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Toxicity of MCPA on non-green potato tuber calli

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Abstract Growth of potato tuber calli cells (non-green) is inhibited by 4-chloro-2-methylphenoxyacetic acid (MCPA) as a consequence of perturbation of membrane integrity. MCPA also depresses ATP content with simultaneous increase of ADP and AMP, i.e., the energy charge is severely compromised. Cell redox state is also affected by MCPA, as a function of concentration. Up to 60 μM, MCPA stimulates glutathione reductase and glutathione transferase, whereas superoxide dismutase and catalase activities are not affected. However, 120 μM MCPA inhibits all these activities. Cell death challenged by MCPA is putatively related to disturbance of membrane integrity responsible for mitochondrial uncoupling with decrease of the energy charge and subsequent loss of ions and metabolites.

Keywords Herbicide · MCPA · Potato tuber calli · Redox state · Energy charge · Antioxidant enzymes

Abbreviations

GST	Glutathione *S*-transferase
CAT	Catalase
GR	Glutathione reductase
SOD	Superoxide dismutase
ROS	Reactive oxygen species
EDTA	Ethylenediamine-tetraacetic acid
MCPA	4-Chloro-2-methylphenoxyacetic acid

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Introduction

2-Methyl-4-chlorophenoxyacetic acid (MCPA) was developed in the 1940s and is a chlorophenoxy herbicide widely used to effectively control a wide variety of broadleaved weeds in cornfilds, grasses, orchards, grapes, flax, sugarcane, pulses, and non-crop areas.

Due to its chemical structure which is similar to that of natural plant hormones (auxins), it causes uncontrolled growth of the meristematae and restrains both DNA and protein synthesis (Fargasova 1994), thereby causing the disruption of basic metabolic processes in plant cells and tissues.

The usual MCPA field dose is 1,000-fold higher than the normal auxin level within plants, which causes extensive cell growth stimulation resulting in the death of the plant (Hopkins 1999).

Toxicological assays in rats show that the liver and the kidneys are the target organs for MCPA. MCPA induces cytochrome P450 isoenzymes in Hep G2 cells; the cytoskeletal components actin and vinculin were dramatically affected by MCPA metabolism cousing protein sulfhydryl groups depletion (Camatini et al. 1998).

Kobal and Budihna (1999) showed that at low concentration (15 mg kg^{-1}) MCPA affects neither the body weight of adult rats and rabbits nor that of their offspring and the weight of inner organs is maintained. However, at higher concentrations (150 mg kg^{-1}) significant changes in