From tactical to strategic herbicide use: On the systematic challenges of herbicide resistance management in New Zealand's arable sector

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Summary Synthetic herbicides are crucial weed management tools in farm systems worldwide that have enabled significant productivity gains and new practices like minimum tillage. However, since their first commercial release in the 1940s there has been an accelerating increase in herbicide resistant weeds, with now 266 confirmed resistant species in 71 countries. Weed scientists and extension professionals have for decades promoted integrative weed management strategies to reduce the over-reliance on specific herbicides, including more diverse crop and herbicide rotations. Yet, herbicide resistance continues to increase, threatening the sustainability of food and fibre production. Much of New Zealand's agricultural sector has been regarded as less susceptible to resistance due to relatively diverse crop and livestock rotations. However, recent surveys identified unexpectedly high incidences of resistance across cropping farms in the Canterbury region, which cautions against resistance as a growing challenge and prompts critical reflections on current herbicide use practices. This paper investigates the complexities of weed management and herbicide resistance prevention within New Zealand's arable sector, particularly the challenges associated with more strategic herbicide use. We draw on qualitative social research with arable farmers, rural professionals, and weed scientists to identify factors that determine current weed management practices and contextualise the problem of herbicide resistance. We outline the drivers of herbicide use through a multi-level perspective that systematically considers i) the individual psycho-social level, ii) farm systems level, and iii) the national agricultural systems level. These interconnected drivers highlight that farmers' herbicide applications are influenced by diverse biophysical, technological, and sociocultural factors, with some hindering best practice herbicide use. Our findings demonstrate that integrated systems-based approaches are needed to holistically understand herbicide resistance as a critical first step in collaborative efforts to shift from tactical to more strategic herbicide use.

Keywords Herbicide resistance, systems thinking, integrated weed management, practice change, sustainability