Research Article

# Contribution of Knowledge in Adaptation of Precautionary Measures to Minimize Pesticides Effects on Human Health in Punjab-Pakistan

**Liaqat Ali, Muhammad Luqman* and Muhammad Yaseen**

*Department of Agricultural Extension & Rural Studies, University of Sargodha, Pakistan.*

**Abstract** | Pesticides are chemical compounds that are used to kill pests (insects, rodents, fungi and weeds). Pesticides are widely used in public health and also in agriculture. Since many decades there is a debate regarding positive and negative impacts of pesticides. Although, pesticides play role in contributing crop productivity thereby reduction in yield losses but also damaging the environment and human health. Unsafe application and poor handling of pesticides lead to human health and environmental hazards. With this context, present research study was designed to find out the contribution of knowledge possessed by farmers (who used to apply pesticides in their fields) in the adoption of protection/precautionary measures so that health hazards connected with application of pesticides can be reduced. The study was conducted in randomly selected three districts of the Punjab province. Targeted study districts were Vehari (from central Punjab), Attock (from North Punjab) and Multan (from south Punjab). Structured interview schedule was used to collect responses from the respondents. Total sample of the present study was 384 (128 from each district) respondents. The collected data were analyzed through SPSS using descriptive and correlational statistics. Findings of the study reveal that farmers give much importance to locally understandable and simple protected and precautionary measures while apply pesticides. Recommended precautionary measures were rarely used by majority of the respondents. The major reason of this is the low awareness and adoption of recommended precautionary measures/protocols while pesticide application. Farmers showed high awareness level about health hazards and farm level risks associated with pesticides applications but low knowledge level about its environmental issues. This has been concluded that farmers understanding are mostly health-driven and experiential rather than environmentally holistic. Spearman correlation and Wilcoxon signed ranked test showed significant difference between knowledge level of farmers and level of use of precautionary measures to avoid pesticide effects on human health.

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***Correspondence** | Muhammad Luqman, Department of Agricultural Extension & Rural Studies, University of Sargodha, Pakistan; **Email:** muhammad.luqman@uos.edu.pk
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## Introduction

Agriculture is the single largest sector of economy worldwide employed more than 1/3rd people (FAO, 2024). Pesticides have a long history of use in agriculture, tracing back to ancient civilizations that used naturally derived compounds for pest control. The Chinese used arsenic and mercury compounds to control lice and other pests as early as 1000 BC (Abdullah *et al*., 2019). Similarly, the Greeks and Romans used sulfur and other natural substances to protect their crops. The modern era of pesticide use began in the early 20th century with the advent of synthetic chemical pesticides. The discovery of DDT (dichlorodiphenyltrichloroethane) in the 1940s marked a significant milestone. DDT was initially celebrated for its effectiveness in controlling insect-borne diseases like malaria and typhus during World War II (Tudi *et al*., 2021). Its success led to widespread use in agriculture post-war, significantly boosting crop yields. However, the environmental and health impacts of DDT soon became apparent, leading to its ban in many countries by the 1970s. This period also saw the development and introduction of other synthetic pesticides, such as organophosphates, carbamates, and Pyrethroids (Tison *et al*., 2024). These chemicals were designed to be more specific and less persistent than earlier pesticides, but they still posed significant risks to human health and the environment. In India, the Green Revolution of the 1960s and 1970s was a critical period that saw a massive increase in the use of chemical pesticides and fertilizers (Ray and Shaju., 2023).

The introduction of high-yielding varieties (HYVs) of wheat and rice required substantial chemical inputs to achieve their full potential. Punjab, as the epicenter of the Green Revolution in India, experienced a dramatic rise in pesticide use, which has continued to the present day (Rehman *et al*., 2015). Also, Masanobu Fukuoka has perfectly blended spirituality and agriculture in his book one straw revolution giving principles of natural farming which suggests and strongly stresses on not inputting any external chemical compounds in any names to the cropping system (Carson, 2002; Fukuoka, 2009).

Chemical compounds exploited blindly are bound to cause inevitable harm on both biotic and abiotic components of nature; they not only cause damage to the targeted organisms but also to all other non-targeted organisms either directly or indirectly (Carson, 2002). Major portion of the pesticides applied to the crops poured into the environment where they are bound to adversely affect public health and beneficial biota and contaminate soil, water and the ecosystem (Afzal *et al*., 2024). Only 25% of the pesticides produced worldwide are used in developing countries, but they experience 99% of the total deaths. The reasons for this are intense and unsafe use of pesticides and weak regulatory, health and education systems in developing countries (Vaagt, 2002). DDT was identified as a potential pesticide by Paul Herman Muller in 1939, for which he was awarded with Nobel Prize (Dhital *et al*., 2015).

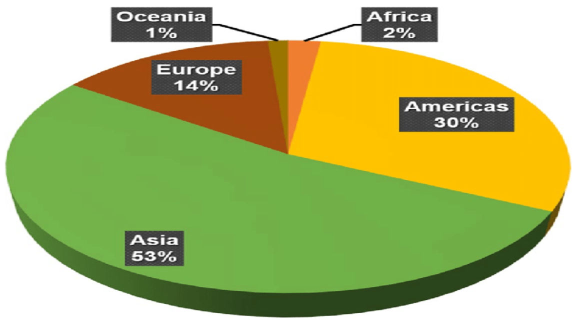


**Figure 1:** *Global distribution of pesticide usage on average for 1990-2018 (FAO,2019)*

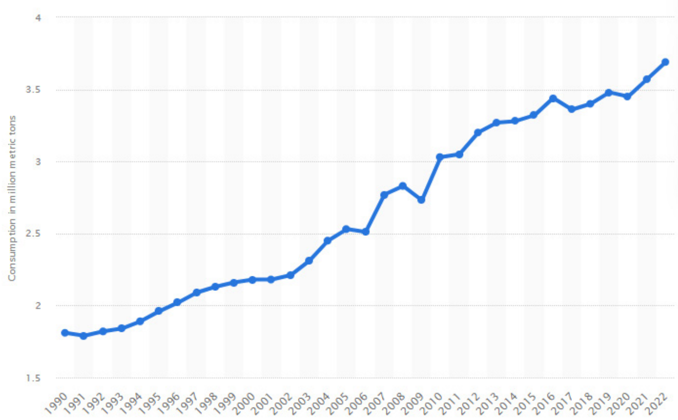

**Figure 2:** *World-wide usage of pesticides till 2022 (Statista, 2023)*

Short-term exposure to pesticides can cause a range of acute health effects, including: - Poisoning: Symptoms of pesticide poisoning include headaches, dizziness, nausea, vomiting, and in severe cases, convulsions and death. Studies have reported high incidence rates of acute pesticide poisoning among farmers in Punjab, often due to improper handling and lack of protective equipment. Skin and Eye Irritation: Direct contact with pesticides can cause skin rashes, burns, and eye irritation. Many farmers in Punjab report these symptoms, particularly during the peak spraying seasons. Respiratory Problems: Inhalation of pesticide vapors and dust can lead to respiratory issues such as coughing, wheezing and shortness of breath (Zhou *et al*., 2025). Agricultural workers frequently exposed to pesticides are at higher risk of developing chronic respiratory conditions (Zheng *et al*., 2023; Dara & Drabovich, 2023; Nawab *et al*., 2021).

While there is substantial evidence linking pesticide exposure to chronic health conditions, more detailed epidemiological studies are required to establish causal relationships. Longitudinal studies tracking health outcomes over extended periods can provide deeper insights into the chronic effects of pesticide exposure on farming communities (Cavalier *et al*., 2023; Sajjad *et al*., 2024). Farmers often use multiple pesticides simultaneously or in succession, leading to complex mixtures in the environment. The combined effects of these mixtures on human health and ecosystems are not well understood. Research on the synergistic and antagonistic interactions between different pesticides is crucial for assessing their overall impact. Majority of the farmers in Pakistan do not adopt precautionary measures while application of pesticides. This is mainly due to low knowledge level about health and environmental issues connected with unsafe and over use of pesticides. With this rational, present research was designed to assess the contribution of knowledge in the adaptation of precautionary measures in order to minimize pesticides effects on human health as well as on the environment.

## Materials and Methods

The study was conducted in the Punjab Province of Pakistan. The reason behind selection of the Punjab province as targeted study province was that it is the most populous province of Pakistan with its maximum contribution in agricultural production and development (Government of Punjab, 2024). The province is divided into three zones as northern, central and southern. One district was randomly selected from each zone as targeted study districts. For the purpose, the face-to-face interviews were conducted using structured interview schedule containing various study related factors. Total sample consisted of 384 respondents from three selected districts. Total sample size was equally distributed among three districts resulting in 128 respondents per district. The collected data then was entered into the computer and analyzed by using software SPSS. The results were discussed by computing different statistical methods. To check whether the data set is normally distributed Shapiro-Wilk test was applied through following formula:

W = (∑n i=1aix(i))2 ∑n i=1(xi− ¯x)2

As the data was not normal due to low p-value non-parametric test (Spearman correlation and Wilcoxon signed ranked) that are being used for non-normal data sets was applied. Additionally, effect size was also calculated by using following formula

$$= \frac{z}{\sqrt{n}}$$

$$= \frac{17.007}{\sqrt{384}}$$

=0.87

The effect size is very large as standard set by Cohen classification of effect size who stated 0.1 as small effect, 0.3 as moderate effect and 0.5 and above as large effect.

## Results and Discussion

Keeping in view the objectives of the study, there are two important variables being used in this study. Various precautionary/preventive measures associated with pesticide application were taken as first variables. However knowledge level of the respondents was the second important variable of the study.

**Table 1:** *Which protected/ precautionary measures you adopted while applying pesticides in your fields?*

| | Mean | Std. Deviation | Rank |
|---|---|---|---|
| Use hand gloves | 1.92 | .344 | 5 |
| Use of hat | 3.09 | .288 | 3 |
| Use sun glasses | 1.34 | .555 | 7 |
| Use overall/long-sleeved clothes | 1.91 | .292 | 6 |
| Use mask/respirator | 3.13 | .359 | 2 |
| Use long/field shoes | 1.93 | .412 | 4 |
| Use of oil | 3.19 | .395 | 1 |
| Valid N (listwise) | 384 | | |

*Scale: 1=Never, 2=Rarely, 3=Occasionally, 4=Frequently, 5=Strictly*

The above given means table shows that use of oil was the most common precautionary measure used by the farmers who apply pesticides on the crops. This precautionary measure received mean value of 3.19 (depicting occasionally adopted precautionary measure). Similarly use of mask/respirator or any other covering material was ranked second highest precautionary taken by the farmers while applying pesticides/chemicals to the crops. This precautionary measure received mean value of 3.13 (depicting occasionally adopted precautionary measure). However, use of hat as precautionary measure for pesticide application was ranked third most common precautionary measures adopted by the farmers. This precautionary measure received mean score of 3.09 (depicting occasionally adopted precautionary measure). Use of sun glasses was the least ranked precautionary measure adopted by the farmers while applying pesticides in the field. This precautionary measure received mean value of 1.34 (depicting almost never adopted precautionary measure).

The data presented in the above table shows knowledge level of farmers about pesticide application and its impact on human health the data depicts that knowledge of farmers and impact about loss of human life (death) due to pesticide's exposure was rated highest as its mean score was highest i.e. 4.51 (Depicting highly likely). However, farmers knowledge level and impact related to Unintentional ingestion cause loss of human life was ranked second highest with mean score of 4.01 (Depicting somewhat likely). Farmers' knowledge level regarding affects of pesticides on human body was ranked third with mean value of 3.71 (Depicting somewhat likely). Whereas farmers' knowledge level regarding Regular application of pesticides disturbs the *pH* of soil, Damage and reduce the soil biomass and reduced efficacy of pesticides when applied immediately

**Table 2:** *What is your knowledge level regarding pesticides application and its impacts on human health and environment?*

| | Mean | Std. Deviation | Rank |
|---|---|---|---|
| Affects of pesticides on human body | 3.71 | .454 | 3 |
| Typology of pesticides | 3.04 | .363 | 11 |
| Mode of action of pesticides | 3.26 | .438 | 6 |
| Unintentional ingestion cause loss of human life | 4.01 | .102 | 2 |
| Application of inappropriate pesticide cause chronic illness | 3.06 | .367 | 10 |
| Affects of pesticides on biodiversity (Aquatic life, damage of beneficial insects, non-targeted vegetation quality and tase especially in vegetables and fruits etc.) | 3.23 | .482 | 7 |
| Affects of pesticides on environment (soil and water contamination) | 1.93 | .260 | 13 |
| Affects of pesticides on agricultural products | 3.03 | .349 | 12 |
| Affects of pesticides on food safety | 1.26 | .438 | 15 |
| Regular application of pesticides disturbs the *pH* of soil | 3.59 | .492 | 4 |
| Contaminate the soil nutrients and disturbs the soil fertility | 3.06 | .367 | 10 |
| Contamination of ground water (water bodies) | 3.23 | .482 | 7 |
| Pesticides application enhances air pollution | 1.93 | .260 | 13 |
| Affects of pesticides on overall plant growth | 3.03 | .349 | 12 |
| Affects of pesticides on nutrients uptake mechanism of plants | 1.32 | .467 | 14 |
| Damage and reduce the soil biomass | 3.59 | .492 | 4 |
| Affects on the quality of milk by using fodder with pesticide's application | 3.06 | .367 | 10 |
| Affects of pesticides on animal health | 3.23 | .482 | 7 |
| Safe use of pesticides | 1.93 | .260 | 13 |
| Application of banned pesticides | 3.09 | .288 | 9 |
| Lose of human life (death) due to pesticide's exposure | 4.51 | .501 | 1 |
| Availability of pure pesticides | 1.93 | .260 | 13 |
| Consultation regarding choice of pesticides | 3.09 | .288 | 9 |
| Efficacy of pesticides being applied | 1.26 | .438 | 15 |
| Reduced efficacy of pesticides when applied immediately before irrigation or rainfall | 3.59 | .492 | 4 |
| Reduction in beneficial insects due to pesticides application | 3.11 | .319 | 8 |
| Methodologies/ways to mitigate risks of pesticides application | 3.43 | .495 | 5 |
| Valid N (listwise) | 384 | | |

*Note: 1=Highly unlikely, 2=Somewhat unlikely, 3=Undecided, 4=Somewhat likely, 5=Highly likely* before irrigation or rainfall were ranked 4th collectively having mean score of 3.59 (Depicting somewhat likely). The knowledge level of farmers regarding Methodologies/ways to mitigate risks of pesticides application was ranked 5th with mean score of 3.43 depicting generally farmers were undecided about it. Similarly the knowledge level of farmers regarding Efficacy of pesticides being applied was ranked least with mean score of 1.26 (depicting highly unlikely). In connection with these findings, Khan *et al*., (2022) concluded that farmers in Sindh province of Pakistan were found to be exposed seriously to pesticides due to inadequate knowledge. Educational and knowledge level of farmers can be improved by introduction of adequate IPM training programs for farmers as also suggested by Mehmood *et al*. (2021). The significance of farmers training regarding pesticide use to reduce health risks and environmental protection was also suggested by Boateng *et al*. (2022). In Pakistan and other Asian countries, research studies reported that in most of the cases, knowledge level of farmers is based on community awareness about causalities connected with pesticide exposure (Khan *et al*., 2010 and Damalas & Koutroubas, 2017).

**Table 1:** *Tests of normality*

| | Knowledge | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|---|
| | | Statistic | Df | Sig. | Statistic | df | Sig. |
| Precautionary measures | Low | .374 | 69 | .000 | .791 | 69 | .000 |
| | Medium | .303 | 232 | .000 | .785 | 232 | .000 |
| | High | .252 | 68 | .000 | .900 | 68 | .000 |
| | Very high | .342 | 15 | .000 | .764 | 15 | .001 |

a. Lilliefors significance correction

First of all Shapiro-Wilk test for normality was run and found that data was not normal (Table 1). The p value was less than 0.05 therefore the data was found to be not normally distributed. Hence different statistical tools for non-normal dataset were searched. Spearman correlation and Wilcoxon signed ranked test was applied on both the variables. After that effect size was also calculated.

As the data was not normal therefore, spearman correlation for non-normal data was applied and found that knowledge and precautionary measures adapted by respondents were significantly correlated whereas correlation coefficient value was calculated to be moderate i.e. 0.444.

**Table 2:** *Correlations*

| | | | Knowledge | Precautionary measures |
|---|---|---|---|---|
| Spearman's rho | Knowledge | Correlation Coefficient | 1.000 | .444** |
| | | Sig. (2-tailed) | . | .000 |
| | | N | 384 | 384 |
| | Precautionary measures | Correlation Coefficient | .444** | 1.000 |
| | | Sig. (2-tailed) | .000 | . |
| | | N | 384 | 384 |

**. Correlation is significant at the 0.01 level (2-tailed).

**Table 3:** *Hypothesis test summary*

| Null hypothesis | Test | Sig. | Decision |
|---|---|---|---|
| The median of differences between TOTKNW and TOTPRCT aquals 0 | Related-Samples wilcoxen signed ranktest | .000 | Reject the null hypothesis |

Hypothesis test summary of Wilcoxon Signed Rank test clearly states that there is clear evidence that significant difference exists between scores of knowledge and precautionary measures to avoid pesticide effects on human health. Wilcoxon Signed Rank test also contains a histogram and a test statistics table shown below.

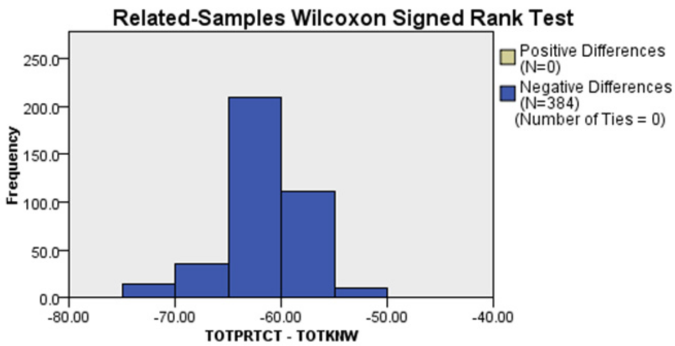


**Figure 3:** *Histogram showing difference among both the variables*

The histogram shows that all the respondents ranked knowledge level highest than the precautionary measures because figure shows only negative values. This confirms that respondents have knowledge about the health risks involved in pesticide application but they are applying the knowledge practically.

**Table 4:** *Test statistics summary*

| **Total N** | **384** |
|---|---|
| Test statistic | .000 |
| Standard error | 2,173.222 |
| Standardized test statistic | -17.007 |
| Asymptotic sig.(2-sided test) | .000 |

The test statistic is zero because there is nothing to compare on positive side hence test statistics is 0. Therefore overall Wilcoxon Signed Rank test shows that there is significant difference ($Z= -17.007$, $p<0.000$) between the scores of both the variables under study.

## Conclusions and Recommendations

It was concluded that majority of the farmers pose much importance to locally understandable and simple protected and precautionary measures during pesticides application. Recommended precautionary measures and safety gadgets were not being used by majority of the respondents due to one or other reason. The major reason behind this low level of use was least awareness and adoption of recommended precautionary measures/protocols by the farmers while pesticide application. Farmers showed high awareness level about health hazards and farm level risks associated with pesticides applications but low knowledge level about its environmental issues. This has been concluded that farmers understanding are mostly health-driven and experiential rather than environmentally holistic. Spearman correlation and Wilcoxon signed ranked test showed significant difference between knowledge level of farmers and level of use of precautionary measures to avoid pesticide effects on human health. Farmers do have knowledge but not being used practically. Knowledge level can have large effect on precautionary measures adapted by respondents for pesticide application. Keeping these major conclusions in view, it can be recommended that farmers must be exposed to practical on-field knowledge as they have basic knowledge but are struggling to apply in the field. Similarly farmers must be made aware of the severe health issues associated with pesticide application or living in an area of continuous pesticide application.

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## Novelty Statement

Present research study exclusively linked farmers' knowledge levels with their actual adoption of precautionary measures during pesticide application across agro-ecological regions of the Punjab province of Pakistan. This also empirically examined how farmers' knowledge specifically influences their adoption of precautionary measures during pesticide application.

## Author's Contribution

**Liaqat Ali**: Conceptualization, conducted research and drafted paper
**Muhammad Luqman**: Supervision and finalized the paper
**Muhammad Yaseen**: Data curation, writing - review & editing

*Generative AI or AI assisted technology statement*
Authors declared that they did not get assistance from any AI tool while completing this manuscript

*Conflict of interest*
The authors have no conflict of interest.

## References

Abdullah A.A., M.B. Baig, S.E.T. Muneer, S.M. Hussain, and F.O. Aldosari. 2019. Farmers' level of knowledge on the usage of pesticides and their effects on health and environment in Northern Pakistan. J. Anim. Plant Sci., 29(6): 1501-1515.

Afzal, W., S.S. Habib, J.A. Ujan, M. Mohany, and H. Bibi. 2024. Assessment of pesticide residues: a comprehensive analysis of seasonal trends and health implications. J. Environ. Sci. Health B., 59(10): 642-653. https://doi.org/10.1080/03601234.2024.2406131

Boateng, K.O., E. Dankyi, I.K. Amponsah, G.K. Awudzi, E. Amponsah, and G. Darko. 2022. Knowledge, perception, and pesticide application practices among smallholder cocoa farmers in four Ghanaian cocoa-growing regions. Toxic. Rep., 16(10): 46-55. https://doi.org/10.1016/j.toxrep.2022.12.008

Carson, R. 2002. Silent spring. Houghton Mifflin Harcourt.

Cavalier, H., L. Trasande, and M. Porta. 2023. Exposures to pesticides and risk of cancer: evaluation of recent epidemiological evidence in humans and paths forward. Int. J. Canc., 152(5): 879-912. https://doi.org/10.1002/ijc.34300

Damalas, C.A. and S.D. Koutroubas. 2017. Farmers' exposure to pesticides: Toxicity types and ways of prevention. Toxics., 6(1). https://doi.org/10.3390/toxics4010001

Dara, D. and A.P. Drabovich. 2023. Assessment of risks, implications, and opportunities of waterborne neurotoxic pesticides. J. Environ. Sci., 125:735-741. https://doi.org/10.1016/j.jes.2022.03.033

Dhital, S., D. Rupakheti, L. Tripathee and S.R. Sigdel. 2015. A Review on Status of Pesticides Use in Nepal. Res. J. Agric. Forest. Sci., 3(3): 26-29.

FAO. 2019. In: FAO. http://www.fao.org/faost at/en/#data/RP. Accessed 22 Sep 2024.

FAO. 2024. Employment indicators 2000–2022 (October 2024 update). Food & Agriculture Organization of United Nations.

Fukuoka, M. 2009. The one-straw revolution: An introduction to natural farming. New York Review of Books.

Government of Punjab. 2024. Punjab Agriculture Statistics. Bureau of Statistics, Planning & Development Board, Lahore.

Khan, A., N. Jaffar, and F. Murad. 2022. Practice and effect of pesticide use on farmers' health in Sindh, Pakistan. J. Pak. Med. Assoc., 72(3): 587-592. https://doi.org/10.47391/JPMA.780

Khan, M., H.Z. Mahmood, and C.A. Damalas. 2010. Pesticide use and risk perceptions among farmers in the cotton belt of Punjab, Pakistan. Crop Protect., 29(4): 498-502.

Mehmood, Y., M. Arshad, N. Mahmood, H. Kächele, and R. Kong. 2021. Occupational hazards, health costs, and pesticide handling practices among vegetable growers in Pakistan. Environ. Res., 200: 111340. https://doi.org/10.1016/j.envres.2021.111340

Nawab, J., Z.U. Din, S. Faisal, S. Khan, A. Ali, Z. Rahman, M. Alam, A. Z. Khan, M.A. Khan, K. Khan, and A. Khan. 2021. Farmlands' degradation with conventional agricultural practices and human health risk assessment: A case-study of Punjab Province, Pakistan. Land Degradat. Develop., 32(16): 4546–4561. https://doi.org/10.1002/ldr.4051

Pimentel, D. 1995. Amounts of pesticides reaching target pests: Environmental impacts and ethics. J. Agric. Environ. Ethic., 8(1): 17-29. https://doi.org/10.1007/BF02286399

Ray, S. and S.T. Shaju. 2023. Bioaccumulation of pesticides in fish resulting toxicities in humans through food chain and forensic aspects. Environ. Anal. Health Toxicol., 38. https://doi.org/10.5620/eaht.2023017

Rehman, A., L. Jingdong, B. Shahzad, A.A. Chandio, I. Hussain, G. Nabi, and M.S. Iqbal. 2015. Economic perspectives of major field crops of Pakistan: An empirical study. Pacific Science Review B: Human. Soc. Sci., 1(3): 145-158. https://doi.org/10.1016/j.psrb.2016.09.002

Sajjad, M.K., A. Bilal, A. Iftikhar, M. Awais, I. Asif, F. Shaheen, and G. Zahoor. 2024. Examining the Association Between Pesticide Exposures and Chronic Diseases in Agricultural Workers. Remittan. Rev., 9(2): 2153-2176.

Statista. 2023. Agricultural consumption of pesticides worldwide from 1990 to 2020. https://www.statista.com/statistics/1263077/global-pesticide-agricultural-use/

Tison, L., L. Beaumelle., K. Monceau and D. Thiéry. 2024. Transfer and bioaccumulation of pesticides in terrestrial arthropods and food webs: State of knowledge and perspectives for future research. Chemospher., 357: 142036. https://doi.org/10.1016/j.chemosphere.2024.142036

Tudi M., R.H. Daniel, L. Wang, J. Lyu, R. Sadler, D. Connell, C. Chu, D.T. Phung. 2021. Agriculture Development, Pesticide Application and Its Impact on the Environment. Int. J. Environ. Res. Publ. Health., 18(3): 1112. https://doi.org/10.3390/ijerph18031112

Vaagt, G. 2002. New Code of Conduct on Pesticides adopted. FAO Newsroom.

Zheng, R., J. García-Gonzalez, R. Romero-del, A. López-Villén, R. García-Alvarez, R. Fadul-Calderon, and R. Alarcón-Rodríguez. 2023. Occupational exposure to pesticides as a risk factor for sleep disorders. Int. J. Environ. Res. Publ. Health., 20(4): 3149. https://doi.org/10.3390/ijerph20043149

Zhou, W., M. Li, and V. Achal. 2025. A comprehensive review on environmental and human health impacts of chemical pesticide usage. Emerg. Contamin., 11(01): 100410. https://doi.org/10.1016/j.emcon.2024.100410