Need for phosphorus input in Austrian organic farming?

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Abstract

On organic farms, phosphorus (P) balances are often negative because no or little P is imported into the farms. Negative P balances may deteriorate P availability over time. We calculated P balances of the main farm production types in organic farming for the main Austrian production areas. Using data from various data bases and expert knowledge, calculations were made by the sustainability assessment tool REPRO. Results can be regarded as balanced to slightly deficient for organic forage dairy farms, cash crop farms and permanent crop farms, and as slightly to highly surplus on organic refinement farms. Slightly deficient P balances, mainly on organic cash crop farms, call for P input, especially on farms where available P fractions in the soil are very low and / or P stocks in the soils and hence the potential for P mobilisation are low. On individual farms where more negative P balances occur, farm management needs to be optimised.

Introduction

Phosphorus (P) is an essential constituent of the metabolism of crop plants, animals and men. World P resources under current demand are predicted to be depleted in the 21st century. In organic farming, both renouncement of readily available P fertilisers and closing nutrient cycles on the farms as far as possible contribute to a sustainable use of this scarce nutrient. Analyses in Austrian farmland soils show a low or very low P availability for a high percentage of soil samples from organic farms (Lindenthal, 2000). Little fertiliser input from outside the farms and negative P balances may deteriorate P availability over time in organic farming. Therefore, our objective was to get an overview of recent P balances on Austrian organic farms and to test if and where additional P input is required. For this, we calculated P balances of the main production types in organic farming for the main Austrian production areas.

Material and methods

Due to varying natural conditions of the eight Austrian Main Production Areas (MPAs), different farm production types (PTs) evolved in Austria. These were defined in the INVECOS data set (Integrated Administration and Control System of the EU) (BMLFUW, 2007). For this study, the agricultural area of "forestry" farms, being mainly grassland and pastures, was designated to "forage production". In each MPA between one and three predominant production types occurred (Table 1).

Table 1: Austrian Main Production Areas (MPAs) with their predominant production types

MPA	Main production area	Production type
1	Alps	Forage production
2	Pre-Alps	Forage production
3	Eastern Alpine Foothills	Forage production
4	Bohemian Massif	Cash crop; Forage production
5	Carinthian Basin	Forage production; Cash crop; Refinement
6	Alpine Foothills	Cash crop; Forage production; Refinement
7	South-Eastern Plains and Hills	Cash crop; Forage production; Refinement
8	North-Eastern Plains and Hills	Cash crop; Permanent crops (wine)

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Table 2: Details of agricultural areas covered and crop distribution of each production type

Area		MPA 1&2	MPA 3	MPA 4		MPA 5	
Production type		F	F	F	C	F	C
Agricultural area covered	1000 ha	129	39	46	18	6	2
Cereals	%	0.6	6.5	21.3	52.3	17.8	36.5
Grain maize	%					6.8	21.7
Oil crops	%			1.8	11.7	3.5	16.3
Root crops	%			1.1	3.8		
Forage (incl. SM)	%	3.2	15.2	20.6	18.3	21.3	12.2
Fallow	%				1.8	1.0	2.1
Intensive pasture	%	80.6	67.2	53.2	9.1	42.3	7.7
Extensive pasture	%	15.4	10.4	0.9	0.7	6.7	0.8

Area		MPA 6			MPA 7			MPA 8	
Production type		F	C	R	F	C	R	C	P
Agricultural area covered	1000 ha	27	8	2	5	6	2	5	9
Cereals	%	10.6	44.3	39	17.6	44.1	22.3	47.2	29.2
Grain maize	%		5.1	11.3	1.4	2.1	25.2	7.2	4.6
Oil crops	%	0.9	18.4	15.4	4.6	21.6	15.3	14.4	12.3
Root crops	%		2.1	0.7				2.1	
Forage (incl. SM)	%	13.7	13.3	9.1	23.7	15.2	11.4	13.9	10.5
Fallow	%		3.4	1.7	1.6	5.4	4.3	5.7	4.8
Intensive pasture	%	72.2	7.7	18.8	47.7	5.1	16.9		
Extensive pasture	%	1.7	0.9	1.3	2.1	2.3	3.7	2.6	4.7
Wine	%								25.1

MPA: Main production area, see Table 1; F: forage; C: cash crops; R: refinement; P: permanent crops (wine); SM: silage maize

In all MPAs, model farms were constructed for the predominant production types. All crops or crop groups that covered at least 1 % of the agricultural area were considered (Table 2). For these species, detailed information was obtained, e.g. the amount and kind of fertilizer applied, yield of main crops / catch crops / undersown crops corresponding to regional mean values, dung delivery according to livestock numbers. Information on animal husbandry, feeding, pasture and animal housing was also considered in the calculations. Data were collected from the INVECOS database (BMLFUW, 2007), from the catalogue of marginal returns (BMLFUW 2008), from regional advisory boards, and other sources. The model farms had a size of 100 ha. The field size corresponded to the area-% covered by the crops. Details on plant production, machinery and tillage operations were obtained and regarded for each region and farm type individually. Nutrient cycles on the farms were calculated with the REPRO (Reproduction of Soil Fertility) sustainability assessment tool for farm management and consultation (Hülsbergen, 2003). Site characteristics are considered in the calculation via the precipitation and the soil quality.

Results

Phosphorus balances were moderately negative on “forage production” farms with values ranging from -3.7 to -5.8 kg P ha^{-1} yr^{-1} (Table 3). “Cash crop” farms reached higher P deficits from -3.7 to -11.4 kg P ha^{-1} yr^{-1}. “Refinement” farms types had positive P balances from 6.1 to 14.2 kg P ha^{-1} yr^{-1}. “Permanent crop” farms, producing a combination of wine and cash crops, were in the range of the cash crop farms. Most negative values on cash crop producing farms can be attributed to export of nutrients with the cash crops without nutrient input by fertilisers or fodder. Highly positive values on refinement farm types are due to nutrient input by fodder from outside the farm.

Discussion

Freyer and Pericin (1993) regard balance results of ±4.5 kg P ha^{-1} yr^{-1} as balanced. Values from -4.5 to -13 kg P ha^{-1} yr^{-1} are valued as "slightly deficient", below -13 kg P ha^{-1} yr^{-1} as "highly deficient", with a related valuation of positive balance values. According to this valuation, results in our study can be regarded as balanced to slightly deficient for organic forage dairy farms, cash crop farms and permanent crop farms, and as slightly to highly surplus on organic refinement farms. Calculations of P balances for Austrian organic forage dairy farms by Weißensteiner et al. (2013) showed balanced results with minimum values of -2 kg P ha^{-1} yr^{-1} at a varying intensity level equivalent to 4000 to 6000 L milk per cow and year. Values in this study are less negative than our results.

Slightly deficient P balances, mainly on organic cash crop farms, call for P input especially on farms where available P fractions in the soil are very low and / or P stocks in the soils and hence the potential for P mobilisation are low, i.e. on sandy soils and on some calcareous soils. On individual farms, more negative P balances can occur than reported in the above-mentioned studies, e.g. on forage dairy farms where no mineral nutrients containing feedstuffs additives are applied. Here, farm management needs to be optimised.

Suggestions to tackle with the future challenges of organic animal husbandry

There is an urgent need to close nutrient cycles on the farm and regional scale and to substitute P from rock phosphate reserves by alternative P fertilisers in the next decades also in organic farming (see also: IMPROVE-P, 2013).

Table 3: Phosphorus balances (kg P ha^{-1} yr^{-1}) of the main production types in organic farming in the Austrian Main Production Areas

MPA	**1&2**	**3**	**4**		**5**	
Production type	**F**	**F**	**F**	**C**	**F**	**C**
P output	25.7	28.1	26.6	20.0	24.2	27.0
Main products	*25.7*	*27.8*	*25.4*	*16.8*	*22.0*	*20.4*
By-products	*0.0*	*0.3*	*1.1*	*3.2*	*2.2*	*6.5*
P input	20.5	22.7	20.8	16.3	19.6	15.6
Seeds	*0.0*	*0.1*	*0.2*	*0.5*	*0.2*	*0.6*
Mineral fertilizer	*0.0*	*0.7*	*1.5*	*4.1*	*1.5*	*0.4*
Organic fertilizer	*20.5*	*22.0*	*19.1*	*11.8*	*17.9*	*14.6*
P balance	-5.3	-5.4	-5.8	-3.7	-4.6	-11.4

MPA	**6**			**7**			**8**	
Production type	**F**	**C**	**R**	**F**	**C**	**R**	**C**	**P**
P output	30.2	22.3	25.0	24.3	19.1	24.4	20.4	18.0
Main products	*29.6*	*18.0*	*19.8*	*23.0*	*15.8*	*19.3*	*16.0*	*13.8*
By-products	*0.6*	*4.3*	*5.2*	*1.3*	*3.3*	*5.1*	*4.4*	*4.1*
P input	24.9	15.4	31.1	20.6	11.5	38.6	10.7	11.3
Seeds	*0.1*	*0.5*	*0.4*	*0.2*	*0.5*	*0.3*	*0.5*	*0.4*
Mineral fertilizer	*0.3*	*2.1*	*1.4*	*2.0*	*1.4*	*2.8*	*0.0*	*0.0*
Organic fertilizer	24.5	12.8	29.3	18.5	9.6	35.6	10.2	10.9
P balance	-5.3	-6.9	6.1	-3.7	-7.6	14.2	-9.7	-6.7

Legend see Table 2.

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