Physiological and biochemical resistance cost of multiple herbicide resistance in *Echinochloa crus-galli*

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Summary Barnyard grass is one of the major malignant weeds infesting rice fields in China and elsewhere in the world. The expansion of herbicide-resistant barnyard grass is increasingly threatening rice production systems. Here, a multiple-resistant *Echinochloa crus-galli* population to quinclorac, penoxsulam and bispyribac-sodium were determined by the whole-plant bioassay. To explore the difference in fitness adaption between the multi-herbicide resistant (R) and susceptible (S) biotypes, a comparative proteomics analysis using iTRAQ were performed. Ten down-accumulated proteins including PSI and PSII, cytochrome b6 and F-type H^+-transporting ATPase, and seven light-harvesting complex I chlorophyll *a/b* binding proteins were identified in the R versus S biotypes. In addition, various xenobiotic metabolising enzymes which play crucial roles in abiotic stress response (such as catalase, Cu/Zn-SOD, aldehyde dehydrogenase, P450, and NADPH-cytochrome reductase) were also down-accumulated in the R biotype. Meanwhile, photosynthetic parameters and physiological indexes of the six-leaf stage seedlings were measured in the R and S biotypes. The R biotypes showed a reduced Chl *a* and carotenoid content by 4.72% and 17.06%, respectively, and a reduced specific leaf area by 47.10% when the first fully expanded leaf was measured. The net photosynthetic rate shows a slight decrease by 18.41% in the R biotypes (11.70 ± 0.57 μmol CO_2 $m^{-2}s^{-1}$) relative to that of the S biotypes (14.34 ± 0.53 μmol CO_2 $m^{-2}s^{-1}$). Therefore, proteomic and physiological analysis demonstrate that the physiological and biochemical resistance costs are associated with multiple herbicide resistance in barnyard grass.

Keywords *Echinochloa crus-galli*, herbicide resistance, proteomics, photosynthesis, resistance cost.