



## Short communication

## On the importance of details in arbuscular mycorrhizal research



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## ABSTRACT

Most journals require authors to provide sufficient experimental detail in their publications to enable other scientists to reproduce the studies presented. However, my personal experience when reading papers in my research field suggests that many details that could be considered important are commonly overlooked. I analysed the work published during 2013 within the field of arbuscular mycorrhizal ecology, assessing whether 15 important details from 5 fundamental criteria were reported about (1) the experimental treatment, (2) the abiotic growing conditions, (3) the soil nutrient concentrations, (4) the duration of the study and (5) a description of the methodology employed to collect the data. Only 26% of the 171 publications analysed reported all 5 of the most important criteria. The need of including more details when reporting research is discussed and recommendations about which details should be included are provided.

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## 1. Introduction

One of the cornerstones of natural sciences is the idea of reproducibility, i.e., the ability of a third party to repeat the same study. Indeed, this is a requisite in most journals for manuscript submission and most journals require a Materials and methods Section that provides “sufficient detail” for other scientists to reproduce the experiments presented. Of course, what is considered “sufficient” will strongly depend on the reader of each paper. Moreover, ecological studies are rarely repeated because this would be almost impossible to do and journals typically demand new research results for publication. For example, in mycorrhizal ecology, exact reproducibility is rarely possible unless the studies use an identical inoculum, identical plant and fungal genotypes and identical growth conditions. Identical inoculum might be achieved by obtaining standardised commercial inoculum (even though the batch is likely to differ), but identical growth conditions are virtually impossible to achieve unless a standardised artificial growth medium is used. Nevertheless, my personal experience when reading papers within my research field of mycorrhizal ecology suggests that there is often an alarming lack of key methodological details when reporting work. The aim of this letter is simply to raise awareness on the importance of details in

reporting research by compiling and analysing evidence using the field of arbuscular mycorrhizal ecology as an example. I believe that this lack of details may delay further advancements in this field and may hinder suitable comparisons among different studies.

## 2. Materials and methods

To infer from a representative sample of work published within the field of arbuscular mycorrhizal ecology, a simple search in Web of Science was performed (January 2014) for papers published in 2013 using the keyword arbuscular (Topic = arbuscular; Time-span = 2013; Databases: SCI-EXPANDED; SSCI; A&HCI). The search returned 769 hits. Because of the large amount of publications; only the top 10 journals in number of publications for 2013 were selected and analysed giving a total of 231 papers (see Table S1 for the complete dataset used). From these; review; editorial; meta-analysis and modelling papers were excluded (as there is usually no experimental set up involved) as well as those not dealing with arbuscular mycorrhizal research and two requested publications which could not be obtained from the authors. For each of the remaining 171 publications; I systematically searched whether fifteen important details about the research performed were specified regarding the experimental treatment; the abiotic growing conditions; the soil nutrient concentration; the duration of the study and a description of the methodology employed to collect the data (Table 1). In addition; I also noted whether or not

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**Table 1**

Aspects searched within the publications. See Supplementary Table S1 for the complete dataset.

| Detail  | Notes                                       |
|---|---|
| Study question? (Yes/No)                            |   |
| Hypothesis/prediction? (Yes/No)                     |   |
| Sample size? (Yes/No)                               |   |
| Mortality? (Yes/No)                                 |   |
| Treatment described? (Yes/No)                       |   |
| Type of study (Field/Greenhouse/Growth chamber/Lab) |   |
| Coordinates? (Yes/No)                               | Only for field studies                      |
| Plant species used? (Yes/No)                        |   |
| Light (photoperiod or intensity)? (Yes/No)          | Only for studies not performed in the field |
| Temperature? (Yes/No)                               | Only for studies not performed in the field |
| Humidity? (Yes/No)                                  | Only for studies not performed in the field |
| Soil analysis? (Yes/No)                             |   |
| Duration of the study? (Yes/No)                     |   |
| Stain used? (Yes/No)                                | Only for studies assessing AMF colonisation |
| Root amount? (Yes/No)                               | Only for studies assessing AMF colonisation |
| Number of intersections? (Yes/No)                   | Only for studies assessing AMF colonisation |
| Magnification used? (Yes/No)                        | Only for studies assessing AMF colonisation |
| Reference for the method used? (Yes/No)             | Only for studies assessing AMF colonisation |

AMF: arbuscular mycorrhizal fungal.

publications presented study questions and hypotheses or predictions tested.

Among all the potentially desirable details, I focused on 5 fundamental criteria (detailed in Table 2) to classify the publications as satisfactory. First, I noted whether the experimental treatment (if any) was clearly described so it would be, in principle, possible to repeat the study. For example, for experiments involving plant defoliation and fertilisation that would mean reporting the proportion of mass removed and how much and how often plants received supplementary nutrients. Special attention was paid to the sort and amount of arbuscular mycorrhizal fungal inocula used because it is widely established that fungal species composition (e.g., Van der Heijden et al., 1998) and source of inoculum (e.g., Abbott et al., 1994) will strongly affect plant performance. Second, I searched whether the abiotic growing conditions were reported since there are established links between temperature and plant and fungal growth (e.g., Heinemeyer and Fitter, 2004). Third, I searched whether the main soil nutrient contents were reported since mycorrhizal benefit is tightly related to soil P concentration (e.g., Smith and Read, 2008). Fourth, I searched whether the duration of the study was reported as not only species composition but also time influences the outcome of plant–fungal interactions (e.g., Hart and Reader, 2005). And fifth, I searched whether the experimental methodology was well described (i.e., how and which data were collected). Special attention was paid to how arbuscular mycorrhizal colonisation was estimated, as this is one of the most widely

reported fungal parameters in mycorrhizal ecology. I considered a publication satisfactory only if these 5 criteria were reported.

### 3. Results and discussion

My results indicate that only 26% of the 171 publications analysed could be considered satisfactory as they detailed all five criteria described in Table 2 (Fig. 1). Notably, the duration of the experiment (criterion 4) was always reported with more or less exactitude (i.e., “the experiment lasted until plants flowered”) as well as how data were collected (criterion 5). Among the publications not considered as satisfactory (i.e., giving insufficient methodological details), most of them failed to provide one or two of the five criteria analysed (66%; Fig. 1) and in 8% of publications three or even four of these criteria were missing.

The reasons to classify the publications as insufficient were numerous. According to my results, 37 publications failed to provide sufficient details about the experimental fungal treatment given (i.e., inexact or unknown inoculum amount was used to inoculate the experimental plants; criterion 1). In 26 publications there were not enough details regarding the experimental conditions used to grow the study organisms (at least light or temperature regimes were not reported; criterion 2) and in 40 more publications the soil phosphorus concentration was not provided (criterion 3). Even though I just focused on whether phosphorus concentration was reported, it is worth mentioning that soil nitrogen and potassium concentration were reported in a

**Table 2**

Criteria used to classify the publications as satisfactory (from the number of details given point of view). Only publications that fulfilled all 5 parameters were considered satisfactory.

|    |                            |   |
|----|----------------------------|---|
| 1. | Treatment                  | Is there a description of the treatment (if any) given?<br>Is the amount of AMF inoculum (if used) reported? <sup>a</sup>   |
| 2. | Abiotic growing conditions | Are the growing conditions (light, temperature, humidity) reported? <sup>b</sup>  |
| 3. | Soil analysis              | Is the soil nutrient concentration reported? <sup>c</sup>   |
| 4. | Duration                   | Is the duration of the study reported?  |
| 5. | Methodology                | Is there a description of how and which data were collected?<br>If AMF colonisation was measured, is the amount of root sample examined reported? <sup>d</sup><br>If AMF colonisation was measured, is the number of intersections and the magnification <sup>a</sup> used reported?<br>If AMF colonisation was measured, is there a description or reference to the method used? |

AMF: Arbuscular mycorrhizal fungal.

<sup>a</sup> If the fungal inocula comprised root fragments and/or mycelia and the number of spores given was not reported, the amount of details were considered unsatisfactory.<sup>b</sup> For greenhouse and growth chamber studies, only if light regime (photoperiod and/or intensity) and temperatures were reported the study was considered satisfactory.<sup>c</sup> At least P content reported.<sup>d</sup> In publications using the methods described by Biermann and Linderman (1981) or Trouvelot et al. (1986) giving root sample was not considered necessary because it is implied that publications used 30 root pieces of 1 cm length and 25 root pieces of 0.5–1 cm length as specified in the original publications.

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