

Physiological Responses of Quinclorac-Resistant *Echinochloa crus-galli*



Sakao Intakaew¹ and Pattarasuda Chayapakdee^{2*}

¹Student special project in B.Sc. (Biology) student code 640510294, Email: sakao_intakaew@cmu.ac.th

^{2*}Lecturer Dr., Department of Biology, Faculty of science, Chiang Mai University, Email: pattarasuda.c@cmu.ac.th

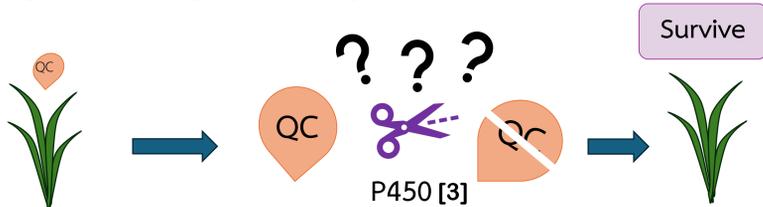
239 Huay Kaew Road, Mueang District, Chiang Mai, Thailand, 52000

Abstract

Herbicide resistance poses a significant challenge to weed management in agricultural systems. This study elucidates the physiological mechanisms associated with quinclorac resistance in *Echinochloa crus-galli* (barnyard grass) by comparing two resistant populations (AY1, NN1) with a susceptible population (2-CM10). Dose-response assays were conducted to evaluate quinclorac efficiency by growing seedlings in herbicide-supplemented, half-strength Murashige and Skoog (MS) solid medium. Seedling growth was monitored over nine days to construct dose-response curves. Additionally, multiple herbicide sensitivity assays were performed by culturing seedlings on MS medium supplemented with five herbicides with different modes of action. Concurrently, the role of cytochrome P450-mediated detoxification was examined through co-treatment with quinclorac and malathion, a known P450 enzyme inhibitor. Results indicate that resistant populations (AY1 and NN1) maintained growth under quinclorac exposure, whereas the susceptible population (2-CM10) exhibited significant growth inhibition ($p < 0.05$). AY1 line exhibited resistance to quinclorac only, whereas NN1 line showed multiple herbicides resistance (quinclorac, penoxsulam and profoxydim). Furthermore, malathion application failed to reverse resistance in AY1 and NN1, suggesting that non-P450 mechanisms predominate in quinclorac detoxification. Current findings suggest that quinclorac resistance in *E. crus-galli* is mediated by multifaceted physiological adaptations beyond P450 metabolism. These findings establish a foundation for molecular studies on resistance mechanisms to mitigate herbicide resistance in agricultural systems.

Introduction

Quinclorac, an auxin mimics herbicide, is widely used to control barnyard grass (*Echinochloa crus-galli*), one of the most troublesome weed in rice fields [1]. Barnyard grass in Thailand evolved resistance to quinclorac [2]. The mechanism of resistance is unknown. Therefore, the study of physiological mechanisms of quinclorac resistance barnyard grass is required for future molecular studies and improving weeds management strategies.



Results and Discussion

Quinclorac dose response assays

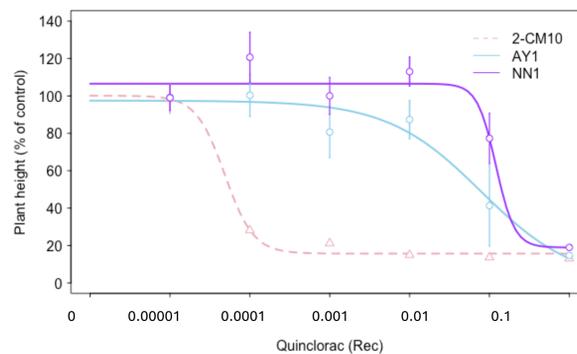


Fig 1: Dose-response curves at various concentrations of quinclorac herbicides in 3 barnyard grass populations by plant height (% of control). The dashed line (---), and solid line (—) represent sensitive, and resistant populations, respectively.

Multiple herbicides sensitivity test

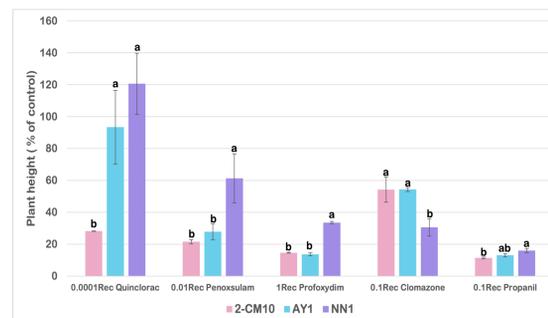


Fig 2: Plant height (% of control) of barnyard grass (2-CM10, AY1 and NN1) under different types of herbicides for nine days. The results showed means of three replicates, with the standard deviation (SD) bar. Different letters (a-b) of the same herbicide indicates significance at $p < 0.05$ by Turkey HSD tests.

Effect of P450 inhibitor malathion

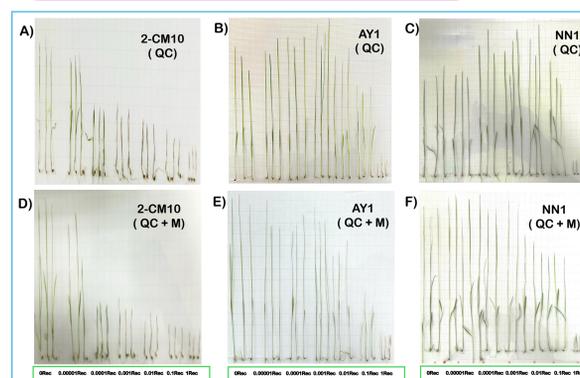


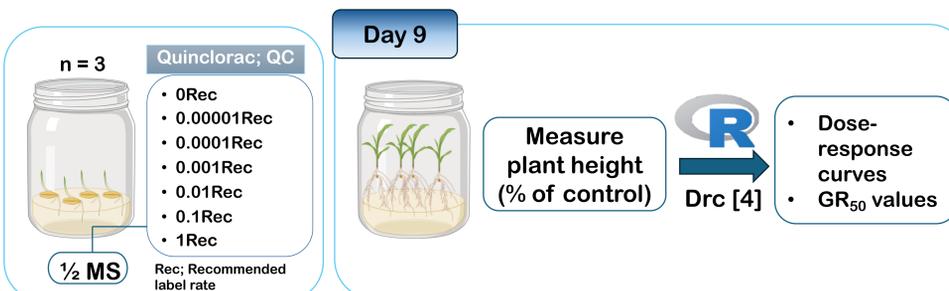
Fig 3: Plant growth after QC (quinclorac) and QC + M (malathion) treatment for nine days. QC inhibited growth of susceptible 2-CM10 line (3A), whereas resistant AY1 and NN1 lines maintained growth under the same condition (3B, 3C). QC + M failed to reverse QC sensitivity in resistant lines (3E, 3F).

Lines	QC GR ₅₀ (xRec) *1	QC + M GR ₅₀ (xRec) *2	Ratio *1/*2
2-CM10	0.00019	0.00003	3.28236
AY1	0.07765	0.00173	44.82796
NN1	0.11451	0.04694	2.43976

Fig 4: *1 & *2 GR₅₀ is the herbicide dose that causes 50% growth reduction. *1/*2 Ratio calculated from QC GR₅₀ divided by the QC + M GR₅₀ of each lines.

Methods

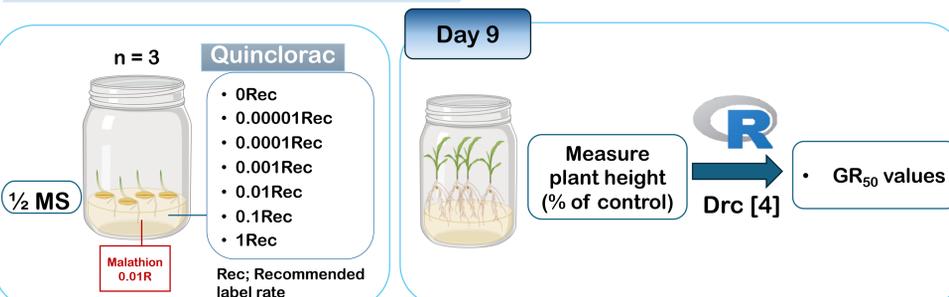
Quinclorac dose response test



Multiple herbicide sensitivity test

Herbicide	Mode of action	Rec (mg ai L ⁻¹)	Treated concentrations (Rec)
Quinclorac	Auxin mimics	750	0.0001
Penoxsulam	ALS inhibitors	37.5	0.01
Profoxydim	ACCase inhibitors	225	1
Clomazone	DOXP-synthase inhibitors	600	0.1
Propanil	PS-II inhibitors	4050	0.1

Effect of P450 inhibitor malathion test



Acknowledgement

This research was funded by Chiang Mai University. Plant samples were partially received from Dr. Jarunya Pinsuda, Plant Protection Research and Development Office.

Conclusion

- AY1 and NN1 maintained growth under quinclorac (QC) exposure, whereas 2-CM10 exhibited growth inhibition.
- AY1 exhibited resistance exclusively to quinclorac. NN1 showed resistance to quinclorac, penoxsulam (ALS-inhibitors) and profoxydim (ACCase-inhibitors).
- Non-P450 mechanisms predominate in quinclorac detoxification.

References

- Mayank S. Malik, Nilda R. Burgos, and Ronald E. Talbert. (2010). Confirmation and Control of Propanil-Resistant and Quinclorac-Resistant Barnyard grass (*Echinochloa crus-galli*) in Rice. *Weed Technology*. 24: 226-233. <https://doi.org/10.1614/WT-09-053.1>
- Pinsupa, J., Chindakul, A. and Intanon, S. 2022. Distribution and resistance of barnyard grass to quinclorac in rice fields in Thailand. 40. <https://doi.org/10.51694/AdvWeedSci/2022;40:00007>
- Iwakami, S., Endo, M., Saika, H., Okuno, J., Nakamura, N., Yokoyama, M., Watanabe, H., Toki, S., Uchino, A. and Inamura, T. 2014. Cytochrome P450 CYP81A12 and CYP81A21 Are Associated with Resistance to Two Acetolactate Synthase Inhibitors in *Echinochloa phylllopogon*. *Plant Physiol* 165: 618-629. <https://doi.org/10.1104/pp.113.232843>
- Ritz C, Baly F, Streibig JC, Gerhard D (2015) Dose-Response Analysis Using R. *PLoS ONE* 10(12): e0146021. <https://doi.org/10.1371/journal.pone.0146021>