The perfect match – P fertilizer demand and fertilizer rates

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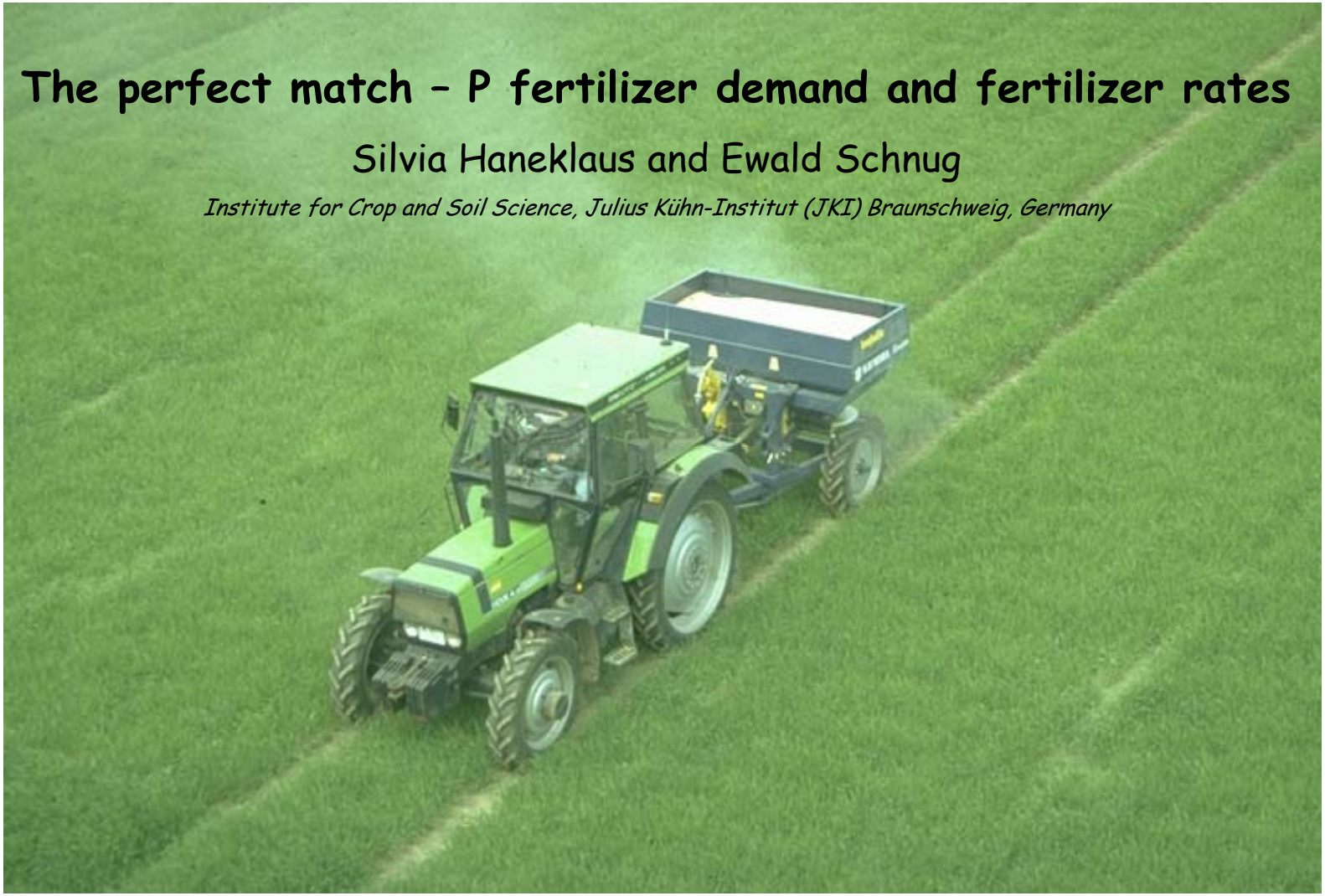


Worldwide P reserves are finite so that a sustainable use of P is imperative on a global scale!

Decree on the admission of additives to foodstuff for technological purposes (Anlage 4 Teil B zur ZZulV, 2012).

Additive	Foodstuff	Maximum permitted amount (mg/kg)
Sodium phosphates (E 339) Potassium phosphates (E 340) Calcium phosphates (E 341) Salts of ortho-phosphoric acid Diphosphate (E 450) Triphosphate (E 451) Polyphosphate (E 452)	Energy drinks, table water	500
	Beverage whitener	30,000
	Beverage whitener for slot machines	50,000
	Ice cream	1,000
	Desserts	3,000
	Powdered dry desserts	7,000
	Fine pastries	20,000
	Flour	2,500
	Flour, baking quality	20,000
	Soda bread	20,000
	Liquid eggs	10,000
	Gravies	5,000
	Soups, broths	3,000
	Breakfast cereals,snacks	5,000

The P intake with food products doubled since the 1990s (Rindlisbacher 2012).

The Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) estimates that in relation to the produce 20-75% of the food or 20 million tonnes of groceries are disposed each year in Germany.

FAO valued the dumping of foodstuff to one third of the total production worldwide.

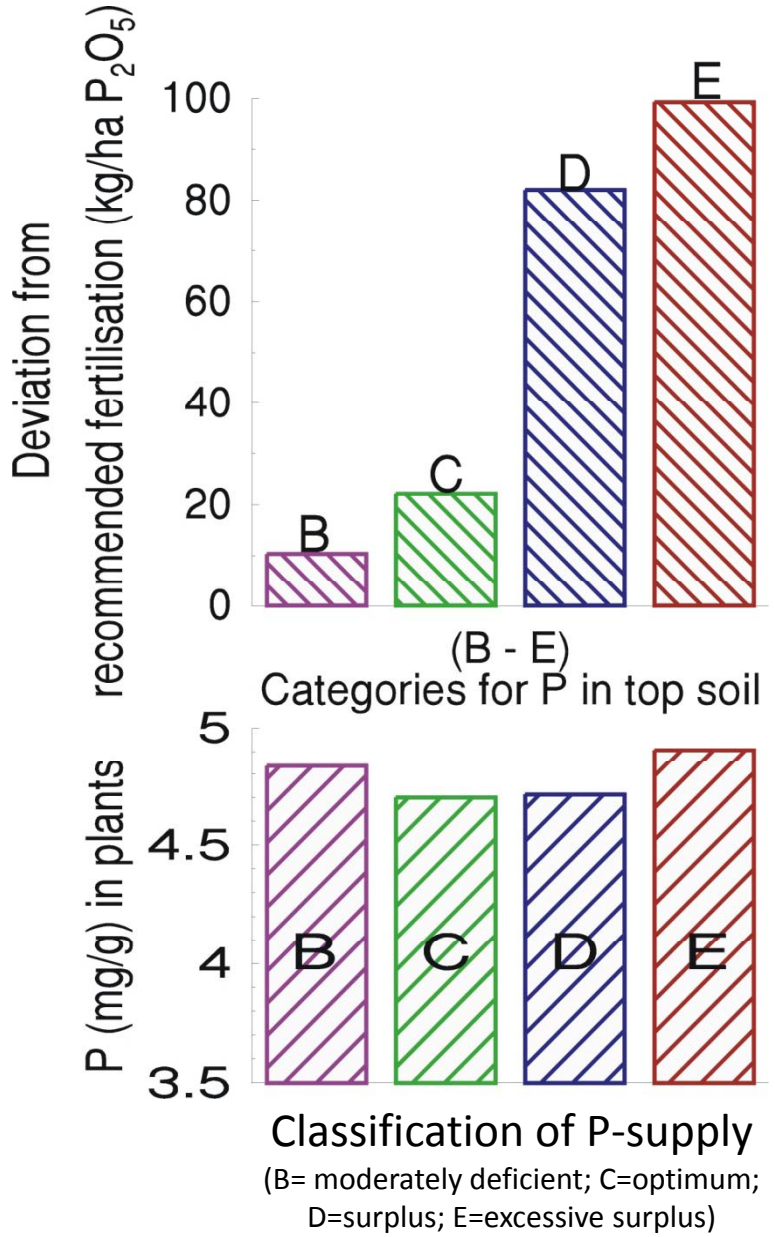
The P dilemma

withering crops or withering waterbodies?

Severe P deficiency in maize

Severe eutrophication of a lake


Agriculture is the largest
consumer and non-point emitter of
P



(Schumann et al. 1997- Landbauforschung Völkenrode, special issue 180)

Manure application is restricted to 170 kg/ha*yr N, but additional mineral fertilizer input is not regulated.

As a consequence increasing soil P levels go along with escalting mineral and organic fertilizer rates.

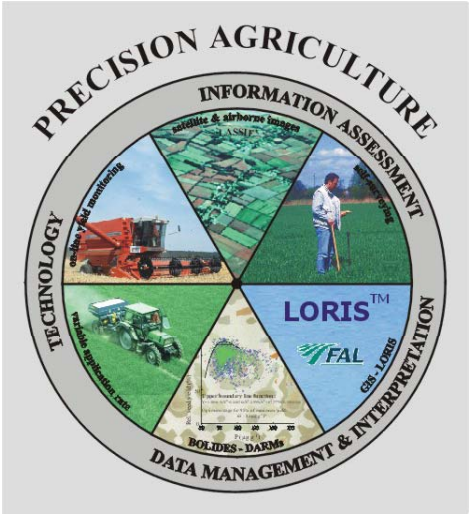
P content of plants is not related to soil P status and P surplus in the nutrient balance.

Options for improving P efficiency in agriculture

P-efficient crop plants

Targeted P nutrition of livestock

Site-specific P management



Safe recycled & new P fertilizer materials

Ultimate target is a closed P cycle on farms!

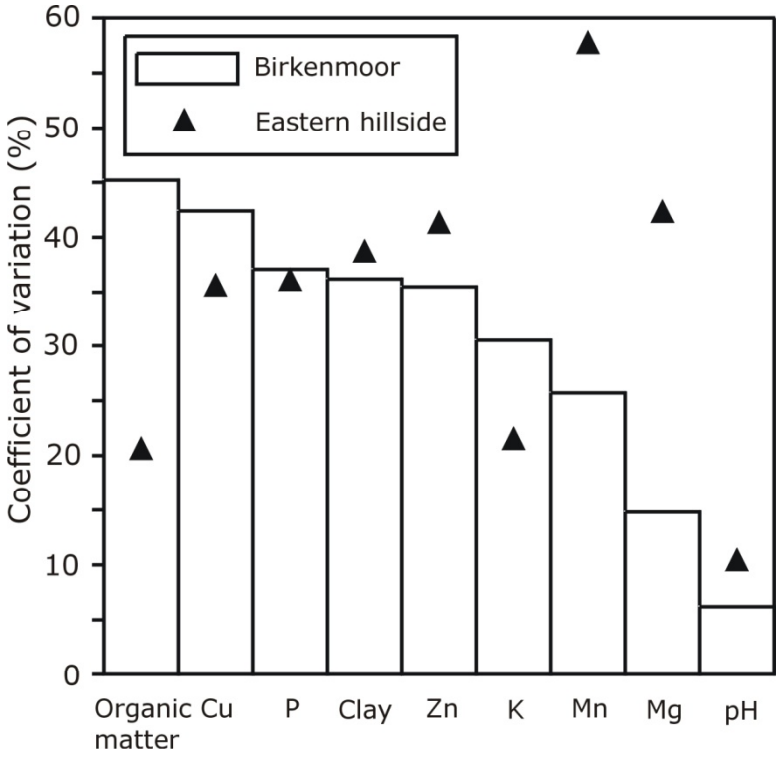
Site-specific nutrient management

Local knowledge

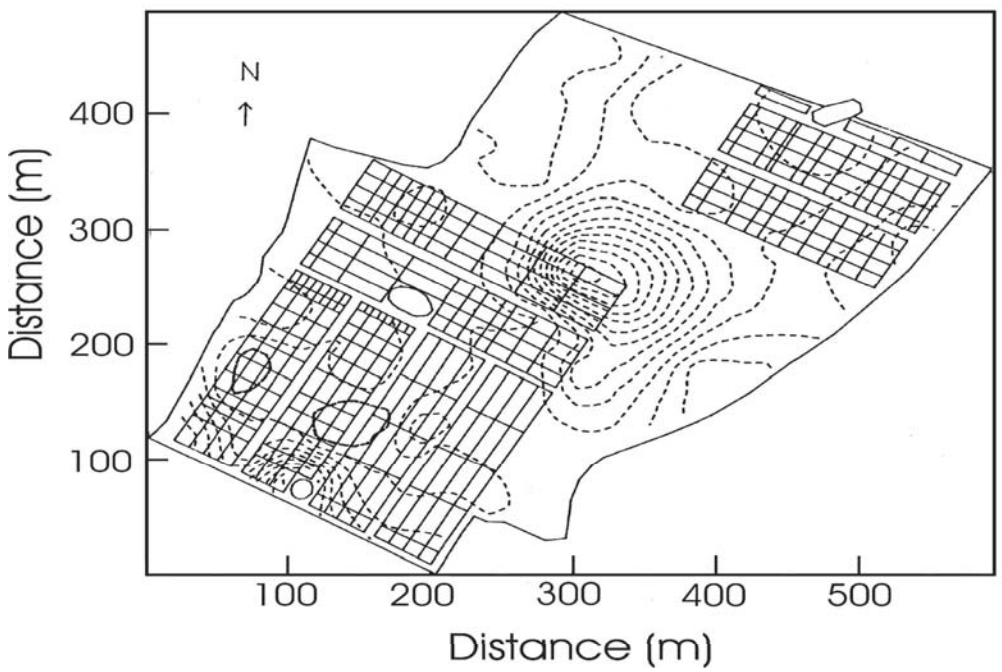
Variable rate fertilisation

(Haneklaus and Schnug 2006. Handbook of Precision Agriculture – A Global Perspective, pp. 91-151)

The small-scale variability of soil and plant parameters may be within a paddock as high as in the whole surrounding landscape.



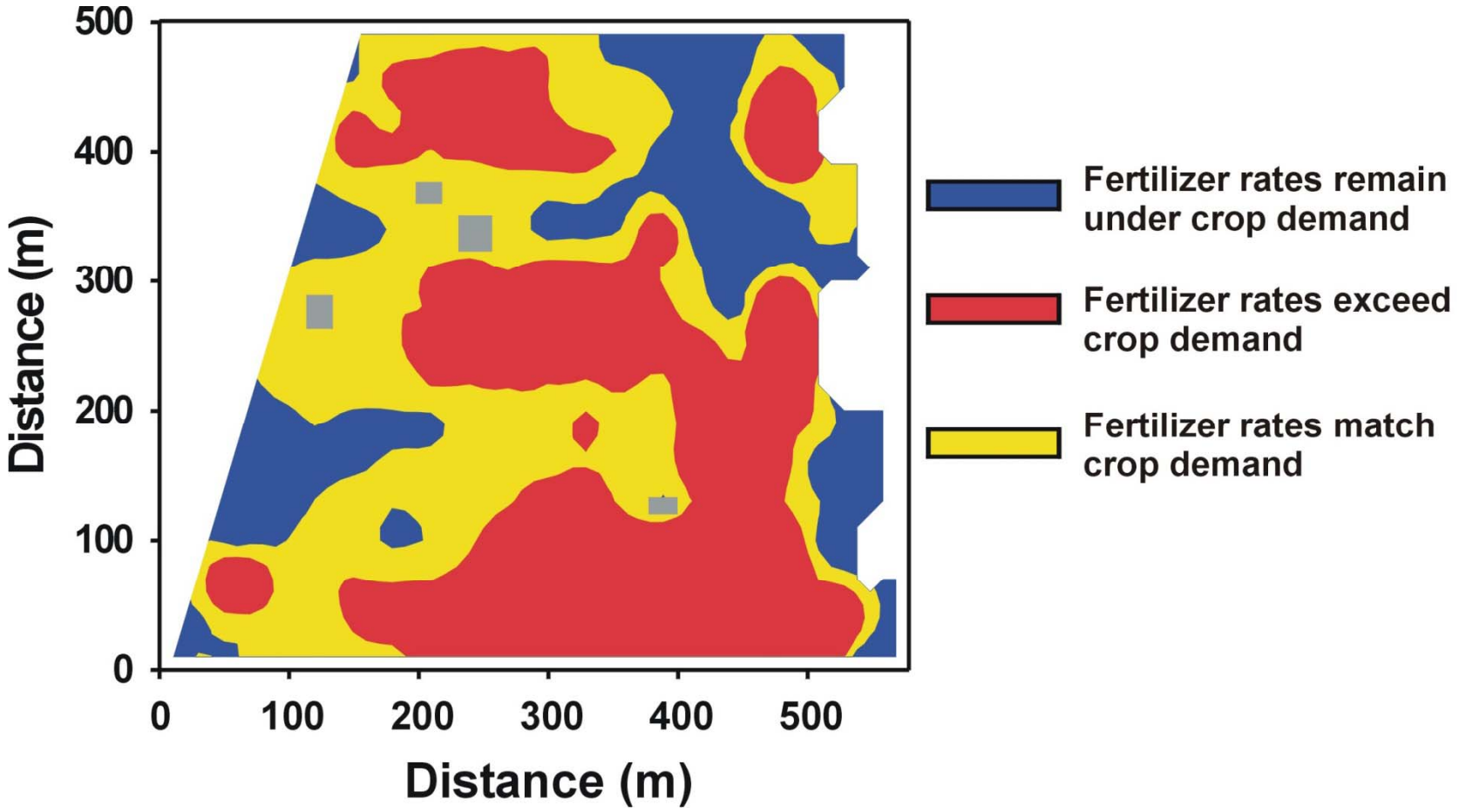
Landsape/Paddock



Paddock

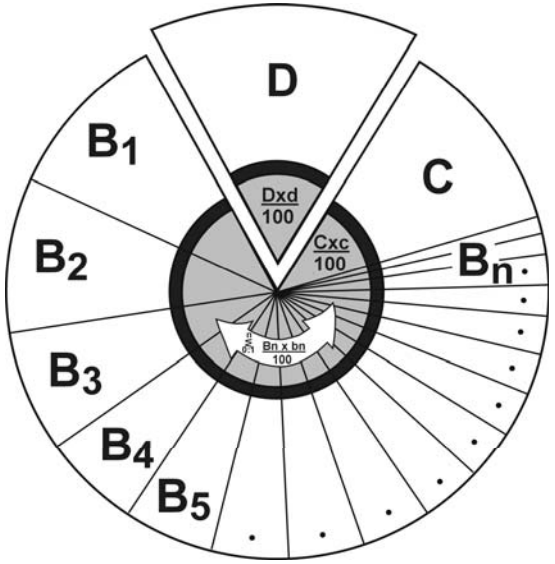
(Haneklaus and Schnug 2006. Handbook of Precision Agriculture – A Global Perspective, pp. 91-151)

Mismatch of P demand and uniform P fertilizer rates



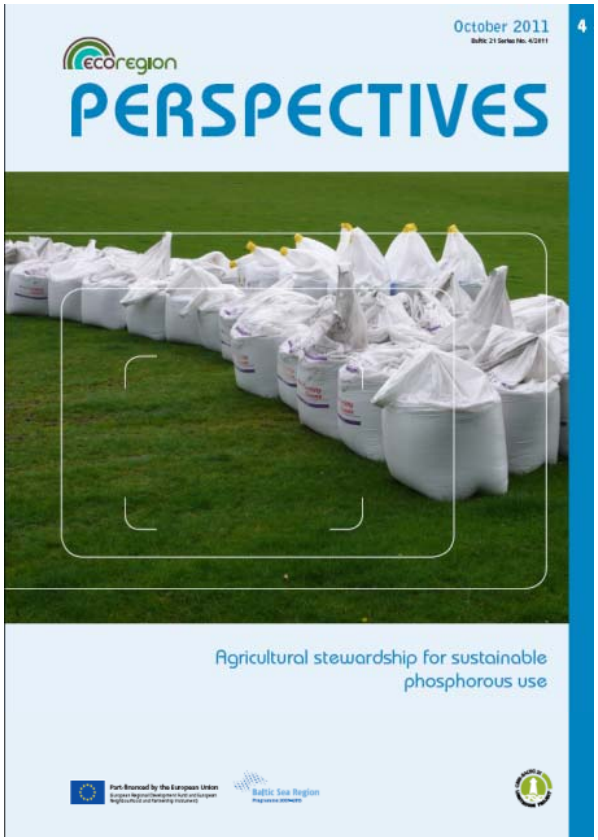
P fertiliser rates may equal off-take by harvest products on soils where the soil P status is sufficiently high for obtaining the potential yield.

Origin of nutrients in harvest products of cultivated plants



Annotation: ◯ off-take with target yield
D = fertiliser; B = nutrients from previous fertiliser applications; C = native soil nutrients; b = Utilisation efficiency of accumulated nutrients; c = utilisation efficiency of native nutrients in soil; d = utilisation efficiency of fertiliser-derived nutrients in the year of application

(Schnug et al. 2003. Landbauforsch Völkenrode 53: 1-11; Schick et al. 2013. Report on P-Engine. www.balticmanure.eu)



http://baltic-ecoregion.eu

P-rates based on off-take are economically viable and ecologically sound!

Assessing and addressing the small-scale spatial variation of P in soils

- Directed sampling
- Identification of monitor pedocells for soil sampling
- Optimizing supply with essential nutrients, organic matter and biological activity
- Using exclusively water or citric acid soluble P forms
- Accounting for P in farmyard manure to 100%
- P fertilizer rates:

  P_{CAL} < 75 mg kg^{-1} P, then rates > off-take

  P_{CAL} > 75 mg kg^{-1} – 100 mg kg^{-1} P, then rates = off-take

  P_{CAL} > 100 mg kg^{-1} P, then no P until P_{CAL} < 100 mg kg^{-1} P

  (rule of thumb: soil P content halfs within 8-10 years)

Algorithms for a balanced variable rate input of N, P and K within a three year crop rotation employing a NPK fertilizer with tailor-made nutrient ratio

Year	Algorithms for NPK fertilizer		
1	**NPK fertilizer**		
	N_{OPT} [1]	$P_{N:P\ (min)}$	$K_{N:K\ (min)}$
2	**NK fertilizer**		**P fertilizer**
	N_{OPT} [1]	$K_{N:K\ (min)}$	$P_{OPT} = P_{tot}$ [2] $- (P_{yr1} + P_{yr3})$
3	**NP fertilizer**		**K fertilizer**
	N_{OPT}	$P_{N:P\ (min)}$	$K_{OPT} = K_{tot} - (K_{yr1} + K_{yr2})$

note: [1]optimum variable rate application; [2]tot = total optimum, spatially variable amount of P and K for the crop rotation

(Haneklaus and Schnug 2006. Handbook of Precision Agriculture – A Global Perspective, pp. 91-151)

Balanced P use of manure = rates compensate P demand

Mean off-take of 22 kg/ha P = 139, 87 and 72 kg/ha N
(dairy cows, pigs and broiler)
Maximum manure rate of 170 kg/ha N = 27, 43 and 52 kg/ha P
(dairy cows, pigs and broiler)

Algorithms for manure application

If P demand ≥ off-take, then variable manure rate.
If P demand = off-take, then uniform manure rate.
If P demand < off-take, then no manure.

Limitations
- Suitable for direct use of poultry manure
- Cattle and pig manure require conditioning

Variation of P content in manure

	cv (%)
Cattle	25.0 – 57.6
Pigs	5.8 – 47.0
Poultry	16.2 – 23.0

Sources:
Barnett 1994. Bioressource Techn. 49: 139-147
Derikx et al. 1997. Netherlands J. Agric. Sci. 45: 65-79
Sharpley and Moyer 2000. J. Environm. Qual. 29: 1462-1469

Norms for recycled fertilizer products

Declaration of P speciation including guideline values for minimum quantities
Contamination with xenobiotics and heavy metals
Hygiene

Mineral composition of manure and digestate samples

Product	d.m	P	Zn	Cu	Pb	Cd	Cr	Ni
	(%)	(% d.m.)			(mg/kg d.m.)			
Original substrate 1	9.9	0.5	188	54	1.4	0.1	25	11
Digestate 1	7.9	0.6	301	81	2.2	0.2	23	10
Original substrate 2	6.6	1.1	1110	81	1.2	0.2	8.5	7.8
Digestate 2	3.8	1.9	2115	145	1.2	0.4	8.9	10
Original substrate 3	5.3	0.6	334	41	0.7	0.2	12	6.9
Digestate 3	8.3	1.1	628	85	1.2	0.3	11	7.8
Gasified pig manure		**3.9**	1605	**241**	**3.1**	0.1	**61**	**28**
		% of total P						
Water		<0.01						
Alkaline ammonium citrate (AAC)		19						
Neutral ammonium citrate (NAC_{EU})		37						
Water + NAC		40						
Citric acid		**54**						
Formic acid		66						

(Schick et al. 2013. Report on the chemical quality of different types of manure (processed and unprocessed) including P solubility. www.balticmanure.eu)

Recommendations for farmers

1. Set-up your own on-farm experimentation
2. Postulate full declaration of fertilizer materials
3. Treat your soils as an unique heritage

Recommendations for policy makers

1. Mandatory recording of whereabouts of manure
2. Adopt full declaration of fertilizer materials (EU)
3. Balanced fertilisation is soil and marine protection


We destine agriculture-to-be!