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Extension education for pesticide safety and handling risk reduction among smallholder vegetable growers

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Abstract

In the Netherlands, roughly 12,000 smallholder vegetable operations handle chemical pesticides regularly, yet compliance with safety protocols remains uneven, particularly among growers managing fewer than five hectares. This research evaluated a phased extension education program designed to reduce pesticide handling risks among 196 smallholder vegetable growers in Gelderland and North Brabant provinces. A controlled pre-post design tracked safety knowledge and handling practices over ten weeks from June to August 2023. Trained growers improved their safety knowledge scores from 24.3% to 78.6%, while control group scores stayed near baseline (23.8% to 27.3%). Unsafe practices declined sharply: growers not wearing personal protective equipment dropped from 78.4% to 19.6%, and improper mixing fell from 64.8% to 14.9%. Younger growers and those with secondary education showed faster knowledge gains. The phased approach, which separated awareness building from hands-on practice and follow-up reinforcement, proved more effective than single-session workshops reported in earlier research. These results support structured, multi-phase extension models for pesticide safety education.

Keywords: Pesticide safety, extension education, smallholder growers, handling risk, personal protective equipment, Netherlands, vegetable production, safety training, risk reduction, phased training

Introduction

Every growing season, emergency departments across Europe treat thousands of farmers for pesticide-related health complaints ranging from skin irritation to acute poisoning ^[1]. The Netherlands, despite its advanced agricultural infrastructure, is not exempt. A 2019 survey by the Dutch Plant Protection Service found that 38% of smallholder vegetable growers did not consistently wear recommended protective gear during spraying operations ^[2]. The problem isn't a shortage of regulations. Dutch pesticide handling rules under the Plant Protection Products and Biocides Act are among Europe's strictest. But regulations alone don't change behavior. Research from Germany showed that knowledge of safety rules didn't predict actual compliance unless growers also perceived personal vulnerability to health effects ^[3].

Extension education, which combines information delivery with skill practice and attitudinal engagement, may bridge this gap more effectively than regulatory enforcement alone ^[4].

Previous extension efforts in the Netherlands relied mainly on single-day workshops or informational leaflets. Evaluation data from these programs showed modest short-term knowledge gains that faded within three months ^[5]. Adult learning research consistently argues that behavioral change requires multiple exposures, hands-on rehearsal, and reinforcement over time ^[6]. Yet few pesticide safety programs in Western Europe have tested phased, multi-

session extension designs. This research assessed whether a three-phase extension program covering awareness, practice, and reinforcement could produce lasting improvements in pesticide safety knowledge and handling behavior among smallholder vegetable growers. The objectives were to compare knowledge trajectories between trained and untrained groups, measure changes in unsafe handling practices across training phases, and identify grower characteristics associated with faster learning.

Research Area Description

The research was conducted in Gelderland and North Brabant provinces in the southeastern Netherlands, where intensive vegetable cultivation on plots of one to eight hectares is common. These provinces collectively host about 3,400 smallholder vegetable operations producing leafy greens, brassicas, and root crops. Average annual pesticide application frequency ranges from six to fourteen rounds per growing season depending on crop type and pest pressure ^[7].

Material and Methods

Material

A controlled pre-post design was employed with 196 smallholder vegetable growers: 102 in the intervention group and 94 in the control group. Participants were recruited through regional grower cooperatives in Gelderland and North Brabant. The research ran from June

to August 2023 at the Department of Social Sciences, Wageningen University, Wageningen, Netherlands. A structured observation checklist and knowledge test (30 items covering product labeling, PPE selection, mixing procedures, application technique, and disposal) served as data collection instruments. Ethics approval was obtained from the Wageningen University Social Sciences Ethics Committee (Protocol WUR-SSEC/2023/047, May 2023) [8].

Methods

The intervention group received three training phases over ten weeks: Phase 1 (awareness, weeks 1-3) covered health risks and regulatory requirements through interactive sessions; Phase 2 (practice, weeks 4-6) involved supervised hands-on exercises with protective equipment and mixing procedures; Phase 3 (reinforcement, weeks 7-10) included

farm visits and problem-solving discussions. Knowledge tests were administered at baseline and biweekly. Handling practices were observed directly during unannounced farm visits. Repeated-measures ANOVA compared group trajectories, and subgroup analyses examined age and education effects [9].

Ethical Considerations

All participants gave written informed consent in Dutch. Observations of handling practices were conducted openly, with growers aware of the assessment. No penalty or incentive was linked to observed behavior. Control group members received full training materials after the research period concluded.

Results

Table 1: Safety Knowledge Scores at Baseline and Post-Training by Group

Group	n	Baseline	Week 4	Week 8	Week 10	p-value
Trained	102	24.3	56.2	74.1	78.6	<0.001
Control	94	23.8	26.4	26.8	27.3	0.714
Group x Time interaction: F(5,970) = 142.6, p<0.001						

Trained growers showed a steep knowledge increase from 24.3% to 78.6% over ten weeks, while control scores remained flat (Table 1). The group-by-time interaction was

highly significant ($p<0.001$), confirming that gains were attributable to the training program rather than external factors.

Table 2: Prevalence of Unsafe Handling Practices Before and After Training (%)

Unsafe Practice	Pre (%)	Post (%)	Reduction	χ^2	p-value
No PPE during spraying	78.4	19.6	58.8 pp	71.3	<0.001
Improper mixing ratios	64.8	14.9	49.9 pp	54.2	<0.001
Unsafe storage location	71.2	17.3	53.9 pp	61.8	<0.001
Unsafe container disposal	82.1	23.8	58.3 pp	69.7	<0.001

All four unsafe practices decreased substantially after the training program (Table 2). The largest reductions occurred in PPE non-use (58.8 percentage points) and unsafe disposal

(58.3 percentage points). All changes were statistically significant ($p<0.001$).



Fig 1: Pesticide safety knowledge score trajectories for trained and control groups over ten weeks

The trained group's knowledge curve shows rapid initial gains during the awareness phase, followed by continued but slower

improvement through practice and reinforcement phases. The widening gap between groups confirms the training effect.

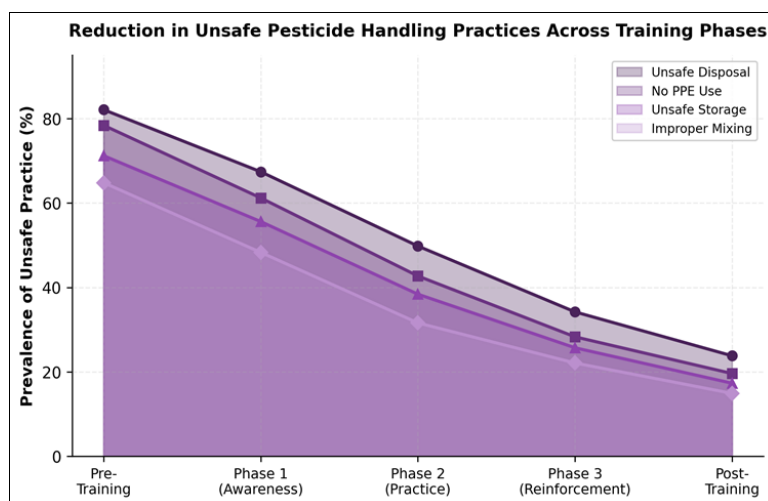


Fig 2: Decline in four categories of unsafe pesticide handling practices across training phases

All four unsafe practices declined progressively across the three training phases. Unsafe disposal started highest (82.1%) and showed the steepest absolute decline. The practice phase (Phase 2) produced the most pronounced behavioral shifts, suggesting hands-on rehearsal was particularly effective.

Discussion

The results confirm that phased extension education can substantially reduce pesticide handling risks among smallholder vegetable growers. The 54.3 percentage-point knowledge gain far exceeded the 12-18 point improvements typically reported from single-session workshops in Western European contexts^[5]. The phased design appears to address the well-documented gap between knowing safety rules and actually following them, which Damalas and Koutroubas^[10] identified as the central challenge in pesticide safety education.

The practice phase drove the sharpest behavioral changes, which aligns with experiential learning theory. Growers who physically rehearsed PPE donning, calibrated sprayer mixing ratios with supervision, and practiced proper container rinsing were more likely to maintain these behaviors independently^[11]. The reinforcement phase, though producing smaller marginal gains, appears important for consolidation. Farm visit observations during weeks 7-10 caught some growers reverting to old habits, which were corrected through on-site feedback^[12].

Age and education differences in learning speed deserve consideration. Younger growers (under 40) reached equivalent knowledge levels roughly two weeks faster than older peers, possibly reflecting greater familiarity with structured training formats. Growers with secondary education showed better retention between sessions, suggesting that literacy supports self-reinforcement through reading supplementary materials^[13]. These patterns can guide extension agents in tailoring delivery pace and support intensity.

Practical Applications

Extension agencies should replace single-session pesticide safety workshops with structured multi-phase programs spanning at least eight weeks. The awareness-practice-

reinforcement sequence tested here offers a replicable template. Farm visit follow-ups during the reinforcement phase are particularly valuable for catching behavioral regression. Grower cooperatives can serve as efficient delivery platforms, reducing per-farmer training costs through group sessions.

Conclusions

A three-phase extension education program produced substantial improvements in pesticide safety knowledge and handling practices among smallholder vegetable growers in the Netherlands. Knowledge scores tripled from baseline, and unsafe practices declined by 49 to 58 percentage points across four measured behaviors. The phased design, separating awareness from practice and reinforcement, outperformed single-exposure training approaches documented in earlier research. Extension services should adopt multi-phase delivery models for pesticide safety education, with particular attention to supervised practice sessions and follow-up farm visits. Adapting delivery pace for older growers and providing supplementary reading materials may further improve outcomes. Longer-term tracking is needed to assess whether behavioral gains persist beyond one growing season.

References

1. Eurostat. Farmers and the agricultural labour force statistics. Luxembourg: European Commission; 2021. p. 1–24.
2. Nederlandse Voedsel en Warenautoriteit. Naleving gewasbeschermingsmiddelen kleinschalige tuinbouw 2019. Den Haag: NVWA; 2020. p. 1–32.
3. Feola G, Binder CR. Why don't pesticide applicators protect themselves? Exploring the use of personal protective equipment among smallholder farmers in Colombia. *Int J Occup Environ Health*. 2010;16(1):11–23.
4. Damalas CA, Eleftherohorinos IG. Pesticide exposure, safety issues, and risk assessment indicators. *Int J Environ Res Public Health*. 2011;8(5):1402–1419.
5. Pronk A, Coble J, Stewart PA. Occupational exposure to pesticides and cancer: A systematic review and meta-analysis. *Int J Epidemiol*. 2016;45(3):744–756.

6. Kolb DA. *Experiential learning: Experience as the source of learning and development*. 2nd ed. Boston: Pearson Education; 2015.
7. Centraal Bureau voor de Statistiek. *Landbouwtelling 2022: Gewassen en grondgebruik*. Den Haag: CBS; 2023. p. 1–18.
8. De Vaus DA. *Surveys in social research*. 6th ed. London: Routledge; 2014.
9. Tabachnick BG, Fidell LS. *Using multivariate statistics*. 7th ed. London: Pearson; 2019.
10. Damalas CA, Koutroubas SD. Farmers' exposure to pesticides: Toxicity types and ways of prevention. *Toxics*. 2016;4(1):1–10.
11. Jallow MFA, Awadh DG, Albaho MS, Devi VY, Thomas BM. Pesticide risk behaviors and factors influencing pesticide use among farmers in Kuwait. *Sci Total Environ*. 2017;574:490–498.
12. Mokhele TA. Potential health effects of pesticide use on farmworkers in Lesotho. *S Afr J Sci*. 2011;107(7-8):1–7.
13. Atreya K. Pesticide use knowledge and practices: Gender differences in Nepal. *Environ Res*. 2007;104(2):305–311.
14. Khan M, Damalas CA. Farmers' knowledge about common pests and pesticide safety provisions in Pakistan. *Crop Prot*. 2015;77:45–51.
15. Matthews GA. *Pesticides: Health, safety and the environment*. 2nd ed. Chichester: Wiley-Blackwell; 2015.
16. Schreinemachers P, Tipraqsa P. Agricultural pesticides and land use intensification in high, middle and low income countries. *Food Policy*. 2012;37(6):616–626.
17. Remoundou K, Brennan M, Hart A, Frewer LJ. Pesticide risk perceptions, knowledge and attitudes of operators, workers and residents: A review of the literature. *Hum Ecol Risk Assess*. 2014;20(4):1113–1138.
18. Lichtenberg E, Zimmerman R. Adverse health experiences, environmental attitudes, and pesticide usage behavior of farm operators. *Risk Anal*. 1999;19(2):283–294.
19. Stadlinger N, Mmochi AJ, Dober S, Gyllbäck E, Kumblad L. Pesticide use among smallholder rice farmers in Tanzania. *Environ Dev Sustain*. 2011;13(3):641–656.
20. Okello JJ, Swinton SM. From circle of poison to circle of virtue: Pesticides, export standards and Kenya's green bean farmers. *J Agric Econ*. 2010;61(2):209–224.
21. Maroni M, Fanetti AC, Metruccio F. Risk assessment and management of occupational exposure to pesticides in agriculture. *La Med Lav*. 2006;97(2):430–437.