Chlorpyrifos: Country Situation Report

1. Introduction

1.1 General overview of India and its agriculture activities

The agriculture in India was traditionally non-mechanised and organic, i.e. without the use of chemical fertilisers and pesticides. These traditional practices persisted in most of India until the 1950s and for much of the 1960s, until the introduction of high yield varieties, popularly known as the Green Revolution. However, the introduction of high yield varieties resulted in an extraordinary increase in the use of chemical fertilisers and pesticides. The total pesticide consumption in India grew nearly tenfold in the two decades between 1958 and 1978.[1]

As a result, India's food grain production has more than quadrupled since its independence in 1947, leading to a substantial increase in available food grain per capita. India ranks second worldwide in agricultural production today. The agricultural sector is the largest employer in India and accounts for a sizeable 18.8 per cent (2021- 22) in Gross Value Added (GVA) of the country. [2] While this approach produced encouraging results in terms of overall food production, it ignored the problems associated with the widespread use of pesticides and their long-term effects.

Any person desiring to import or manufacture any insecticide in India must have the pesticide registered under the Insecticides Act, 1968. The Act requires data on the safety of human beings, wildlife, birds, domestic animals, beneficial parasites, and predators, before registration for new pesticides can be granted.

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[1] Farmers' education and perception on pesticide use and crop economies in Indian agriculture - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Schema-illustrating-selected-hotspots-and-survey-methodology*fig1*267407441 (accessed 6 Dec, 2022)

[2] Economic Survey 2021-22

1.2 The country's history on the registration and use of chlorpyrifos

Chlorpyrifos has been registered in India under the Insecticides Act since 1977. Additionally, seven formulations of chlorpyrifos have been registered for use under the Act. As of 2016-17, chlorpyrifos is the most frequently used pesticide in India accounting for 9.4% of the total insecticide consumption.[3] The Central Insecticide Board and Registration Committee (CIB&RC) under the Directorate of Plant Protection, Quarantine & Storage (PPQS), Ministry of Agriculture & Farmers Welfare, Government of India, recommends the agricultural use of chlorpyrifos for rice, beans, gram, sugarcane, cotton, groundnut, mustard, brinjal (eggplant), cabbage, onion, apple, ber (Indian jujube/Indian plum), citrus and tobacco.

The CIB&RC has also recommended chlorpyrifos for use on cotton, rice, brinjal and cabbage in combination with cypermethrin (synthetic pyrethroid) and for use on cotton in combination with alphacypermethrin (synthetic pyrethroid) depending on the type of pests.[4]

2. Status of Chlorpyrifos Use in India

2.1. When did the country register chlorpyrifos?

Chlorpyrifos has been registered in India under the Insecticides Act since 1977.

2.2. How much chlorpyrifos was imported in the country in 2021?

There is no reliable data available on the quantity of imported chlorpyrifos.

2.3 What are the main crops using chlorpyrifos in the country?

This pesticide is recommended for rice, beans, gram, sugarcane, cotton, groundnut, mustard, brinjal (eggplant), cabbage, onion, apple, ber (Indian jujube/Indian plum), citrus and tobacco.

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[3] Calculated using data from the PPQS Statistical Database. http://ppqs.gov.in/statistical-database

[4] PESTICIDES AND FORMULATIONS REGISTERED FOR USE IN THE COUNTRY UNDER THE INSECTICIDES ACT, 1968 AS ON 01.10.2022 on PPQS website. http://ppqs.gov.in/divisions/cib-rc/registered-products

2.4 Sources of chlorpyrifos

2.4.1 Does the country produce chlorpyrifos?

India is the second largest producer of chlorpyrifos in the world, after China. In 2021, the total production of chlorpyrifos in India was 24000 tonnes, out of which 11000 tonnes were used domestically, 12000 tonnes were exported and the rest was used to build stockpiles.[5]

2.4.2 Does it import? If so, from where? Related pesticide companies?

The CIB&RC approved five companies as sources of import for chlorpyrifos to India. They are Dow AgroSciences LLC, USA; Dow AgroSciences LLC, UK; Mekhteshim Chemical Works, Israel; FMC Corporation, USA; and Cheminova, Denmark.

[5] Figures are from the Draft Risk Profile of Chlorpyrifos published in April 2022.

3. Human Health and Environmental Impacts of Chlorpyrifos

Chlorpyrifos is considered **moderately hazardous to humans (Class II)** by the World Health Organization (WHO) due to its acute toxicity. A major effect of organophosphate pesticides is the inhibition of an enzyme (acetyl cholinesterase), which controls the transmission of nerve impulses.[6] Symptoms resulting from **acute exposure** to chlorpyrifos are listed below.[7]

Initial Symptoms	Signs of Progression	Severe Toxicity
Tearing of the eyes, runny nose, increased saliva and sweat production, nausea, dizziness and headache	Muscle twitching, weakness or tremors, lack of coordination, vomiting, abdominal cramps, diarrhoea, and pupil constriction with blurred or darkened vision	Increased heart rate, unconsciousness, loss of control of the urine or bowels, convulsions, respiratory depression, and paralysis

Chronic exposure to chlorpyrifos is also linked to a number of serious longer term health impacts such as adverse effects on neurodevelopment, reduced birth size, endocrine disruption, lung and prostate cancer. Human toxicity studies on chlorpyrifos conducted globally have found the following chronic effects:

Study	Chronic effects observed
Brain anomalies in children exposed prenatally to a common organophosphate pesticide[8]	Changes in brain morphology

[6] Lionetto, M. G., Caricato, R., Calisi, A., Giordano, M. E. & Schettino, T. Acetylcholinesterase as a Biomarker in Environmental and Occupational Medicine: New Insights and Future Perspectives. BioMed Res. Int. 2013, 321213 (2013).

[7] Chlorpyrifos General Fact Sheet (orst.edu)

[8] Rauh VA, Perera FP, Horton MK, Whyatt RM, Bansal R, Hao X, Liu J, Barr DB, Slotkin TA, Peterson BS. Brain anomalies in children exposed prenatally to a common organophosphate pesticide. Proc Natl Acad Sci U S A. 2012 May 15;109(20):7871-6. doi: 10.1073/pnas.1203396109.

Neurodevelopmental disorders and prenatal residential proximity to agricultural pesticides[9]	Linkage of neurodevelopmental disorders, like autism spectrum disorder and developmental delays with gestational exposure to chlorpyrifos
Seven-year neurodevelopmental scores and prenatal exposure to chlorpyrifos, a common agricultural pesticide[10]	Evidence of chlorpyrifos exposure at 7 years of age affecting memory and full-scale IQ
Genotoxic effects of chlorpyrifos, cypermethrin, endosulfan and 2,4-D on human peripheral lymphocytes cultured from smokers and non-smokers[11]	Potential genotoxicity in humans
Impact of chlorpyrifos on human villous trophoblasts and chorionic villi[12]	Placental *ex vivo* exposure to CPF produces tissue alterations and suggest that human placenta is a potential target of CPF toxicity

3.1 Human health impacts reported in India

There are several studies from India on chlorpyrifos residues in crops and the human exposure resulting from it. In a 2015 study in Punjab, India, chlorpyrifos was detected in

[9] Rauh VA, Perera FP, Horton MK, Whyatt RM, Bansal R, Hao X, Liu J, Barr DB, Slotkin TA, Peterson BS. Brain anomalies in children exposed prenatally to a common organophosphate pesticide. Proc Natl Acad Sci U S A. 2012 May 15;109(20):7871-6. doi: 10.1073/pnas.1203396109.

[10] Rauh V, Arunajadai S, Horton M, Perera F, Hoepner L, Barr DB, Whyatt R. Seven-year neurodevelopmental scores and prenatal exposure to chlorpyrifos, a common agricultural pesticide. Environ Health Perspect. 2011 Aug;119(8):1196-201. doi: 10.1289/ehp.1003160

[11] Sandal S, Yilmaz B. Genotoxic effects of chlorpyrifos, cypermethrin, endosulfan and 2,4-D on human peripheral lymphocytes cultured from smokers and nonsmokers. Environ Toxicol. 2011 Oct;26(5):433-42. doi: 10.1002/tox.20569.

[12] Ridano ME, Racca AC, Flores-Martin JB, Fretes R, Bandeira CL, Reyna L, Bevilacqua E, Genti-Raimondi S, Panzetta-Dutari GM. Impact of chlorpyrifos on human villous trophoblasts and chorionic villi. Toxicol Appl Pharmacol. 2017 Aug 15;329:26-39. doi: 10.1016/j.taap.2017.05.026

6.4% of the milk samples with a mean level of 2.2 µg/kg and has the greatest (20.2 %) share in the total pesticide residue load in milk samples.[13]

A case study from 2017 found that chlorpyrifos toxicity can cause delayed myeloneuropathy. On ingesting 50 mL of chlorpyrifos 50% EC formulation, the subject needed mechanical ventilation for 2 weeks and needed support to walk for up to 6 months.[14]

In a 2019 study in Rajasthan, India, researchers surveyed the medical history of 50 farmers using chlorpyrifos (and other pesticides) and found complaints of itchiness of the skin, redness of the eyes, muscle pains, dry throat, excessive sweating, and headaches.[15]

3.2 Environmental and biodiversity impacts reported in India

A 2021 study from West Bengal, India, found that chlorpyrifos is able to promote chromosomal alteration in *Allium cepa* root cells and concluded that the pesticide has the potential to cause genotoxicity among exposed organisms.[16]

A 2019 study from Tamil Nadu, India, found severe behavioural and histological changes (i.e. structural alterations of the gills, liver, and intestine) in freshwater fish *Channa punctatus* exposed to a sub-lethal concentration (5 ppm) of chlorpyrifos.[17]

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[13] Bedi JS, Gill JP, Aulakh RS, Kaur P. Pesticide Residues in Bovine Milk in Punjab, India: Spatial Variation and Risk Assessment to Human Health. Arch Environ Contam Toxicol. 2015 Aug;69(2):230-40. doi: 10.1007/s00244-015-0163-6

[14] Ostwal P, Dabadghao VS, Sharma SK, Dhakane AB. Chlorpyrifos toxicity causing delayed myeloneuropathy. Ann Indian Acad Neurol. 2013 Oct;16(4):736. doi: 10.4103/0972-2327.120443.

[15] Neha Sharma and Subroto Dutta. 2019. Analysis of Pesticide Residues on Crops with Related Health Impact on Farmers in Agriculture Field of Sikrai Tehsil, Dausa District, Rajasthan. Int.J.Curr.Microbiol.App.Sci. 8(5): 161-169. doi: https://doi.org/10.20546/ijcmas.2019.805.020

[16] Md Shabbir, Mukesh Singh, Swati Maiti, Samar K Saha. Organophosphate pesticide (Chlorpyrifos): Environmental menace; study reveals genotoxicity on plant and animal cells\ https://doi.org/10.1016/j.envc.2021.100313.

[17] Stalin, A., Suganthi, P., Mathivani, S. et al. Impact of chlorpyrifos on behavior and histopathological indices in different tissues of freshwater fish Channa punctatus (Bloch). Environ Sci Pollut Res 26, 17623–17631 (2019). https://doi.org/10.1007/s11356-019-05165-3

A 2018 study from Punjab, India, found that the use of chlorpyrifos on cauliflower fields at higher concentrations (≥500 ppm) leads to a reduction in the microbial and enzyme activity in soil[18]. This lead to reduced crop yields by preventing the action of the Plant Growth Promoting Bacteria (PGPB).

A 2015 study in Uttar Pradesh, India, reported that chlorpyrifos was more toxic to earthworms, as measured through their higher mortality rate, reduced reproductive potential and lower cast production, compared to alternatives (quercitin/azadirachtin)[19]

3.3 Measures taken as a result of human health and environmental impacts

In 2013, Anupam Verma Committee was set up to review 66 pesticides that had been banned, restricted, or withdrawn in other countries, but which were still in use in India. In its report[20] submitted in 2015, the Committee recognised that chlorpyrifos is toxic to fish and bees, and recommended that it should not be sprayed near water bodies or during the foraging period of bees. It also recommended phasing out 6 pesticides, and a review of 27 others, including chlorpyrifos.

4. National Policy Related Initiatives

4.1 Any government initiative, if any, to minimize the use of and/or to replace with other alternatives or ban chlorpyrifos

Based on the review, a draft order banning 27 pesticides, including chlorpyrifos, was issued in May 20, 2021 but has not been enforced till now. There have been short-term bans on chlorpyrifos by different states since under the Insecticides Act, 1968, states can a pesticide for maximum 60 days. In August 2022, the governments of Punjab and Haryana banned

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[18] Abhishek Walia., et al. "Effect of Chlorpyrifos and Malathion on Soil Microbial Population and Enzyme Activity". Acta Scientific Microbiology 1.4 (2018) 14-22. DOI: 10.31080/ASMI.2018.01.0033

[19] Kumar P, Bhadauria T, Mishra J (2015) Impact of application of insecticide quercetin/azadirachtin and chlorpyrifos on earthworm activities in experimental soils in Uttar Pradesh India. Science Postprint 1(2): e00044. doi:10.14340/spp.2015.02A0001.

[20] http://ppqs.gov.in/anupam-varma-committee-report-volume-i

[21] https://chemrobotics.in/2020/05/25/indian-government-draft-order-banning-27-pesticides/

the use of 10 pesticides, including chlorpyrifos, in order to boost exports of Basmati rice to countries with stringent regulations.2223 In December 2022, the government of Tamil Nadu passed an order banning six pesticides, including chlorpyrifos, to curb farmer suicides in the state. The state also sought permanent bans on these pesticides from the Central government.24

5. Primary Data based on Survey

5.1 Survey Methodology

Mixed-method (quantitative and qualitative) of research was conducted to develop a clear picture of chlorpyrifos use in India, its environmental and health impacts, and the viability of its alternatives.

Semi-structured interviews were conducted with 90 farmers in 9 states (see map). The bulk of these interviews (74) were conducted in Maharashtra, Manipur, Tamil Nadu and Odisha, while the rest were conducted in Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh and Bihar. Cotton, paddy and sugarcane growing regions were targeted as these crops account for the major part of chlorpyrifos use. Discussions were also conducted with pesticide dealers and agricultural experts, including agricultural entomologists, to build a qualitative understanding of local pesticide-use practices.

The surveys in Tamil Nadu and Manipur were conducted by our partner NGOs Arugulam, Tamil Nadu and Institute of Social Research and Development, Manipur to whom we extend our gratitude.

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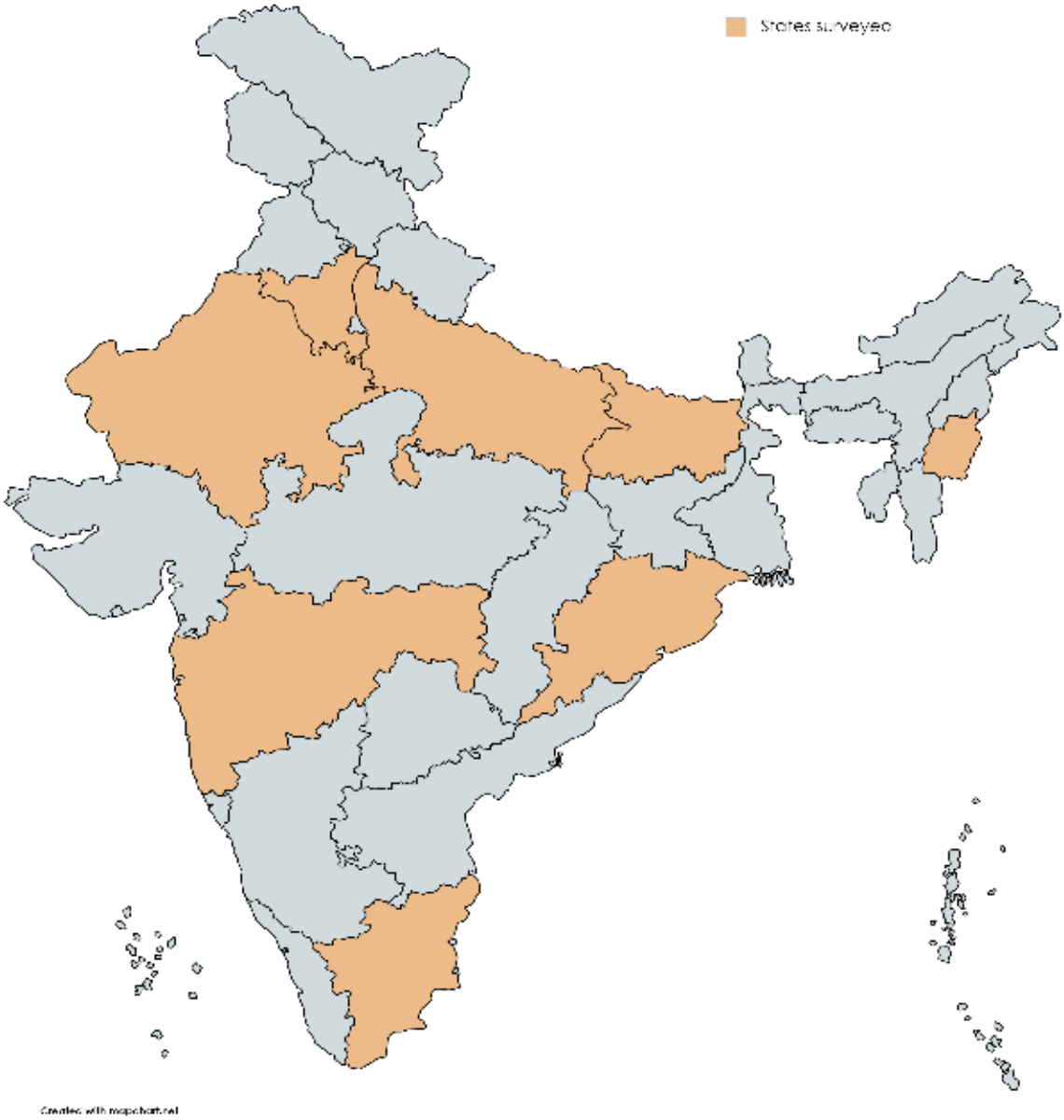
[22] Punjab for ban on 10 agro-chemicals for basmati - Hindustan Times

[23] After Punjab, Haryana bans 10 pesticides for 'pure' Basmati production | After Punjab, Haryana bans 10 pesticides for 'pure' basmati production | PiPa News

[24] Tamil Nadu to seek Centre's permanent ban on six pesticides for suicide prevention, says Health Minister - The Hindu

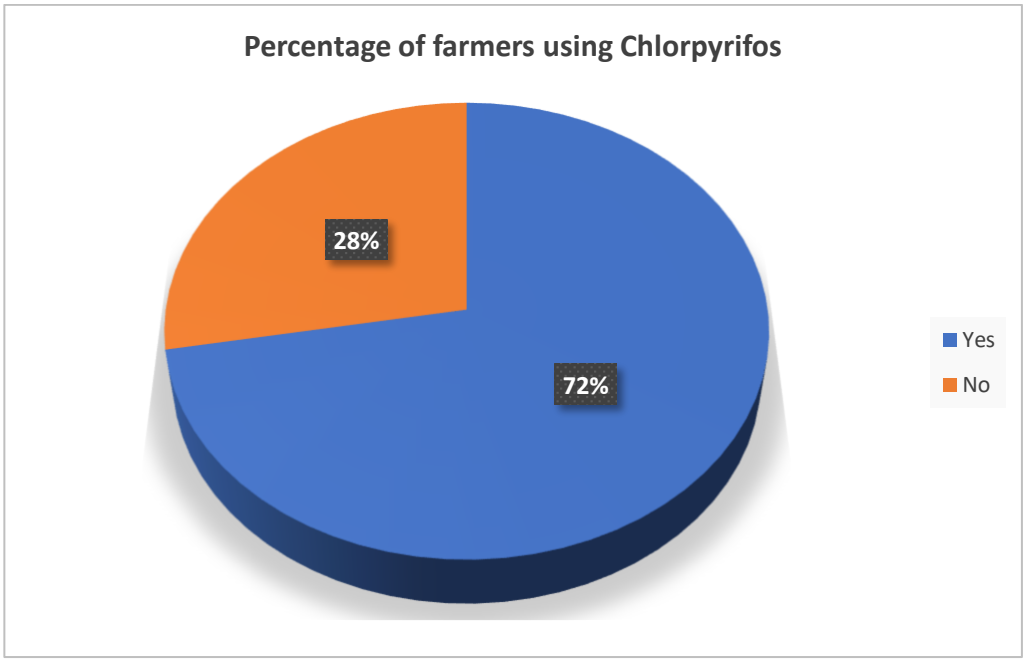


Map 1. The following Indian states were surveyed during the study: Rajasthan, Haryana, Uttar Pradesh, Bihar, Maharashtra, Manipur, Odisha and Tamil Nadu.

5.2 Survey Findings

5.2.1 Chlorpyrifos use

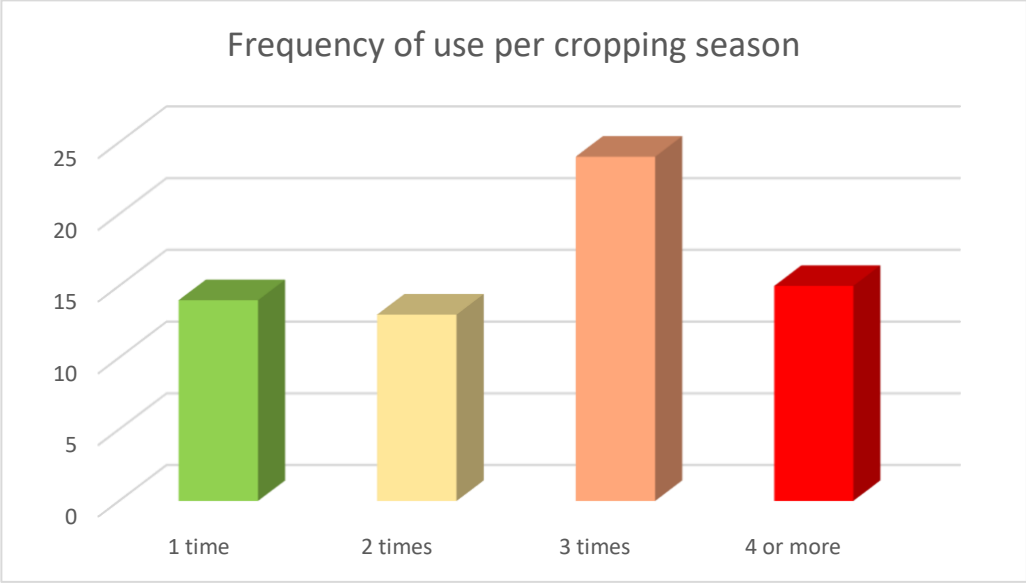
Around 97 per cent of farmers surveyed used pesticides (87 of 90 respondents). 72% used chlorpyrifos (Figure 1). Some of the farmers that were not using chlorpyrifos used other HHPs such as monocrotophos and lambda-cyhalothrin.



(Figure 1)

5.2.2 Frequency of use

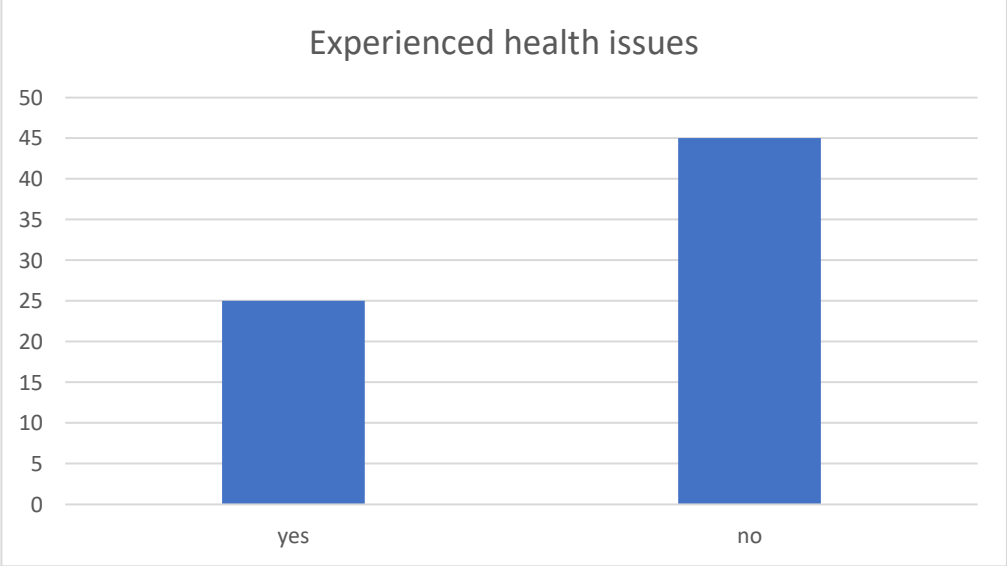
Being a broad-spectrum pesticide, chlorpyrifos is used to control many different pests, sometimes within the same crop. The frequency of use depends upon the crop and the number of pest-attacks. The highest frequency of spraying was seen in cotton crops, however, the majority of farmers sprayed chlorpyrifos four or more times. The lowest frequency was seen in sugarcane and some paddy-growing regions, where most farmers applied chlorpyrifos only once.



(Figure 2)

5.2.3 Health issues experienced by farmers

The majority of farmers reported experiencing no health issues due to the use of chlorpyrifos (Figure 3). The farmers, who had experienced health issues, faced relatively minor issues like irritation of the skin and eyes. As a result, most farmers did not wear adequate protection over the eyes and skin while spraying chlorpyrifos, whereas they may use protective equipment while applying other pesticides that they considered more harmful.

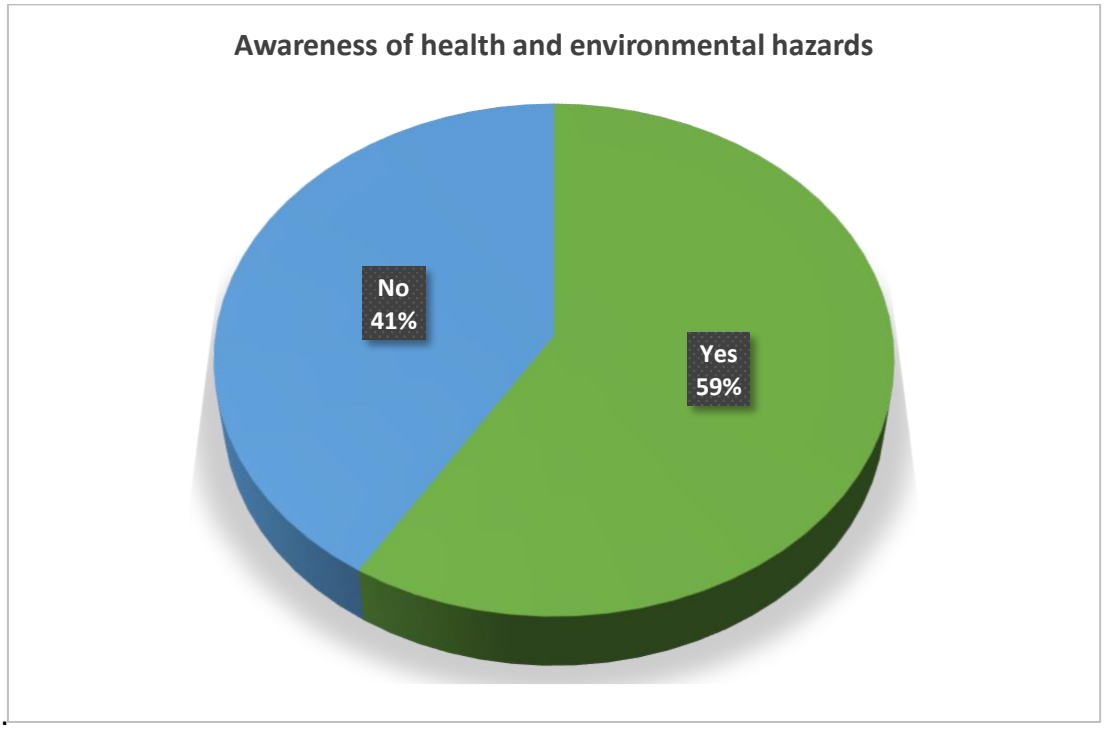


(Figure 3)

5.2.4 Level of awareness on health and environmental hazards

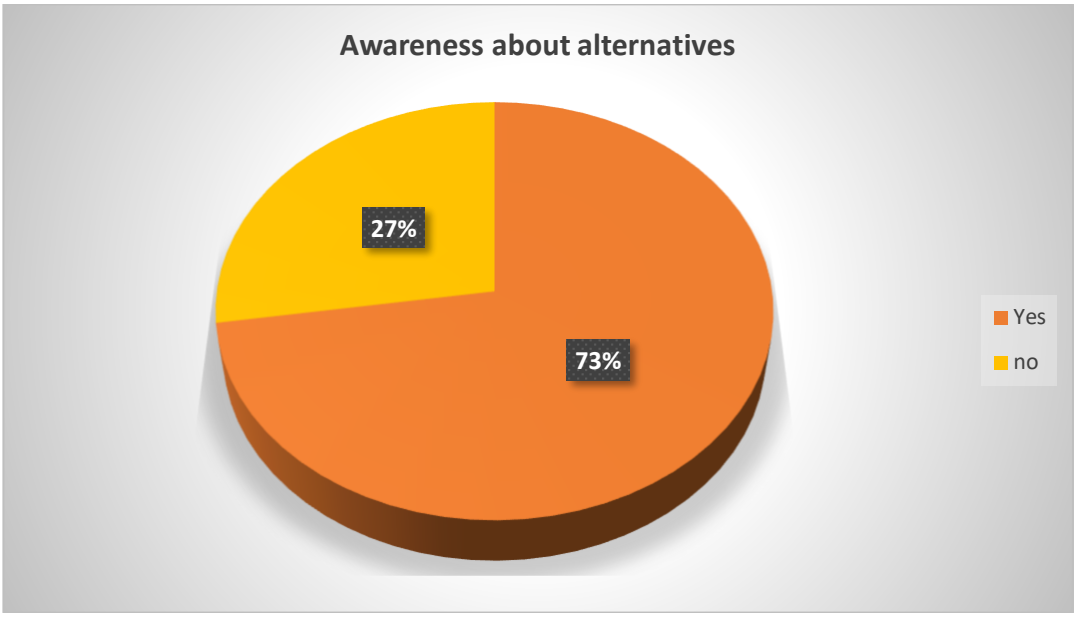
Nearly 59 per cent of farmers (53 out of 90 respondents) reported some awareness of the health and environmental hazards of chlorpyrifos (Figure 4). There is no awareness of the

specific health and environmental impacts of chlorpyrifos or its hazards relative to other pesticides.



(Figure 4)

Chlorpyrifos is used to control a wide variety of pests. Its alternatives may not have an equally broad spectrum of action, so they may only be effective on some of the pests currently controlled using chlorpyrifos. For example, in some cotton growing regions of central India, pesticide dealers recommend **Imidacloprid** as an alternative to chlorpyrifos to curb sucking pests, while **Diafenthiuon** is recommended for use against whiteflies. In some parts of eastern India, some rice farmers have adopted such alternatives as **Pyraxalt™** for hoppers, and **Cartap Hydrochloride** and **Chlorantraniliprole** for stem-borers with considerable success. While these alternatives are well-known (see Figure 5) and available on the market, they have not widely replaced chlorpyrifos. Instead, these pesticides are often used in combination with chlorpyrifos.



(Figure 5)

6 Conclusion

Chlorpyrifos is effective against a wide range of pests. Since it is both cost-competitive and widely available across India, it is applied extensively and has often been used to replace persistent organochlorinated compounds which are banned in India, such as lindane and endosulfan. It has consistently been the most used pesticide in India during the last five years. As chlorpyrifos has now been proposed for listing as a Persistent Organic Pollutant (POP) in Annex A under the Stockholm Convention to eliminate its production and use, the study looks at its pattern of use in India to ascertain if *just transition* to alternative pesticides is feasible.

The findings of the current study indicate that chlorpyrifos use is prevalent across India though trends and specifics of use differ from region to region. In some arid regions of northwestern India, chlorpyrifos use has recently become necessary due to changing agroclimatic conditions. On the other hand, in cotton-growing regions of central India, the farmers reiterated that chlorpyrifos is losing effectiveness against some pests, as they develop metabolic resistance against it. However, this has not led to a marked decline in its use.

The study reveals that while some awareness about the environmental and health hazards of chlorpyrifos exists among famers, the short-term health impacts of chlorpyrifos at low concentrations are not that serious, and so it is perceived as relatively harmless. The surveys in eastern India show that some rice farmers successfully moved away from chlorpyrifos use. The study reveals that although there is some awareness about alternatives to chlorpyrifos, the chemical was not replaced on a large scale.

Considering its impact on human health and the environment, many countries have restricted or banned the use of chlorpyrifos. Phasing out chlorpyrifos in India can help protect the environment and farmers' health. However, given the prevalence of its use across India, a transition away from chlorpyrifos will require the active support of government institutions.

This may include –

- Awareness raising about the environmental and health impacts of chlorpyrifos, especially, its possible chronic health impacts, which are not documented.
- Encouraging government institutes to introduce a hazard-lens in their recommendations to farmers. Currently, these institutes in their periodic advisories recommend the use of chlorpyrifos along with less hazardous alternatives, without indicating any preference.
- Creating a strategy to reduce dependence on chlorpyrifos and allow a phased transition towards alternatives using interventions at district, state and national levels.

Annex I

Questionnaire used for survey

1. What is your name?

2. What crops do you grow?

3. Do you use pesticides for farming?

4. Do you use chlorpyrifos? (Mention local brand names for easy identification)

5. How many times do you use chlorpyrifos (for each crop)?

6. Have you experienced any health problems due to the use of chlorpyrifos?

7. Do you know any alternatives to chlorpyrifos?

8. Are you aware of the hazards posed by chlorpyrifos to human health and the environment? (If no, explain it to them)

Annex II

Chlorpyrifos brands available in the market

(Figure 6: Perse - Chlorpyrifos 50%EC + Cypermethrin 5%EC)

(Figure 7: Lethal- Chlorpyrifos 20%EC)

(Figure 8: Cyclone- Chlorpyrifos 50%EC+Cypermethrin 5%EC)

(Figure 9: Milban- Chlorpyrifos 20%EC)

(Figure 10: Thanedar 505- Chlorpyrifos 50%EC + Cypermethrin 5%EC)

(Figure 11: Motiban 505- Chlorpyrifos 50%EC Chlorpyrifos +5%Cypermethrin EC)

(Figure 12: Durmet (FMC)- 20%EC)