance potato



Before planting: 150 kg N per ha

N top-dressings:

- 1st measurement: 125 kg N per ha
- 2nd and 3th measurement: awaiting next one
- 4th measurement: 15 kg N per ha → 0



Before planting: 150 kg N per ha

N top-dressings:

- 1st and 2nd measurement: 0
- 3th measurement: 41 kg N per ha
- 4th measurement: 0

State-of-the-art crop-sensing-based N fertilization

- Crop-sensing-bases N fertilization looks promising
- Advantages: quick advice
  saving of labour (no/less sampling)
  location specific top dressing within the field
- Improvement / refining is necessary and possible
- May also be applicable in seed potatoes
  → development of specific target values
- Sensors are expensive and need control and maintenance

Type of fertilizer: nitrogen form

- Nitrate: entirely solved in soil moisture
  can easily taken up by plant roots
  can easily leach
- Ammonia: adsorbed to clay particles and organic matter
  ↕ balance
  small part solved in soil moisture

  slower available
  transformed in the soil into nitrate by bacteria (within a few days at ≥20 °C) = nitrification
  risk ammonia volatilization (esp. on limy soils)
- Urea: transformed in the soil into ammonia and next into nitrate

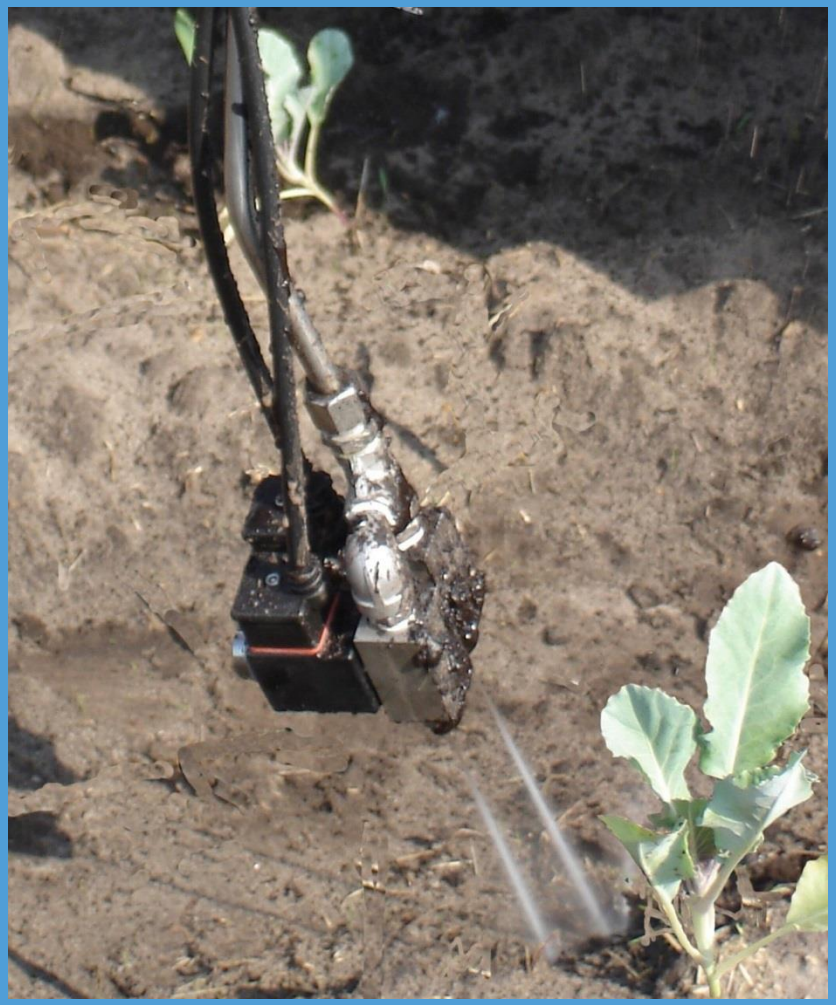
Common N fertilizers

- Ammonium sulphate
- Calcium ammonium nitrate (CAN)
- Urea
  - 80-90% replacement value of CAN on limy (clay) soils, 90-95% on sandy soils with pH <7
- Urea ammonium nitrate (UAN)
  - almost similar to CAN on sandy soils with pH <7, 90-95% on limy soils
- NP and NPK fertilizers (MAP, DAP, KNO_3, blends)

Improvement nitrogen fertilizer use (1)

- For a major part N is applied in the form of urea
  - Gaseous losses: ammonia volatilization
  - → Incorporate / inject fertilisers into the soil

Pulstec



Improvement nitrogen fertilizer use (2)

- Risks for surface runoff / leaching
  - Especially in wet periods
  - Very heavy soils → low water infiltration capacity
  - → Incorporate fertilizers into the soil
  - Coarsely textured soils with limiting rooting depth → low water holding capacity, susceptible to leaching
  - → Use of fertilizers that prevent leaching
    - Ammonium fertilizers with nitrification inhibitor
    - Slow-release fertilizers (coating or molecular compounds)

Foliar application of nitrogen

- Top dressing(s) during the growing season
- Liquid urea or UAN
- Can be combined with spraying of fungicides (late blight)
- Risk of leaf damage (UAN) → ≤20 kg/ha N per time
- Faster N uptake than soil fertilization
  → advantage under dry conditions
  In other cases similar tot CAN

Effects of special fertilizers

Conclusions from field trials

- Sometimes better than CAN
- Limited contribution to improve nitrogen use efficiency
- Guided nitrogen fertilization provides better opportunities to improve nitrogen use efficiency

Fertigation

Fertilization by the (drip) irrigation system

Benefits of drip irrigation / fertigation

- Regular supply of water and nutrients
- Makes accurate fertilization possible
- Improves N utilization
- Increases yield and quality
- Saving of water and nitrogen
- Use of saline water (to certain extent)
- Highest profit in arid regions (on desert soils)

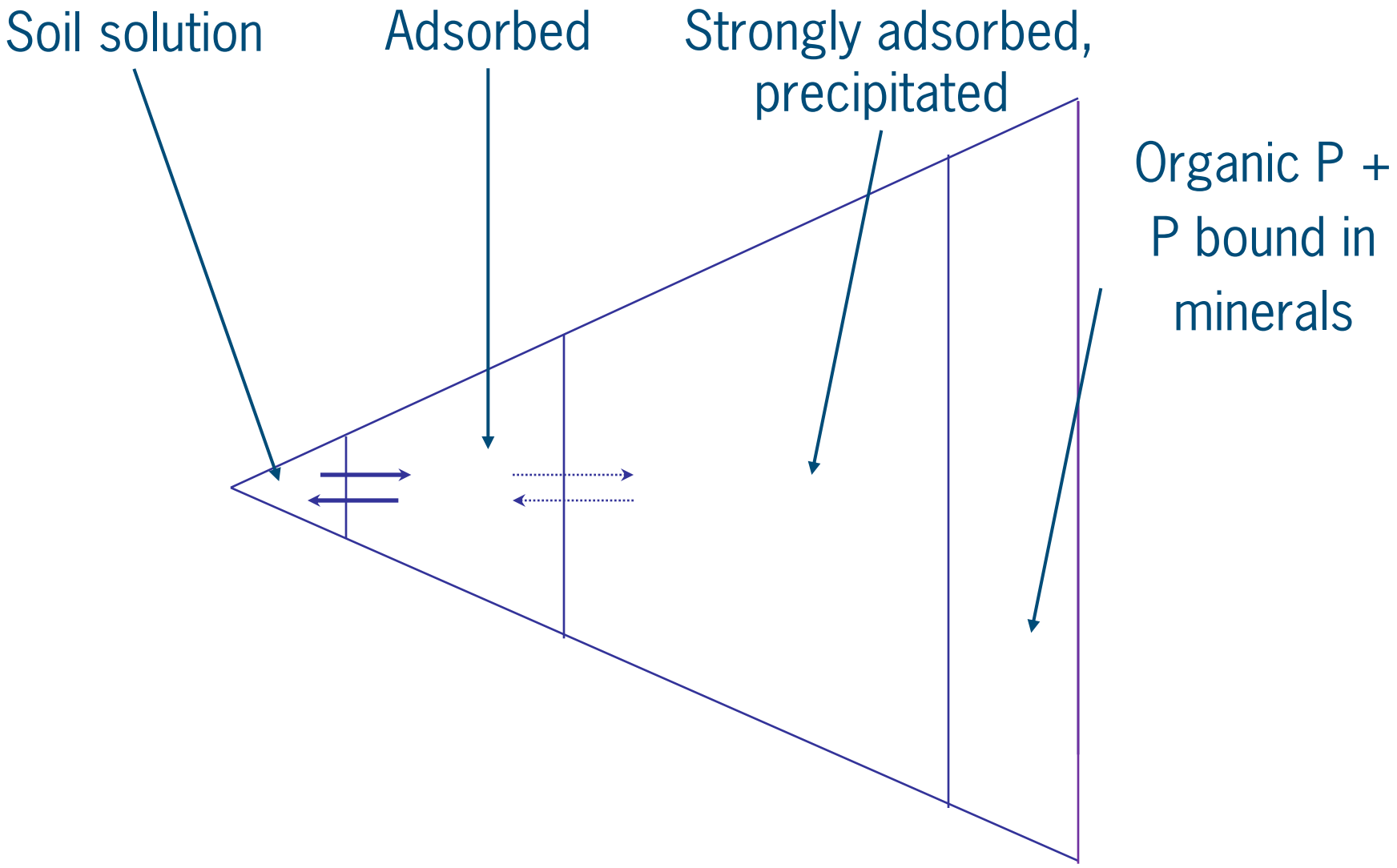
Disadvantage: high costs

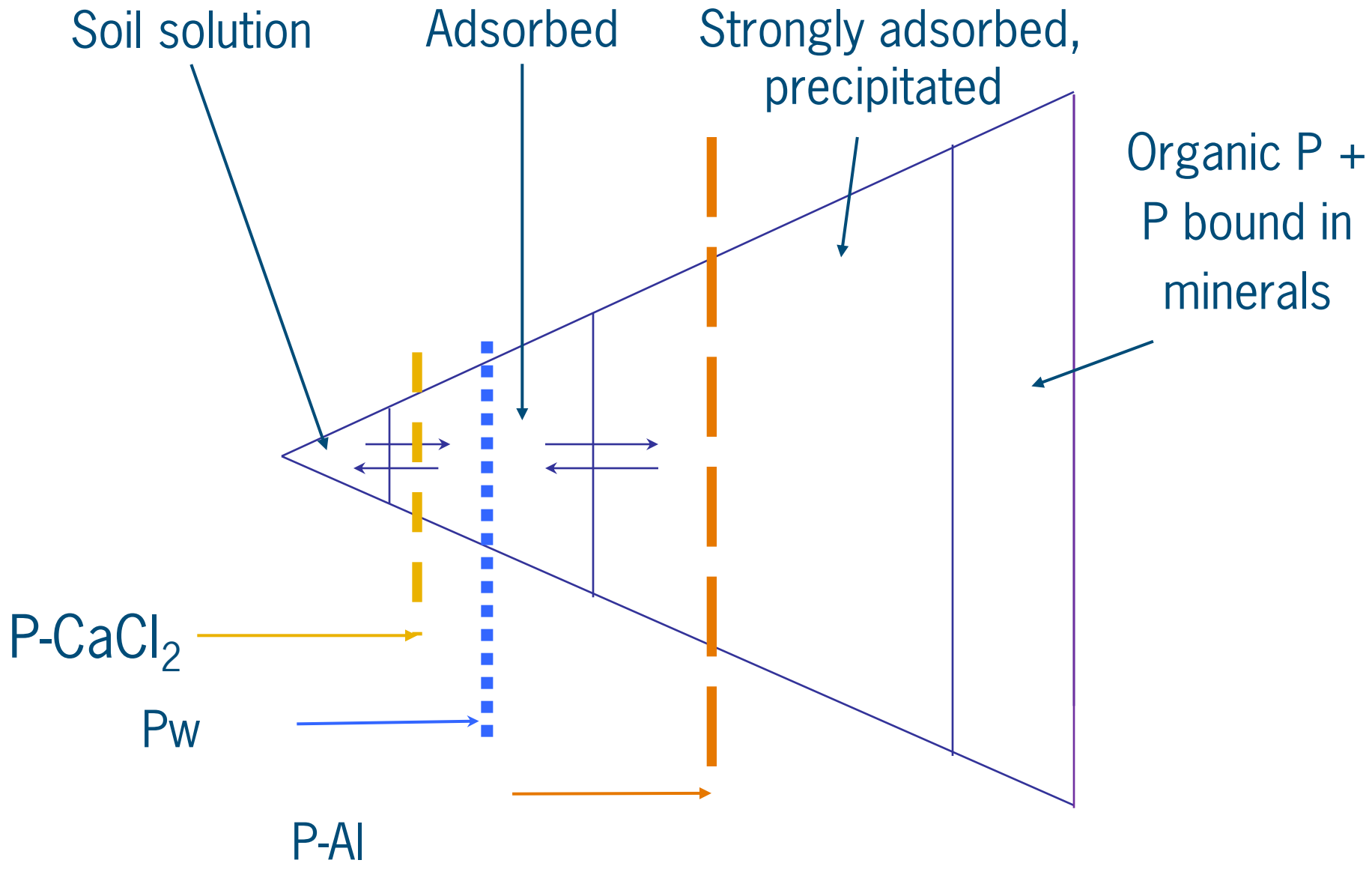
Soil sampling soil fertility

- Once in the rotation cycle (4-5 year)
- Top layer (0-20/25 cm)
- Parameters
  - Organic matter
  - pH
  - Phosphorus
  - Potassium
  - Magnesium, sulphur
  - Micronutrients

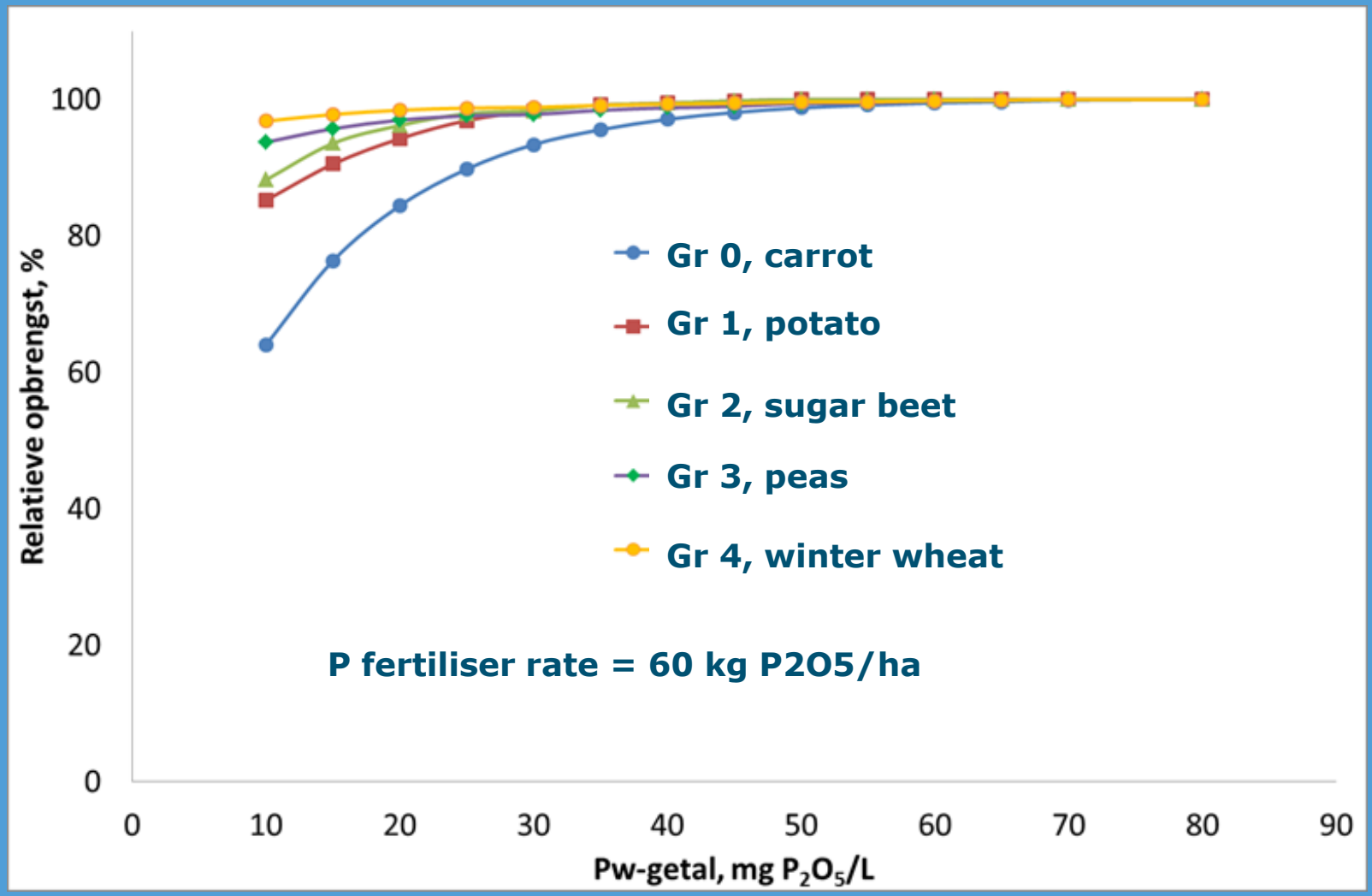
Phosphorus recommendations

- Depending on:
  - Plant available phosphorus content in the soil (analyses)
  - Crop demand
  - Soil type
- Target levels available content in the soil
- In general a broadcast application
- Major sources: manure, triple super phosphate

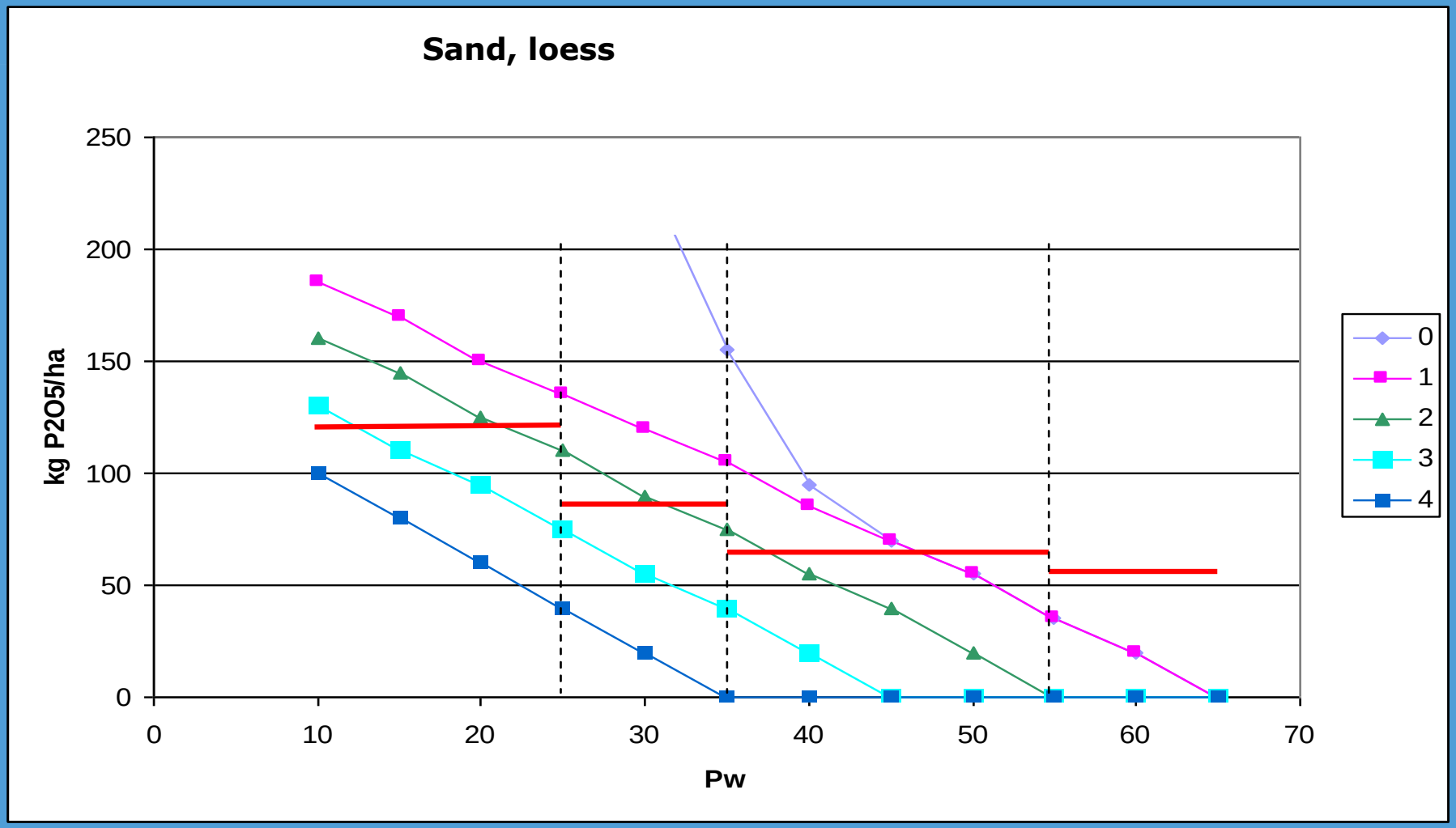

Soil solution
Adsorbed
Strongly adsorbed, precipitated
Organic P + P bound in minerals


Soil solution
Adsorbed
Strongly adsorbed, precipitated
Organic P + P bound in minerals
P-CaCl2
Pw
P-Al

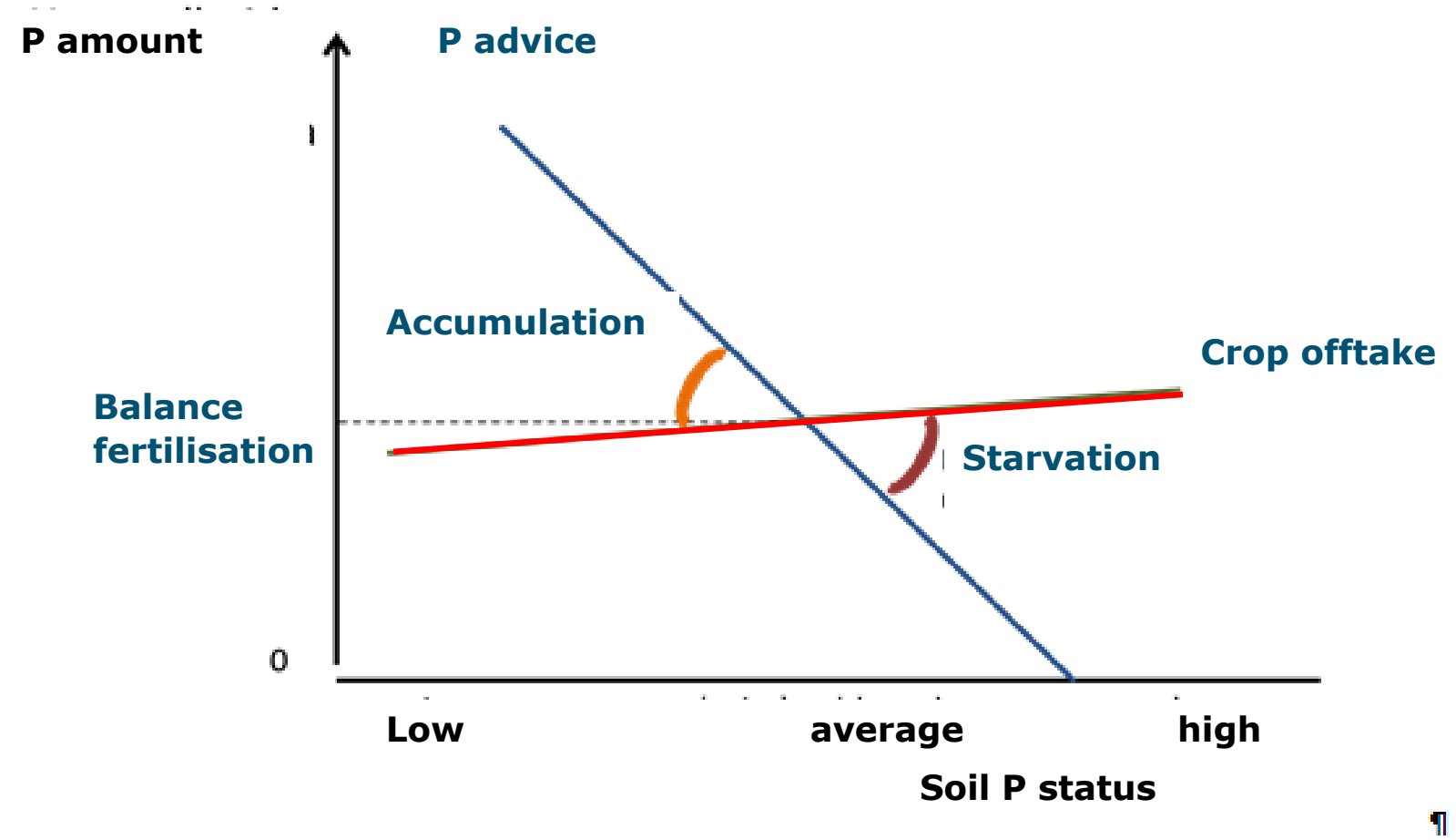
Crop response on P soil status



P fertiliser demand in relation to soil P status



Self correcting advisory system



Attention phosphorus

- Phosphorus is not mobile in the soil
- Roots must grow to the phosphorus stock
- Limited root development, especially during juvenile growth
- High P demand at the start of the growing season
- Apply P fertilizers at start of growing season, preferably close to the plants and incorporate in the soil

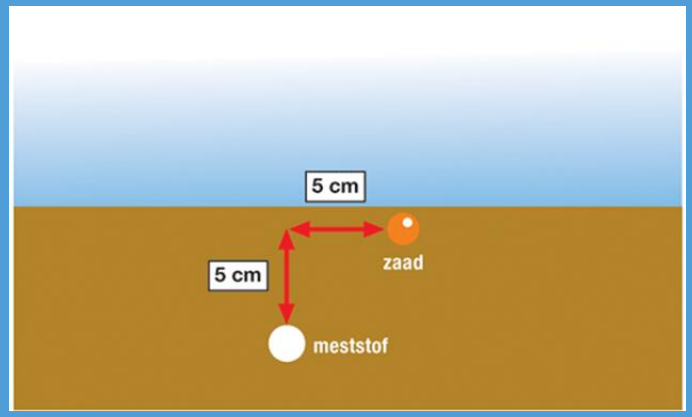
Improvement phosphorus fertilization

Risk phosphorus deficiency:

- Soils with low phosphate availability
  - Low phosphorus content
  - High P sorption capacity of the soil / fixation
  - Low pH (<4.5)
- Poor root growth (start growing season)
  - Poor soil structure
  - Low temperatures

→ Apply fertilisers near by the plants (placement)

→ Foliar application



Effect of phosphorus placement in maize

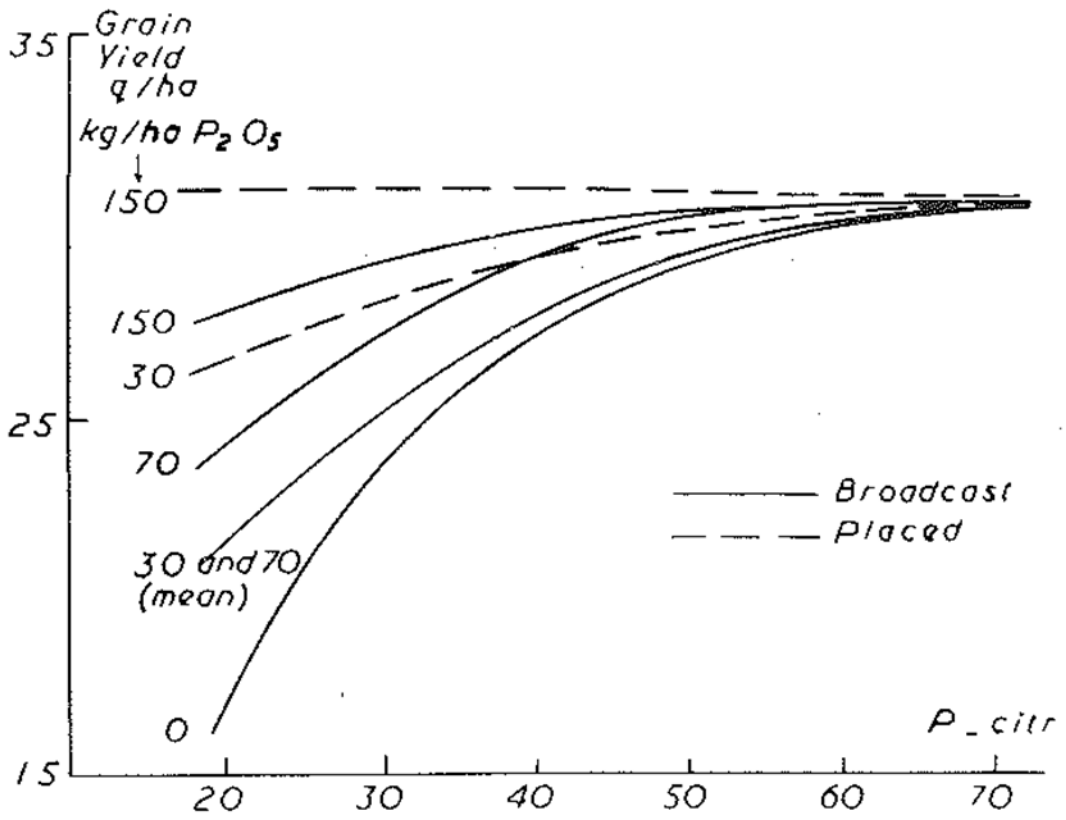
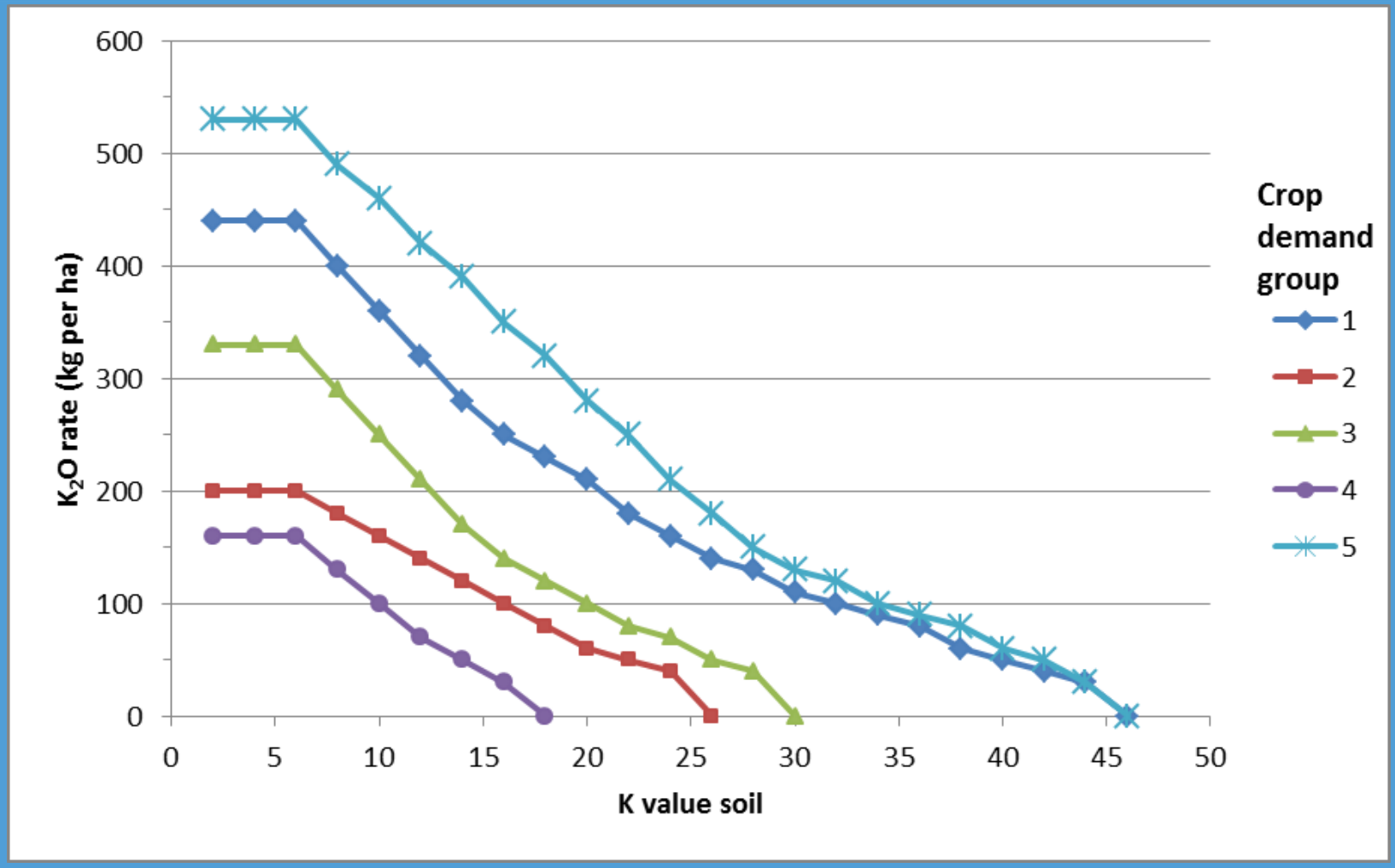


Fig. 4. Comparison between placement and broadcasting with phosphate for maize in dependence on P-citr on sandy soil (Exp. Pr 1482).

Potassium recommendations

- Depending on:
  - for plant uptake available soil content (analyses)
  - crop demand
  - soil type (sandy soil, clay soil, loess soil)
  - other soil properties: clay content, organic matter content, pH
- Target levels available content in the soil
- Broadcast application
- Major sources: manure, potassium chloride (KCl)

Recommendation table potassium (kg K_2O per ha) for marine and river clay soils with <10% organic matter



Magnesium

- Recommendation based on soil Mg content
- Risk for deficiency
  - Low soil content
  - Low pH
  - Soils with little organic matter
  - → Apply Mg-fertilizers to the soil before planting
    → Foliar application during the growing season
- Potatoes are in general sensitive for Mg deficiency
- Also differences between potato varieties

Sulphur

- Recommendation based on a balance
  - Crop offtake, deposition, mineral sulphur in the soil, mineralisation in the soil, leaching, sulphur in irrigation water
- Supply:
  - Soil: mineral sulphur
    mineralisation of sulphur
    sulphur in groundwater
  - Fertilizers: accompanying anion in several fertilizers blends, for example ammonia sulphate nitrate or CAN + S

Micro elements

- Recommendations for manganese, boron, molybdeen and copper
  - Based on soil analysis
  - Don’t apply too much
- Right pH for the soil conditions
- Apply of fertilizers with micro elements:
  - Animal manure
  - Compost
  - Fertilizer with micro elements (mostly combined fertilizers)
  - Specific fertilisers (foliar application)

pH recommendation

- Important for availability nutrients and soil structure
- Soil sampling
- Target levels depending
    - Soil type
    - Organic matter and clay content
    - Rotation

pH recommendation sandy soils

Crop rotation		Organic matter content			
%-potato	%-sugar beet	<5.0	5-8	8-15	>15
50	0	5.1-5.5	4.9-5.3	4.7-5.1	4.6-5.0
20-40	0	5.3-5.7	5.1-5.5	5.0-5.4	4.8-5.2
33-50	16-25	5.6-5.9	5.4-5.8	5.3-5.7	5.1-5.5

4. Organic fertilizer use

- Unprocessed manure
- Digested manure
- Processed manure (separation)

Average composition of some organic manures (g/kg)

	Dry matter	Org. matter	Total N	% mineral N	P_2O_5	K_2O	N/P
Slurry (liquid manure)							
Cattle	85	64	4,1	49	1,5	5,8	2.7
Pigs	93	43	7,1	65	4,6	5,8	1.5
Solid manure							
Cattle (on straw)	194	152	5,3	17	2,8	6,1	1.9
Chickens	699	401	29,2	11	24,3	18,8	1.2
Compost							
Household compost	696	242	12,8	0.09	6,3	11,3	2.0
Green compost	559	179	5,0	0.10	2,2	4,2	2.3

N replacement value (NRF)

- Part of the nitrogen that has the same effectiveness as mineral fertiliser
- NRF depends on
  - Ratio mineral N (N-NH_3) and organic N
  - Application technique: effects volatilization of N-NH_3
  - Application time: autumn, spring
  - Animal type: ruminant, pigs, poultry, other
  - Nitrogen uptake period of the crop

Mineral N

- During application: Volatilisation NH_3
- Not volatilised Nm: NH_3 --- > NO_3
- Directly available for plant uptake
- Susceptible for leaching
- N fertilizer value Nm depends on:
    - Volatilization losses --- > Application method
    - Leaching losses --- > Application time

Ammonia volatilisation

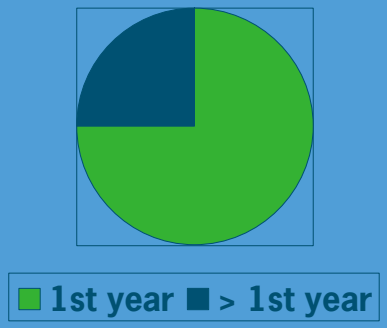
Application technique	Ammonia volatilization (% of Nm)
Surface spreading	75-80%
Surface spreading + incorporation	20-30%
Injection	≤5%

Organic N

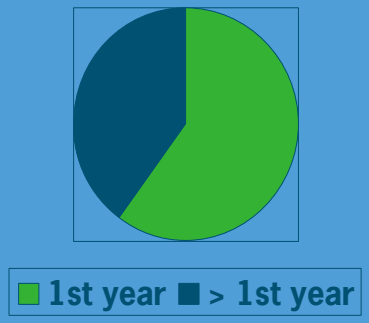
- Part of organic matter
- Not directly available
- N must be broken down to mineral N
    - Depending on temperature and soil moisture content
    - Differences in degradability
        - Cattle manure < pig, poultry manure

Degradibility organic N

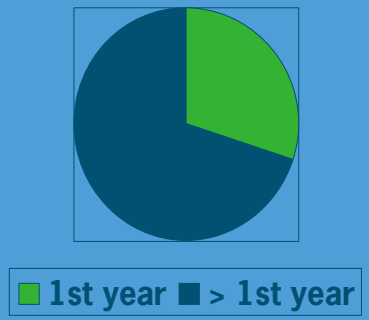
Fresh plant material



Pig, poultry manure



Cattle manure



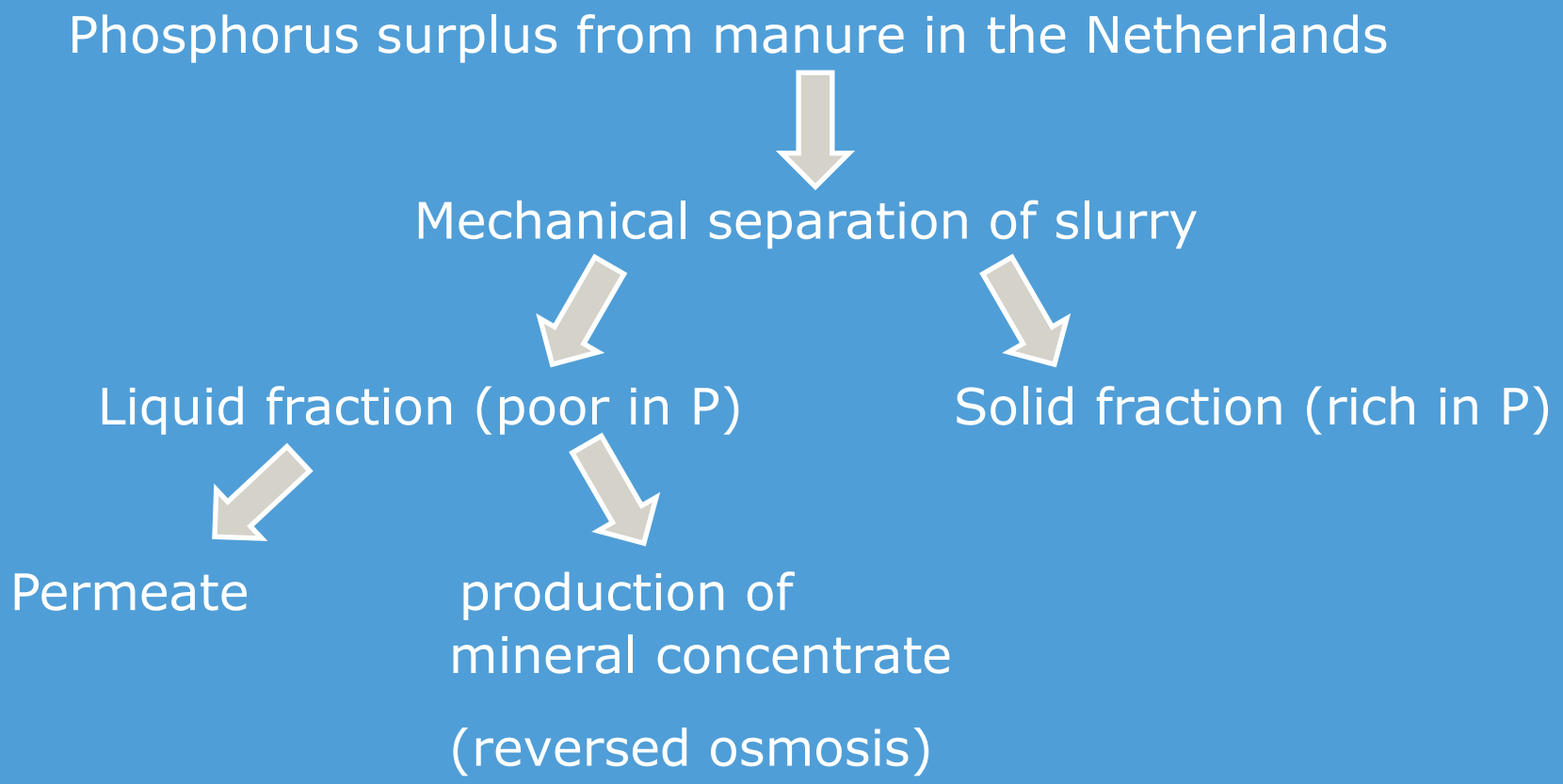
Manure: effectiveness NPK

- N:
  - Fertiliser replacement value (spring applied)
    - slurries:55-80% of CAN
    - solid manures: 30-60% of CAN
- P: 60-100%, depending on animal type (100% on the long term)
- K: similar to mineral fertilizers (100%)

Digestate

- Fermentation of manure
  + other organic materials
- Remainder product is digestate
  → suited as organic fertilizer
- All inputted minerals remain in the digestate
- Organic nitrogen partly converted tot N-NH_3 by decomposition of the organic matter
- Composition digestate varies, depending on:
  - type and composition of the fermented manure
  - type and amount of co-fermented products
- N replacement value is up to 10% higher than the value of unprocessed manure (when injected)

Processing of manure



Manufacture of mineral concentrates

- High-grade separation
- Processing steps:
  1. Accurate separation technique
  2. Ultrafiltration of liquid fraction
  3. Reversed osmosis

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Example separation of pig slurry

Effect on the composition of the separated fractions (kg/ton)

	DM	OM	N tot.	$N\text{-}NH_3$	P_2O_5	K_2O	$N\text{-tot.}/P_2O_5$
Input slurry	90	45	7.0	60%	4.0	5.6	1.8
Separation (high efficiency technique)							
Solid fraction	270	146	10.5	57%	18.7	5.7	0.6
Liquid fraction	58	25	6.4	58%	1.4	5.6	4.5
Ultra filtration and reversed osmoses of the liquid fraction							
Mineral concentrates	38	17	8.1	90%	0.5	9.3	17.3

Agronomic value of mineral concentrates

- Liquid NK fertilizer
  - Ratio N : K_2O = 1 : 1.2 (average)
  - N-total: 90% mineral nitrogen
    10% organic nitrogen (4-13%)
- Incorporation obliged
- N replacement value: 70-85%
- Small amounts of micro nutrients
- No contamination or harmful side effects
- Application in arable crops, forage crops and horticulture
- Replacement of chemical fertilizer

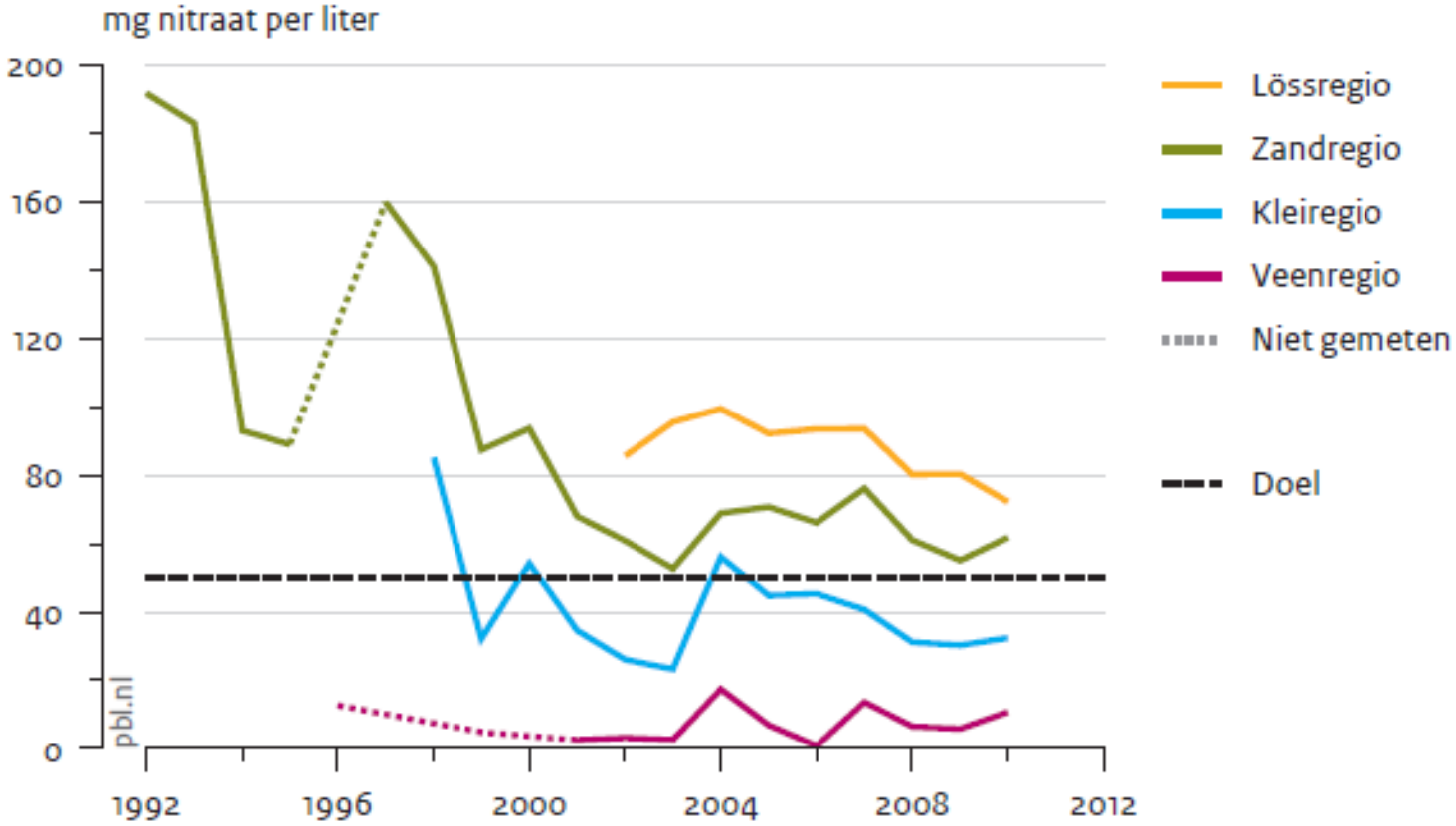
5. Legislation and market requirements on fertilization

- Why legislation
- What is the legislation
- Market requirements

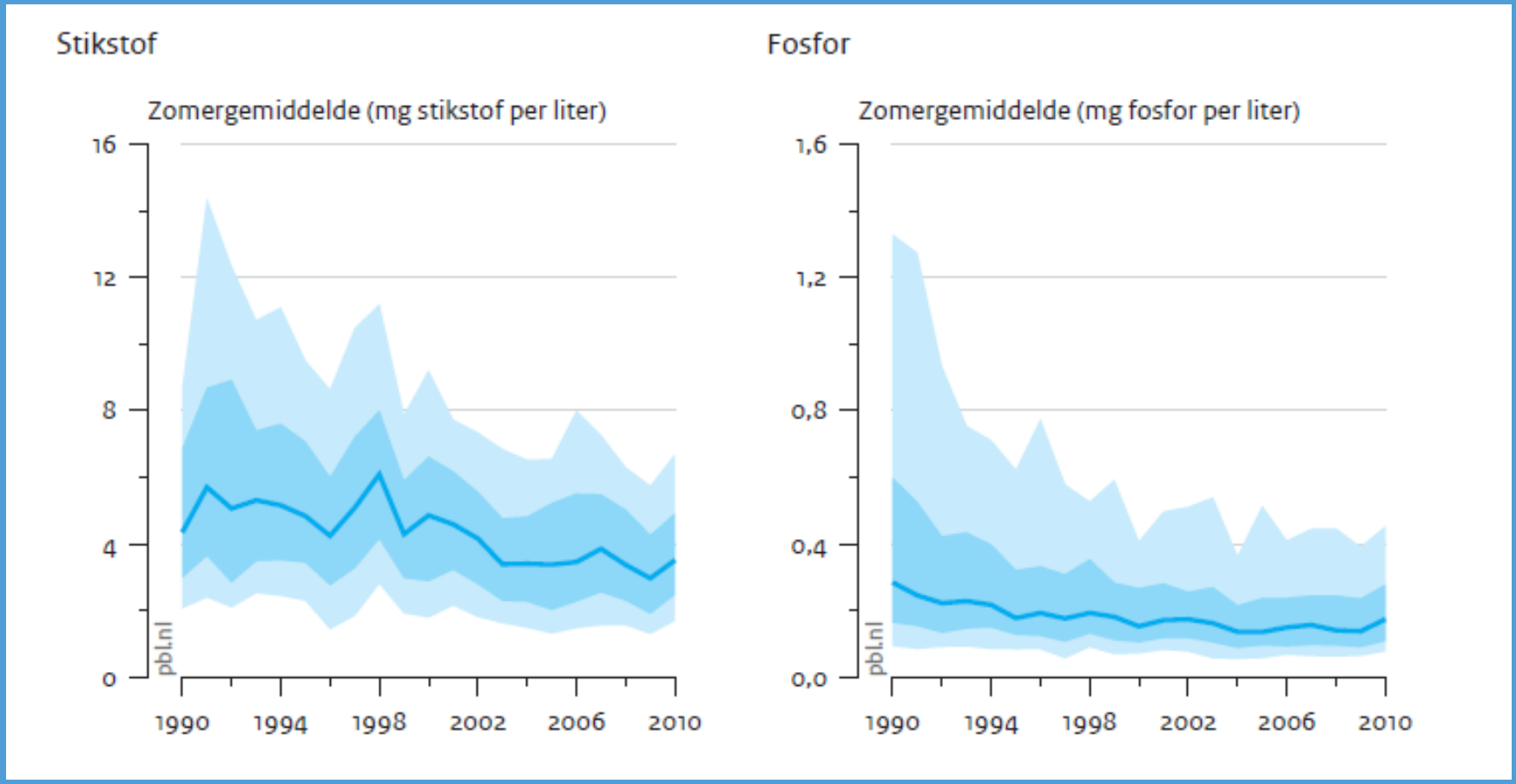
Why legislation?

- Water quality
  - Nitrogen and phosphorus leaching
  - Ground- and surface water
  - EU: Nitrate Directive & Water Framework Directive
- Ammonia losses
  - Around nature areas
- Food safety
  - Nitrate concentrations in produce
  - Heavy metals and microbiological contamination

Nitrate-N concentration in groundwater
Monitoring network The Netherlands



N and P concentration in surfacewater
Monitoring network The Netherlands



Nitrogen and phosphorus legislation

- Maximum allowed levels for nitrogen and phosphorus
    - Application standards
- Rules for incorporation of manure
- Application time of manure and mineral fertilisers
- Obligations on applications along water courses
- Catch crop after maize
- Obliged manure procession

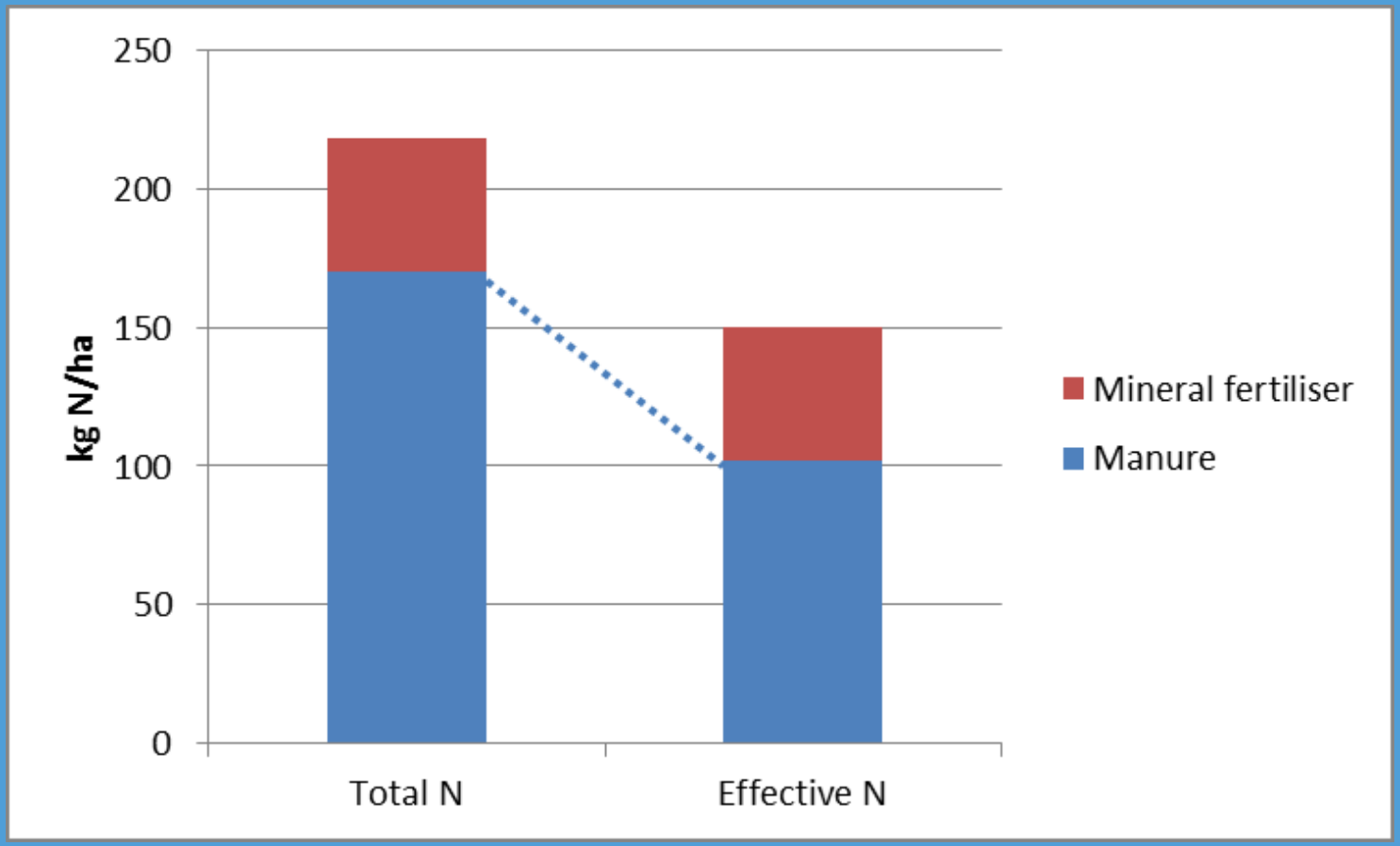
Nitrogen: application standards

- Manure
  - Maximum 170 kg N/ha
  - Derogation: 250 kg N/ha
    - Farms with > 80% grassland
- Total N (manure + mineral fertilisers)
  - Application standard per crop
  - Restricted to effective N
    - Manure: 40-80%
    - Mineral fertiliser: 100%

Standards for effective N in manure

Manure type	Clay	Sand/loess
Slurries		
Cattle	60	60
Pig	60	80
Solid manure		
Chicken	55	55
Cattle	45	45
Compost	10	10

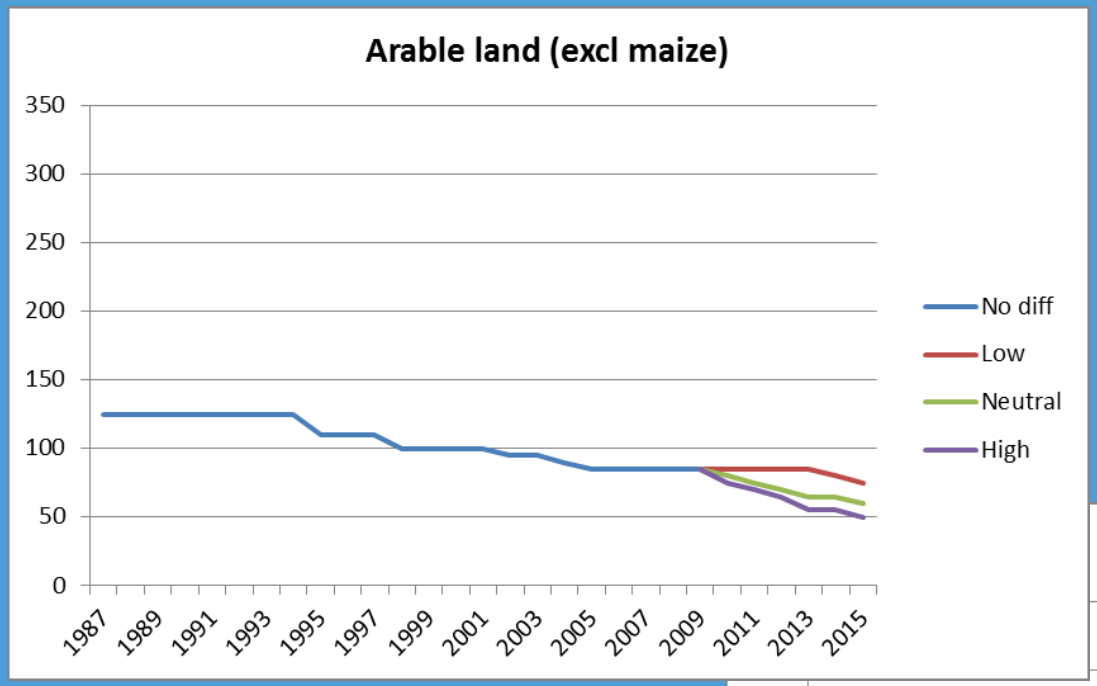
Example: Sugar beet
Application standard: 150 kg N/ha



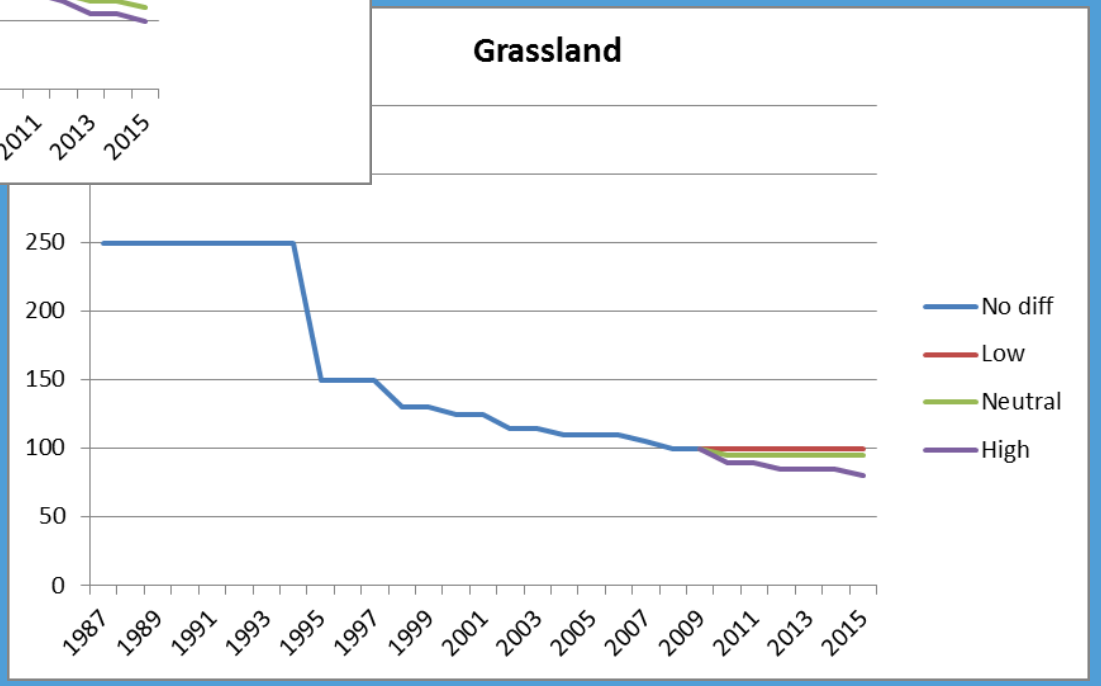
Crop nitrogen application standards

- MIN (recommendation, 50 mg N/l in groundwater)
  - Clay soils: 100% of recommendation
  - Sandy and loess soils: 70-80% of recommendation
    - Risk of yield reduction
    - Efficient N use important
- Crop specific values

Phosphorus application standards



- Application standard depending on:
  - Land use:
  - P soil status
- Total P in manure and mineral fertiliser



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Market requirements and other legislation

- Use of organic manure in vegetables
- Heavy metals
- Nitrate content of vegetables
- Certification
- Sky lark project

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6. Overview of trends and developments

- Declining soil quality
  - Organic matter content
  - Compaction of soils
  - Soil health
- Legislation restricts fertilization strongly
  - Decreasing organic matter input
- Solutions
  - Extensification of crop rotation
  - Organic fertilizers with higher carbon content
  - Reduced tillage

Overview of trends and developments

- Need for improved fertilizer recommendations
  - Recommendations based on intensity and capacity parameters
  - Precision fertilisation advices
    - Using sensing techniques
    - Using information on soil variability
  - Incorporating other aspects
    - Soil physical and biological aspects
    - Plant health and crop quality

Overview of trends and developments

- Recycling and optimizing organic fertilizers
  - Manure processing
    - For products fit on need of crop
    - For export of nutrients
  - Recycling of nutrients & organic matter from waste
    - Struvite (NH_4MgPO_4) from sewage sludge
    - Composts
    - Anaerobic digestation products

7. Differences between China and the Netherlands, questions and discussion

- What is the largest similarity in fertilization between China and the Netherlands?
- What is the largest difference between China and the Netherlands?
- What is the most important subject to take home?
- What was this morning the most remarkable subject?

Thank you for your attention