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# Impacts of Pesticide Use on Human Health and the Environment among Horticultural Farmers: A Conceptual Review

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**ABSTRACT**

Pesticides are widely used in horticultural production to control pests and plant diseases and to enhance agricultural productivity. However, improper pesticide use may pose significant risks to both farmers' health and the environment. This study aimed to examine the health and environmental impacts of pesticide use among horticultural farmers through a conceptual review approach. Relevant articles were retrieved from the ScienceDirect database using keywords related to pesticide exposure, health, environment, farmers, and horticulture. The article selection process was conducted based on predefined inclusion and exclusion criteria, resulting in 10 articles published between 2016 and 2025 being included in the review. The findings indicate that pesticide exposure among horticultural farmers is associated with a variety of adverse health effects, including acute poisoning, respiratory disorders, thyroid dysfunction, and other chronic health conditions. In addition, pesticide use contributes to soil and water contamination, the accumulation of pesticide residues in the environment, ecotoxicological risks to non-target organisms, and the degradation of ecosystem quality. The magnitude of these impacts is influenced by several factors, including farmers' knowledge and training, the use of personal protective equipment (PPE), pesticide type, spraying intensity, and pest management practices. Therefore, the implementation of safe and sustainable pesticide management practices is essential to minimize the adverse effects of pesticides on human health and the environment.



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## 1. INTRODUCTION

Agriculture plays a crucial role in ensuring food security and meeting the increasing food demands of a growing global population. To improve agricultural productivity and minimize crop losses caused by pests and diseases, various technologies and innovations have been developed, among which pesticide use has become one of the most widely adopted approaches. Pesticides are effective in reducing pre-harvest losses caused by pests, which can account for 20-40% of global annual crop production losses (Koul et al., 2022; Tudi, Ruan, et al., 2021). Their use has been linked to significant increases in agricultural output, with estimates suggesting that without

pesticides, fruit, vegetable, and cereal production could decline by 78%, 54%, and 32%, respectively (Tudi, Ruan, et al., 2021)

Pesticide contamination represents a major concern for both food safety and public health. Among various food categories, fruits and vegetables account for the largest share of pesticide-related hazards (58.81%), likely because these crops frequently receive pesticide applications to prevent pest infestations and maintain product quality. Several commonly used pesticide groups, including organophosphates, carbamates, pyrethroids, and organochlorines, have been associated with neurotoxic effects in humans. Organophosphate compounds exert their toxic effects mainly by disrupting the activity of acetylcholinesterase, an enzyme responsible for regulating nerve signal transmission, resulting in the excessive accumulation of acetylcholine within the nervous system (Botnaru et al., 2025). While pesticide residues in food pose risks to consumers, agricultural workers face even greater exposure due to their direct involvement in pesticide handling, mixing, and application.

The use of pesticides is a common practice in horticultural crop production for pest control and the maintenance of agricultural productivity. However, intensive pesticide application may increase farmers' risk of exposure, particularly in situations where occupational safety measures are inadequately implemented. Many farmers continue to neglect the use of personal protective equipment (PPE) due to long-established practices, limited knowledge regarding occupational safety, and concerns about comfort during agricultural activities. Although education and extension programs have been widely recognized as important drivers of PPE adoption, increased awareness alone does not necessarily lead to consistent compliance with PPE requirements. This suggests that additional factors, including behavioral habits, perceived inconvenience, and practical barriers, may significantly influence farmers' willingness to use protective equipment in their daily work (Parasram & Choudhury, 2025).

Socioeconomic conditions can influence farmers' pesticide-use behaviors. Economic pressures often encourage farmers to prioritize productivity and cost efficiency over safety considerations, resulting in improper pesticide handling and inadequate use of protective measures. In economically disadvantaged regions, such as Uganda, high levels of pesticide exposure have been reported, particularly among male farmers (Muhumuza et al., 2026).

In addition to respiratory disorders, various other health complaints have been reported among farmers exposed to pesticides. The most frequently reported symptom was dizziness, affecting 10.6% of respondents. Other common complaints involved the head, eyes, ears, nose, and throat and were primarily associated with irritation and allergic reactions, including watery, itchy, and red eyes. Neurological symptoms were also commonly observed, including confusion, weakness, and headaches. Skin irritation and gastrointestinal symptoms, such as nausea, have likewise been frequently reported. One study found that 60.5% of farmers experienced skin irritation following pesticide application (Maldonado et al., 2025; Muhumuza et al., 2026)). These findings suggest that the adverse health effects of pesticide exposure are not confined to a single organ system but may involve multiple physiological systems throughout the body.

Although these symptoms are typically acute and easily recognized, pesticide exposure can also result in more extensive health consequences that may develop and persist over the long term. Long-term exposure to certain pesticides has been associated with an increased risk of cancer and endocrine disorders. A systematic review reported consistent associations between chronic pesticide exposure and various non-communicable diseases, including cancer and neurodegenerative diseases(Curl et al., 2020; Shekhar et al., 2024). Organochlorine pesticides consist of different chemical subclasses, such as dichlorodiphenylethanes, chlorinated cyclodienes, and chlorinated benzenes. Their high chemical stability, lipophilic nature, and resistance to degradation enable them to persist in the environment and accumulate along food chains, increasing the risk of adverse ecological and health outcomes. In addition, carbamate insecticides, which are synthesized from carbamic acid derivatives, display a broad spectrum of acute toxicity, ranging from relatively low toxicity in certain compounds to highly toxic effects in others, depending on their chemical structure and formulation (Botnaru et al., 2025)

Although numerous studies have investigated the impacts of pesticide use on farmers' health and the environment, the existing literature remains fragmented across different geographical settings, horticultural production systems, and impact dimensions. Most studies tend to focus on either health-related outcomes or environmental consequences separately, resulting in a limited understanding of the interconnected effects of pesticide use in horticultural farming. Furthermore, variations in pesticide application practices, environmental conditions, and farmers' levels of awareness contribute to the complexity of these impacts. Therefore, a conceptual review is needed to integrate existing knowledge, clarify the relationships between pesticide use, health outcomes, and environmental effects, and develop a more comprehensive understanding of the challenges associated with pesticide use among horticultural farmers.

## 2. METHOD

This study employed a conceptual review approach by examining articles retrieved from the ScienceDirect database using the keywords "pesticide exposure," "pesticide use," "horticultural farmers," "human health," and "environmental impact." The selected articles were full-text publications published between 2016 and 2025, written in English, and focused on the health and environmental impacts of pesticide use among horticultural farmers. Articles that met the inclusion criteria were subsequently analyzed descriptively through concept synthesis to identify patterns of findings, relationships among variables, and factors influencing the health and environmental impacts of pesticide use on horticultural farmers.

## 3. RESULTS AND DISCUSSION

Pesticides are widely used in horticultural production to control pests and plant diseases. However, improper pesticide use may have adverse effects on environmental health, including soil and water contamination and negative impacts on non-target organisms. The accumulation of pesticide residues in the environment can degrade ecosystem quality and threaten the sustainability of agricultural systems. Therefore, a review of the environmental health impacts of pesticide use among horticultural farmers is necessary to improve understanding of the various environmental risks associated with pesticide application (Tudi, Daniel Ruan, et al., 2021). Based on the literature search, a total of 10 articles met the inclusion criteria and were included in the analysis to identify the environmental health impacts of pesticide use among horticultural farmers. A summary of the characteristics of the selected studies and their key findings is presented in Table 1.

**Table 1. Summary of Studies Examining the Health and Environmental Impacts of Pesticide Use among Horticultural Farmers**

| No | Author(s) and Year | Article Title | Research Method | Key Findings |
|---|---|---|---|---|
| 1 | (Houbraken et al., 2016) | Pesticide knowledge and practice among horticultural workers in the Lâm Đồng region, Vietnam | Observational survey with occupational and environmental health risk assessment | The use of pesticides remained prevalent even though farmers were aware of the associated health and environmental risks. Occupational exposure risk among workers was considered high, and several pesticide products were found to pose potential threats to environmental health. |

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| 2 | (Schreinemachers et al., 2017) | Too much to handle? Pesticide dependence of smallholder vegetable farmers in Southeast Asia | Cross-sectional quantitative study | Dependence on synthetic pesticides remained high among farmers. Higher levels of pesticide use were associated with an increased prevalence of pesticide poisoning symptoms, whereas the use of biopesticides, knowledge of pest management practices, and the use of personal protective equipment (PPE) contributed to reduced health risks and lower pesticide use. |
| 3 | (Akter et al., 2018) | Vegetable farmers' behaviour and knowledge related to pesticide use and related health problems: A case study from Bangladesh | Cross-sectional quantitative study | Limited knowledge and inadequate training contributed to the low adoption of protective practices, resulting in continued pesticide poisoning symptoms among farmers due to pesticide exposure. |
| 4 | (Dhananjayan & Ravichandran, 2018) | Occupational health risk of farmers exposed to pesticides in agricultural activities | Global literature review | Pesticide exposure is associated with health impacts (such as respiratory disorders and cancer) as well as environmental risks. Therefore, pesticide use needs to be managed more safely to protect human health and ecosystems. |
| 5 | (Wyckhuys et al., 2020) | Resolving the twin human and environmental health hazards of a plant-based diet | Literature Review | Pesticide residues are frequently found in fruits and vegetables and may pose risks to human health and the environment. |
| 6 | (Marete et al., 2021) | Pesticide usage practices as sources of occupational exposure and health impacts on horticultural farmers in Meru County, Kenya | Cross-sectional quantitative research (questionnaire survey) | Exposure to pesticides among horticultural farmers causes symptoms of poisoning and health problems, which are associated with low use of personal protective equipment and unsafe pesticide handling practices. |

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|---|---|---|---|---|
| 7 | (Mac Loughlin et al., 2022) | Multiple pesticides occurrence, fate, and environmental risk assessment in a small horticultural stream of Argentina | Observational longitudinal study with pesticide residue analysis and Environmental Risk Assessment (ERA). | Residues of various pesticides were detected in water and sediment, indicating a high risk to aquatic organisms. Horticultural activities have been shown to contribute to water pollution and threaten ecosystem biodiversity. |
| 8 | (Liem et al., 2023) | The determinants of thyroid function among vegetable farmers with primary exposure to chlorpyrifos | Cross-sectional quantitative study | Exposure to chlorpyrifos among vegetable farmers may potentially cause thyroid dysfunction due to long-term pesticide exposure. |
| 9 | (Weiss et al., 2023) | Agricultural pesticides pose a continuous ecotoxicological risk to aquatic organisms in a tropical horticulture catchment | Observational study with ecotoxicological risk assessment | Pesticides detected in horticultural water bodies pose a high ecotoxicological risk to aquatic organisms and degrade the quality of aquatic environments. |
| 10 | (Räsänen et al., 2025) | Characterizing ecotoxicity impacts of pesticides applied to vegetable crops in Finland during 2003–2019 and recommendations for impact reduction | Longitudinal study on pesticide use in agricultural land in Finland from 2003 to 2019. | The ecotoxicity impacts of pesticides vary widely across crops and over time, with differences of more than seven orders of magnitude. Environmental impacts are not proportional to usage amounts, as certain active ingredients (e.g., lambda-cyhalothrin and mancozeb) contribute disproportionately higher impacts compared to other pesticides. |

Based on the synthesis of 10 reviewed articles, pesticide use among horticultural farmers not only affects workers' health but also leads to various environmental problems. Several studies indicate that pesticide exposure is associated with health issues such as acute poisoning, thyroid dysfunction, respiratory disorders, and an increased risk of chronic diseases. On the other hand, improper pesticide use also contributes to soil and water contamination, pesticide residue accumulation, and ecotoxicological risks to non-target organisms and biodiversity. In addition, factors such as knowledge, training, use of personal protective equipment, and pesticide management practices influence the level of exposure and the magnitude of the resulting impacts.

**Effects of Pesticide Use on Farmers' Health**

Synthetic pesticide use is one of the most widely adopted methods in horticultural cultivation due to its effectiveness in controlling plant pests and relatively fast results. However, improper or excessive use of pesticides can lead to various negative impacts, such as soil and water pollution, pest resistance, and adverse health effects on farmers due to long-term exposure. Pesticide exposure is known to affect various body systems, including the respiratory, nervous, digestive, and skin systems. Therefore, pesticides should be used wisely in accordance with Integrated Pest Management (IPM) principles to minimize risks to human health and the environment (Ditjen Hortikultura, 2023).

The review results show that pesticide exposure remains a common issue among horticultural farmers. Houbraken et al. (2016) found that high pesticide use persists even though farmers are aware of the associated health and environmental risks. These findings indicate a gap between knowledge and actual pesticide application practices in the field. Similar conditions were also reported by Akter et al. (2018) and Marete et al. (2021), who noted that limited training and low use of personal protective equipment (PPE) contribute to farmers still experiencing various symptoms of pesticide poisoning.

The health impacts are not only acute but can also develop into long-term health disorders. Dhananjayan and Ravichandran (2018) explained that pesticide exposure is associated with a range of health problems, including respiratory disorders, neurological disorders, and certain types of cancer. This is supported by Liem et al. (2023), who showed that chlorpyrifos exposure among vegetable farmers may affect thyroid function, indicating potential endocrine disruption due to long-term pesticide exposure.

In addition to exposure factors, pesticide use behavior also plays an important role in determining health risks. Schreinemachers et al. (2017) found that high reliance on synthetic pesticides increases the risk of poisoning symptoms among farmers. Conversely, the use of biopesticides, proper pest management practices, and the use of personal protective equipment can help reduce health risks while also minimizing excessive pesticide use.

**Impacts of Pesticide Use on Environmental Health**

Pesticide use is one of the main strategies in horticultural farming to control pests and plant diseases, thereby improving agricultural productivity. However, improper pesticide use can cause various negative impacts on human health and the environment. The Food and Agriculture Organization (FAO) states that pesticide residues can persist in the environment for a long time and potentially threaten the ecological systems that support food production. In addition, uncontrolled pesticide exposure can increase the risk of health problems among farming communities as well as consumers (FAO, 2026).

In line with this,, (Kaur et al., 2024) states that pesticide residues can persist in the environment for long periods, accumulate in the food chain, and affect both target and non-target organisms. Some persistent pesticide compounds can even cause continuous environmental contamination if their use is not properly controlled. The results of this literature review support these statements. Several studies indicate that pesticide use in the horticultural sector contributes to environmental pollution, particularly in aquatic ecosystems. Mac Loughlin et al. (2022) found that residues of various pesticides were detected in water and sediment with a high risk level for aquatic organisms. Similar findings were reported by Weiss et al. (2023), who showed that pesticides in tropical horticultural areas pose significant ecotoxicological risks to aquatic organisms and overall environmental quality. In addition, Räsänen et al. (2025) revealed that pesticide ecotoxicity impacts are strongly influenced by the characteristics of the active ingredients used, meaning that the quantity of pesticide applied does not always reflect the magnitude of environmental impact.

**Factors Influencing the Magnitude of Pesticide Use Impacts**

The magnitude of pesticide impacts on farmers' health and the environment is not determined solely by the quantity of pesticides used, but is influenced by several interrelated factors. Based on

the review findings, these factors include farmers' level of knowledge, use of personal protective equipment (PPE), intensity of pesticide application, type of active ingredients used, and pest management practices implemented in agricultural fields. Knowledge and training on safe pesticide use are important factors in reducing exposure risks. Akter et al. (2018) and Marete et al. (2021) showed that low levels of knowledge and limited training lead farmers to inadequately apply protective behaviors during pesticide spraying, resulting in a higher risk of poisoning and health problems. In contrast, farmers with better understanding of pesticide use tend to adopt safer practices.

The use of personal protective equipment also plays an important role in reducing health impacts from pesticide exposure. Several studies indicate that farmers who do not use complete PPE face a higher risk of exposure compared to those who apply adequate personal protection (Houbraken et al., 2016; Marete et al., 2021). Therefore, the availability of and compliance with PPE use are key determinants of health risk levels among horticultural farmers.

In addition to individual factors, pesticide usage characteristics also influence the magnitude of impacts. Schreinemachers et al. (2017) found that high dependence on synthetic pesticides increases the risk of health problems among farmers. Meanwhile, Räsänen et al. (2025) showed that environmental impacts are not always proportional to the amount of pesticides used, as some active ingredients have significantly higher toxicity levels than others. This indicates that the type of pesticide used may be a key determinant of environmental impact.

Other contributing factors include agricultural management practices and pesticide handling in the field. Weiss et al. (2023) showed that poor pesticide handling and runoff from agricultural land contribute to water contamination and increased ecotoxicological risks to aquatic organisms. In addition, repeated pesticide use over time can lead to residue accumulation in the environment, affecting soil and water quality as well as biodiversity (Mac Loughlin et al., 2022).

**Conceptual Model**

Based on the synthesis of the reviewed literature, pesticide use among horticultural farmers is shaped by a combination of individual, technical, and management-related factors that influence both human and environmental health outcomes. These factors include farmers' knowledge and awareness regarding pesticide safety, participation in pesticide-use training, adherence to personal protective equipment (PPE) use, frequency and intensity of pesticide application, selection of active ingredients, and pest management practices implemented in agricultural fields. Together, these factors determine the extent of pesticide exposure experienced by farmers and the level of pesticide residues introduced into the surrounding environment. Consequently, they play a critical role in shaping the short and long-term impacts of pesticide use on farmers' health and environmental sustainability.

High pesticide exposure can cause various health problems among farmers, such as symptoms of acute poisoning, respiratory system disorders, thyroid dysfunction, and an increased risk of chronic diseases due to long-term exposure. On the other hand, pesticide residues entering the environment may lead to soil and water contamination, disruption of non-target organisms, reduced ecosystem quality, and increased ecotoxicological risks to aquatic organisms. Therefore, the implementation of prudent pesticide use, the use of PPE, and integrated pest management are necessary to reduce negative impacts on both human health and the environment. Based on this description, the relationships between the factors influencing pesticide use and their impacts on farmers' and environmental health can be formulated in the following conceptual model.

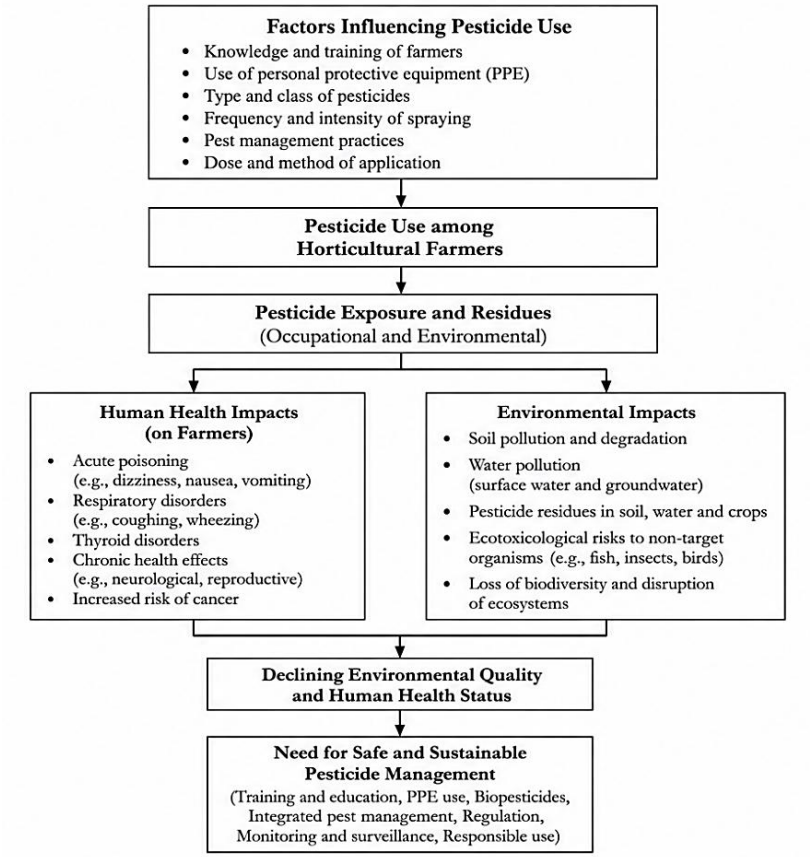


**Figure 1. Conseptual Framework of The Impacts of Pesticide Use on Human Health And The Environment Among Horticultural Farmers**

Figure 1 shows a conceptual model of the impacts of pesticide use on farmers' health and the environment in horticultural systems, developed based on the synthesis of the literature. The model illustrates that pesticide use is influenced by several factors, such as farmers' level of knowledge and training, use of personal protective equipment (PPE), type of pesticide, spraying intensity, and pest management practices. These factors contribute to the level of pesticide exposure and residue, which in turn lead to impacts on both farmers' health and the environment.

The most commonly reported health impacts include acute poisoning, respiratory disorders, thyroid dysfunction, and chronic health conditions. Meanwhile, environmental impacts include soil and water contamination, pesticide residue accumulation, ecotoxicological risks to non-target organisms, and biodiversity loss. Overall, these relationships indicate that increased pesticide use and exposure may reduce both human health and environmental quality, highlighting the need for safe and sustainable pesticide management.

This review provides a conceptual overview of the relationships between pesticide use, exposure levels, and their impacts on health and the environment, and may serve as a basis for developing more sustainable pesticide management strategies in horticultural farming systems..

## 4. CONCLUSION

Pesticide use in horticultural farming provides benefits in controlling plant pests and diseases; however, it also causes various impacts on farmers' health and the environment. The literature review indicates that pesticide exposure is associated with health problems such as acute poisoning, respiratory disorders, thyroid dysfunction, and an increased risk of chronic diseases due to long-term exposure.

In addition, pesticide use contributes to soil and water contamination, accumulation of pesticide residues in the environment, ecotoxicological risks to non-target organisms, and a decline

in ecosystem quality. The magnitude of these impacts is influenced by several factors, including farmers' level of knowledge and training, use of personal protective equipment, type of pesticide, spraying intensity, and pest management practices.

Therefore, safer and more sustainable pesticide management is needed through improved farmer education, proper use of personal protective equipment, implementation of Integrated Pest Management (IPM), and the adoption of more environmentally friendly control methods to minimize risks to both human health and the environment.

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