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Should English Language Teachers (ELTs) be Co-authors in Scientific Papers?

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ABSTRACT

English is most probably the single most important factor for the success of a publication other than its scientific content when submitted to a peer reviewed scientific journal. Although it is difficult to quantify the number of non-native English speakers who publish in international, peer-reviewed journals, it is highly likely that this number may in fact exceed the number of so-called native English-speaking scientists. *A priori*, these non-native English-speaking scientists are at a disadvantage, such as most in Asia, and to bridge this linguistic gap, they seek assistance, free or paid, usually from language revision services or from English language teachers, or ELTs. In several cases, authorship is attributed to the ELT in exchange for language assistance, which may pose ethical hurdles in the scientific community. In this manuscript, I exemplify how ELTs, although offering some skeletal advice on sentence structure and grammar, fail to significantly improve the manuscript quality, especially the scientific content and accuracy, and even English expressions and grammar. However, a writing collaboration partner who is both a native English speaker (and/or an ELT) can provide significant improvements to the linguistic and scientific aspects of a scientific paper. An ELT should not be attributed co-authorship unless: 1) they make significant improvements to the linguistic aspects; and 2) they are competent professionals in that field of study. An ELT who fulfills both criteria – and not only one – could be entitled to co-authorship if at the request of all co-authors, provided that all other publishing ethics are respected.

Keywords: authorship; ethics; publishing; scientific merit

INTRODUCTION

The world of publishing is entering a phase of great chaotic movement. On the surface, it may seem dynamic and smoothly fluid, but below the surface there are serious deficiencies, gaps, misunderstandings and abuses that are not often spoken openly about. One of those gray zones is the issue of co-authorship, particularly that which relates to English language teachers, or ELTs. Co-authorship itself is a thorny topic and depending on whether your viewpoint if from the perspective of an author, an editor, or a publisher, it is most likely to have strong and different meanings, even though there is a broad consensus concerning the most fundamental aspects. Even so, there are big gaps and differences between publishers, ethical bodies and institutional bodies, made worse by the strong cultural influence underlying each research group, especially at the multi-national level (Teixeira da Silva 2011a).

Non-native English-speaking scientists often called upon ELTs, who are either their friends or form part of a formal education body such as a school, university, institute or even a commercial set-up such as a language editing service, to assist in the language improvement of a manuscript. While the knowledge of an ELT maybe good for picking up grammatical errors or perhaps offering broad advice regarding basic/pure English (including sentence structure, punctuation or other more subtle aspects of the language issues), they are in no way qualified to comment on or even assist with the scientific aspects. Thus, an ELT who assists with a school project, a verbal presentation or even touching up on a final version of a scientific manuscript, would most likely fulfill this function competently, and in the latter case, should be acknowledged in the Acknowledgements section. However, unless they are at least BSc, MSc or PhD graduates in a scientific discipline, they are, overall, not competent to deal with the intricacies that are fundamental to scientific English, which go far beyond regular or standard English.

In this study, I hypothesized, from my long-term and broad experience, that it is essential to be both an ELT and a specialist to be able to make large, significant and meaningful edits to a scientific paper that would merit co-authorship. To prove this, four ELTs were invited to review the exact same scientific text, blindly, to assess whether they would be able to make competent edits sufficient to merit submission and subsequent publication (Van et al. submitted).

METHODOLOGY

An international writing collaboration, partnership and co-operation, or CPC, pact was established between the first and second authors adhering strictly to the ethical guidelines proposed in Teixeira da Silva (2011b). Over the period of approximately 9 months, 8 revisions were completed, including responses to editorial requests. After the manuscript had already been successfully edited and submitted, including the peer review process, the original (raw) version was submitted to three ELTs who were highly qualified and revered by their peers. The professional profiles of the ELTs and CPC are listed in **Table 1**. They were requested to assist, as much as possible, in the improvement of an entire manuscript, with the final version prepared by the non-native English speaker. A portion of the manuscript, including the title, abstract, introduction and part of the materials and methods, is shown in the **Annex**, followed by the edits made by all three ELTs and the final edited version as made by the author of this paper, who is both an ELT and a highly experienced scientist (ELT+S). No time limits were imposed on any of the test subjects. Only one manuscript was tested. The Results and Discussion are not shown since almost no edits were made by ELTs 1 and 2, and only minor ones by ELT3; major edits were made by the CPC. Note: the three ELTs only help

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Opinion Paper

Table 1 Profile of ELTs and CPC (ELT+S) "tested" in this study.

ELT/ CPC	Gender	Nationality	Higher education	Age	No. of scientific publications	Years of professional experience as an ELT/scientist	Current profession
ELT 1	Male	Canadian	Yes; MA	42	Unknown	18-20; 0	ELT at Japanese University
ELT 2	Female	Canadian	Yes; MA	44	Unknown	16; 0	ELT at university in British Columbia, Canada
ELT 3	Male	Australian	Unknown	>40	Unknown	22; 0	ELT at Japanese University
ELT4	Male	British	No	33	No	8-10 years; 0	ELT (JET) in Japan
CPC	Male	British	Yes; PhD	39	> 400 (incl. books and journals)	12-14; 18	Researcher at Japanese University

to check the version of the manuscript before submission and not during the peer review process because, in this manuscript, the reviewer did not require that the English be improved.

RESULTS AND DISCUSSION

CPCs are fundamental to advancing science (The Royal Society 2011), especially in a world that is moving so fast, with excellence in science being achieved at alarmingly rapid rates. These CPCs can either take the form of research or writing, but in the latter case, they should be established between all parties using strict ethical guidelines (Teixeira da Silva 2011b) to avoid misunderstandings and conflicts of interest. When done appropriately, international writing CPCs are now becoming recognized as a valid co-authorship model, already (and recently) validated at the highest level of the scientific community (Teixeira da Silva 2011a).

From the **Annex**, its is more than evident that the inclusion of a ELT+S to make the necessary improvements to a manuscript before and during submission to a peer-reviewed journal results in a much more comprehensive revision than if only an ELT were to have assisted. Although it is actually difficult to quantify such CPCs, to the eye of a well-trained ELT+S, the weakness of an ELT is more than evident. However, the ELTs often admit to weaknesses in scientific knowledge, despite a long career as an ELT. The first author is of the opinion that were the manuscript submitted to the journal following the suggestions of the three ELTs in the Annex, that the manuscript would have most likely been rejected, due to gross inefficiencies both in language (ELTs 1 and 2) and in scientific content (mainly ELTs 1 and 2). ELT4's results were not included since, upon receiving the manuscript, the comment "I have no idea about how to improve the content" was the response. In this case, all three ELTs should be acknowledged while the ELT+S should become a co-author.

Several issues are in dispute regarding co-authorship: a) Who has the right to be a co-author? b) What should the position be of each co-author? c) Should each co-author have a different weighting, how is this weighting determined and should a quantitative weighting system be used to discriminate between who should/could be a co-author and who should not? d) When paid language services are provided, should that ELT or ELT+S be included as a co-author? e) If a paid language editing service is used to improve the English and/or scientific content, and should that person or entity not be awarded co-authorship, but they are not acknowledged openly, is this considered to be unethical or ghost writing?

These questions will be tacked in separate papers in order to unravel the enigmatic tumultuous crisis that underlies scientific publishing at present. One thing remains clear, however: a person (such as an ELT) who only provides English language revision assistance without simultaneous advice on scientific aspects should be only acknowledged and should not be awarded co-authorship. An ELT+S who is suitably qualified (Teixeira da Silva unpublished data) and who accompanies the publication process from submission right through to publication, including responses to editors and all editorial requests, can and should, however, be awarded co-authorship, provided that they are not receiving financial remuneration for this task.

Criticisms of the methodology: This study suffers from some inherent flaws which are not easy to overcome due to sample size, and the timing of revisions and submissions. However, it does provide a unique study, a small window of perspective on a topic never previously abridged, opening thus an avenue for discussion on the ethics and appropriateness of authorship by an ELT in a scientific paper with which they have provided language assistance only.

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REFERENCES

Teixeira da Silva JA (2011a) The ethics of collaborative authorship. *EMBO Reports* **12**, 889-893

Teixeira da Silva JA (2011b) Weaknesses in publishing: Identify, correct and strengthen. *Maejo International Journal of Science and Technology* **5 (1)**, S11-S20

The Royal Society (2011) Knowledge, Networks and Nations: Global scientific collaboration in the 21st century. RS Policy document 03/11, DES2096, London, UK, 114 pp

ANNEX

Red indicates actual edits made; blue indicates comments made. Edits made by the CPC (ELT+S) can be perceived in the final, submitted version (Van et al. unpublished).

ORIGINAL TEXT

Study on the effects of permanent magnetic fields on micropropagation of some ornamental plants

ABSTRACT

It has been stated that magnetic fields did affect biological system. It is the first time the effects of permanent magnetic fields (MFs) on the micropropagation of *Spathiphyllum* cv. Merry and *Cymbidium* Music Hour 'Maria' were studied. *Cymbidium* and *Spathiphyllum* shoots cultured in 'Miracle pack'® culture system were exposed to different MFs intensities, polarities and exposure duration. The results showed that: Increasing intensity (from 5.10^{-6} (natural MF) < 0.1 < 0.15 < 0.2 Tesla (T)) negatively influenced *Cymbidium* plant height and fresh weight of roots and had no significant effect on the other plantlet parameters. Long-term exposure (1, 2, 3 months) of *Cymbidium* shoots to 0.15 T - MFs negatively influenced plant height, positively affected the number of leaves and had no effect on other parameters compared to the control. MFs (0.1, 0.15 and 0.2 T), regardless of different polarities increased chlorophyll content (SPAD value) and number of leaves but slightly decreased dry weight of shoots of treated *Spathiphyllum* shoots. Different exposure duration to 0.15 T – magnet (2, 4, 8 weeks) had no significant influence on *Sphathiphyllum* plantlet development than increased SPAD value.

Introduction

It is well known that all organisms are living on the earth under the action of the Earth's magnetic field (5.10^{-6} T - Geo-magnetic

field, GMF), which is the natural component of their environment (Belyavskaya, 2004). However, do external MFs, lower or higher than GMF affect biological mechanism? Many scientists used to do not believe that MFs had biological active until there were some studies reported that MFs affected the metabolism and mechanism of growth of different plants based on the type of magnet, MF intensity, polarity orientation and length of duration of exposure. There are some studies showed that MFs affected the development of cells and tissues cultured *in vitro*. Shoot and root formation rates of *Paulownia* tissue culture were increased when exposed to external MFs (2.9 – 4.8 mT for 2.2, 6.6 and 19.8 sec. or 0.1 – 0.3 T) compared to the control (Le *et al*., 2004; Yaycili and Alikamanoglu, 2005; Celik *et al*., 2008). Similarly, Atak *et al*. (2007) found that both regeneration and growth of soybean shoot tip cultures exposed to MFs (2.9 – 4.6 mT) at various durations (2.2 and 19.8 sec.) increased relative to the controls. In the present study, we for the first time investigated the effects of MFs on micropropagation of 2 important commercial ornamental plants: *Cymbidium* Music Hour 'Maria' and *Spathiphyllum* cv. Merry as the new abiotic factor. We were not aware for extraordinary response. The objective of this study was to investigate the effects of MFs on micropropagation of orchid as a very fundamental exploration.

Materials and Method

Plant materials and culture conditions

The explants used were: *Cymbidium* Music Hour 'Maria' shoots with 3 leaves, no roots, 4.5 cm in length, with the similar size of stems obtained from a mass of Protocorm-like bodies (PLBs) from shoot-tip culture. And terminal apices with 3 leaves, no roots and 4.5 cm in length obtained from a mass of shoots derived from the *in vitro* culture of *Spathiphyllum* cv. Merry.

Twenty-five shoots were cultured in each culture vessel for 2 month in *Spathiphyllum* case and 3 months in *Cymbidium* case, respectively under the conditions: temperature (25 ± 1°C), photoperiod (16-hrs per day), light intensity (45 µmol m^{-2} s^{-1}; Plant Lux, Toshiba Co., Japan), CO_2 enrichment (3000 µmol mol^{-1} $24h^{-1}$ d^{-1}). Three culture vessels were used for each treatment.

ELT 1

Study on the effects of permanent magnetic fields on micropropagation of different ornamental plants species

ABSTRACT

Previous studies showed that magnetic fields affect biological systems. This is the first study on the effects of permanent magnetic fields (MFs) on the micropropagation of *Spathiphyllum* cv. Merry and *Cymbidium* Music Hour 'Maria' were studied. *Cymbidium* and *Spathiphyllum* shoots cultured in a 'Miracle pack'® culture system were exposed to different MFs intensities, polarities and exposure duration. The results showed that: Increasing intensity (from 5.10^{-6} (natural MF) < 0.1 < 0.15 < 0.2 Tesla (T)) negatively influenced *Cymbidium* plant height and fresh weight of roots and had no significant effect on the other plantlet parameters. Long-term exposure (1, 2, 3 months) of *Cymbidium* shoots to 0.15 T - MFs negatively influenced plant height, positively affected the number of leaves and had no effect on other parameters compared to the control. MFs (0.1, 0.15 and 0.2 T), regardless of different polarities, increased chlorophyll content (SPAD value) and number of leaves but slightly decreased dry weight of shoots of treated *Spathiphyllum* shoots (this is not a sentence; come and talk to me about this). Different exposure duration to a 0.15 T – magnet (2, 4, 8 weeks) had no significant influence on *Sphathiphyllum* plantlet development other than increased SPAD value.

Introduction

As the general knowledge, all (terrible start- sounds like a fairy tale. rewrite! Still bad. Come and see me) organisms are living on the earth under the action of the Earth's magnetic field (5.10^{-6} T - Geo-magnetic field, GMF), which is the natural component of their environment (Belyavskaya, 2004). However (However is not n appropriate conjunction), do external MFs, lower or higher than GMF affect biological mechanism? Many scientists used to do not believe (check this) that MFs had biological activy until some studies reported that MFs (poorly written) affected the metabolism and mechanism of growth of different plants based on the type of magnet, MF intensity, polarity orientation and length of duration of exposure. Some studies found that MFs affected the development of cells and tissues cultured *in vitro* (re-write this). Shoot and root formation rates of *Paulownia* tissue culture were increased when exposed to external MFs (2.9 – 4.8 mT for 2.2, 6.6 and 19.8 sec. or 0.1 – 0.3 T) compared to the control (Le *et al*., 2004; Yaycili and Alikamanoglu, 2005; Celik *et al*., 2008). Similarly, Atak *et al*. (2007) found that both regeneration and growth of soybean shoot tip cultures exposed to MFs (2.9 – 4.6 mT) at various durations (2.2 and 19.8 sec.) increased relative to the controls. It is the first study (come see me), investigated the effects of MFs on micropropagation of two (Numbers 1- 10 are usually written. One… Three, etc!) important commercial ornamental plants: *Cymbidium* Music Hour 'Maria' and *Spathiphyllum* cv. Merry as the new abiotic factor (?????? Not clear). We were not aware for extraordinary response (rewrite). The objective of this study was to investigate the effects of MFs on micropropagation of orchid as a fundamental exploration.

Materials and Method

Plant materials and culture conditions

The explants used were: *Cymbidium* Music Hour 'Maria' shoots with 3 leaves, no roots, 4.5 cm in length, with a similar size of stems obtained from a mass of Protocorm-like bodies (PLBs) from a shoot-tip culture. And terminal apices with 3 leaves, no roots and 4.5 cm in length obtained from a mass of shoots derived from the *in vitro* culture of *Spathiphyllum* cv. Merry. (NO verb – this is not a sentence; come and see me)

Twenty-five shoots were cultured in each culture vessel for two months in a *Spathiphyllum* case and 3 months in a *Cymbidium* case, respectively, under these conditions: temperature (25 ± 1°C), photoperiod (16-hrs per day), light intensity (45 µmol m^{-2} s^{-1}; Plant Lux, Toshiba Co., Japan), CO_2 enrichment (3000 µmol mol^{-1} $24h^{-1}$ d^{-1}). Three culture vessels were used for each treatment.

ELT 2

Study on the Effects of Permanent Magnetic Fields on Micro-Propagation of Some Ornamental Plants

ABSTRACT

It has been stated (where – in the literature?) that magnetic fields affect biological systems. The first time the effects of permanent magnetic fields (MFs) was studied was in (date) when (name of scientist) studied the micro-propagation of *Spathiphyllum* cv. Merry and *Cymbidium* Music Hour 'Maria'. In this study, *Cymbidium* and *Spathiphyllum* shoots cultured in a 'Miracle pack'® and a culture system were exposed to different MFs intensities, polarities and exposure duration. The results showed that: Increasing intensity (from 5.10^{-6} (natural MF) < 0.1 < 0.15 < 0.2 Tesla (T)) negatively influenced *Cymbidium* plant height and the fresh weight of roots and had no significant effects on the other plantlet parameters. Long-term exposure (1, 2, 3 months) of *Cymbidium* shoots to 0.15 T - MFs negatively influenced plant height; positively affected the number of leaves; and had no effect on other parameters compared to the control. MFs (0.1, 0.15 and 0.2 T), regardless of different polarities increased chlorophyll content (SPAD value) and the number of leaves, but slightly decreased dry weight of shoots of treated *Spathiphyllum* shoots. Different exposure duration to 0.15 T – magnet (2, 4, 8 weeks) had no significant influence on *Sphathiphyllum* plantlet development than increased SPAD value.

Key words: m*icropropagation, Cymbidium, Spathiphyllum, 'Miracle Pack'® culture system, magnetic field.*

Abbreviations Protocorm-like body: **PLB**; Magnetic field: **MF**; North: **N**; South: **S;** Tesla: **T**; 'Miracle Pack'® culture system: **MP**; Plastic tray: **PLT**; Plant height: **PH**; Root length: **RL**; Chlorophyll content: **SPAD value**; Number of leaves: **NL**; Number of roots: **NR**; Fresh weight of shoots: **FWS**; Fresh weight of roots: **FWR**; Dry weight of shoots: **DWS**; Dry weight of roots: **DWR**, Vacin and Went medium: **VW**; Murashige and Skoog medium: **MS.**

Introduction

It is well known that all organisms are living on the earth under the action of the Earth's magnetic field (5.10^{-6} T - Geo-magnetic field, GMF), which is a natural component of their environment (Belyavskaya, 2004). However, do external MFs (lower or higher than GMF's) affect biological mechanisms? (You didn't define GMFs). In the past, many scientists did not believe that MFs were biologically active until some studies reported that MFs affected the metabolism and mechanism of growth of different plants based on the type of magnets, MF intensity, polarity orientation and length of duration of exposure. Some studies showed that MFs affected the development of cells and tissues cultured *in vitro*. Shoot and root formation rates of *Paulownia* tissue culture were increased when exposed to external MFs (2.9 – 4.8 mT for 2.2, 6.6 and 19.8 sec. or 0.1 – 0.3 T) compared to the control (Le *et al*., 2004; Yaycili and Alikamanoglu, 2005; Celik *et al*., 2008). Similarly, Atak *et al*. (2007) found that both regeneration and growth of soybean shoot tip cultures exposed to MFs (2.9 – 4.6 mT) at various durations (2.2 and 19.8 sec.) increased relative to the controls. In this study, we investigated the effects of MFs on micropropagation of 2 important commercial ornamental plants: *Cymbidium* Music Hour 'Maria' and *Spathiphyllum* cv. Merry as the new abiotic factor for the first time. We were not expecting this extraordinary response. The objective of this study was to investigate the effects of MFs on micro-propagation of orchids as a very fundamental exploration.

Materials and Methods

Plant Materials and Culture Conditions

The explants used were: *Cymbidium* Music Hour 'Maria' shoots with 3 leaves, no roots, 4.5 cm in length, with the similar size of stems obtained from a mass of Protocorm-like bodies (PLBs) from shoot-tip culture and terminal apices with 3 leaves, no roots and 4.5 cm in length obtained from a mass of shoots derived from the *in vitro* culture of *Spathiphyllum* cv. Merry.

Twenty-five shoots were cultured in each vessel for 2 months in *Spathiphyllum* case and 3 months in *Cymbidium* case, respectively under the following conditions: temperature (25 ± 1°C), photoperiod (16-hrs per day), light intensity (45 µmol m^{-2} s^{-1}; Plant Lux, Toshiba Co., Japan), CO_2 enrichment (3000 µmol mol^{-1} $24h^{-1}$ d^{-1}). Three culture vessels were used for each treatment.

ELT 3

The effect of permanent magnetic fields on micropropagation of some ornamental plants (I think it would be better to name the plants**)**

ABSTRACT

It has been stated that magnetic fields do not affect biological systems. The present study investigated the effect of permanent magnetic fields (MFs) on the micropropagation of *Spathiphyllum* cv. Merry and *Cymbidium* Music Hour 'Maria'. *Cymbidium* and *Spathiphyllum* shoots cultured in a 'Miracle pack'® culture system were exposed to different MF intensities, polarities and exposure durations. The results showed that MFs of increasing intensity (from 5.10^{-6} (natural MF) < 0.1 < 0.15 < 0.2 Tesla (T)) negatively influenced *Cymbidium* plant height and fresh weight of roots, but had no significant effect on other plantlet parameters. Long-term exposure (1, 2, 3 months) of *Cymbidium* shoots to a 0.15 T MFs negatively influenced plant height and positively affected the number of leaves, but had no effect on other parameters compared with control. MFs (0.1, 0.15 and 0.2 T), regardless of different polarities, increased chlorophyll content (SPAD value) and number of leaves but slightly decreased dry weight of shoots of treated *Spathiphyllum* shoots. Different exposure durations (2, 4, 8 weeks) to a 0.15 T magnet had no significant influence on *Spathiphyllum* plantlet development other than increased SPAD value.

Introduction

It is well known that all organisms living on the Earth are subject to the action of the Earth's magnetic field (5.10^{-6} T - Geo-magnetic field (GMF)), which is a natural component of their environment (Belyavskaya, 2004). However, do external MFs, lower or higher than GMF, affect biological mechanisms? Previously, many scientists did not believe that MFs affected biological activity until some studies reported that MFs affected the metabolism and mechanism of growth of different plants based on the type of magnet used, MF intensity, polarity orientation and length of duration of exposure. There are some studies (Are these studies the same studies referred to in the previous sentence, or different studies? If the former: "These studies showed ..."; if the latter: "Other studies showed ...".) showed that MFs affected the development of cells and tissues cultured *in vitro*. Shoot and root formation rates of *Paulownia* tissue culture increased when exposed to external MFs (2.9–4.8 mT for 2.2, 6.6 and 19.8 s or 0.1–0.3 T) compared with control (Le *et al*., 2004; Yaycili and Alikamanoglu, 2005; Celik *et al*., 2008). Similarly, Atak *et al*. (2007) found that both regeneration and growth of soybean shoot tip cultures increased when exposed to MFs (2.9–4.6 mT) for various durations (2.2 and 19.8 s) compared with control. In the present study, we investigated the effect of MFs on micropropagation of 2 important commercial ornamental plants: *Cymbidium* Music Hour 'Maria' and *Spathiphyllum* cv. Merry as the new abiotic factor. To our knowledge, this is the first study of MFs on these two plants. We were not aware for extraordinary response. (I don't understand what this means. Please clarify.) The objective of this study was to investigate the effect of MFs on micropropagation of orchids as a fundamental exploration (What is meant by this?).

Materials and Methods

Plant materials and culture conditions

The explants used were *Cymbidium* Music Hour 'Maria' shoots with 3 leaves, no roots, 4.5 cm in length, with stems of similar size obtained from a mass of protocorm-like bodies (PLBs) from shoot-tip culture. Terminal apices with 3 leaves, no roots and 4.5 cm in length were obtained from a mass of shoots derived from the *in vitro* culture of *Spathiphyllum* cv. Merry.

Twenty-five shoots each of *Spathiphyllum* and *Cymbidium* were cultured in each culture vessel for 2 and 3 months, respectively, under the following conditions: temperature (25 ± 1°C), photoperiod (16 h per day), light intensity (45 µmol m^{-2} s^{-1}; Plant Lux, Toshiba Co., Japan), and CO_2 enrichment (3000 µmol mol^{-1} $24h^{-1}$ d^{-1} (Is this correct?)). Three culture vessels were used for each treatment.

Ensuing sections are provided only for **ELT3** because edits provided by **ELT 1** and **ELT 2** were basically null.

Culture media

Cymbidium shoots were cultured in VW medium (1949) supplemented with Nitsch's microelements (Nitsch and Nitsch, 1967), 2 g l^{-1} tryptone (Bacto, Difco Laboratories, USA), 0.1 mg l^{-1} β-naphthalene acetic acid (NAA) (Nacalai Tesque, Kyoto, Japan), and 0.1 mg l^{-1} kinetin (Wako Chemicals Ltd., Tokyo, Japan) ($VW_{mod.}$).

Spathiphyllum shoots were cultured in full-strength Murashige and Skoog (MS, 1962) sugar-free medium.

All media were adjusted to pH 5.3 and 5.5 for *Cymbidium* and *Spathiphyllum*, respectively, by adding 1 N NaOH or 1 N HCl before autoclaving at 121° C for 17 min.

Preparation of 'Miracle Pack'® culture system

The 'Miracle Pack'® (MP) culture system was used as the culture vessel for all experiments and for control. The MP culture system, with valuable properties such as super thermal, high light transmittance and high gas exchange, is an ideal vessel for photoautotrophic cultures (Tanaka *et al*., 1999, 2005). The MP is made of fluorocarbon polymer film (Neoflon® PFA film 25 µm thick, Daikin Industries, Japan) supported by a clear polystyrene frame. The substrate is a 25 joined-block of rockwool (5 × 5 of Grodan® Rockwool Multiblock™, AO 18/30, Grodiana A/S, Denmark) (Figure 1: BIO-U Co. Ltd., Japan). The rockwool was sterilized in a dry sterilizer at 150°C for 2 h and placed in the MP when it completely cooled down. Sterilized MK medium (210 ml) was poured evenly over the rockwool. Twenty-five plantlets were inserted into the small holes (Ø 5 mm × depth 10 mm) in each multiblock™ (see Figure 1). All procedures were carried out under aseptic conditions according to Tanaka *et al*. (1999).

Magnetic device

The magnets (Kinkimagnet Co. Ltd., Osaka, Japan) used were permanent magnets made from magnetized "hard" ferromagnetic materials. The magnets are square and have different intensities based on their thickness (Table 1). Different surfaces of the magnet show different MF polarities: North (N) and South (S). The 0.2 T magnets were made by attaching one 0.1 T magnet to the opposite polarity of a 0.15 T magnet (Figure 2; note that strengths are not additive). The polarities and MF intensities of magnets were determined by a Tesla meter (model TM-701, Kanetec Co. Ltd., Tokyo, Japan).

In order to set up experiments in a culture chamber, we designed a suitable system for the magnets. Preventing an interaction between the magnets was the most important factor in designing the system. Therefore, a plastic tray (PLT) and thick wooden pieces were used which significantly prevented magnetic field interaction. The PLTs were made of polypropylene (43.1 × 14.6 cm). Each PLT had 3 magnets which were separated by pieces of wood (Figure 3). MF intensities were confirmed by the Tesla meter.

Culture vessels were put directly on the surfaces of each magnet in the PLT system. For the shoot development experiments, the PLT systems were set up in a CO_2-enriched culture room (Figure 4).

Effect of intensity and polarity of magnetic fields on *Spathiphyllum* cv. Merry shoot development

Each MP culture system containing 25 *Spathiphyllum* shoots and 210 ml MS medium (full strength) were put directly on the N and S polarities of 3 magnets with different intensities (0.1, 0.15 and 0.2 T) while the control had no extra-MF treatment other than natural GMF. After 8 weeks, plantlet growth was assessed using the following parameters: plant height (PH), root length (RL), number of leaves (NL), number of roots (NR), fresh weight of shoots (FWS), fresh weight of roots (FWR), dry weight of shoots (DWS) and dry weight of roots (DWR).

The chlorophyll content of the third leaf counting downwards from the plantlet apex was measured by a chlorophyll meter (SPAD-502, Minolta Co., Japan) and reported as SPAD value (Teixeira da Silva *et al*., 2005).

Effect of duration of exposure to magnetic fields on *Spathiphyllum* cv. Merry shoot development

In this investigation, six MPs containing 210 ml full-strength, sugar-free MS medium and 25 explants were exposed to N and S polarities of 0.15 T magnets for 2, 4 and 8 weeks with corresponding equal rest time durations (Table 2). Control was exposed to GMF (5.10^{-6} T) only. Data were recorded after 8 weeks.

Effect of intensity and polarity of magnetic fields on *Cymbidium* Music Hour 'Maria' shoot development

Twenty five explants were cultured in an MP containing 210 ml VW_{mod}. Six cultured vessels with 150 explants in total were exposed to MFs at different intensities (0.1, 0.15 and 0.2 T) combined with different polarity orientation (N and S). Controls with the same amount of medium and the number of explants were not exposed to external MF other than GMF. Both controls and treatments were cultured in a CO_2 enriched culture room. Growth parameters (PH, RL, NL, NR, FWS, FWR, DWS, DWR and SPAD value) were recorded on the 90th day.

Effect of duration of exposure to magnetic fields on *Cymbidium* Music Hour 'Maria' shoot development

In this study, 6 MPs each containing 210 ml VW_{mod} and 25 explants were exposed to N and S polarities of a 0.15 T magnet for 1, 2 and 3 months with corresponding equal rest time durations (Table 3). For comparison, the control was an MP not exposed to extra MFs. Data (PH, RL, NL, NR, FWS, FWR, DWS and DWR and SPAD value) were recorded on the 90th day.