

# Combined Toxicity of Multi-Walled Carbon Nanotubes and Cu<sup>2+</sup> on the Growth of Ryegrass: Effect of Surface Modification, Dose, and Exposure Sequence

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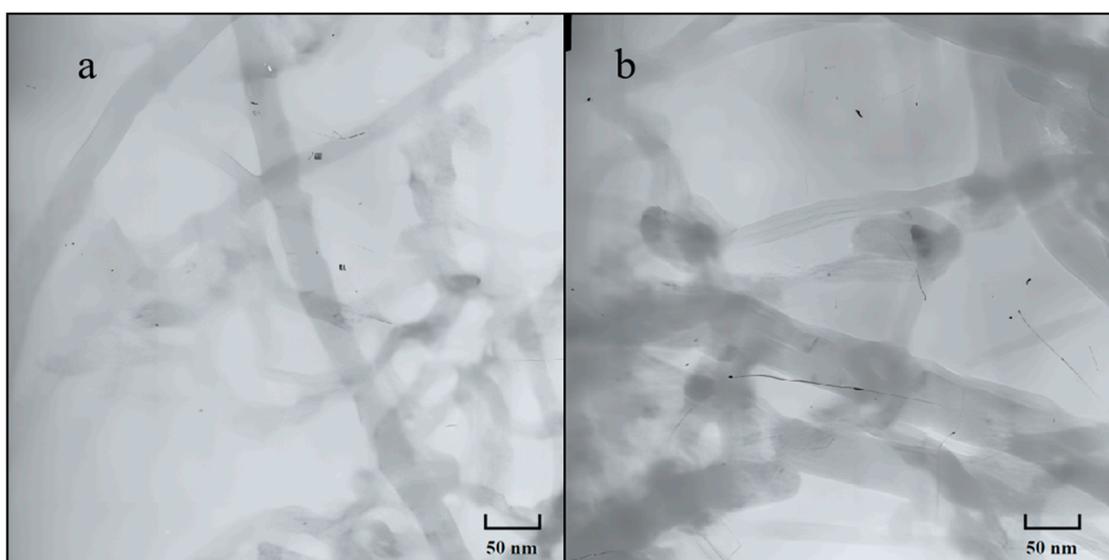


Figure S1. TEM images of (a) MWCNT; (b) MWCNT-COOH.

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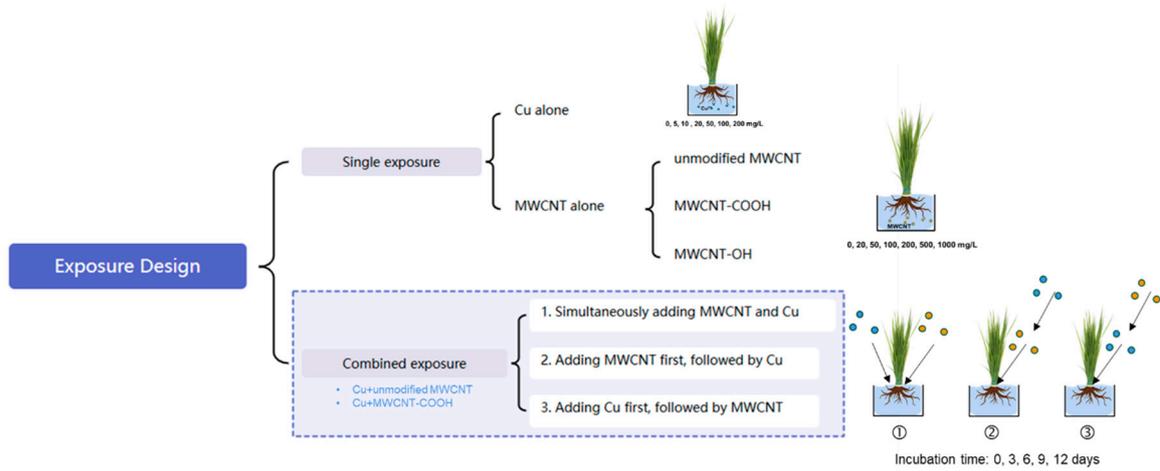


Figure S2. Exposure design of the study

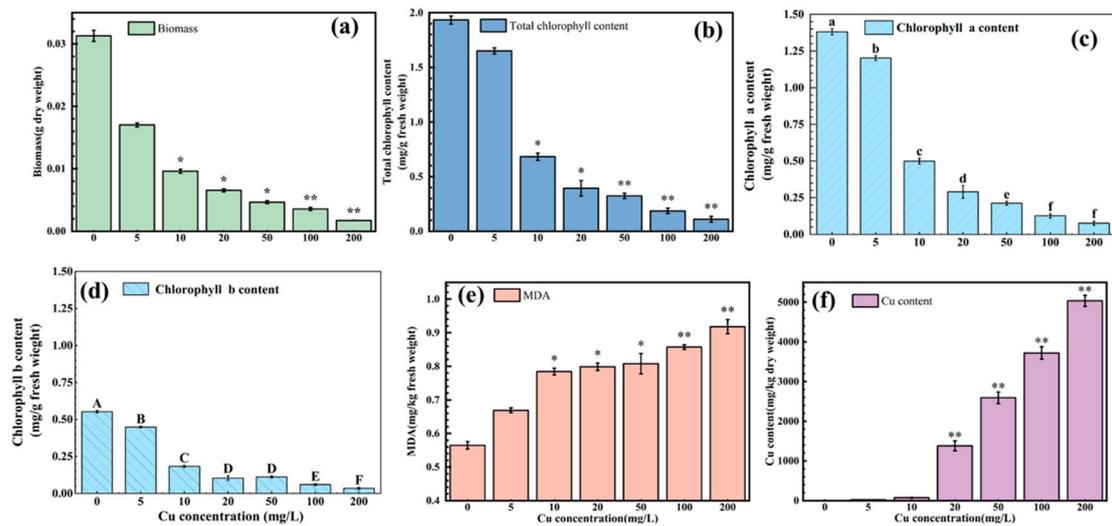


Figure S3. Comparison of the effects of  $\text{Cu}^{2+}$  on ryegrass: biomass (a), total chlorophyll content (b), chlorophyll a content (c), chlorophyll b content (d), MDA content (e) of the ryegrass and the  $\text{Cu}^{2+}$  concentration in the root of the ryegrass (f). (The asterisk \* indicates a significance level of  $p < 0.05$  and \*\* indicates  $p < 0.01$ , as revealed using one-way analysis of variance (ANOVA) followed by the Turkey's post-hoc test.)

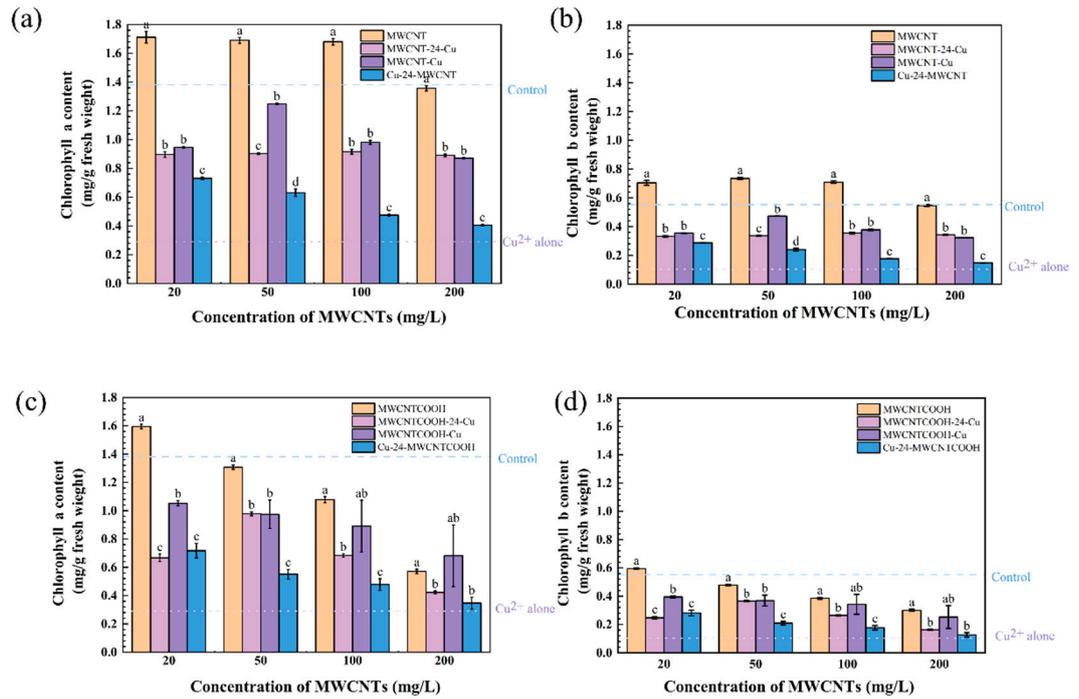


Figure S4. Impact of MWCNT concentration under combined effects on chlorophyll a content (a and c) and chlorophyll b content (b and d) of unmodified MWCNT (a and b), and MWCNT-COOH (c and d). The dot line represents the value of the control group (treated with only Cu<sup>2+</sup> and without MWCNT). The dashed line represents the value of the Cu<sup>2+</sup>-alone group (treated without MWCNT and Cu<sup>2+</sup>). Different letters denote the significant difference ( $p < 0.05$ ) across treatments at the same concentration, as revealed using one-way analysis of variance (ANOVA) followed by the Duncan's post-hoc test.

Table S1. Pearson Correlation Analysis of MWCNT Concentration and Chlorophyll Content in Ryegrass

Treatments	MWCNTs concentration	
MWCNTCOOH-24-Cu	Pearson Correlation	-0.94*
	Sig. (2-tailed)	0.017
	N	5
MWCNTCOOH-Cu	Pearson Correlation	-0.234
	Sig. (2-tailed)	0.704
	N	5
Cu-24-MWCNTCOOH	Pearson Correlation	-0.777
	Sig. (2-tailed)	0.122
	N	5
MWCNT-24-Cu	Pearson Correlation	-0.920*

	Sig. (2-tailed)	0.027
	N	5
	Pearson Correlation	-0.772
MWCNT-Cu	Sig. (2-tailed)	0.126
	N	5
	Pearson Correlation	-0.77
Cu-24-MWCNT	Sig. (2-tailed)	0.128
	N	5

The symbol \* indicates a significant correlation at the 0.05 level (two-tailed).