AGROECOLOGICAL INDICATORS OF CROPPING SYSTEMS: THE PHOSPHORUS INDICATOR IN THE SUD MILANO AGRICULTURAL PARK (NORTHERN ITALY)

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Introduction

Agroecological indicators (OECD, 2001) are useful to integrate data about cropping and farming systems and to draw conclusions about their sustainability. One important aspect of sustainability is the management of nutrients; for this reason we calculated nutrient budgets (Bechini et al., 2004) for the farms of the regional agricultural metropolitan Park "Parco Agricolo Sud Milano" (PASM). However, nutrient budgets do not consider the availability to the crop of nutrients contained in the soil. To overcome this limitation, in this paper we describe the application of a phosphorus (P) indicator (Bockstaller and Girardin, 2000) at the cropping systems of PASM.

Materials and methods

After simplifying it, we calculated the P indicator proposed by Bockstaller and Girardin (2000) as: $Ip=10+\max(\min(P_{soil}, P_{res}), -10)$. P_{soil} considers soil P depletion generated by insufficient P fertilizer application: if $P_{ina}<P_R$, then $P_{soil}=(P_{ina}-P_R)/30$, where P_{ina}=P applied which is available to crop in that soil (kg P_2O_5 ha^{-1}); P_R=crop P requirement (kg P_2O_5 ha^{-1}), calculated on the basis of available P in soil (P_{avail}, ppm) and expected crop P uptake ($P_{uptk,}$ kg P_2O_5 ha^{-1}). P_R can be zero if P_{avail} is at least sufficient. On the other side, P_{res} considers excess fertilizations, which would consume non-renewable resources (and accumulate P in soil) when organic and/or inorganic P are applied to soils with sufficient P_{avail}: if $P_{in}>P_R$ then $P_{res}=-(P_{in}-P_R)/30$, where P_{in}=P applied to the soil (kg P_2O_5 ha^{-1}). Ip=10 identifies the systems where P fertilization is correct; lower values indicate excess or deficit fertilization (e.g. Ip=5 indicates an excess or deficit fertilization of 150 kg P_2O_5 ha^{-1}). The indicator was calculated for the cropping systems described in the SITPAS database, which includes detailed information about crop management; crop data are georeferenced through the cadastral map. One or more cadastral parcels may be cultivated with one rotation, which in turn is composed of one or more crops. Therefore, by using the rotation entity-set, it is possible to georeference all the data related to a particular crop. To calculate the indicator: i) we derived P_{ina}, P_{in} and P_{uptk} from the database, with the same methodology used for the nutrient budgets (Bechini et al., 2004); ii) we derived P_{avail} from the SITPAS soil fertility information system, which includes estimates of soil variables obtained with ordinary kriging on a 100 m by 100 m grid (De Ferrari et al., 2002); iii) by overlaying the cadastral map and the grid of soil fertility, we assigned P management information (P_{in}, P_{ina} and P_{uptk}) to each grid point; iv) we calculated the indicator for each grid point and for each crop of the rotation linked to that grid point; v) we finally averaged the results (weighing by the area occupied by each crop), for each crop type (to derive table results) and for each grid point (to derive the map). The calculations were made on 576 farms, 965 rotations, 2349 crops, 54 crop types, covering 24,516 ha (69% of PASM agricultural area).

Results and discussion

Overall (Table 1), the average value (6.6) is not at all encouraging, when one reminds that 30 kg P_2O_5 ha^{-1} (excess or deficit) correspond to 1 indicator unit. Its value is mainly determined by P_{res}, which for 96% of the area is lower than P_{soil} (for 4% of the area $P_{soil}=P_{res}=0$, i.e. Ip=10; only on 2.6 ha P_{soil} is lower than P_{res}). This indicates a substantial excess of P fertilizers applied. For the entire

Table 1 – Phosphorus indicator (Ip) and contribution to Ip of excess fertilisations (Pres) for the most important crop types

		Ip				Pres			
Crop	**Area (ha)**	**avg.**	**s.d.**	**5°**	**95°**	**avg.**	**s.d.**	**5°**	**95°**
Maize	9394	5.0	2.6	0.0	8.6	-5.9	5.1	-14.7	-1.4
Rice	5966	7.0	1.7	3.3	9.2	-3.0	1.7	-6.7	-0.8
Permanent meadows	2799	7.2	2.8	1.2	10.0	-2.9	3.1	-8.8	0.0
Soybean	1650	9.0	1.0	7.1	9.9	-1.0	1.0	-2.9	-0.1
Barley	1006	8.3	2.1	3.4	9.9	-1.9	3.3	-6.6	-0.1
Italian ryegrass	927	7.7	2.5	2.1	9.9	-2.4	2.8	-7.9	-0.1
Winter wheat	691	8.2	1.8	5.1	9.8	-2.0	3.0	-4.9	-0.2
Rotated meadows	416	7.4	1.8	3.8	10.0	-2.6	1.8	-6.2	0.0
Rape	386	9.3	0.3	8.8	9.7	-0.7	0.3	-1.2	-0.3
Alfalfa	266	8.6	2.3	3.4	10.0	-1.4	2.4	-6.6	0.0
Set-aside	139	9.3	0.5	8.2	9.7	-0.7	0.5	-1.8	-0.3
Other crops	877	7.7	2.6	2.6	10.0	-2.6	3.8	-7.4	0.0
All Park	24516	6.6	2.7	0.2	9.9	-3.8	4.1	-9.9	-0.1

Avg. = average; sd = standard deviation; 5° and 95° = 5th and 95th percentiles

Park, 30% of the area has Ip<5.8, 50% is below 7.0, and 70% is below 8.5. For rape, set-aside and soybean, excess P fertilization is not very relevant. For most crop types, Ip is still above the Park average, but with relevant excess fertilizations in the range 40-90 kg P_2O_5 ha^{-1}. The lowest average, indicating a large, useless P consumption, was obtained for maize, for which the average excess is 150 kg P_2O_5 ha^{-1}. In general, the excess fertilization is determined by the high levels of P_{avail} in the soil: P_{avail} is so high that P fertilization would almost never be required (P_R<1.3 kg P_2O_5 ha^{-1} for 99% of the area). The map (Figure 1) allows to analyse the spatial distribution of Ip and to identify the most critical situations.

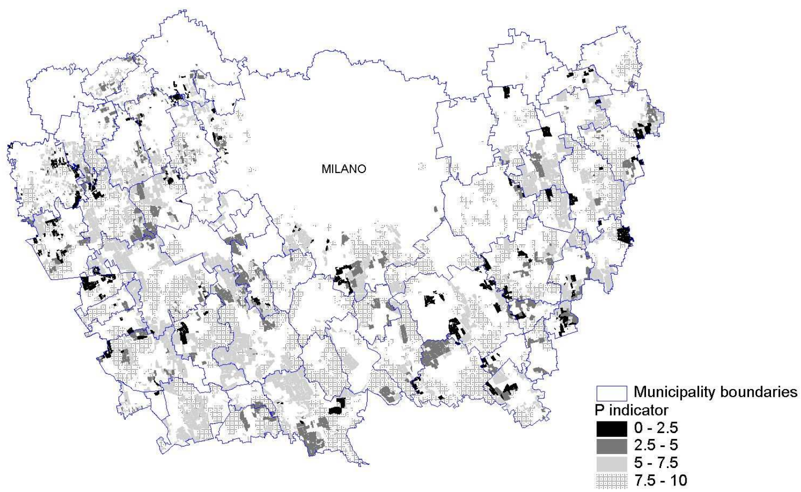

Figure 1 - Map of the phosphorus indicator for the entire Park

Conclusions

By integrating different data, we can conclude that one of the most important actions to be taken in the Park is to reduce or eliminate P applications on P-rich soils. However, because most of the data used in this study are uncertain kriged estimates, literature data or collected during interviews, we will develop methodologies to assess the uncertainty of the indicator.

References

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Acknowledgments

Prof. T. Maggiore coordinated the SITPAS project, which was financed by Provincia di Milano, Regione Lombardia, CCIAA. Prof. S. Bocchi and Dr. R. Confalonieri started this work with us.