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Leaving synthetic pesticides behind

In their Research Article, "Pervasive sublethal effects of agrochemicals on insects at environmentally relevant concentrations" (24 October 2024, p. 446-453), L. Gandara *et al*. found that agrochemicals have overwhelmingly negative effects on non-target insects, even at low dosages (*1*). Their results add to an extensive body of evidence on the social-environmental costs of synthetic pesticides (*2*). Many of the chronic, sublethal effects that Gandara *et al*. identify may strengthen under global warming, and regulatory systems are unprepared for the challenges they present (*3*). By disrupting ecosystem services, pesticides can also cause ecological instability, drive pest resurgence or resistance, and jeopardize food or nutrition security (*4*). To prevent and rectify the environmental and societal harm caused by pesticides, the global community must take resolute action.

Mitigating pesticide effects will require integrative measures and holistic systems thinking. Chemical pesticides should be progressively replaced with agroecological measures, invertebrate biological control agents and biopesticides, many of which are cost-effective, environmentally sound, and practicable (*5*). Preventative pest management without chemical pesticides can include planting pest-tolerant varieties (*6*), using light, pheromone or sticky traps (*7*), removing critical pest resources such as harvest residues or alternative host plants (*8*), or cultural control methods including altered sowing dates (9). Other strategies include crop diversification through inter- or cover crops, mulching or organic manuring, flower strips that attract natural enemies of pests, and co-culture approaches in which e.g., aquatic animals such as fish, ducks or frogs consume the pestiferous arthropods and weeds in rice paddy fields (*10*).

Precision agriculture and digital tools could also decrease pesticide use. Robotics, unmanned aerial vehicles (UAVs), artificial intelligence-based computer vision, and data-driven forecasting or advisory systems can all enable timely, targeted interventions (*11*). Tractor-pulled or autonomous camera-equipped mechanical weeders for instance can surgically remove weeds from a standing crop, whereas UAVs can 'precision-drop' natural enemies or deliver biopesticide patch sprays on infestation hotspots. We note however, that access to such technologies may prohibit wider uptake of such approaches.

Closer engagement among farmers, scientists, value chain actors and decision-makers can limit pesticide use by providing financial transition support and gauging endpoints that resonate with end-users i.e., income and return-on-investment (*12*), conducting outreach to adjust consumer expectations e.g., on the aesthetic appeal of harvested produce, addressing farmers' concerns about eventual risks or losses, and finetuning strategies to local farming context. Pesticide policies and regulations should focus on fast-tracking registration for low-risk alternatives, implementing creative incentive schemes, imposing differential pesticide taxation, and valuing the multi-dimensional benefits of nature-friendly production (*13*).

By clarifying the biophysical, social and economic determinants of pesticide use and by increasing accessibility to alternatives, global agribusiness and small farmers can improve the ecological resilience of the agri-food system profitably and safeguard the interconnected health of plants, people, and the environment.

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COMPETING INTERESTS

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