

A statistical approach to assess soil biodiversity and biological activity responses to repeated organic amendment applications in cultivated soils - Relationships with soil functions.

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Abstract

We apply the statistical methodology elaborated in the national program Bioindicators Phase 2 (2008-2012) to the QualiAgro experiment, which have been included as one of the agricultural sites [1]. One step was the establishment of a score of sensitivity of responses to stress factors. In the case of QualiAgro experiment, the screening of biological responses has shown the level of their sensitivity to the repeated organic amendments. Then we use a tool to assess the variation of biological indicators into the 13 sites of the program. The application of this tool to the biological responses in QualiAgro experiment was discussed.

Introduction

As impact of agricultural practices on pedological and geochemical soil properties are well documented, knowledge of the response of soil ecosystems and biological activity to these perturbations has to be developed in the context of biodiversity conservation and the functional role of soils ecosystems. The Bioindicator programme (2005-2012) aims to screen and develop indicators of soil biological activities and diversity in relation to land-use, agricultural and chemical disturbances with a focus on organic residues treatments, and intends to propose a selected set of Bioindicators for soil quality assessment and advice in management practice to improve soil activity [2]. In this context, some statistical tools were elaborated in the aims to make the interpretations of data easier for everyone [3]. The first one allows us to screen the univariable responses to a stress factor. The second one allows to position the univariable response in the range of variation measured into the Bioindicators program for one land-use context.

Material and methods

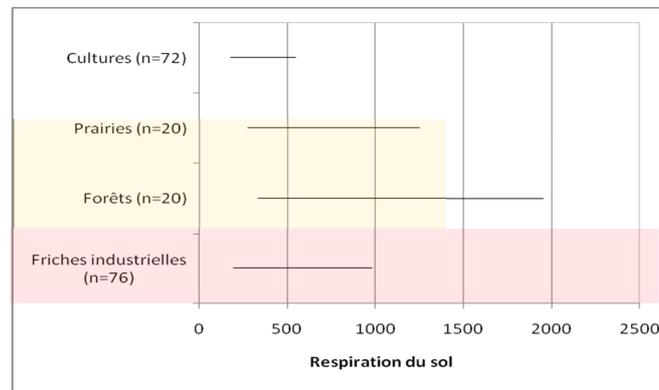
Sensibility to various factors

Sensitivities of biological activities and diversity were all tested according to the perturbation factors as defined in the program. The methodology developed to screen the potential biological indicators is based on nonparametric Kruskal-Wallis or Mann-Whitney statistical tests, followed by Dunn test. The variables are then set to descending order according to a score fixed by the p-value of the test : Score=6 if $p < 0,001$; Score=5 if $p < 0,01$; Score=4 for $p < 0,05$; Score=2 for $p < 0,1$ et score=0 if $p \geq 0,1$. Score at 4, 5 and 6 means that response is significant. All the repetitions per plot were taken account. Only the significant results from the QualiAgro site, showing the sensitivity of biological variables to the repeated organic amendments were shown.

Reference scale of the biological variables

A reference scale was elaborated for each variable in the respect of land-use of the sites in the program. The polluted sites were used to describe the scale of the values for each indicator in the contaminated context (“Friches industrielles” in Fig.1). The results for the sites QualiAgro, Gotheron, Thil, Yvetot and ANDRA were aggregated for the determination of the scale in Culture and Pasture (“Culture” and “Prairie” in Fig.1), and five forest sites were aggregated for the scale in forest (“Forets in Fig.1). The limits of the scale were the first and last deciles of value for each indicator. Routines with SAS software were used for the sensitivity screening and the reference tool. The reference scale was calculated for 94 variables describing numerous indicators, as shown in Fig.1 for the microbial respiration.

Figure 1: Reference values of microbial respiration, calculated according to cultures, pastures, forest agrosystems and polluted sites.



Application to QualiAgro experiment

A large set of biological parameters was measured, describing enzymatic and global biological activities, microbial communities including fungal and bacterial description, faunal communities at micro-, meso- and macro-levels, leading to a large description of soil biodiversity. This description was repeated on plots undergoing regular application of 4 different organic amendments and one control treatment, in the QualiAgro¹ field experiment (Yvelines, France), to assess the effects of organic amendments on soil functioning and biodiversity. The 4 organic treatments applied are a co-compost of urban sewage sludge and green wastes (DVB), a co-compost of home sorted biowastes and green wastes (BIO), a compost from residual municipal solid waste of dry and clean packaging (OMR) and a cattle manure (FUM). The 4 organic treatments were compared to a no treatment plot (TEM).

¹ The Qualiagro field experiment is conducted within a collaboration between INRA UMR EGC and Veolia Environment Research and Innovation.

Results and discussion

Sensitivity to repeated organic amendments

Table 1. Score values for the most significant responses to organic amendments.

Variable	P_KW	nc	score
LACCASE	0.0072	20	5
IBQS	0.0041	20	5
AB Tot_VdT	<0.0001	20	6
AB_Aneic	<0.0001	20	6
ADN_RDT_EXTRACT	<0.0001	20	6
ARYLN	<0.0001	20	6
N_min	0.001	20	5
BIOMASSE/Carbon_Tot	0.018	20	4
ERGO_LIBRE	0.009	20	5
FONG_nem	0.040	20	4
LIP	0.025	20	4
NCR_nem	0.033	20	4
PLFAIA	0.009	20	5
PLFASM	0.004	20	5
PLFA_GTP	0.006	20	5
PLFA_TOT	0.002	20	5
P_ALC	0.0027	20	5
TOT_ENTOM_coll	0.0366	20	4

Many biological variables are very sensitive to the organic amendments. These results and the boxplot graphs (not shown), make to evidence the impact of repeated amendments on soil functions: FUM contains more anecic and total biomass of earthworms, OMR shows the most important specific microbial biomasses, but also the nitrogen mineralization and activities as arylaminase and lipase, DVB and BIO shows similarities for microbial functions, except for fungal biomass significantly higher in DVB [4].

Position in sensitive indicators into the “reference scale”

Table 2: In cultivated agrosystems in the Bioindicator program, limits of the scale for height variables among all the set of variables. The responses of these variables are significant to the organic amendments.

table	indicateur	Usage	effectif	P10	P90
microbio	ergo_libre	Cultures (n=48)	48	0.50	3.87
nemato	fong_nem	Cultures (n=48)	48	115.08	360.71
lombric	Ab_tot_Vdt	Cultures (n=48)	48	58	294
lombric	ab_anecic	Cultures (n=48)	48	31	188
microbio	N_MIN	Cultures (n=47)	47	7.89	27.62
microbio	RESP	Cultures (n=48)	48	261.43	582.56
microbio	aryln	Cultures (n=48)	48	1.69	7.71
microbio	BIOMASSE_CT	Cultures (n=48)	48	1.31	4.30

One objective of the « reference scale » was to make possible to compare responses in QualiAgro site to the responses given by all the cultivated agrosystems included in this program. In fact, the abundances in earthworm, (Ab_tot_Vdt and ab_anecic), in fungivore group of nematods (fong_nem), in fungi (free ergosterol), in bacterial (Biomasse/CT) and the nitrogen respiration and arylaminase are into the reference scale, even if some plots are sometimes in the lower part of these limits (case of BIO for Aryln). On the other hand, the microbial respiration (mediane = 150 in TEM, 220-250 in the amended soils) shown values under the reference scale, as the ratio Biomasse/Carbon (Biomasse_CT) for TEM only. In this first approach, it seems that Qualiagro site presented some biological values in the lower part of the range, comparing to the other sites used to establish this partial “reference scale”.

Acknowledgments

We thank V. Mercier, J. Harris-Hellal, C. Villenave, F. Dubs, A. Richard, I. Gattin, S. Dequiedt, M Hedde, N. Ruiz, J. Cortet, D. Cluzeau, R. Chaussod, C. Gangneux, M. Legras, N. Cheviron, J. Bodilis, T. Beguiristain, N. Laurent, S. Criquet and all other collaborators of the project who have managed, measured and provided data. This project was financed by ADEME. <http://ecobiosoil.univ-rennes1.fr/ADEME-Bioindicateur/>

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