Soil fertility management in high and less intensive NW-European (moderate climate) OGH systems

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BioGreenhouse

cost
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IN SCIENCE AND TECHNOLOGY

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Outline

- Main characteristics of OGH systems in Central Europe
- Technical features and productivity levels
- Main crops and crop rotations
- Soil fertility management
- Main constraints and bottlenecks
- Knowledge gaps/challenges

Main production aims and characteristics

- production of vegetables during the summer season,
- combined with an anticipation and extension of the production season,
- sometimes production of winter leafy vegetables

Some characteristics

Highly intensive

- Mostly on specialized farms
- heated
- Application of additional CO_2
- Production focused on fruit vegetables
- Crop rotation: 1) Tomatoes; 2) cucumber/sweet pepper
- Green manuring: rarely
- Productivity: 40 – 50 kg tomatoes m^{-2}

Less intensive

- Generally farms also producing vegetables in open fields
- Mostly kept frost free
- No CO_2 application
- More diverse production
- Crop rotation: higher variety, often with pre-crops, main crops and subsequent crops
- Green manuring: rarely
- Productivity: 7 – 25 kg tomatoes m^{-2}

Technical features and productivity levels of the main greenhouse cropping systems in NW-Europe

	Northern high intensive	Northern less intensive
Building	Permanent greenhouses	Semi-permanent or permanent greenhouses
Heating	Intensive full heating system	frost protection (5°C), additional heating for earliness or humidity control
Ventilation	Controlled	Controlled or natural
CO_2 enrichment	Generally used with regional exception	No, or together with heating
Cropping period	Growth year -round	Mostly season crops
Productivity level [kg m^{-2}]	Tomatoes: > 40, Sweet pepper: > 20, Cucumber: > 60	Tomatoes: 7-25 Cucumbers: 5-25 Sweet pepper:2-7
Main region	Mainly in Netherlands, Belgium, Scandinavian countries and few in Germany	Central & Northern, Northwest Europe
Crop breaks	biofumigation (some)	Winter leafy crop

Typology of crop rotations in greenhouses in Central Europe

	Very intensive	Simple, focused on main crop	Diverse	Very diverse
Precrop	none	Kohlrabi	corn salad, endive	Kohlrabi, spinach, turnip, radish, chives, loose leaf lettuce, endive, spring onions, parsley
Main crop	Tomato, cucumber, pepper, eggplant	Tomato, cucum-ber, pepper, eggplant	Tomato, cucumber, pepper, eggplant, common beans	Tomato, cucumber, pepper, eggplant, common beans, radish, spinach, rocket
Subse-quent crop	none	none	Lettuce	corn salad, head lettuce, radish, rocket, parsley, chives, loose leaf lettuce

Main characteristics of the soil fertility management in typical greenhouse cropping systems in NW-Europe

	Northern high intensive	Northern less intensive
Base dressing	Composts or/and solid animal manures	
Complementary fertilizers	yes	
Mulching	Plastic mulch	Plastic mulch/dead mulch
Decision making (DSS)	Nutrient dynamic balance (N, P, K)	Nutrient balance (N), or standard fertilization schedule
Top dressing	Common for N and K, never for other nutrient, Based on N up to 75 % of the inputs (50-90 %)	complementary fertilizers up to 50-60 % of N input
Fertigation	usual	Sometimes to fruit vegetables
Micronutrients	Occasionally	no

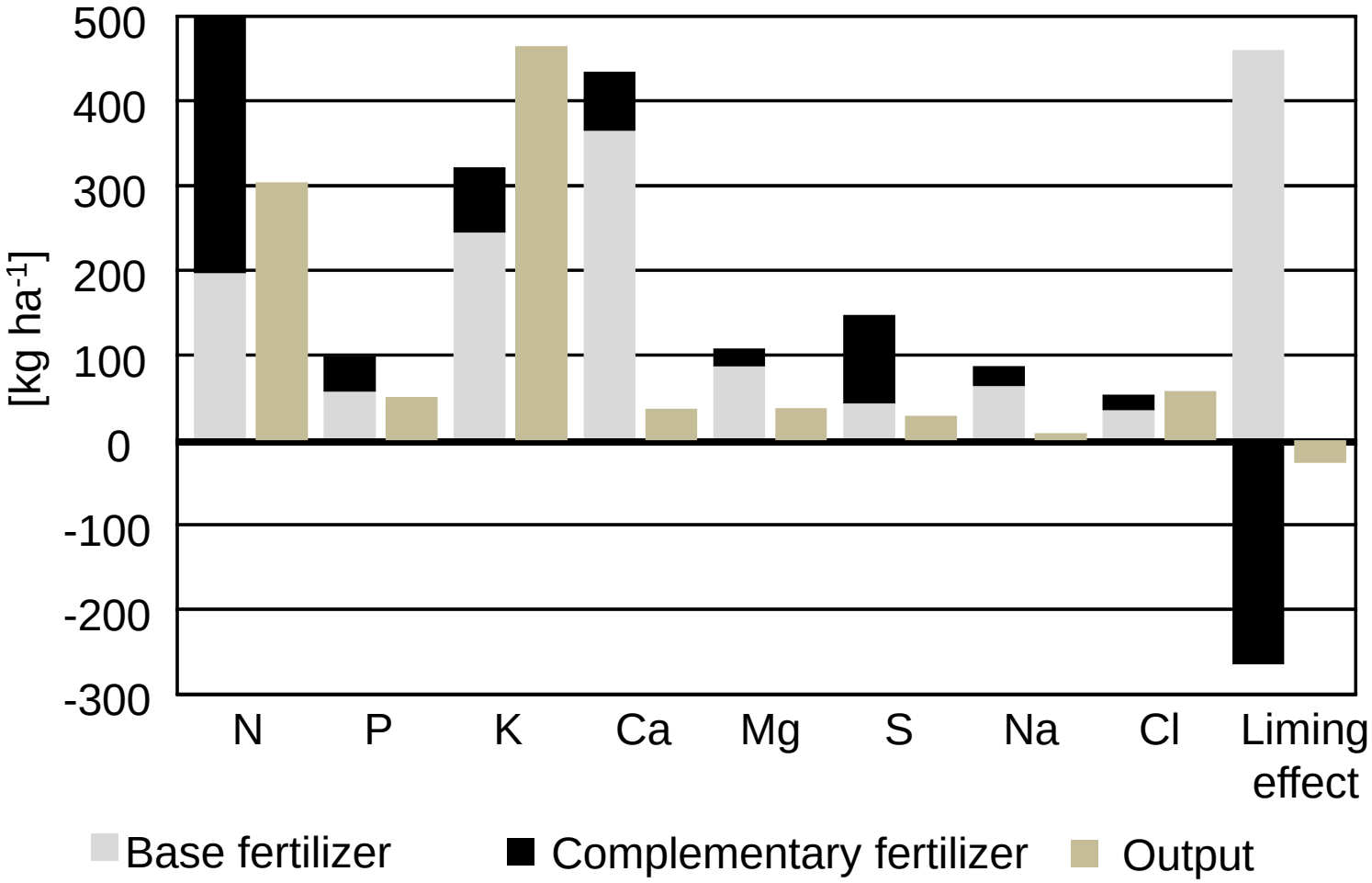
Soil fertility management in highly intensive systems

- High OM content between 5 and 7 %, high soil pH,
- Base dressings before crop establishment: solid animal manures, composts,
- Top dressings:
  - rapid mineralising fertilisers are applied throughout the growing season,
  - Occasionally, fertigation with liquid organic fertilisers,
- Yearly N outputs: 700 – 1,200 kg N ha^{-1},
- Quantification of the fertilisers to be supplied is based on the estimated crop demand,
- Use of calculation tools,
- soil and plant analyses are taken throughout the growing season → to adjust top dressing

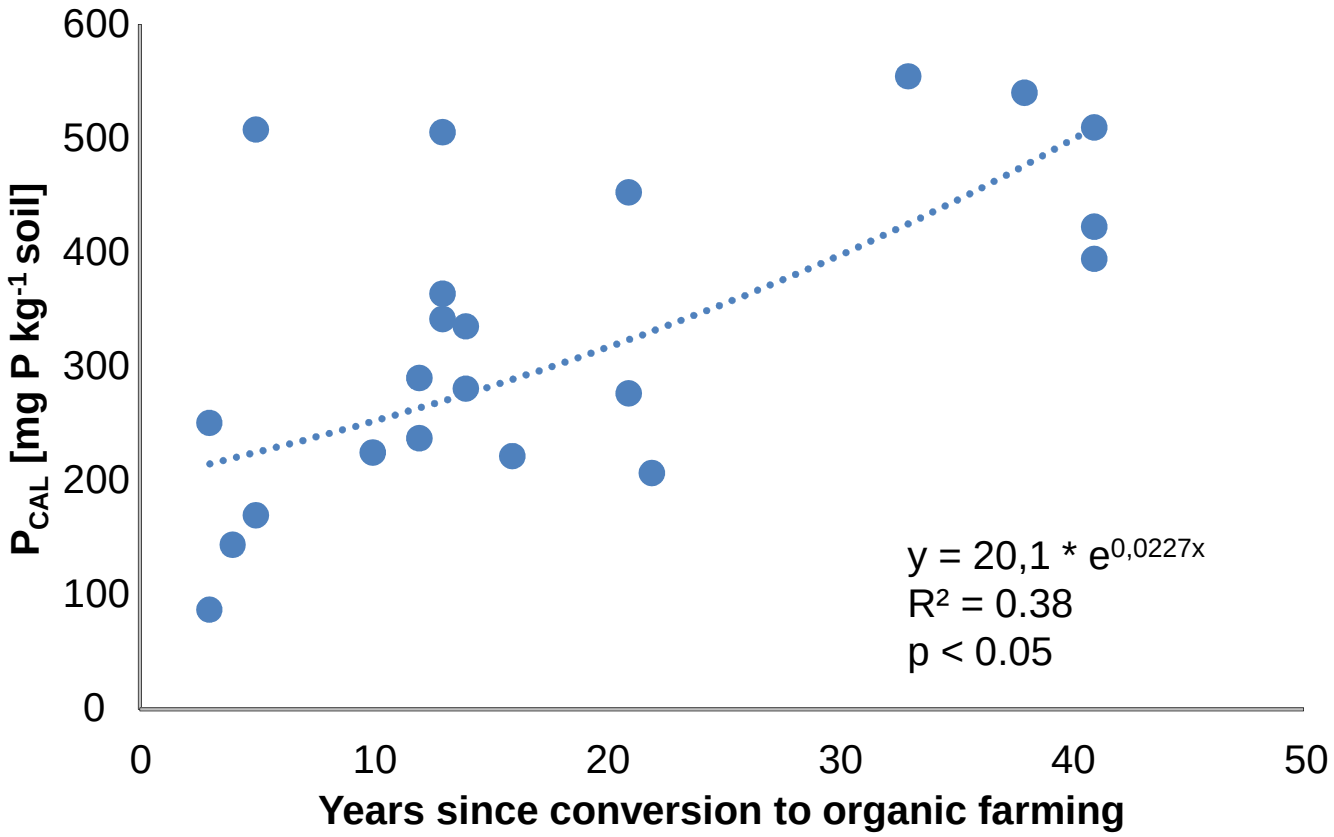
Soil fertility management in less intensive systems

- High C_{org} content between 2 and 8 %, high soil pH,
- Base dressings before crop establishment: solid animal manures, composts,
- Top dressings:
  - rapid mineralising fertilisers are applied throughout the growing season,
  - Occasionally, fertigation with liquid organic fertilisers,
- Yearly N outputs: 300 – 500 kg N ha^{-1},
- Fertility management often less elaborated/less professional than in highly intensive systems:
  - Quantification of the fertilisers based on standard advice,
  - No use of calculation tools,
  - No soil and plant analyses

Average nutrient inputs and nutrient outputs of the greenhouses for three years study period



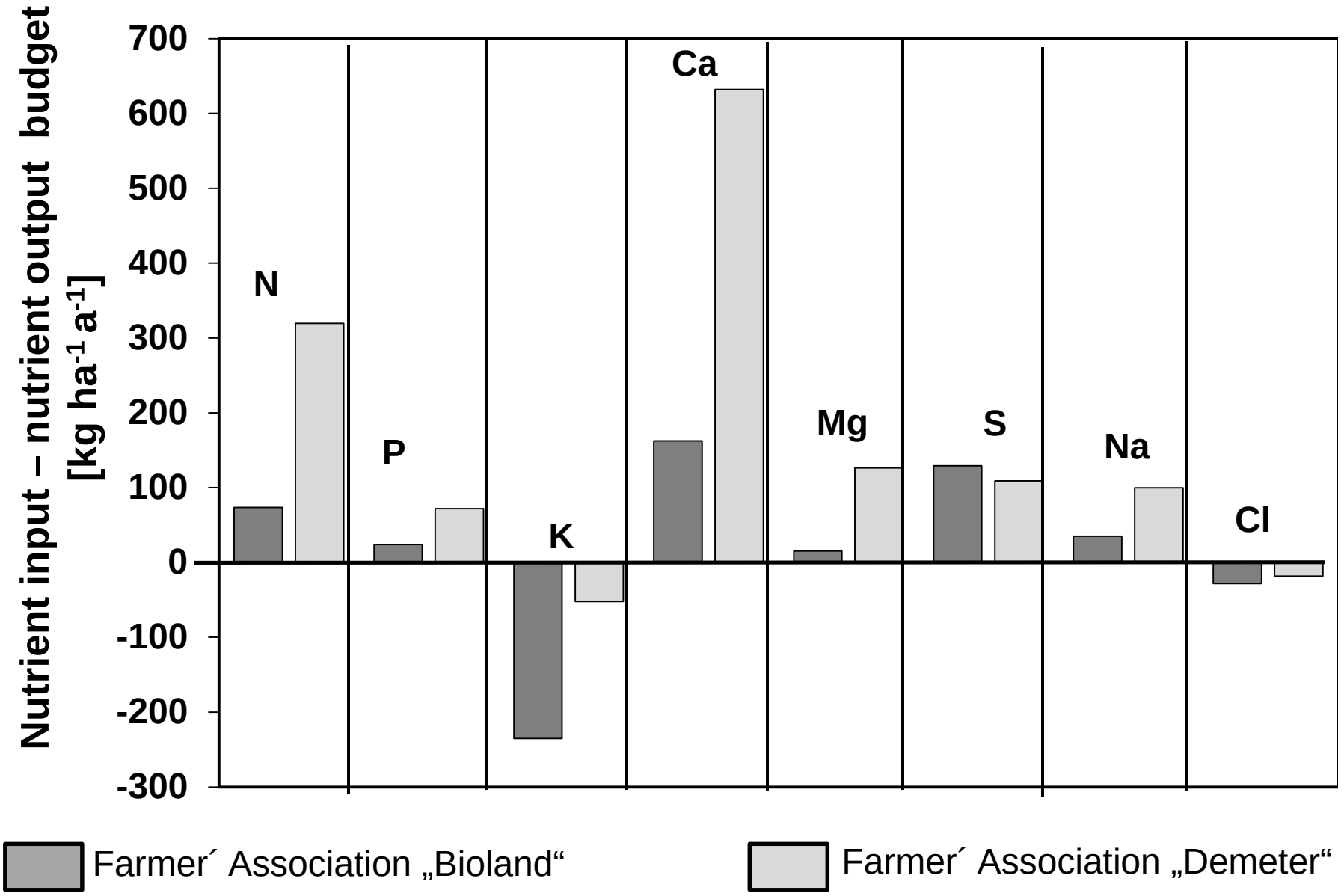
Relationship between the age of the green-house and the plant available P_{CAL}-contents in the soil



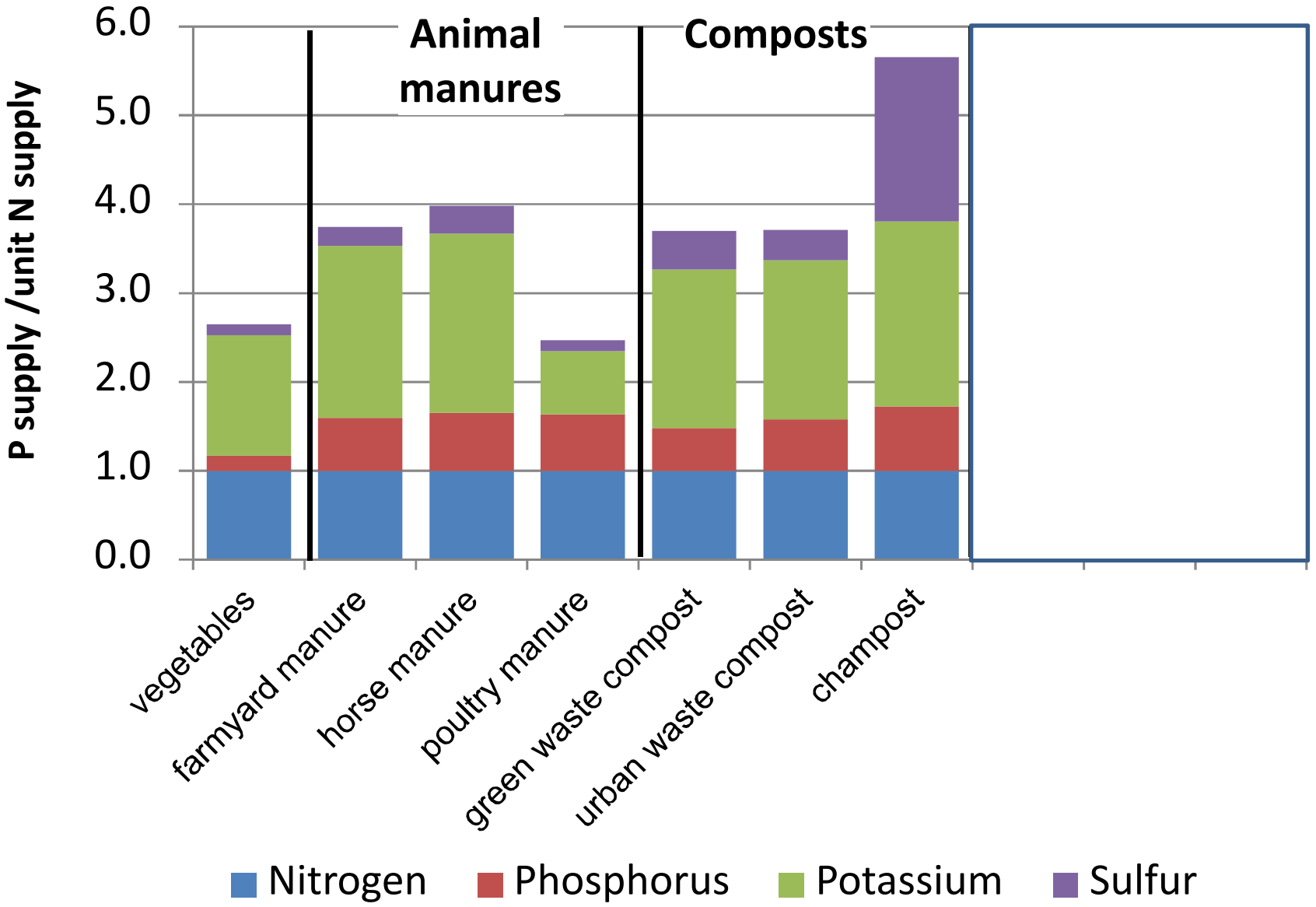
Fertilizer strategies of different farming types

fertilizer type	Bioland			Demeter		
	MW	Min	Max	MW	Min	Max
	dt ha^{-1} a^{-1}			dt ha^{-1} a^{-1}		
Base fertilizers						
Compost	52	0	156	641	0	810
Solid farmyard manure	120	0	520	769	0	1200
Liquid animal manure	-	-	-	133	0	248
Green manure	-	-	-	83	0	250
Complementary fertilization						
Faba bean grit	-	-	-	78	0	110
Vetch grains	-	-	-	6,2	0	18,7
MALTaflor®	26,8	0	36,4	-	-	-
Vinasse	20,0	0	27,8	5,2	0	15,6
Bioilsa®	20,7	0	41,0	15,2	0	18,2
Hornmeal	14,2	0	56,0	25,7	0	36,9
K_2SO_4	6,9	0	12,0	0,8	0	2,3

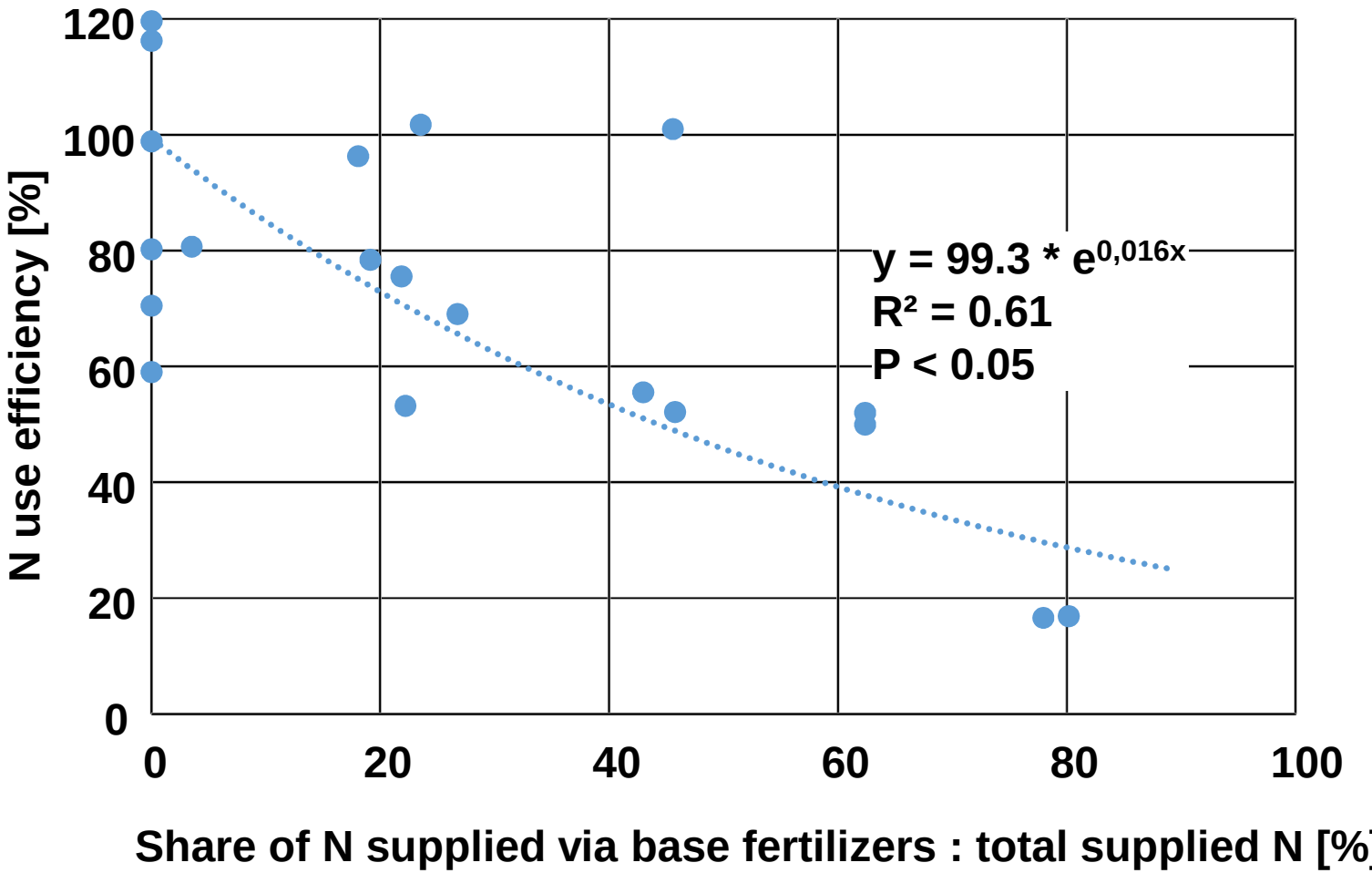
Average nutrient inputs and nutrient outputs of the greenhouses in the study period depending on farmers´ organization (n=22)



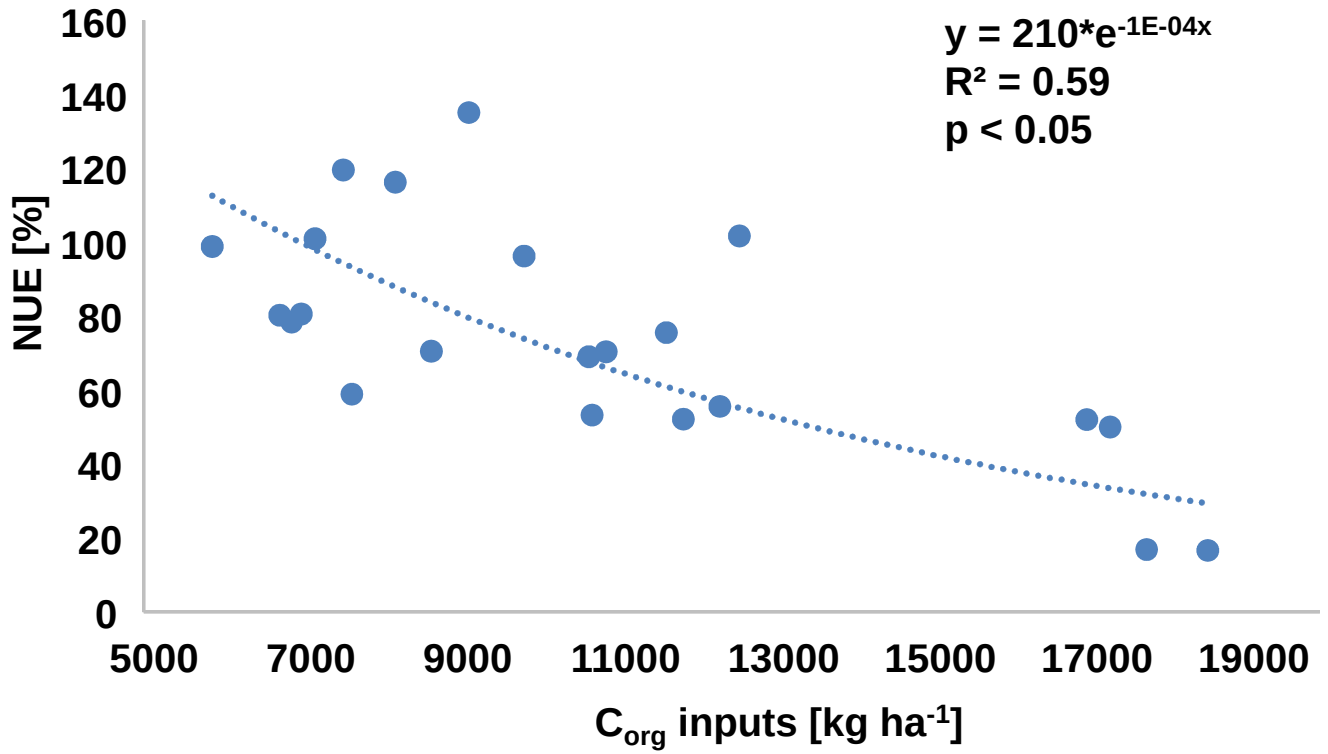
Nutrient spectra of base dressings (after correction on long term plant N availability) in comparison to vegetable crop NPKS uptake



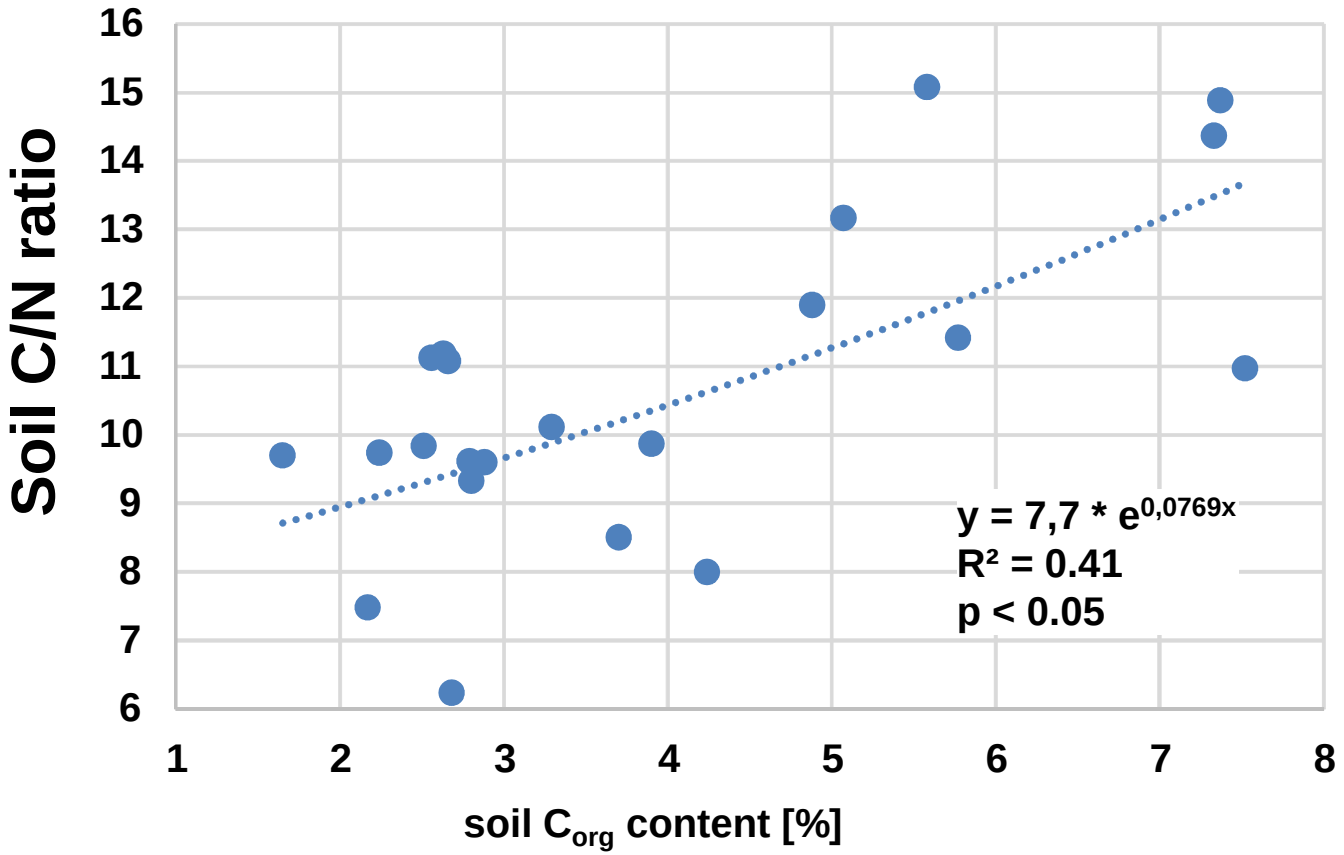
Relationship between the share of N supplied via base organic fertilizers to total N supplied (%) and the N use efficiency (%)



Relationship between C_{org}-Inputs via organic amendments and N use efficiency



Relationship between soil C_{org} and C/N ratio of the soil organic matter in organically managed greenhouses in SW-Germany



Main constraints and bottlenecks of the main greenhouse cropping systems in NW-Europe

	Northern high intensive	Northern less intensive
Nutrient balances	N (++), K (--), Ca (-/++), S (++)	N (++), K (-), Ca (+), S (+)
P accumulation	Base fertilizers with a low N/P	
salinization	Na, S, Ca, (Cl?)	
NPKS fertilizer ratios	K-, Mg- and Ca-fertilizers high content in S	
N synchronisation (release and fertilization schedule)	mineral N peak at the beginning of the crop (losses, physiological effects), late N lack	
Nutrient losses (leaching, gases)	Depends on fertilizer choice and management- denitrification (rapid decay of exogenous OM)	
Soil pH	Steady long term increase	
SOM, humus	SOM content/quality (base and complementary fertilizers)	

Knowledge gaps/challenges

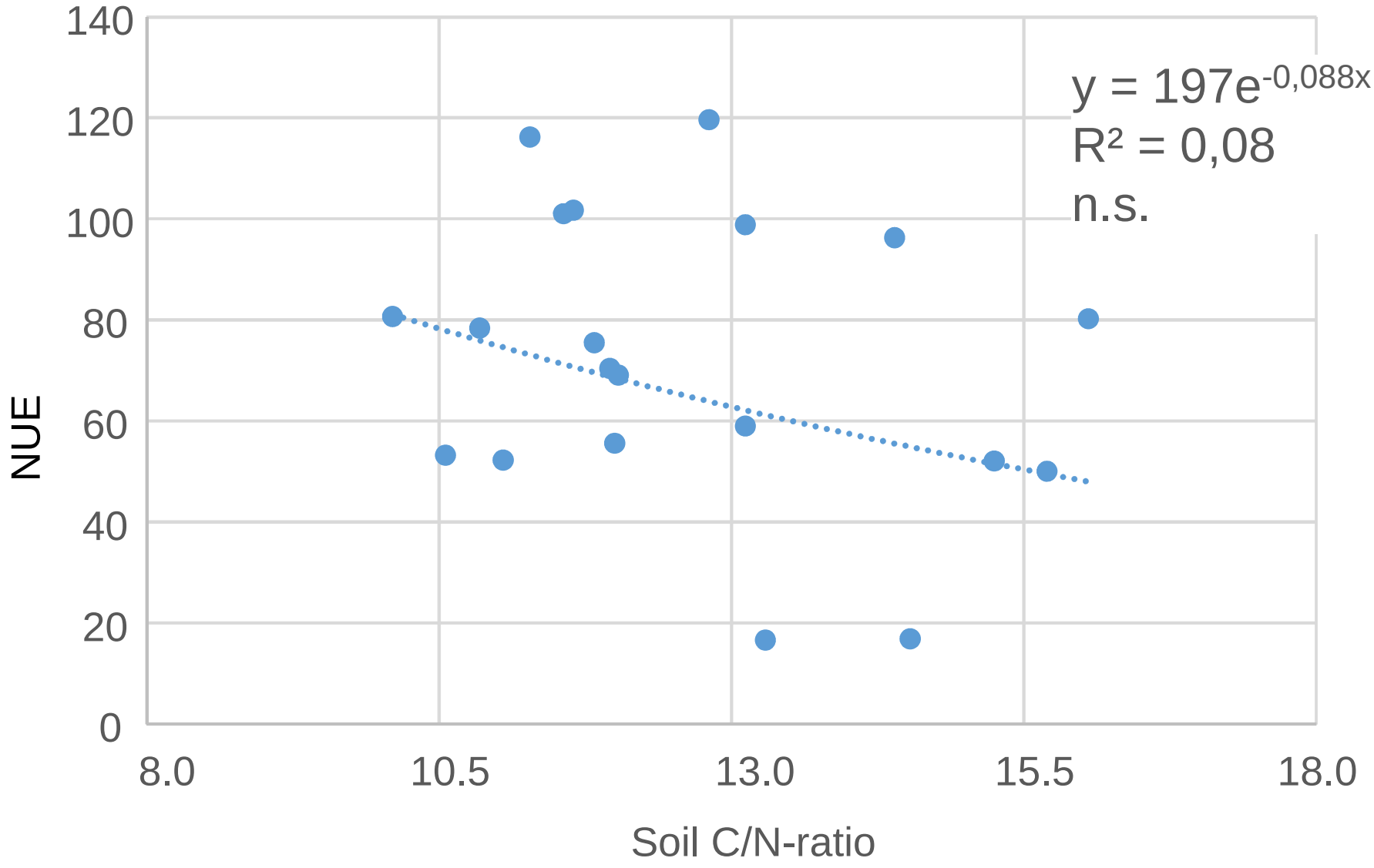
- Balanced management of soil fertility/ nutrient flows
- N household, N mineralization, N losses
- control of soil pH
- Soil organic matter turnover
- Interaction of irrigation & fertility management
- Effect of fertility management on crop quality

Overall conclusion

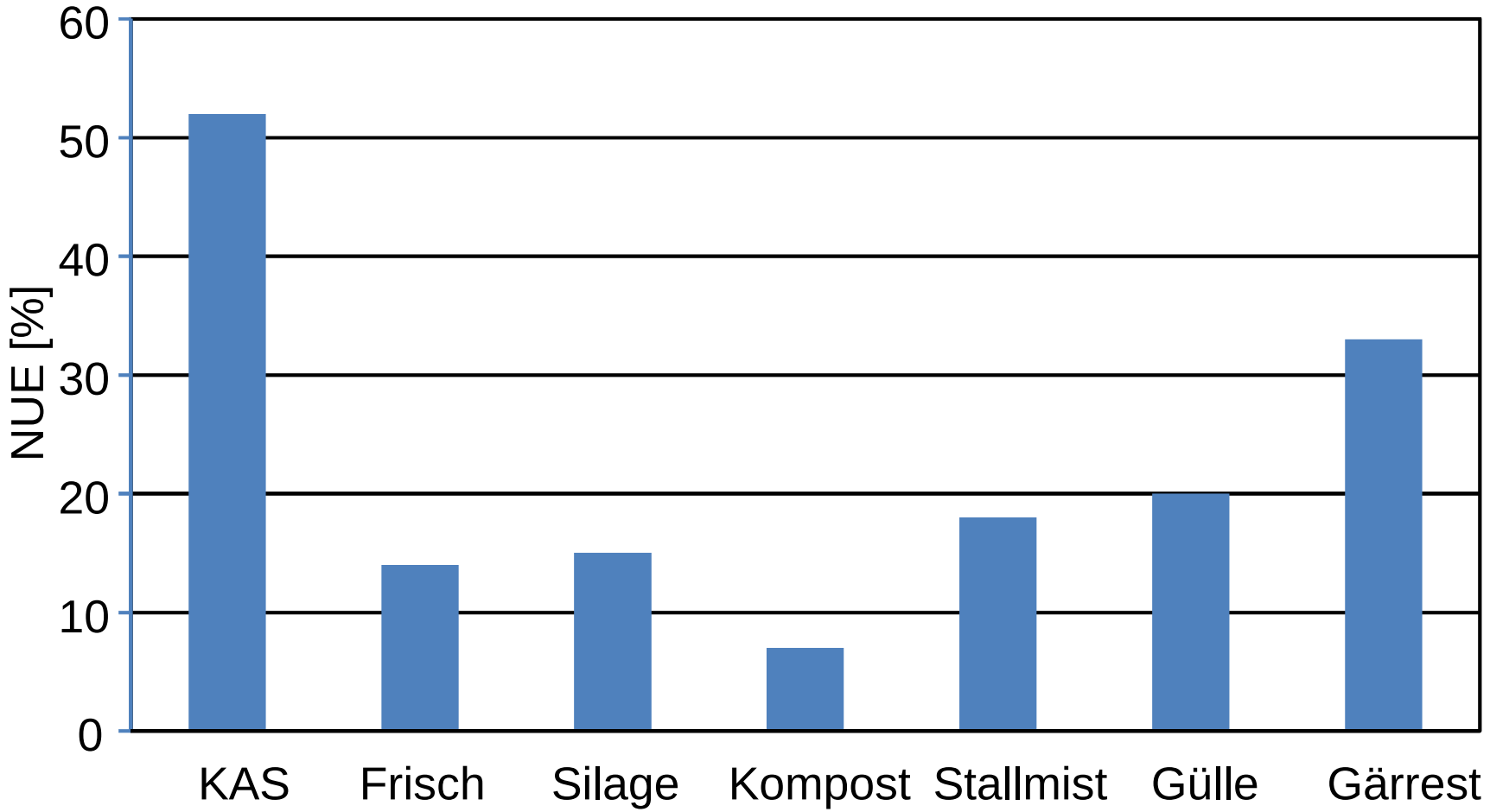
- The are huge differences in the setup and performance of the OGH systems in Central and Northern countries
  - crop rotation, crop diversity,
  - soil fertility approach,
  - productivity,
- All available soil fertility approaches are related to strong soil matter imbalances compromising long term sustainability
- With relevant compost applications currently it is impossible to get balanced systems (elements flows)
- IFOAM-Paper ask for a max. 25% liquid fertilizers → a balanced system in terms of Phosphorus and soil pH is only possible with a maximum of 15-25 % of solid base fertilizers
- With increasing “political correctness” (in terms of compatibility to organic ideas), the nutrient imbalances increases, the nitrogen use efficiency decreases
- For the current systems we need leaching to out-balance problems with salinity and pH increase !?!

Thank you very much!

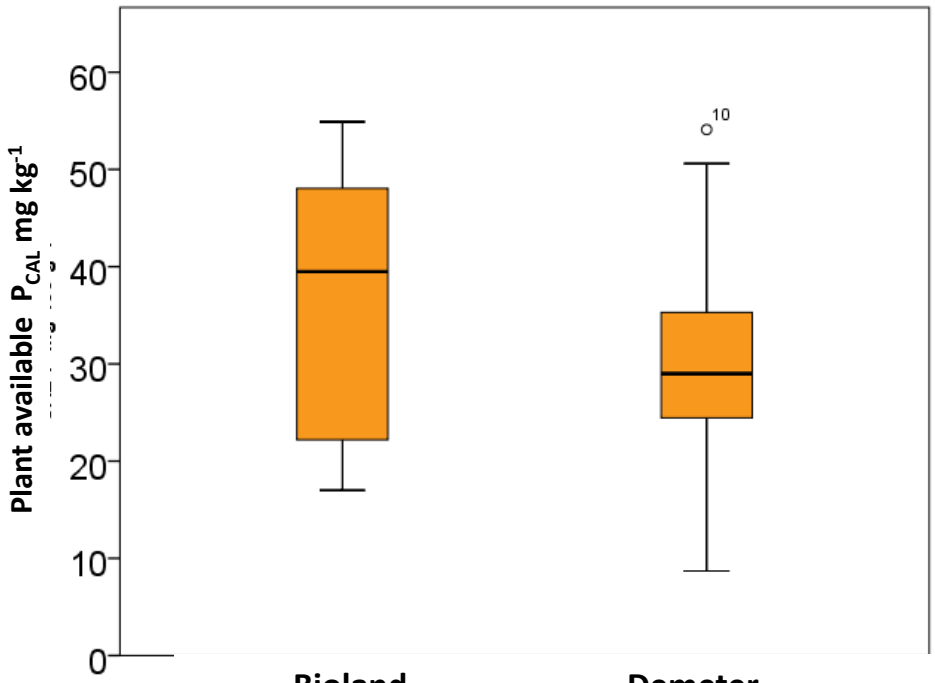
Regression between the soil C/N ratio and the nitrogen use efficiency



Nutrient use efficiency of clover grass „fertilizer products“



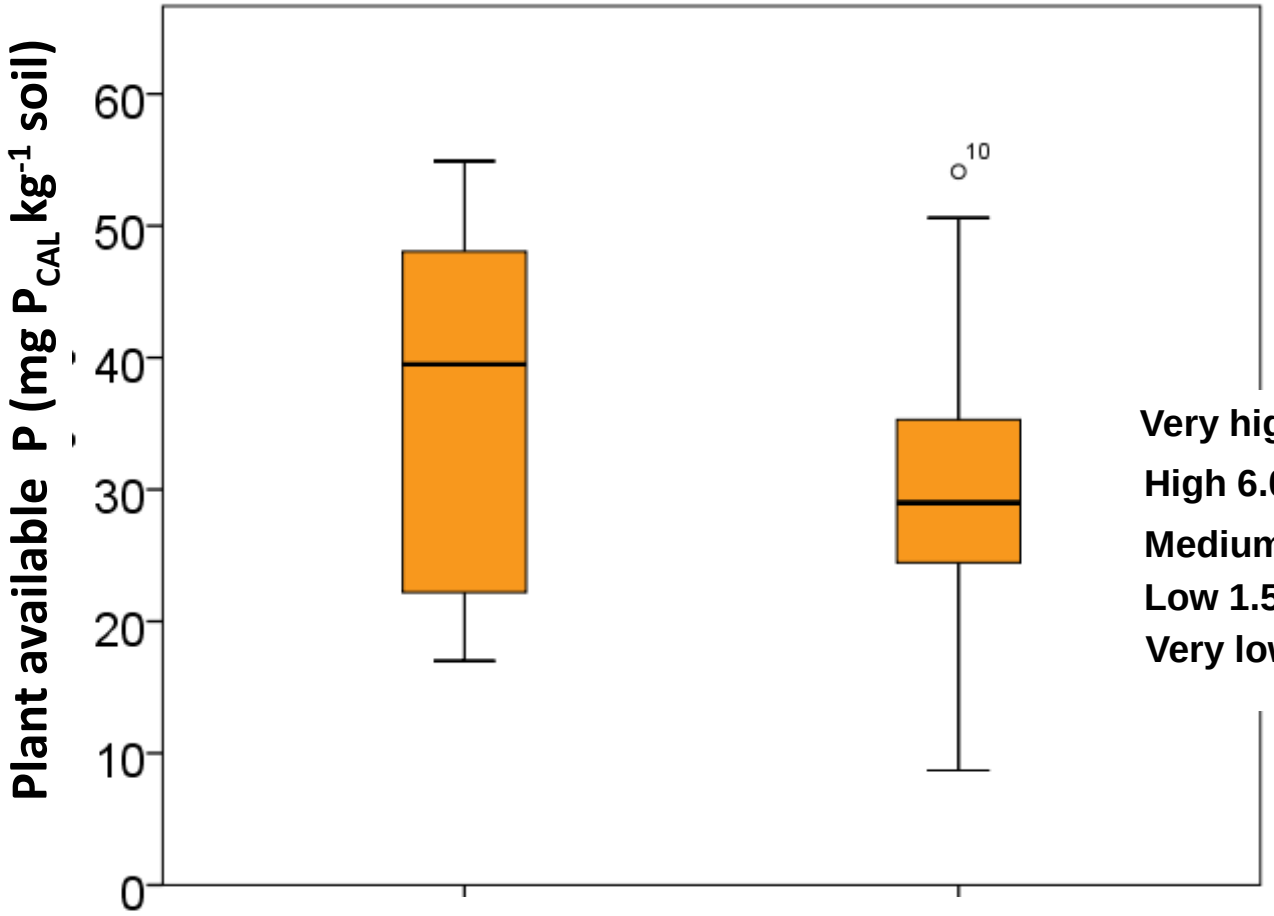
Assessment of the content of plant available P_{CAL} based on fertilisation recommendations



Affiliation to farmers' association
Number of greenhouses

Very high > 20 mg P_{CAL} 100 g^{-1}
High 9,1 - 20 mg P_{CAL} 100 g^{-1}
Medium 4,1 - 9 mg P_{CAL} 100 g^{-1}
Low 2,1 - 4 mg P 100 g^{-1}
Very low < 15 mg P kg^{-1}

Assessment of the content of plant available P_{CAL} based on fertilization recommendations



Very high > 12 mg P_{CAL} 100 g^{-}

High 6.0 - 12 mg P_{CAL} 100 g^{-1}

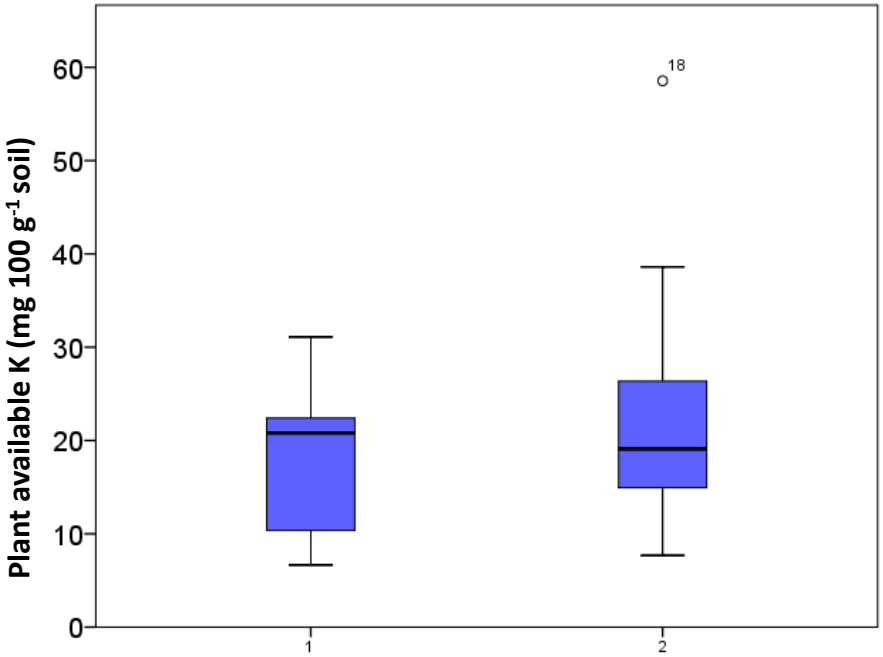
Medium 3,0 – 6.0 mg P_{CAL} 100 g^{-1}

Low 1.5 – 3.0 mg P 100 g^{-1}

Very low < 1.5 mg P kg^{-1}

Figure 7

Mittlere Textur
(LTZ, 2011)



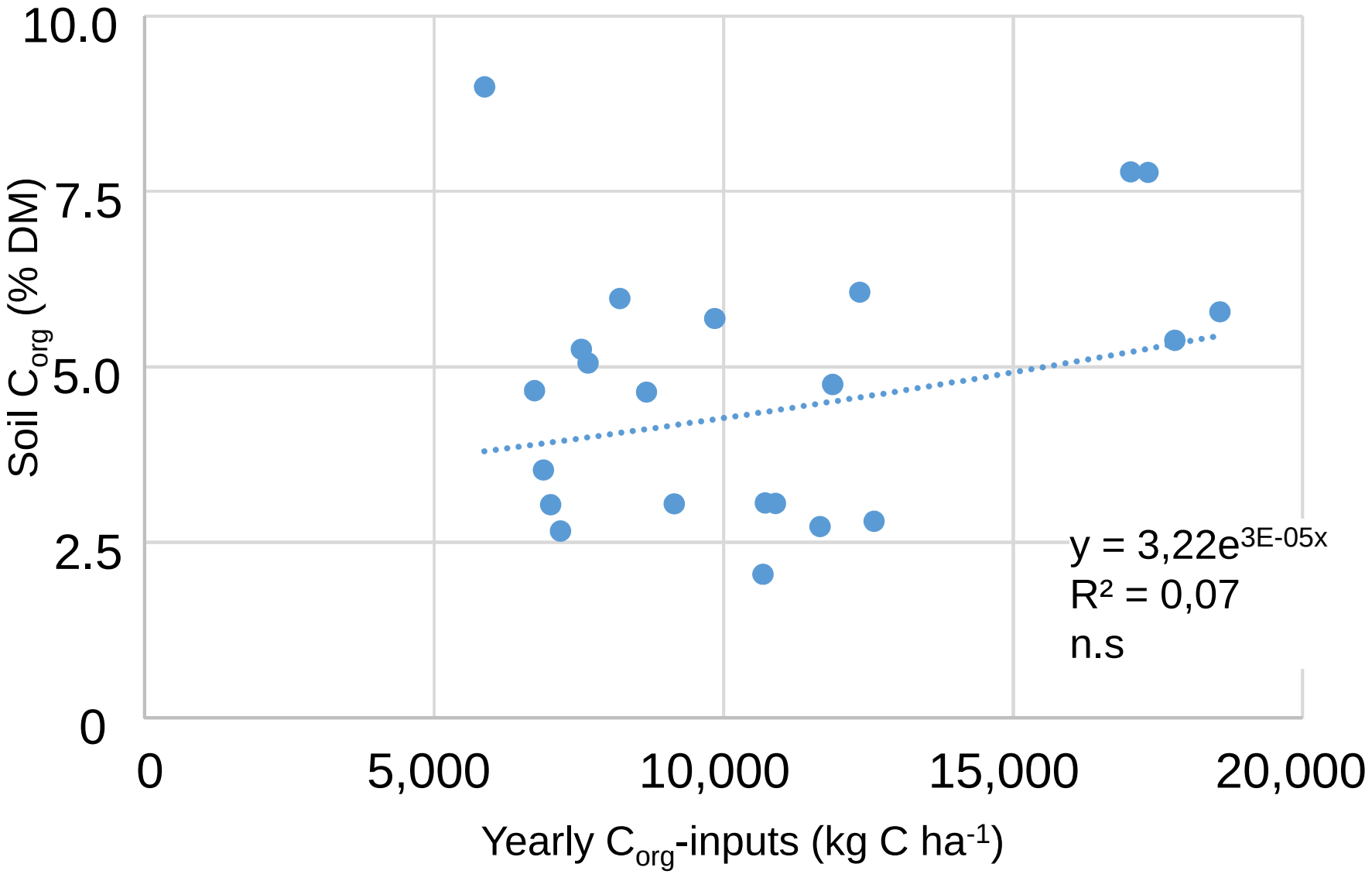
farmers‘ association:

Bioland
N=11

Demeter
N=11

Assessment of the content of plant available K_{CAL} based on fertilisation recommendations

Very high > 29 mg K_{CAL} 100 g^{-1}
High 22 – 29 mg K_{CAL} 100 g^{-1}
Medium 13 – 21 mg K_{CAL} 100 g^{-1}
Low 6 -12 mg K_{CAL} 100 g^{-1}
Very low < 6 mg K_{CAL} 100 g^{-1}


Regression between the yearly C_{org}-input via organic amendments of the last three years and the soil C_{org} concentration
10.0
7.5
5.0
2.5
0
Soil C_{org} (% DM)
0
5,000
10,000
15,000
20,000
Yearly C_{org}-inputs (kg C ha^{-1})
$y = 3{,}22e^{3E-05x}$
$R^2 = 0{,}07$
n.s