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ORIGINAL ARTICLE

Effects of weak static magnetic fields on the development of seedlings of *Arabidopsis thaliana*

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Abstract

To study magnetoreception of *Arabidopsis thaliana*, we analysed several developmental responses including cryptochrome-independent seed germination and the phytochrome- and cryptochrome-dependent hypocotyl elongation and photo-accumulation of anthocyanins and chlorophylls in weak static magnetic fields ranging from near null to 122 μT. A field of 50 μT accelerated seed germination by about 20 h relative to samples maintained in a near-null field. The double mutant, *cry1cry2*, lacking cryptochromes 1 and 2 displayed the same magnetic field–induced germination acceleration under blue light as the wild-type strain. Magnetic field–induced germination acceleration was masked in the presence of exogenous sucrose. Stimulus–response curves for hypocotyl elongation in a range between near-null to 122 μT indicated maxima near 9 and 60 μT for the wild-type strain as well as mutant *cry1cry2*. The photo-accumulation of anthocyanins and chlorophylls could be effectively modulated by magnetic fields in the presence of low-irradiance red and blue light, respectively. The findings indicate that *Arabidopsis thaliana* possesses light-independent mechanisms of magnetic field reception, which remain presently unidentified. Our results are in better agreement with predictions of the level crossing mechanism (LCM) of magnetoreception rather than those of the cryptochrome-associated radical-pair mechanism (RPM).

Keywords *Arabidopsis* · Magnetism · Cryptochrome · Elongation growth · Germination · Pigment synthesis

Abbreviations

CRY	Cryptochrome
FAD	Flavin adenine dinucleotide
LCM	Level crossing mechanism
MF	Magnetic field
MS	Murashige-Skoog growth medium
RP	Radical pair
RPM	Radical-pair mechanism
PHOT	Phototropin
PHY	Phytochrome
SUT	Sucrose transporter
TRP	Tryptophan
WT	Wild type

Introduction

The literature on magnetic field (MF) reception of plants pertains to a large extent on developmental responses from a plethora of different species and test systems. Only during the past two decades, investigators have begun to focus on *Arabidopsis thaliana* as a model system amenable to genetic and molecular dissection (Ahmad et al. 2007; Harris et al. 2009; Bertea et al. 2015; Xu et al. 2012, 2014, 2017, 2018). Despite this advance, the progress of plant magneto-biology is still somewhat hampered in several respects: stimulus–response relationships for MF-induced developmental responses are still rare, the employed magnetic flux densities are rather disparate, and the employed growth media can greatly differ. As a result, it is almost impossible to make meaningful comparisons between different experimental systems and to arrive at general conclusions. Our work was thus aiming at (i) the generation of stimulus–response relationships for some developmental responses, (ii) assessment of the ability of MFs to affect the kinetics of developmental responses, and (iii) investigation to what extent different growth media, specifically exogenous sucrose, can affect magnetoreception of *Arabidopsis* seedlings.

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