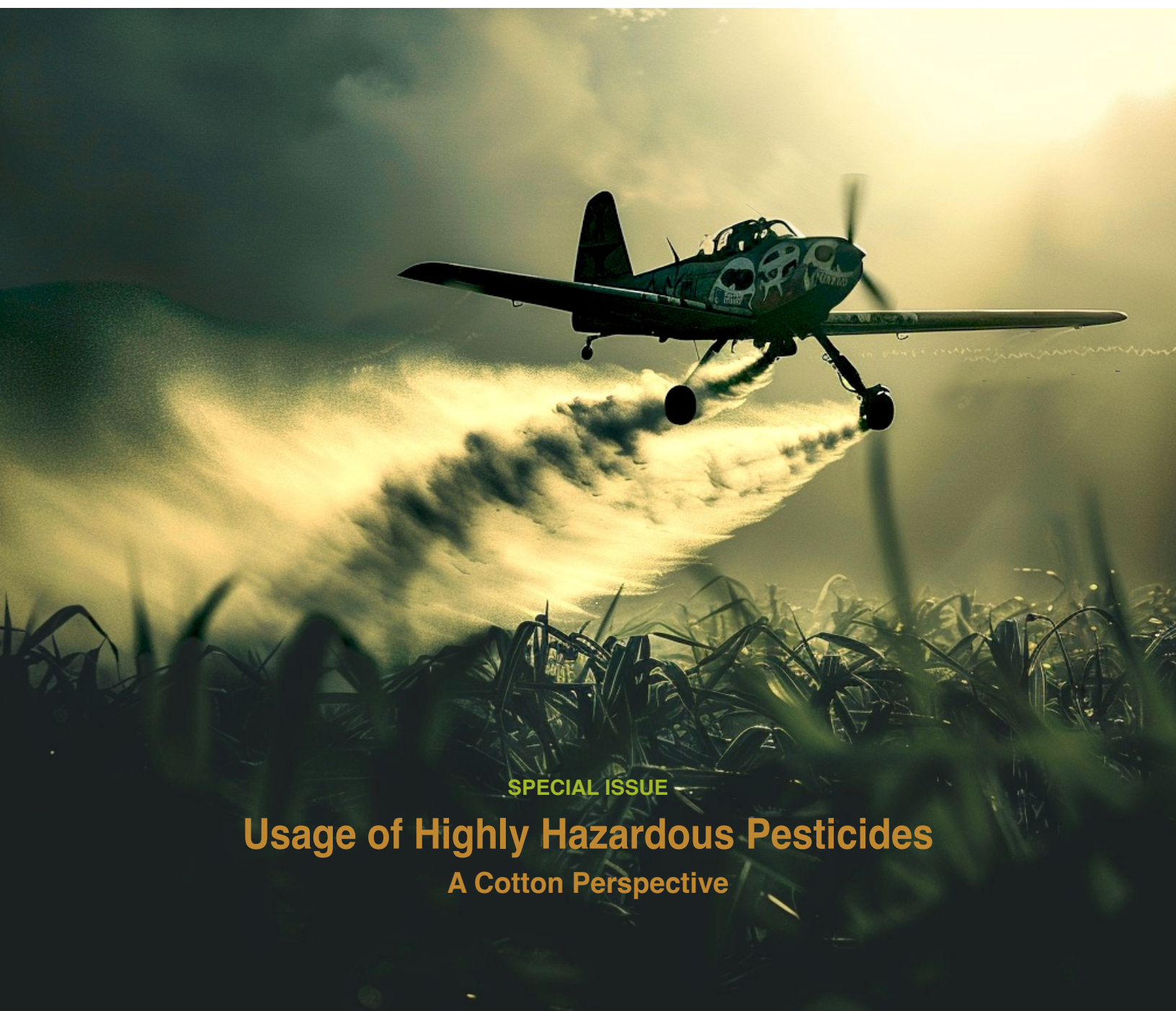


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International Cotton Advisory Committee



SPECIAL ISSUE

Usage of Highly Hazardous Pesticides
A Cotton Perspective

This is a special issue on 'Usage of Highly Hazardous Pesticides - A Cotton Perspective,' which is a sequel to the article published in March 2024. This issue aims to shed light further on the usage of highly hazardous pesticides (HHPs) in cotton compared to other crops.

In the global agricultural landscape, few issues spark more controversy than the use of HHPs. Cotton is often depicted as a primary offender in the excessive and dangerous use of pesticides. This narrative, driven by various environmental organizations, paints a grim picture: despite cotton occupying only 2.3% of global arable land, it is accused of using over 16% of the world's insecticides and a significant 69.1% share of HHPs. However, a deeper examination of data by the International Cotton Advisory Committee (ICAC) reveals a more nuanced reality, challenging these widely accepted claims and calling for a more informed discussion. ICAC publishes the Cotton Data Book, which includes the world's most comprehensive data on cotton production and trade of 38 major cotton producing and consuming countries. The Data Book draws from official sources and covers aspects related to number of farmers, area, production, productivity (yield), seed processing, tillage methods, planting methods, stalk usage, weeding practices, methods of harvesting and ginning, spray application methods, fertilizer usage, cropping systems, water footprint, cost of production, and cost of cultivation.

Over the past few decades, cotton production systems have been bombarded with alarmist narratives. For instance, the Environmental Justice Foundation (EJF) asserts that cotton cultivation is exceptionally pesticide-intensive, claiming that "cotton uses over 16% of global insecticides and a higher proportion of HHPs than any other crop." They state that "globally, 69.1% of pesticides used on cotton are HHPs, compared to 25.8% on cereals and 43.5% on rice." Similar claims are echoed by other sources, including 'The World Counts,' which labels cotton as the most pesticide-intensive crop, consuming 16% of all insecticides and 7% of all herbicides used worldwide.

While these assertions are grounded in legitimate environmental concerns, they often lack the detailed scrutiny and examination of the data needed to understand the full context. Consequently, they promote a narrative that oversimplifies the complex dynamics of agricultural pesticide use, leading to widespread misconceptions and, in some cases, policy recommendations that might not effectively address the core issues.

The datasets presented in the March and June editions of the ICAC Recorder provide a crucial counterpoint to these alarmist claims. According to ICAC data, cotton, while indeed cultivated on 2.3% of the world's arable land, accounted for only 4.0% of global pesticide use and 10.51% of total insecticides used in agriculture worldwide from 2018 to 2022. Cotton's share of 10.51% insecticide use is significant, but is a more modest figure than the 16% often cited. Moreover, the data shows that cotton's share of global herbicide usage is 3.1% (not 7.0% as claimed by The World Counts), trailing behind several other crops such as soybeans (20.9%), maize (20.0%), wheat (7.3%), rice (5.3%), and sugar cane (4.2%). These figures suggest that while cotton's pesticide usage is notable, it is not as disproportionately high as some sources claim. The ICAC data underscores the importance of context and precision in discussions about pesticide use, revealing that some extreme assertions about cotton may be exaggerated.

One of the most contentious points in the pesticide debate is the proportion of HHPs used in cotton cultivation. The EJF's claim that 69.1% of pesticides used on cotton are HHPs starkly contrasts with ICAC's findings. According to ICAC, the average share of HHPs in cotton's pesticide use from 2018 to 2022 was 13.04%, significantly lower than the figures presented by advocacy groups. This discrepancy highlights how selective data presentation can skew public perception and policy discourse. Moreover, ICAC data indicates that other crops also have significant shares of HHPs in their pesticide use. For example, bananas have a share of 26.74% HHPs, wheat 12.09%, citrus 10.98%, and vegetables and flowers 10.69%. These numbers show that the issue of HHPs is not unique to cotton but is a broader agricultural challenge that requires comprehensive and targeted solutions.

A comparative analysis of pesticide use across different crops shows that vegetables and flowers, soybeans, wheat, and rice exhibit higher overall pesticide usage than cotton. For instance, cotton's average usage of highly hazardous fungicides (HHFs) at 1,475 tonnes annually from 2018 to 2022 ranks below 14 crops, compared to the highest value of 18,011 tonnes used by vegetables and flowers. With an average of 2,144 tonnes of highly hazardous herbicides (HHHs), cotton ranks fourth behind soybeans, canola, and vegetables and flowers. This data dispels the narrative that cotton is uniquely reliant on HHHs and places its pesticide use in a broader agricultural context. Cotton's use of highly hazardous insecticides (HHIs) is notably high, which aligns with some claims made by environmental groups.

During 2018-2022, cotton ranked third in global 'highly hazardous insecticide (HHI) usage, averaging 8,671 tonnes annually. This positions cotton behind rice and vegetables and flowers but still reflects significant usage. Cotton's share of the global HHI use is 12.69%, suggesting that while cotton does use a significant portion of global HHIs, the figures presented by some sources may be overstated.

The use of HHPs in cotton cultivation is a complex issue that requires careful consideration of all available data. While cotton does use a higher proportion of pesticides and insecticides relative to its cultivated area, the extent of this usage is often exaggerated in public discourse. The debate over HHPs and cotton cultivation underscores the need for accurate data and careful analysis in environmental policymaking. Exaggerated claims and alarmist rhetoric can lead to misguided policies that may not effectively address the real issues at hand. Instead, a balanced approach that considers the full spectrum of data is essential.

In conclusion, the extent of pesticide use in cotton must be contextualized within broader agricultural practices. The ICAC data provides a critical foundation for this discussion, offering insights that challenge simplistic narratives and advocate for evidence-based policymaking. By embracing a nuanced understanding of pesticide use and promoting sustainable agricultural practices, we can effectively address environmental concerns without succumbing to sensationalism. This balanced approach will pave the way for a healthier and more sustainable agricultural future globally.

– Keshav Kranthi



Usage of Highly Hazardous Pesticides A Cotton Perspective

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INTRODUCTION

Per FAO (2016): ‘Highly Hazardous Pesticides (HHPs) means pesticides that are acknowledged to present particularly high levels of acute or chronic hazards to health or environment according to internationally accepted classification systems such as WHO or GHS or their listing in relevant binding international agreements or conventions. In addition, pesticides that appear to cause severe or irreversible harm to health or the environment under conditions of use in a country may be considered to be and treated as highly hazardous.’

HHPs represent a subset of agricultural chemicals categorized by the Joint Meeting on Pesticide Management (JMPM) of the Food and Agriculture Organization (FAO) and the World Health Organization (WHO).

The categorization of HHPs is based on their inherent hazardous properties, including acute toxicity, carcinogenicity, mutagenicity, reproductive toxicity, and environmental persistence. These pesticides are identified as posing significant risks to human health and the environment, often requiring stringent regulatory measures for their safe use.

The JMPM’s classification system aims to guide national and international efforts in managing and regulating HHPs, promoting the adoption of safer alternatives, integrated pest management strategies, and sustainable agricultural practices to mitigate their adverse impacts. Understanding the classification and regulatory framework surrounding HHPs is crucial for policymakers, agricultural professionals, and researchers to address global concerns related to pesticide safety and environmental sustainability.

This article aims to contextualize cotton’s global usage of highly hazardous, by comparing it with other major crops and the relative usage in different cotton growing countries. While historical data shows that cotton exhibits significant usage of HHPs, particularly in the form of highly hazardous insecticides (HHIs) and herbicides (HHHs), its overall contribution and intensity vary compared to other major crops like soybeans, rice, wheat, and vegetables and flowers.

Understanding these variations is crucial for developing targeted strategies to mitigate environmental and health impacts associated with pesticide usage in agriculture.

METHODOLOGY

“Highly Hazardous Pesticides” were classified as defined by the FAO/WHO Joint Meeting on Pesticide Management (JMPM) based on the pesticides listed by the WHO (2020). The JMPM (2008) recommended that HHPs should be defined as those possessing one or more of the following characteristics:

- **Criterion 1:** Pesticide formulations that meet the criteria of classes Ia or Ib of the WHO Recommended Classification of Pesticides by Hazard; or
- **Criterion 2:** Pesticide active ingredients and their formulations that meet the criteria of carcinogenicity Categories 1A and 1B of the Globally Harmonized System on Classification and Labelling of Chemicals (GHS); or
- **Criterion 3:** Pesticide active ingredients and their formulations that meet the criteria of mutagenicity Categories 1A and 1B of the Globally Harmonized System on Classification and Labelling of Chemicals (GHS); or
- **Criterion 4:** Pesticide active ingredients and their formulations that meet the criteria of reproductive toxicity Categories 1A and 1B of the Globally Harmonized System on Classification and Labelling of Chemicals (GHS); or
- **Criterion 5:** Pesticide active ingredients listed by the Stockholm Convention in its Annexes A and B, and those meeting all the criteria in paragraph 1 of Annex D of the Convention; or
- **Criterion 6:** Pesticide active ingredients and formulations listed by the Rotterdam Convention in its Annex III; or
- **Criterion 7:** Pesticides listed under the Montreal Protocol; or
- **Criterion 8:** Pesticide active ingredients and formulations that have shown a high incidence of severe or irreversible adverse effects on human health or the environment.

The list of pesticides categorized as HHPs, according to the 8 criteria defined by the JMPM (2008) can be found in the supplementary appendix (Jepson et al., 2020), presented as Annexure-1 in this chapter. Although listed as HHPs under the ‘severe effects’ criterion by Jepson et. al., this article did not include data on the following pesticides: aluminum phosphide, atrazine, clothianidin, fipronil, imidacloprid, magnesium phosphide, paraquat dichloride, phosphine, and thiamethoxam, due to the subjective nature of the “severe effects” criterion.

DATA SOURCES

Bayer Crop Sciences: Data on pesticide usage in agriculture from 2018 to 2022.

FAOSTAT (<https://www.fao.org/faostat/en/#data>): Data on the area (hectares) of crops under cultivation in various countries worldwide.

Data Analysis: The data analysis was conducted using Excel.

CROPS AND CROP GROUPS

List of crops and crop groups considered in the analysis: Bananas, barley, sugar beets, cereals (buckwheat, quinoa, triticale, oats, and rye), citrus (grapefruit, lemons, limes, mandarin, oranges, tangelo, and tangerines), corn (transgenic and non-GM), cotton (transgenic and non-GM), environmental markets (trees and turf), forage crops (alfalfa, fodder beans, pastures and grasses, forage legumes, peas-field-fodder, ryegrass, serradella, and vetches), fruits and nuts (berries, blackberries, blueberries, currants, strawberries, coconuts, tropical and sub-tropical fruits, stonnie-fruits, pome-fruits, and tree nuts), grapes/vines, oilseed rape/canola, other crops (flax, jute, groundnuts, lupine, safflower, sesame, mulberries, sorghum, cardamom, ginger, cumin, areca nuts, betel nuts, pepper, fallows, nursery stocks, and sunflower), plantation (cacao, coffee, palm oil, rubber, tea, and tobacco), potatoes, rice, soybeans (transgenic and non-GM), sugarcane, vegetables, and flowers, and wheat (transgenic and non-GM).

rins, oranges, tangelo, and tangerines), corn (transgenic and non-GM), cotton (transgenic and non-GM), environmental markets (trees and turf), forage crops (alfalfa, fodder beans, pastures and grasses, forage legumes, peas-field-fodder, ryegrass, serradella, and vetches), fruits and nuts (berries, blackberries, blueberries, currants, strawberries, coconuts, tropical and sub-tropical fruits, stonnie-fruits, pome-fruits, and tree nuts), grapes/vines, oilseed rape/canola, other crops (flax, jute, groundnuts, lupine, safflower, sesame, mulberries, sorghum, cardamom, ginger, cumin, areca nuts, betel nuts, pepper, fallows, nursery stocks, and sunflower), plantation (cacao, coffee, palm oil, rubber, tea, and tobacco), potatoes, rice, soybeans (transgenic and non-GM), sugarcane, vegetables, and flowers, and wheat (transgenic and non-GM).

HIGHLY HAZARDOUS PESTICIDES

Data presented in this section under the category “HHPs” represents the cumulative total of all synthetic chemicals utilized across various categories such as highly hazardous insecticides (HHIs), highly hazardous fungicides (HHFs), highly hazardous herbicides (HHHs), highly hazardous plant growth regulators (HH-PGRs), highly hazardous seed dressing chemicals (HSDCs) and highly hazardous acaricides, and molluscicides -categorized as highly hazardous others (HHOs).

HHPs encompass a broad range of chemical or biological substances designed to repel, destroy, or control pests or regulate plant growth. This classification is based on criteria defined by the Joint Meeting on Pesticide Management (JMPM) of the Food and Agriculture Organization (FAO) and the World Health Organization (WHO). HHPs include synthetic chemicals that are identified for their significant risks to human health and the environment, necessitating rigorous regulatory oversight and consideration of safer alternatives in agricultural practices. Understanding the scope and implications of HHPs is crucial for effective pesticide management strategies and sustainable agricultural development.

Table 1. Crop-wise temporal trends in the usage of HHPs in agriculture. Data represent the quantity of active ingredients in metric tonnes over a five-year period (2018-2022)

PESTICIDES	2018	2019	2020	2021	2022	Average
Vegetables and Flowers	29,472	32,098	27,405	30,362	30,651	29,998
Soybeans	18,229	17,924	23,019	32,366	37,785	25,865
Wheat	30,795	31,276	28,361	15,169	14,893	24,099
Rice	20,937	21,005	19,694	11,657	11,398	16,938
Cotton	16,755	18,963	19,881	9,966	10,139	15,141
Fruits and Nuts	12,910	13,850	12,521	16,759	17,704	14,749
Corn/maize	13,539	14,976	14,608	11,836	11,765	13,345
Other Crops	10,195	8,481	9,116	9,267	23,575	12,127
Citrus	11,966	13,982	12,113	7,416	5,856	10,267
Bananas	7,628	8,323	8,456	9,179	8,804	8,478
Potatoes	9,540	9,096	7,610	4,643	4,568	7,091
Plantation	6,657	7,350	5,427	5,148	4,902	5,897
Rapeseed/Canola	5,428	5,243	4,945	5,899	5,646	5,433
Grapes/Vines	4,293	4,353	3,914	2,592	2,161	3,463
Sugar Cane	4,443	3,098	2,600	3,460	3,649	3,450
Barley	2,717	2,553	2,002	1,090	922	1,857
Forage Crops	1,272	1,223	1,114	1,225	1,519	1,271
Cereals	651	834	727	859	620	738
Beets	702	745	697	541	395	616
Environmental Markets	231	320	338	514	543	389
Grand Total	208,361	215,691	204,549	179,952	197,496	201,210

Table-1 presents the crop-wise temporal trends in the usage of HHPs in agriculture from 2018 to 2022. Vegetables and flowers show consistently high values throughout the five years, peaking at 32,098 tonnes in 2019. Soybeans exhibited a substantial increase from 18,229 tonnes in 2018 to a peak of 37,785 tonnes in 2022. Wheat recorded a notable decline from 30,795 tonnes in 2018 to 14,893 tonnes in 2022. Rice and cotton show a decrease in pesticide use towards the end of the period, with rice dropping to 11,398 tonnes and cotton to 10,139 tonnes in 2022.

In contrast, crops such as cereals, beets, and environmental markets exhibit very low HHP usage. Cereals had the lowest usage of 620 tonnes in 2022. Beets have a slightly higher

average at 616 tonnes, with a steady decline to 395 tonnes by 2022. Environmental markets (trees and turfs) also show minimal pesticide use, reflecting a gradual increase from 231 tonnes in 2018 to 543 tonnes in 2022. These trends highlight the varying dependency on HHPs among different crops, with some agricultural sectors relying heavily on these chemicals while others maintain minimal usage.

Comparison of Cotton Pesticide Use with Other Crops

Cotton, with an average usage of 15,141 tonnes of HHPs from 2018 to 2022, ranks lower compared to several crops. For instance, vegetables and flowers, soybeans, wheat, and rice exhibit notably higher HHP usage, averaging 29,998 tonnes, 25,865 tonnes, 24,099 tonnes, and 16,938 tonnes, respectively.

Table-2. Usage (tonnes) of different types of HHPs in various crops. Average over five years (2018-2022)

CROPS	HHFs	HHHs	HHIs	HH-PGRS	HH-OTHERS	HHPs
Veg. and Flowers	18,011	2,496	9,333	0	158	29,998
Soybeans	12,846	8,321	3,576	0	1,122	25,865
Wheat	9,898	927	5,218	0	8,056	24,099
Rice	4,264	861	11,631	0	183	16,938
Cotton	1,475	2,144	8,671	0	2,851	15,141
Fruits and Nuts	8,507	1,899	4,321	0	22	14,749
Corn/maize	4,638	1,889	5,525	0	1,293	13,345
Other Crops	3,562	4,183	4,093	0	290	12,127
Citrus	4,845	1,260	4,161	0	1	10,267
Bananas	7,068	354	1,052	0	4	8,478
Potatoes	5,098	334	1,615	7	38	7,091
Plantation	1,536	597	3,756	0	8	5,897
Rapeseed/Canola	940	4,110	301	0	81	5,433
Grapes/Vines	1,772	529	1,159	3	0	3,463
Sugar Cane	221	309	2,910	1	9	3,450
Barley	1,591	131	62	0	74	1,857
Forage Crops	670	237	345	0	18	1,271
Cereals	348	15	339	0	37	738
Beets	444	33	131	0	8	616
Env. Markets	230	38	121	0	0	389
Grand Total	87,963	30,664	68,318	10	14,253	201,210

The dataset in table-2 presents the usage of HHPs across various crops over five years (2018-2022), categorized into highly hazardous fungicides (HHFs), highly hazardous plant growth regulators (HH-PGRs), highly hazardous herbicides (HHHs), highly hazardous insecticides (HHIs), and highly hazardous others (HHOs) including highly hazardous seed dressings (HHSDs).

Vegetables and flowers show the highest average pesticide usage, with a total of 29,998 tonnes, comprising 18,011 tonnes of HHFs, 2,496 tonnes of HHHs, and 9,333 tonnes of HHIs. Soybeans follow with a total of 25,865 tonnes, including 12,846 tonnes of HHFs, 8,321 tonnes of HHHs, and 3,576 tonnes of HHIs. Wheat records a total of 24,099 tonnes, with significant contributions from HHFs (9,898 tonnes) and HHIs (5,218 tonnes), supplemented by 8,056 tonnes from other pes-

ticide categories. Rice shows a total of 16,938 tonnes, dominated by HHIs at 11,631 tonnes, followed by HHFs at 4,264 tonnes.

Cotton, another major crop, has a total pesticide usage of 15,141 tonnes, comprising 1,475 tonnes of HHFs, 2,144 tonnes of HHHs, 8,671 tonnes of HHIs, and 2,851 tonnes from other categories. On the lower end, environmental markets exhibit the least pesticide usage with a total of 389 tonnes, including 230 tonnes of HHFs and 121 tonnes of HHIs. Beets also show low usage with 616 tonnes in total, split among 444 tonnes of HHFs, 33 tonnes of HHHs, and 131 tonnes of HHIs. Cereals and forage crops similarly report minimal pesticide usage, with totals of 738 tonnes and 1,271 tonnes respectively. Barley records a modest usage of 1,857 tonnes, dominated by HHFs (1,591 tonnes) and minor contributions from other categories.

Comparison of Pesticide Usage in Cotton and Other Crops

Cotton’s reliance on HHIs is substantial amounting to 8,671 tonnes, which is notable but still less than rice’s 11,631 tonnes. In terms of HHFs, cotton’s usage of 1,475 tonnes is relatively low compared to vegetables and flowers (18,011 tonnes) and soybeans (12,846 tonnes). For HHHs, cotton uses 2,144

tonnes, which is less than soybeans (8,321 tonnes) but comparable to vegetables and flowers (2,496 tonnes). Overall, cotton’s pesticide usage pattern highlights a heavy dependence on HHIs, similar to rice, but with moderate usage of HHFs and HHHs compared to crops like vegetables, flowers, and soybeans.

Figure-1 Average annual usage (active ingredients in tonnes) of HHPs across various crops. Data represent the average of the five-year period from 2018 to 2022.

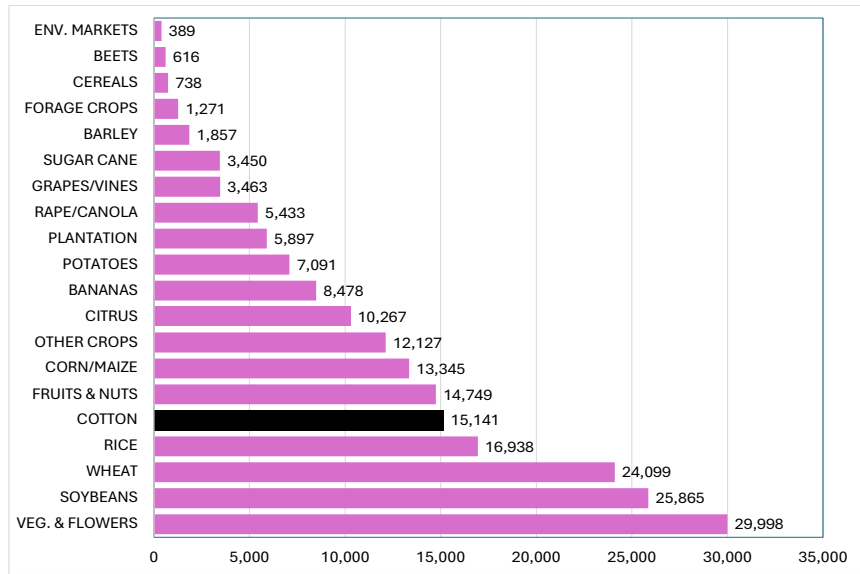
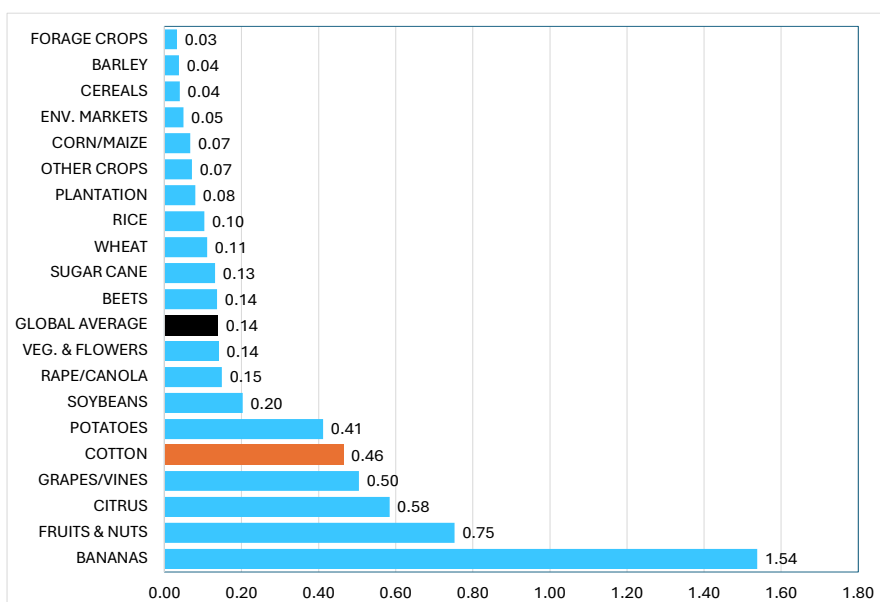


Figure-1 showcases the average usage of HHPs in active ingredients in tonnes across different crops over the five-year period from 2018 to 2022. Among the highlighted crops, vegetables and flowers emerged as the highest user with an annual average of 29,998 tonnes, followed by soybeans at 25,865 tonnes, wheat at 24,099 tonnes, rice at 16,938 tonnes, and cotton at 15,141 tonnes. Conversely, crops such as beets, environmental markets, and cereals exhibited notably low usage, with averages of 616 tonnes, 389 tonnes, and 738 tonnes, respectively. The grand total for all crops combined stood at 201,210 tonnes, indicating the cumulative usage of HHPs across various agricultural activities.

Table-3. Average annual usage of HHPs as kg/ha in various crops over five years (2018-2022)

CROPS	HHFs	HHHs	HHIs	HH-PGRS	HH-OTHERS	HHPs
Bananas	1.282	0.064	0.191	0.000	0.001	1.538
Fruits and Nuts	0.434	0.097	0.221	0.000	0.001	0.753
Citrus	0.276	0.072	0.237	0.000	0.000	0.584
Grapes/Vines	0.258	0.077	0.169	0.000	0.000	0.505
Cotton	0.045	0.066	0.266	0.000	0.087	0.465
Potatoes	0.296	0.019	0.094	0.000	0.002	0.411
Soybeans	0.101	0.065	0.028	0.000	0.009	0.203
Rapeseed/Canola	0.026	0.113	0.008	0.000	0.002	0.149
Vegetables and Flowers	0.085	0.012	0.044	0.000	0.001	0.141
Grand Total	0.061	0.021	0.047	0.000	0.010	0.139
Beets	0.098	0.007	0.029	0.000	0.002	0.136
Sugar Cane	0.008	0.012	0.111	0.000	0.000	0.131
Wheat	0.046	0.004	0.024	0.000	0.037	0.111
Rice	0.026	0.005	0.071	0.000	0.001	0.103
Plantation	0.021	0.008	0.051	0.000	0.000	0.080
Other Crops	0.021	0.025	0.024	0.000	0.002	0.071
Corn/maize	0.023	0.009	0.028	0.000	0.006	0.067
Environmental Markets	0.029	0.005	0.015	0.000	0.000	0.049
Cereals	0.019	0.001	0.018	0.000	0.002	0.040
Barley	0.032	0.003	0.001	0.000	0.001	0.038
Forage Crops	0.017	0.006	0.009	0.000	0.000	0.032

Figure-2. Average annual usage of HHPs as kg/ha in various crops over five years (2018-2022)

The dataset in table-3 and figure-2 presents the average annual usage of HHPs in kilograms per hectare (kg/ha) across various crops from 2018 to 2022.

Bananas exhibit the highest total pesticide usage at 1.538 kg/ha, predominantly using HHFs (1.282 kg/ha) and HHIs (0.191 kg/ha). Fruits and nuts follow with

a total of 0.753 kg/ha, comprising 0.434 kg/ha of HHFs and 0.221 kg/ha of HHIs. Citrus crops show a total usage of 0.584 kg/ha, with notable contributions from HHIs (0.237 kg/ha) and HHFs (0.276 kg/ha). Grapes and vines record a total of 0.505 kg/ha, dominated by HHFs (0.258 kg/ha) and HHIs (0.169 kg/ha).

Cotton, with a total HHP usage of 0.465 kg/ha, relies significantly on HHIs (0.266 kg/ha) and HHFs (0.045 kg/ha), along with 0.087 kg/ha from others. In contrast, several crops exhibit very low HHP usage. Forage crops have the lowest total usage at 0.032 kg/ha, with minimal contributions from HHs (0.006 kg/ha) and HHIs (0.009 kg/ha). Barley also shows low HHP usage, totaling 0.038 kg/ha, with negligible HH (0.003 kg/ha) and HHIs (0.001 kg/ha) applications. Environmental markets report a total of 0.049 kg/ha, primarily from HHFs (0.029 kg/ha) and HHIs (0.015 kg/ha).

Cereals and corn/maize reflect similarly low totals, with 0.040 kg/ha and 0.067 kg/ha respectively, indicating minimal dependency on HHPs.

Comparison of HHP Usage in Cotton and Other Crops

When comparing cotton's HHP usage with other crops (table-3), it is evident that cotton's reliance on HHIs (0.266 kg/ha) is significant but less than bananas (0.191 kg/ha) and fruits and nuts (0.221 kg/ha). Cotton's HHF usage (0.045 kg/ha) is relatively low compared to bananas (1.282 kg/ha) and fruits and nuts (0.434 kg/ha). In terms of HHs, cotton's us-

age of 0.066 kg/ha is modest, especially when compared to rapeseed/canola (0.113 kg/ha) and other crops like fruits and nuts (0.097 kg/ha). Overall, while cotton has a balanced but notable reliance on various types of pesticides, other crops like bananas and fruits and nuts show higher usage percentages, particularly in HHFs and HHIs.

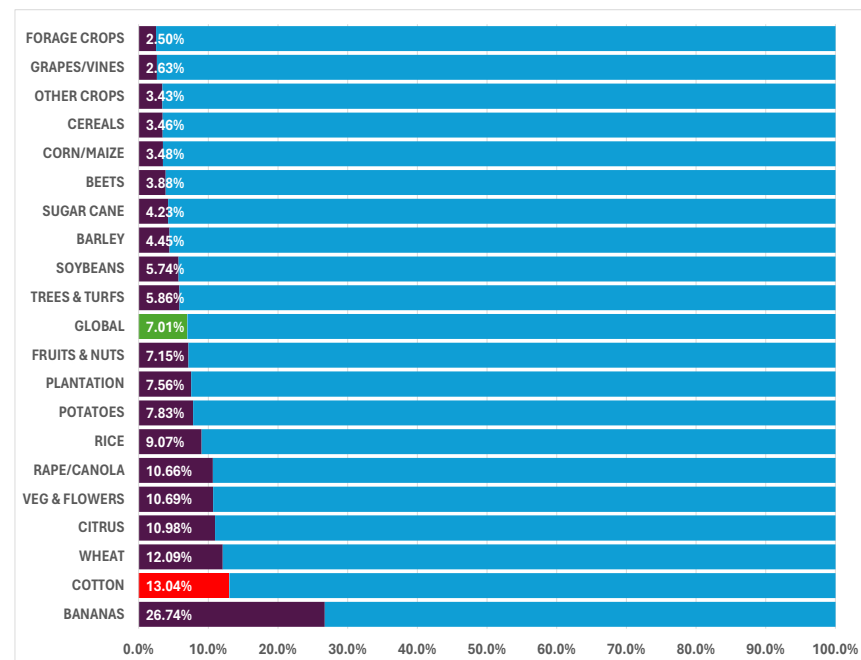
Figure-3. percentage share of HHPs within the total pesticide use on crops.

Figure-3 shows the percentage share of HHPs within the total pesticides used in a crop. Among the top five crops, bananas exhibit the highest percentage at 26.74%, followed by cotton (13.04%), wheat (12.09%), citrus (10.98%), and vegetables and flowers (10.69%).

Conversely, forage crops and grapes/vines show the lowest usage percentages at 2.50% and 2.63%, respectively. Notably, several crops like environmental markets, soybeans, and barley also have relatively low percentages, ranging from 4.45% to 5.86%.

Comparison of Cotton With Other Crops

Cotton, accounting for 13.04% of its total pesticide use, shows a significant share of HHPs. In contrast, bananas exhibit the highest proportion of HHPs at 26.74%, almost double that of cotton.

Additionally, the share in HHP usage in the total pesticide used in crops like wheat (12.09%), citrus (10.98%), and vegetables and flowers (10.69%) was also significant.

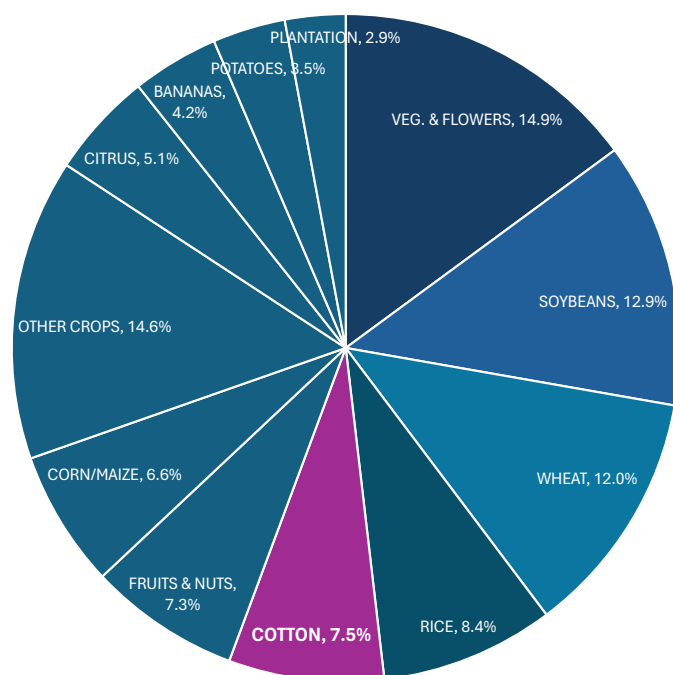
Figure-4. Global distribution of HHPs use across crops

Figure-4 showcases the percentage share of different crops in the overall global use of HHPs in agriculture over five years (2018-2022). Among the top five crops, vegetables and flowers account for the largest share at 14.91%, followed closely by soybeans at 12.85%, illustrating the significant use of HHPs in these sectors. Wheat and rice also hold substantial shares, contributing 11.98% and 8.42% respectively, to the global usage of HHPs. Cotton secures the fifth position with a notable 7.52% share. Conversely, crops such as barley, forage crops, cereals, beets, and environmental markets demonstrate minimal usage, collectively constituting less than 3% of the global HHP usage during the specified period.

Comparison of HHP Usage in Cotton and Other Crops

Cotton, with a 7.52% share, falls behind vegetables and flowers, soybeans, wheat, and rice in the global usage of HHPs. While it maintains a significant share, cotton's percentage is notably lower compared to the top four crops. This comparison highlights the varying degrees of dependence on HHPs across different agricultural sectors. While cotton remains an important crop in terms of HHP usage, its share indicates that other crops such as vegetables and flowers and soybeans rely more heavily on HHPs in global agricultural practices.

Table 4. Temporal trends in the usage of HHPs in agriculture (all crops) by cotton growing countries. Data represent the quantity of active ingredients in tonnes over a five-year period (2018-2022)

PESTICIDES	2018	2019	2020	2021	2022	Average
China	97,320	99,686	91,466	60,217	55,577	80853
Brazil	16,552	19,944	26,723	34,959	42,540	28143
USA	15,015	14,408	14,115	18,830	16,747	15823
India	14,558	12,224	11,563	10,981	9,698	11805
Mexico	7,030	7,272	6,036	5,800	5,966	6421
South-Africa	2,068	2,162	2,297	2,211	17,443	5236
Australia	4,255	2,379	2,530	1,849	1,984	2600
Colombia	1,892	2,402	2,474	2,523	2,154	2289
Russia	2,439	2,506	2,887	2,900	3,196	2786
Argentina	1,388	1,667	1,631	1,683	2,089	1692
Zimbabwe	2,086	2,472	1,056	1,250	946	1562
Pakistan	1,699	1,502	1,564	1,419	1,403	1517
Indonesia	2,240	2,074	1,600	1,397	1,229	1708
Bangladesh	701	701	701	777	778	732
Egypt	388	389	385	387	395	389
Israel	489	489	307	307	296	378
Turkey	423	452	342	289	247	351
Kazakhstan	188	299	368	242	214	262
Spain	349	374	220	40	0	197
Taiwan	448	419	0	0	0	173
Zambia	141	103	59	174	102	116
Mozambique	82	46	64	180	54	85

Table-4 shows that China stands out as the top consumer, with a notable decreasing trend in HHP use. The highest volume recorded in 2019 was 99,686 tonnes, which then sharply declined to 55,577 tonnes by 2022, averaging 80,853 tonnes over the period. Brazil follows China as the second-highest user of HHPs, with a consistent increase over the five years. Starting at 16,552 tonnes in 2018, Brazil's usage rose steadily to 42,540 tonnes by 2022, averaging 28,143 tonnes annually.

The USA shows relatively stable HHP use, with minor fluctuations. From 15,015 tonnes in 2018, the usage peaked slightly at 18,830 tonnes in 2021 before slightly decreasing to 16,747 tonnes in 2022, averaging 15,823 tonnes.

India, another significant user, displays a decreasing trend

similar to China. Starting at 14,558 tonnes in 2018, the usage steadily decreased to 9,698 tonnes by 2022, averaging 11,805 tonnes. This decline could be due to the recently imposed ban on a few HHPs by the regulatory agencies in India.

Mexico, while lower in total usage compared to the top four, shows a gradual decline in pesticide use. From 7,030 tonnes in 2018 to 5,966 tonnes in 2022, Mexico's average stands at 6,421 tonnes, indicating efforts towards reducing dependency on hazardous pesticides.

In contrast, several countries exhibit very low HHP usage. For instance, Ethiopia (19 tonnes annual average), Kenya (19 tonnes average), and Mali (19 tonnes average) are among the lowest, reflecting the use of less hazardous alternatives.

Table 5. Crop-wise usage of HHPs by cotton growing countries. Data represent the annual average quantity of active ingredients in tonnes for the five-year period (2018-2022). Categories such as Environmental markets, cereals, beets etc., have not been included in this table.

	CHINA	BRAZIL	USA	INDIA	MEXICO	SOUTH-AFRICA	RUSSIA	AUSTRALIA	COLOMBIA	OTHERS	TOTAL
SOYBEANS	1,194	15,631	6,759	289	73	102	37	0	13	734	24,832
VEG & FLOWERS	15,848	553	1,050	2,345	1,600	231	20	378	442	1,968	24,434
WHEAT	15,674	1,032	414	375	233	66	2,059	709	0	522	21,085
Cotton	6,240	3,827	1,869	2,405	31	12	0	29	7	719	15,140
RICE	10,205	62	100	2,655	13	0	4	0	218	1,127	14,384
CORN/MAIZE	5,356	3,919	1,235	182	435	521	2	0	56	580	12,287
FRUITS & NUTS	7,590	164	1,145	800	427	97	5	398	192	476	11,294
CITRUS	8,747	112	97	94	98	162	0	133	0	191	9,634
POTATOES	2,419	308	738	201	277	587	27	63	598	429	5,646
PLANTATION	1,593	438	3	148	231	5	0	0	133	1,849	4,399
SUGAR CANE	755	1,428	0	288	560	52	0	5	1	261	3,349
GRAPES/VINES	1,853	70	280	557	37	78	2	100	0	128	3,106
BANANAS	880	25	0	183	232	9	0	117	326	86	1,858
OTHERS	2,500	575	2,132	1,283	2,173	3,314	630	670	303	320	13,899
GRAND TOTAL	80,853	28,143	15,823	11,805	6,421	5,236	2,786	2,600	2,289	9,391	165,347

The dataset in table-5 on the usage of HHPs across various crops from different countries shows that China leads with a total usage of 80,853 tonnes, prominently in vegetables and flowers (15,848 tonnes), wheat (15,674 tonnes), and rice (10,205 tonnes).

Brazil follows with 28,143 tonnes, heavily invested in soybean cultivation (15,631 tonnes) and significant usage in cotton (3,827 tonnes) and corn/maize (3,919 tonnes).

The USA records 15,823 tonnes, with soybeans (6,759 tonnes) and vegetables and flowers (1,050 tonnes) being the major recipients.

India's HHP application totals 11,805 tonnes, with notable usage in rice (2,655 tonnes) and cotton (2,405 tonnes).

Mexico and South Africa show varied usage, focusing on vegetables and flowers, and potatoes respectively. Russia, Australia, and Colombia have comparatively lower totals,

with Russia's significant application on wheat (2,059 tonnes) and Colombia on potatoes (598 tonnes).

Cotton, with an HHP usage of 15,140 tonnes globally, ranks lower compared to soybeans (24,832 tonnes) and vegetables and flowers (24,434 tonnes).

However, it surpasses other crops like rice (14,384 tonnes) and corn/maize (12,287 tonnes), indicating its significant but not dominant role in global HHP application relative to other major crops.

Notably, the distribution of HHP use highlights China's extensive agricultural practices, particularly in high-value crops, while Brazil's focus on soybeans underscores its role as a major global producer.

The diversity in HHP use across countries and crops underscores the complexity of managing agricultural sustainability and safety.

Table 6. Temporal trends in the usage of HHPs in cotton. Data represent the quantity of active ingredients in tonnes over a five-year period (2018-2022)

Countries	2018	2019	2020	2021	2022	Average
China	9,803	10,009	10,179	631	577	6,240
Brazil	2,389	3,633	4,021	4,078	5,013	3,827
India	2,334	2,391	2,753	2,389	2,160	2,405
USA	1,571	2,096	1,989	2,058	1,632	1,869
Pakistan	430	608	755	528	545	573
Zimbabwe	51	51	62	57	10	46
Mexico	19	20	0	58	57	31
Australia	57	17	17	44	9	29
Argentina	23	23	23	32	36	27
Mali	0	43	16	7	27	19
Burkina Faso	0	0	0	19	22	8
Egypt	20	20	21	21	8	18
Togo	0	0	0	15	14	6
Israel	16	16	11	11	8	12
South-Africa	16	16	19	6	4	12
Colombia	5	5	6	8	13	7
Turkey	12	5	6	3	3	6
Zambia	2	0	0	0	0	0
Spain	0	6	2	0	0	2
Greece	3	1	1	1	1	1
Kazakhstan	2	0	0	0	0	1
Mozambique	1	0	0	0	0	0
Benin	0	0	0	0	0	0
Grand Total	16,754	18,962	19,880	9,966	10,140	15,140

Table-6 shows that China leads significantly, with its usage of HHPs in cotton cultivation peaking at 10,179 tonnes in 2020 but dramatically dropping to 631 tonnes in 2021 and 577 tonnes in 2022.

The average annual usage over the five years stands at 6,240 tonnes, indicating a substantial reduction in recent years.

Brazil follows, with a consistent increase from 2,389 tonnes in 2018 to 5,013 tonnes in 2022, averaging 3,827 tonnes annually. This steady rise suggests an ongoing reliance on HHPs in Brazil's cotton sector.

India maintains relatively stable usage, starting at 2,334 tonnes in 2018 and peaking at 2,753 tonnes in 2020, with an average of 2,405 tonnes per year.

The USA's usage fluctuates, peaking at 2,096 tonnes in 2019 and averaging 1,869 tonnes annually, showing some variation but no clear upward or downward trend.

Pakistan, though using significantly less than the top four,

shows a gradual increase from 430 tonnes in 2018 to 755 tonnes in 2020, averaging 573 tonnes annually.

Countries with very low usage of HHPs in cotton include Zimbabwe, which starts at 51 tonnes in 2018 and drops to 10 tonnes in 2022, averaging 46 tonnes annually, and Mexico, with usage peaking at 58 tonnes in 2021 but zero in 2020, averaging 31 tonnes.

Other countries like Australia, Argentina, and Israel show minimal and relatively stable usage, each averaging below 30 tonnes annually.

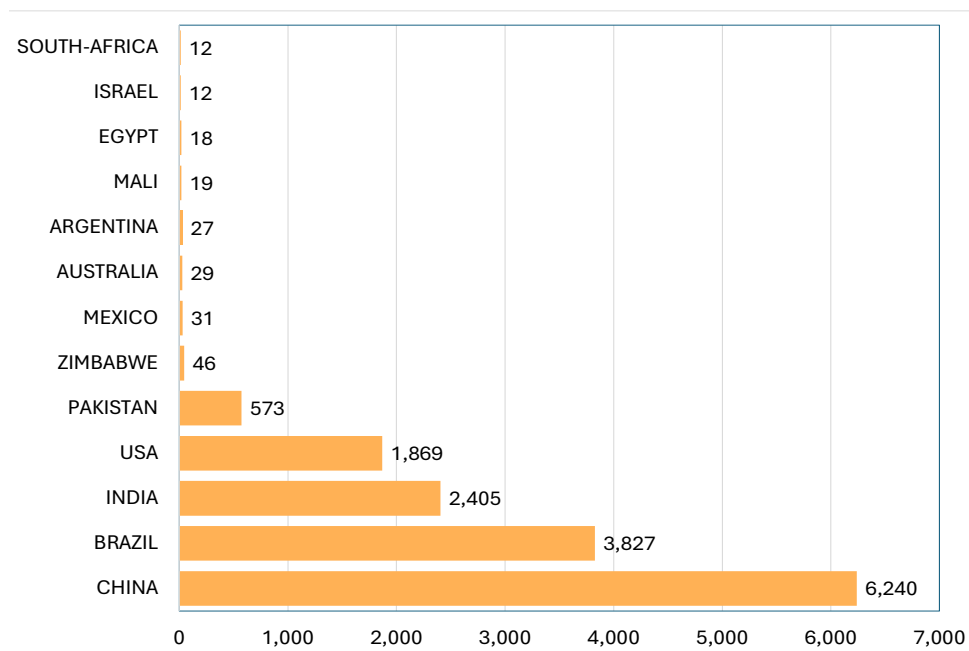
In regions like Africa, countries such as Mali and Burkina Faso report very low average usage.

Overall, the data indicates diverse trends in HHP pesticide use in cotton cultivation, with some countries reducing their usage significantly, while others show steady or increasing reliance, reflecting varied agricultural practices, pest pressures, and regulatory environments.

Table-7. Utilization of HHPs on cotton across countries. Data represent average of five years (2018-2022) of active ingredients in tonnes.

Countries	HHFs	HHHs	HHIs	HH-PGRS & OTHERS	HHPs
China	214	199	2,987	2,840	6,240
Brazil	968	524	2,327	7	3,827
India	264	72	2,066	3	2,405
USA	0	1,287	583	0	1,869
Pakistan	0	0	573	0	573
Zimbabwe	0	19	27	0	46
Mexico	5	0	26	0	31
Australia	20	0	8	0	29
Argentina	0	0	27	0	27
Mali	0	18	1	0	19
Egypt	0	0	18	0	18
Israel	0	0	12	0	12
South-Africa	0	0	12	0	12
Burkina-Faso	0	8	0	0	8
Colombia	3	4	1	0	7
Togo	0	6	0	0	6
Turkey	0	5	1	0	6
Spain	0	0	2	0	2
Greece	0	1	0	0	1
Grand Total	1,475	2,143	8,671	2,851	15,140

Figure-5. Usage of HHPs on cotton across countries. Data represent average of five years (2018-2022) of active ingredients in tonnes.



The data provided in Table-7 and figure-5 illustrates the average use of various types of HHPs, including HHFs, HHHs, HHIs, HH-SDCs, and the total amount of HHPs in active ingredients in tonnes, employed by different countries over a five-year period (2018-2022).

Among the top five countries, China exhibits the highest utilization of HHPs, with a total of 6,240 tonnes, primarily driven by substantial usage of HHIs and HHHs.

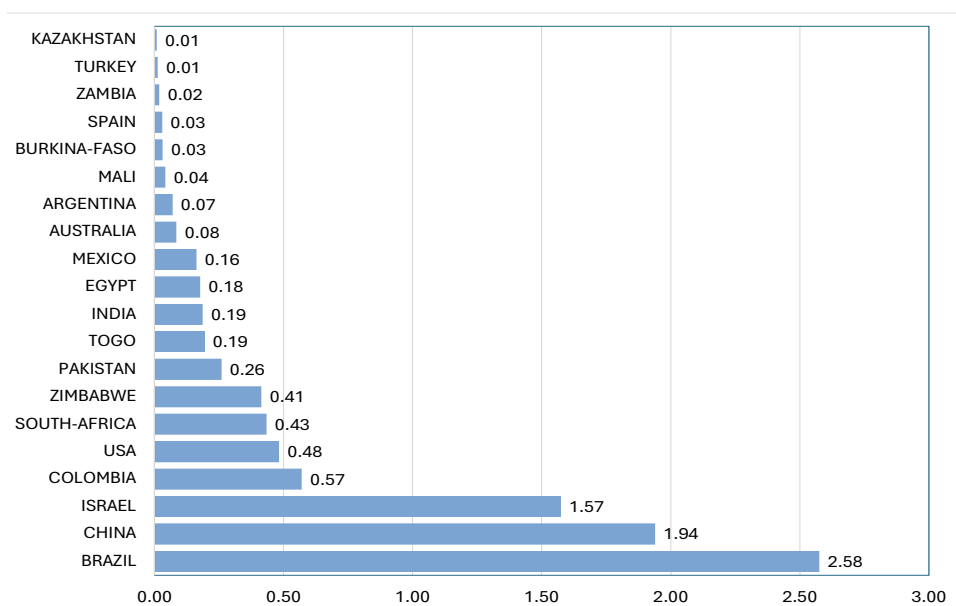
Brazil follows closely, with 3,827 tonnes, with significant contributions from HHFs and HHHs. India ranks third, utilizing 2,405 tonnes, predominantly due to HHIs and HHF application.

The USA and Pakistan show lower usage, with 1,869 and 573 tonnes, respectively, primarily attributed to HHHs and HHIs.

Conversely, countries like Zambia, Mozambique, Benin, and Kazakhstan exhibit negligible or zero usage of HHPs during the specified period. These findings underscore the observation that merely five countries (China, Brazil, USA, India and Pakistan) contribute to 98.5% of the overall usage of HHPs in cotton cultivation.

Table-8. Utilization of HHPs kg per hectare on cotton across countries.

Countries	HHFs	HHHs	HHIs	HH-PGRS & OTHERS	PESTICIDES
Brazil	0.65	0.35	1.57	0.00	2.58
China	0.07	0.06	0.93	0.88	1.94
Israel	0.00	0.01	1.56	0.00	1.57
Colombia	0.22	0.29	0.05	0.00	0.57
USA	0.00	0.33	0.15	0.00	0.48
South-Africa	0.00	0.00	0.43	0.00	0.43
Zimbabwe	0.00	0.17	0.24	0.00	0.41
Pakistan	0.00	0.00	0.26	0.00	0.26
Togo	0.00	0.19	0.00	0.00	0.19
India	0.02	0.01	0.16	0.00	0.19
Egypt	0.00	0.00	0.18	0.00	0.18
Mexico	0.03	0.00	0.14	0.00	0.16
Australia	0.06	0.00	0.02	0.00	0.08
Argentina	0.00	0.00	0.07	0.00	0.07
Mali	0.00	0.04	0.00	0.00	0.04
Burkina-Faso	0.00	0.03	0.00	0.00	0.03
Spain	0.00	0.00	0.03	0.00	0.03
Zambia	0.00	0.02	0.00	0.00	0.02
Turkey	0.00	0.01	0.00	0.00	0.01
Kazakhstan	0.00	0.00	0.01	0.00	0.01
Grand Total	0.06	0.08	0.33	0.11	0.57

Figure-6. Usage of HHPs on cotton across countries. Data represent average of five years (2018-2022) of active ingredients in kg/ha.

Data in table-8 and figure-6 shows that Brazil leads in the usage of HHPs per hectare, with a total of 2.58 kg/ha, primarily driven by the significant application of HHHs and HHIs. China follows closely with 1.94 kg/ha, showing substantial usage of HHIs and HHHs. Israel ranks third, utilizing 1.57 kg/ha, largely attributed to HHIs application.

Colombia and the USA exhibit relatively lower but noteworthy usage, with 0.57 kg/ha and 0.48 kg/ha, respectively.

Conversely, several countries such as Greece, Mozambique, Benin, and Kazakhstan, among others, show minimal or zero usage of HHPs per hectare during the specified period, highlighting the significant variations in the types of HHPs used globally.

The data also reveals a notable disparity in pesticide application rates across different countries.

For instance, South Africa, Zimbabwe, and Pakistan each demonstrate moderate HHP use, predominantly through insecticides, with rates just under 0.5 kg/ha. In contrast, countries like Togo, India, and Egypt have similarly low HHP usage, primarily due to their restrained application of herbicides and insecticides. across the globe.

HIGHLY HAZARDOUS FUNGICIDES (HHFs)

Table 9. Temporal trends in the usage of highly hazardous fungicides (HHFs) in agriculture (all crops) by cotton growing countries. Data represent the quantity of active ingredients in tonnes over a five-year period (2018-2022)

Crops	2018	2019	2020	2021	2022	Average
Vegetables and Flowers	16,453	19,665	15,508	19,422	19,007	18,011
Soybeans	5,798	7,321	12,199	17,222	21,687	12,846
Wheat	10,630	12,654	9,326	8,622	8,256	9,898
Fruits and Nuts	7,000	7,846	6,451	10,368	10,869	8,507
Bananas	6,272	6,855	7,053	7,757	7,402	7,068
Potatoes	7,319	7,076	6,040	2,609	2,446	5,098
Citrus	6,001	7,075	4,822	3,736	2,593	4,845
Corn/maize	4,034	5,103	5,536	4,777	3,743	4,638
Rice	3,806	3,644	3,442	5,317	5,110	4,264
Other Crops	3,249	3,290	3,859	3,900	3,510	3,562
Grapes/Vines	2,412	2,292	1,924	1,207	1,023	1,772
Barley	1,954	2,416	1,881	930	772	1,591
Plantation	1,291	1,760	1,407	1,616	1,607	1,536
Cotton	804	1,255	1,688	1,644	1,984	1,475
Rapeseed/Canola	1,039	1,124	825	843	870	940
Forage Crops	691	648	630	690	692	670
Beets	465	497	466	480	313	444
Cereals	287	431	334	445	242	348
Environmental Markets	209	226	246	233	235	230
Sugar Cane	66	116	129	366	429	221
Grand Total	79,780	91,296	83,766	92,184	92,791	87,963

The dataset in Table-9 presents the annual usage of HHFs in active ingredients, measured in tonnes, across various crops from 2018 to 2022.

The highest usage is observed in vegetables and flowers, which consistently demonstrate the greatest dependency on HHFs, peaking at 19,665 tonnes in 2019 and averaging 18,011 tonnes annually.

Soybeans follow a significant upward trend, increasing from 5,798 tonnes in 2018 to a peak of 21,687 tonnes in 2022, with an average of 12,846 tonnes.

Wheat also shows substantial usage, although with a slight decline towards the end of the period, averaging 9,898 tonnes annually.

Fruits and nuts maintain high HHF usage, with an average of 8,507 tonnes, peaking at 10,869 tonnes in 2022.

Bananas, another high-usage crop, display a steady usage pattern, averaging 7,068 tonnes, with a notable peak of 7,757

tonnes in 2021.

In contrast, several crops exhibit much lower usage of HHFs. Sugarcane shows minimal usage, averaging only 221 tonnes annually, despite a small peak of 429 tonnes in 2022.

Cereals also reflect low usage, with an average of 348 tonnes and a peak of 445 tonnes in 2021.

Beets, with an average usage of 444 tonnes, and environmental markets, with 230 tonnes, both show minimal reliance on HHFs.

Forage crops have an average usage of 670 tonnes, indicating limited dependency on these chemicals.

These trends highlight the variability in HHF application across different agricultural sectors, with certain crops like vegetables and flowers, soybeans, and wheat heavily relying on HHFs, while others like sugar cane, cereals, and environmental markets (trees and turf) use them minimally.

Figure-7. Average annual usage (active ingredients in tonnes) of HHFs across various crops. Data represent the average of the five-year period from 2018 to 2022.

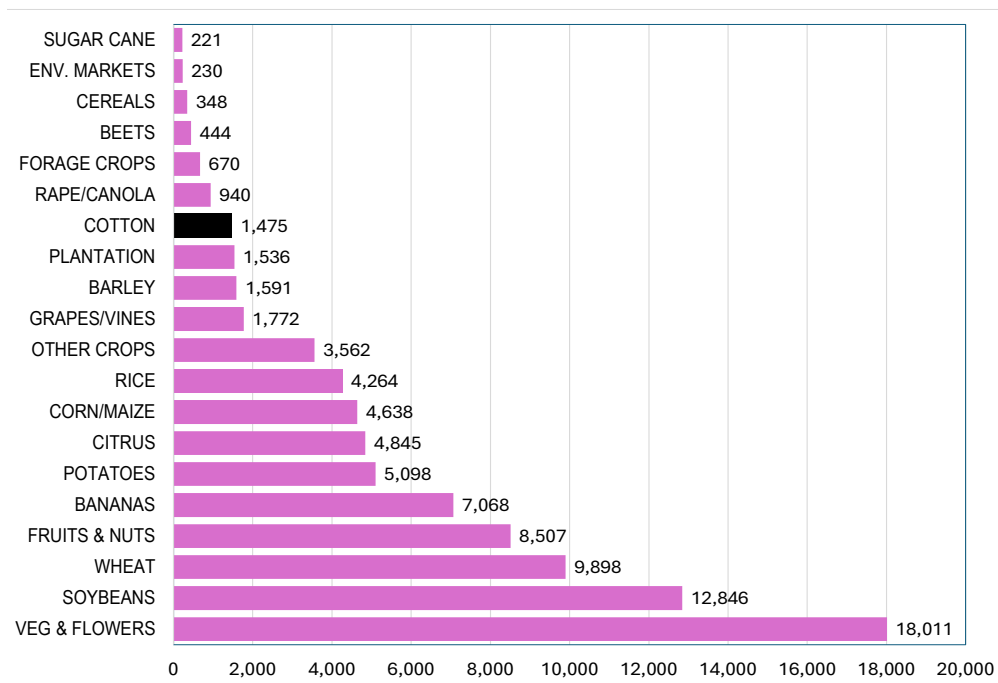


Figure 7. shows that among the top five crops, vegetables and flowers exhibit the highest usage with an average of 18,011 tonnes, followed by soybeans (12,846 tonnes), wheat (9,898 tonnes), fruits and nuts (8,507 tonnes), and bananas (7,068 tonnes). Conversely, crops such as barley, plantation, cotton, rapeseed/canola, and forage

crops demonstrate relatively lower usage, with quantities ranging from 940 to 1,591 tonnes on average. These findings highlight the significant reliance on HHFs in crops like vegetables and flowers and soybeans.

Comparison of Cotton with Other Crops

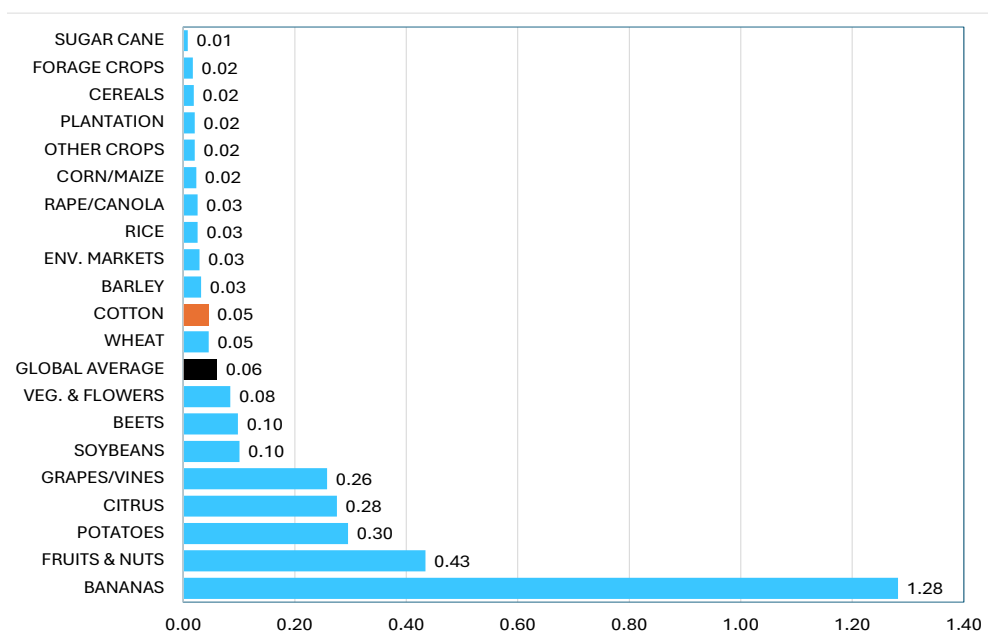
When comparing HHF usage in cotton with other crops, cotton shows a moderate level of dependency.

Cotton averages 1,475 tonnes of HHF use annually, with a noticeable increase from 804 tonnes in 2018 to 1,984 tonnes in 2022.

This is significantly lower than crops like vegetables and flowers (18,011 tonnes), soybeans (12,846 tonnes), and wheat (9,898 tonnes).

However, it is higher than crops like rapeseed/canola (940 tonnes) and forage crops (670 tonnes).

Figure-8. Average annual usage of HHFs as kg/ha in various crops over five years (2018-2022).



The data in figure-8 presents the kilograms per hectare (kg/ha) of HHFs utilized across various crops over a five-year period (2018-2022). Among the top five crops with the highest HHF usage are bananas (1.28 kg/ha), fruits and nuts (0.43 kg/ha), potatoes (0.30 kg/ha), citrus (0.28 kg/ha), and grapes/vines (0.26 kg/ha). These crops typically require intensive fungal disease management due to their susceptibility. Conversely, crops like

corn/maize, other crops, plantation, cereals, and forage crops exhibit notably low usage of HHFs, each registering 0.02 kg/ha, indicating potentially lesser vulnerability to fungal diseases or alternative management practices.

Comparison of Cotton with Other Crops

Cotton, with a HHF usage of 0.05 kg/ha, demonstrates a relatively moderate level of HHF application compared to crops like bananas, fruits and nuts, potatoes, citrus, and grapes/vines, which exhibit higher percentages. This suggests a relatively lower dependency on HHFs for disease management in cotton cultivation. However, despite its moderate usage, cotton remains a significant crop in terms of total HHFs applied due to its large cultivation area, warranting continued attention towards sustainable disease management strategies.

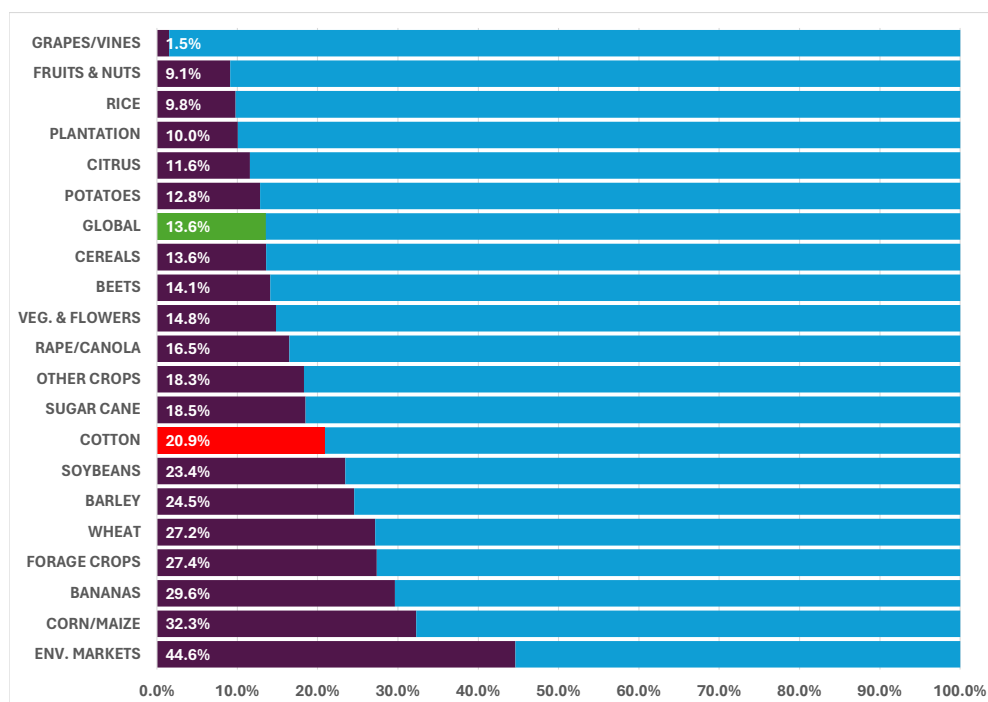
Figure-9: Proportion of HHFs in the total fungicides used in each Crop (2018-2022).

The data presents the proportion of HHFs within the total fungicides used in various crops over the span of five years (2018-2022).

The percentage share of HHFs within crop use is as follows: environmental markets lead with 44.61%, followed by corn/maize at 32.27%, bananas at 29.63%, forage crops at 27.39%, and wheat at 27.15%.

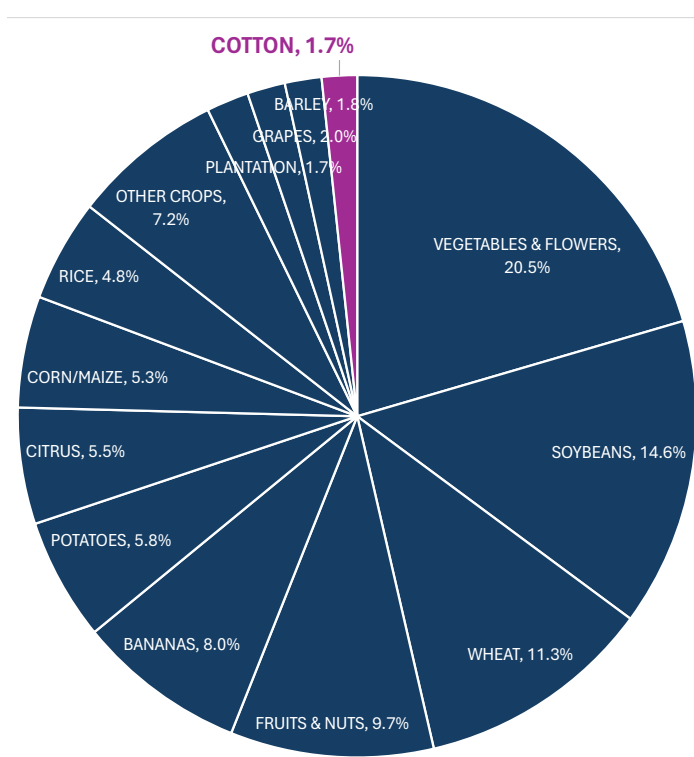
Notably, these top five crops exhibit relatively higher utilization of HHFs compared to others.

Additionally, significant proportions of HHFs are observed in barley (24.54%), soybeans (23.43%), and cotton (20.93%), while crops like grapes/vines demonstrate the least reliance on HHFs at 1.53% within the total fungicide usage.



Comparison of Cotton with Other Crops: In comparison to cotton, which accounts for 20.93% of HHFs within its total fungicide use, several other crops exhibit a notably higher re-

liance on HHFs. For instance, environmental markets, corn/maize, bananas, forage crops, and wheat all surpass cotton in their usage of HHFs.

Figure-10. Global distribution of HHFs use across crops

The data in figure-10 reveals the percentage share of different crops in the overall global use of HHFs.

Among the top five crops, vegetables and flowers dominate the usage, accounting for a significant 20.48%.

Soybeans follow closely with a share of 14.60%, indicating substantial reliance on HHFs in soybean cultivation.

Wheat and fruits and nuts also exhibit notable shares at 11.25% and 9.67% respectively, reflecting the reliance on HHFs in protecting these crops from fungal diseases.

Bananas secure the fifth position with 8.04% share, highlighting the significant use of HHFs in banana cultivation.

Conversely, crops such as cereals, environmental markets, and sugarcane demonstrate minimal usage, collectively constituting less than 1% of the global HHF usage during the specified period.

Comparison of Cotton with Other Crops

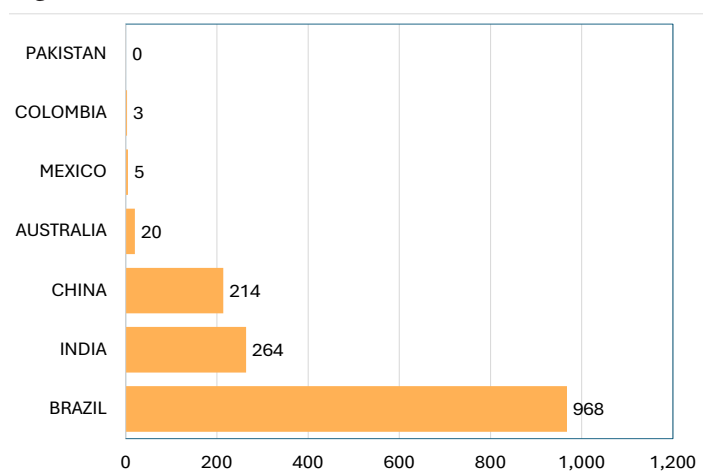
Cotton, with a mere 1.68% share, falls behind several other crops in the global usage of HHFs.

While it maintains a share, cotton's percentage is notably lower compared to top crops like vegetables and flowers, soybeans, wheat, and fruits and nuts, signifying a lesser dependence on HHFs in cotton cultivation.

Table-10. Temporal trends in the usage of HHFs in cotton. Data represent the quantity of active ingredients in tonnes over a five-year period (2018-2022).

Countries	2018	2019	2020	2021	2022	Average
Brazil	227	691	1,047	1,244	1,629	968
India	208	230	308	308	268	264
China	299	301	313	78	79	214
Australia	55	17	17	9	4	20
Mexico	12	13	0	0	0	5
Colombia	3	3	3	2	3	3
Pakistan	0	0	0	1	1	0
Grand Total	804	1,254	1,688	1,643	1,984	1,475

Figure-11. Usage of HHFs on cotton across countries. data represent average of five years (2018-2022) of active ingredients in tonnes.



Data presented in Table-10 and figure-11 on the global use of HHFs in cotton cultivation shows that Brazil had the most notable increase, with HHF volumes rising from 227 tonnes in 2018 to 1,629 tonnes in 2022, averaging 968 tonnes annually.

This upward trend underscores a significant escalation in HHF use in Brazil's cotton farming over the five years.

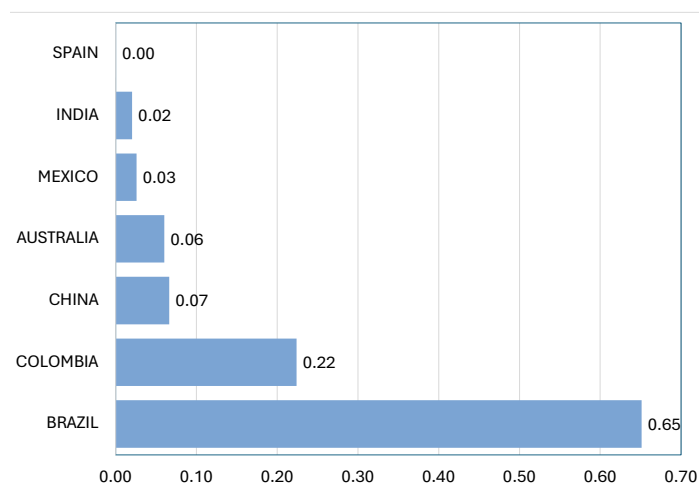
India follows, maintaining relatively stable usage, starting at 208 tonnes in 2018 and peaking at 308 tonnes in 2020 and 2021, with an average of 264 tonnes annually.

China, on the other hand, shows a decline, starting with 299 tonnes in 2018 and dropping to 79 tonnes by 2022, averaging 214 tonnes per year. This indicates a substantial reduction in HHF application over the observed period.

Australia's use of HHFs in cotton is low and decreasing, from 55 tonnes in 2018 to just 4 tonnes in 2022, averaging 20 tonnes annually. This trend highlights a significant reduction in reliance on these chemicals.

Mexico, Colombia, and Pakistan have very low HHF usage. Mexico starts with 12 tonnes in 2018 and drops to zero by 2020, averaging just 5 tonnes annually.

Figure-12. Average annual usage of HHFs as kg/ha on cotton over five years (2018-2022)



The data in figure-12 on HHF application rates (HHF-kg/ha) highlights Brazil as the highest user at 0.65 kg/ha, followed by Colombia at 0.22 kg/ha. China and Australia follow with 0.07 and 0.06 kg/ha, respectively. Many countries, including the USA, South Africa, and Israel, report negligible or zero HHF usage. The overall global average application rate is 0.06 kg/ha.

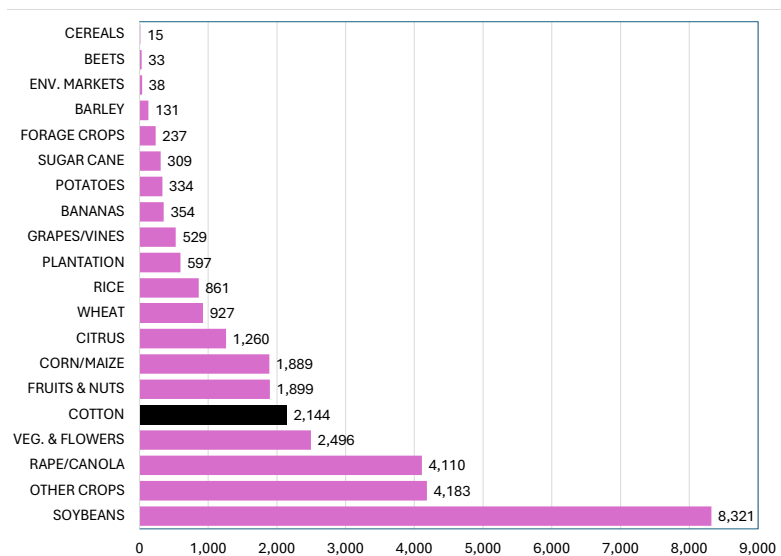


HIGHLY HAZARDOUS HERBICIDES (HHHs)

Table 11. Temporal trends in the usage of highly hazardous herbicides (HHHs) in agriculture (all crops) by cotton growing countries. Data represent the quantity of active ingredients in tonnes over a five-year period (2018-2022)

Crops	2018	2019	2020	2021	2022	Average
Vegetables and Flowers	16,453	19,665	15,508	19,422	19,007	18,011
Soybeans	5,798	7,321	12,199	17,222	21,687	12,846
Wheat	10,630	12,654	9,326	8,622	8,256	9,898
Fruits and Nuts	7,000	7,846	6,451	10,368	10,869	8,507
Bananas	6,272	6,855	7,053	7,757	7,402	7,068
Potatoes	7,319	7,076	6,040	2,609	2,446	5,098
Citrus	6,001	7,075	4,822	3,736	2,593	4,845
Corn/maize	4,034	5,103	5,536	4,777	3,743	4,638
Rice	3,806	3,644	3,442	5,317	5,110	4,264
Other Crops	3,249	3,290	3,859	3,900	3,510	3,562
Grapes/Vines	2,412	2,292	1,924	1,207	1,023	1,772
Barley	1,954	2,416	1,881	930	772	1,591
Plantation	1,291	1,760	1,407	1,616	1,607	1,536
Cotton	804	1,255	1,688	1,644	1,984	1,475
Rapeseed/Canola	1,039	1,124	825	843	870	940
Forage Crops	691	648	630	690	692	670
Beets	465	497	466	480	313	444
Cereals	287	431	334	445	242	348
Environmental Markets	209	226	246	233	235	230
Sugar Cane	66	116	129	366	429	221
Grand Total	79,780	91,296	83,766	92,184	92,791	87,963

Figure-13 Average annual usage (active ingredients in tonnes) of HHHs across various crops. Data represent the average of the five-year period from 2018 to 2022.



diverse application trends. Soybeans emerge as the leading crop, with an average usage of 8,321 tonnes, followed by other crops (4,183 tonnes), rapeseed/canola (4,110 tonnes), and vegetables and flowers (2,496 tonnes). While cotton ranks fifth with an average usage of 2,144 tonnes, it exhibits lower reliance compared to soybeans and several other crops. Fruits and nuts, corn/maize, citrus, wheat, and rice also demonstrate moderate to low usage, ranging from 861 to 1,899 tonnes on average. Conversely, crops such as barley, environmental markets, beets, and cereals display minimal utilization, with quantities ranging from 15 to 131 tonnes on average.

Comparison of Cotton with Other Crops

While cotton ranks fifth in the utilization of HHHs, its average usage of 2,144 tonnes is notably lower compared to soybeans, which top the list with 8,321 tonnes. Other crops such as rapeseed/canola, vegetables and flowers, and other crops also demonstrate higher HHH usage compared to cotton.

The average quantities of HHHs used in various crops over a five-year period (2018-2022) presented in table-8 and Figure-13 illustrate

Figure-14. Average annual usage of HHHs as kg/ha in various crops over five years (2018-2022).

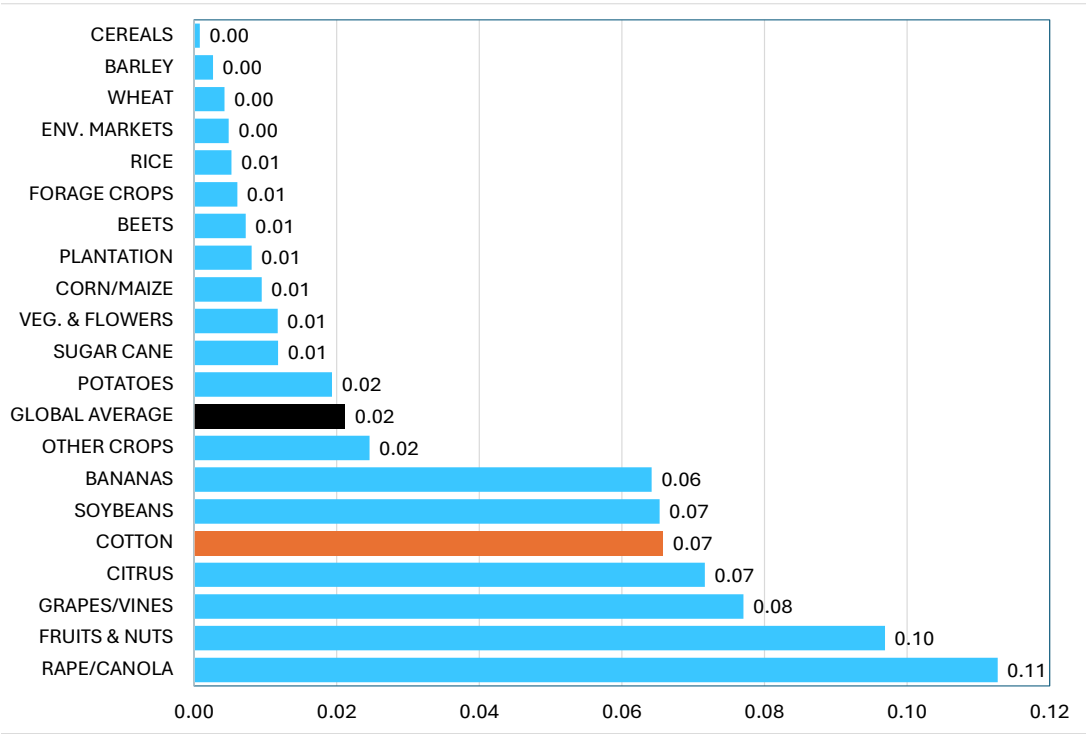


Figure-14 presents the average application rate of HHHs in kilograms per hectare (kg/ha) across various crops over a five-year period (2018-2022).

Notably, rapeseed/canola leads in HHPs usage with 0.11 kg/ha, followed closely by fruits and nuts (0.10 kg/ha), grapes/vines (0.08 kg/ha) and citrus (0.07 kg/ha).

Comparison of Cotton with Other Crops

In terms of HHH usage, cotton registers a comparable level of application (0.07 kg/ha) to crops like grapes/vines, citrus, and soybeans.

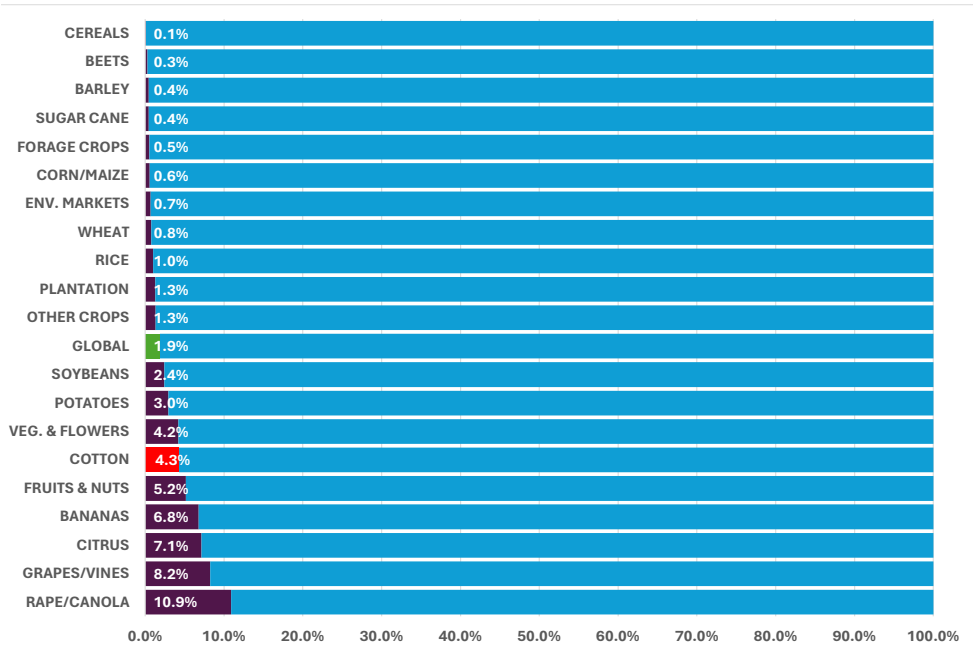
However, crops like rapeseed/canola and fruits and nuts demonstrate relatively higher usage of highly hazardous herbicides, suggesting a greater reliance on HHHs for weed management in these crops compared to cotton.

Figure-15. Proportion of HHHs in the total herbicides used in each individual crop over five years from 2018 to 2022.

The data in figure-15 highlights the percentage share of HHHs within the total herbicide usage across different crops. Rapeseed/canola leads in HHH utilization at 10.89%, followed by grapes/vines at 8.23%, citrus at 7.12%, bananas at

6.76%, and fruits and nuts at 5.16%. Interestingly, these top five crops exhibit a relatively higher reliance on HHHs compared to others.

Notably, crops like cotton (4.29%), vegetables and flowers



also demonstrate considerable proportions of HHH use. Conversely, cereals, barley, sugar cane, and forage crops exhibit minimal usage, with percentages below 1%.

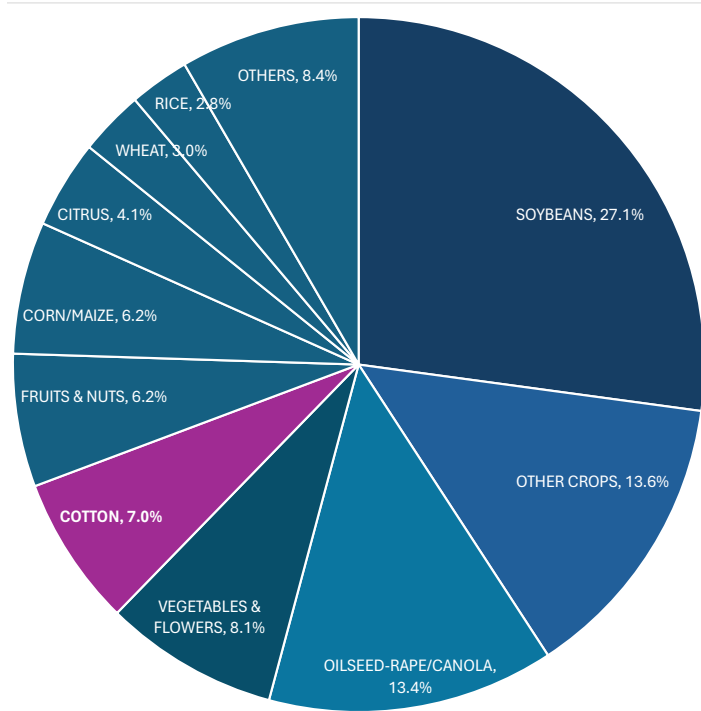
Comparison of Cotton with Other Crops

In comparison to cotton, which registers 4.29% of HHHs within its total herbicide usage, several other crops, including rapeseed/canola, grapes/vines, citrus, bananas, fruits and nuts, showcase notably higher reliance on HHHs.

This discrepancy emphasizes the necessity for tailored approaches to mitigate the usage of highly hazardous substances in cotton and other crops.

Figure-16: Global distribution of highly hazardous herbicide (HHH) use across crops

The data presented in figure-16 illustrates the percentage distribution of different crops in the overall global use of HHHs. Soybeans emerge as the leading crop in terms of HHH usage,



constituting a substantial 27.13% of the global share. Other crops collectively contribute 13.64%, highlighting a significant reliance on HHHs across various agricultural sectors beyond the major crops listed.

Rapeseed/canola follows closely with a share of 13.40%, underscoring the reliance on HHHs in the cultivation of oil-seed crops. Vegetables and flowers and cotton secure notable shares at 8.14% and 6.99% respectively, indicating significant usage in these sectors. Fruits and nuts and corn/maize also exhibit considerable shares, reflecting the widespread use of HHHs in these crop categories.

Conversely, crops such as cereals, environmental markets, and beets demonstrate minimal usage, collectively accounting for less than 1% of the global HHH usage during the specified period.

Comparison of Cotton with Other Crops

Cotton's share of 6.99% in the global usage of HHHs places it among the top crops reliant on HHHs.

However, it falls behind leading crops like soybeans and rapeseed/canola, indicating a lesser dependence on HHHs in cotton cultivation compared to these crops.

This comparison highlights variations in HHH usage across different agricultural sectors, with certain crops exhibiting higher reliance on HHHs for weed control compared to others.

Table 12. Temporal trends in the usage of HHHs in cotton. Data represent the quantity of active ingredients in tonnes over a five-year period (2018-2022)

Countries	2018	2019	2020	2021	2022	Average
USA	1,096	1,537	1,498	1,427	875	1,287
Brazil	534	663	479	405	541	524
China	293	305	305	49	42	199
India	8	43	95	89	126	72
Mali	0	43	14	5	27	18
Burkina Faso	0	0	0	17	22	8
Zimbabwe	19	19	23	25	10	19
Togo	0	0	0	15	14	6
Turkey	7	4	6	3	3	5
Colombia	2	2	2	3	9	4
Zambia	2	0	0	0	0	0
Australia	0	0	0	0	2	0
Greece	2	0	1	1	1	1
Spain	0	1	0	0	0	0
Grand Total	1,962	2,618	2,423	2,040	1,673	2,143

Data presented in table-12 and figure-17 on the global use of HHHs in cotton cultivation shows that the United States

leads in usage, with HHH volumes peaking at 1,537 tonnes in 2019 and then fluctuating, averaging 1,287 tonnes annually.

Figure-17. Usage of HHHs on cotton across countries. Data represent average of five years (2018-2022) of active ingredients in Tonnes.

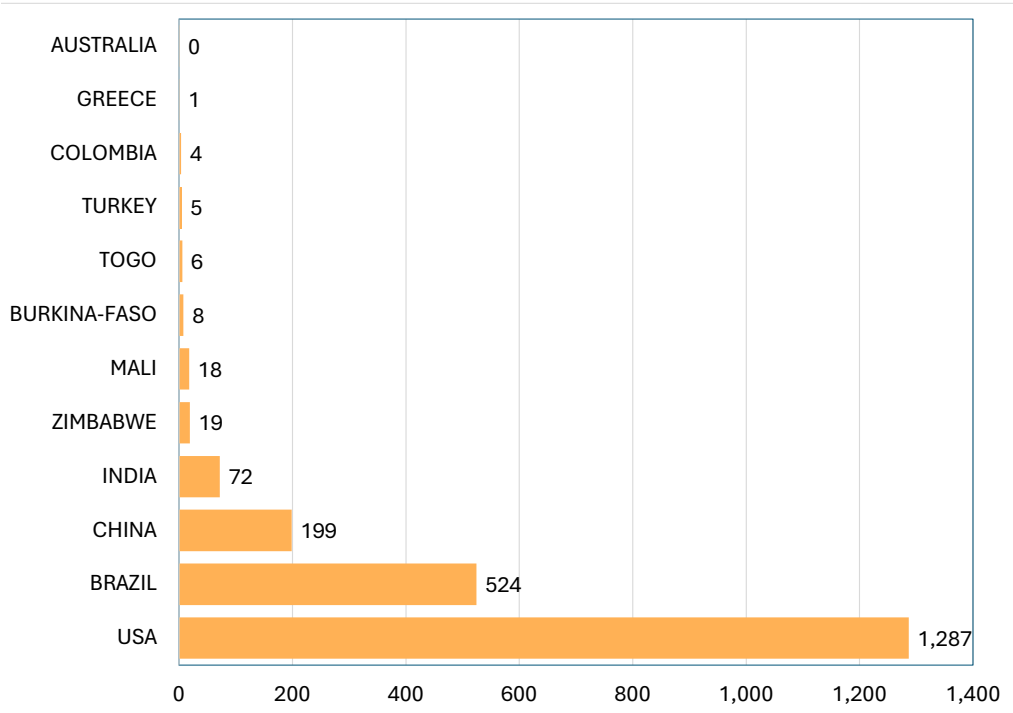


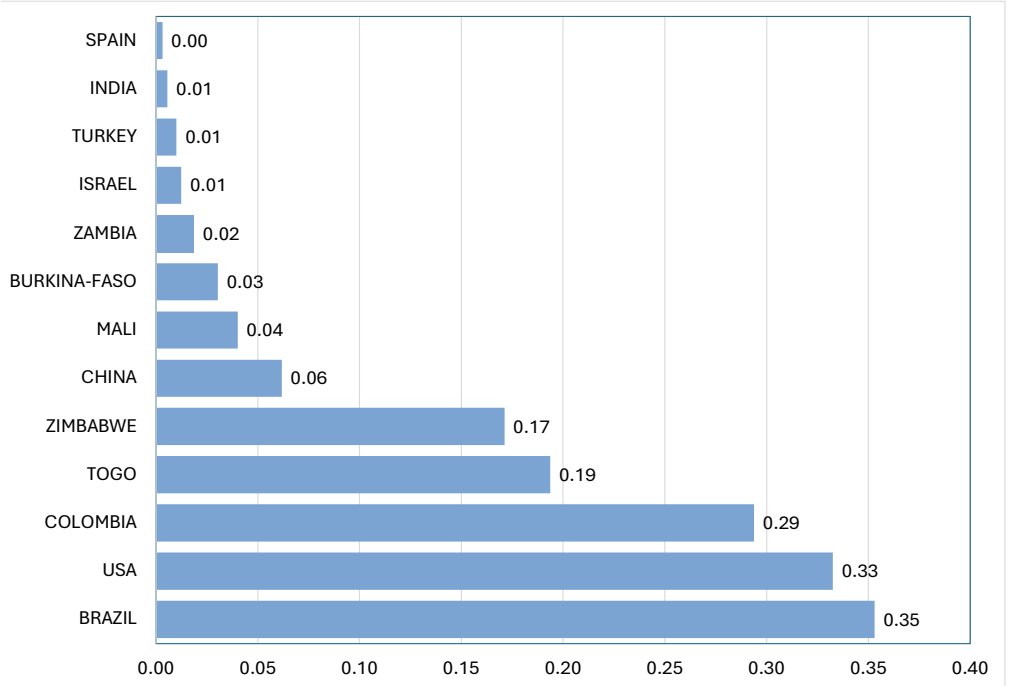
Table 12 and figure-17 show that Brazil follows, with a relatively stable trend averaging 524 tonnes of HHHs per year, reflecting consistent use over the five-year period.

In China, HHH usage drops significantly from 293 tonnes in 2018 to just 42 tonnes in 2022, averaging 199 tonnes, indicating a substantial reduction within a short time.

India shows an increasing trend, starting at 8 tonnes in 2018 and rising to 126 tonnes in 2022, with an average of 72 tonnes. Mali also displays an upward trend from zero in 2018 to 27 tonnes in 2022, averaging 18 tonnes annually.

In contrast, several countries exhibit very low HHH usage. Burkina Faso, Togo, Turkey, Colombia, and Zambia all have minimal usage, with averages ranging from 0 to 19 tonnes. For instance, Burkina Faso's usage only starts in 2021 with 17 tonnes and averages 8 tonnes, while Togo, Turkey, and Colombia report sporadic and minimal usage over the years.

Figure-18. Average annual usage of HHHs as kg/ha on cotton over five years (2018-2022)



The dataset provides a detailed overview of the average kilograms per hectare (kg/ha) usage of highly hazardous herbicides (HHPs) across various countries, focusing specifically on their application in agriculture.

Brazil emerges as the leader in herbicide application, with a usage rate of 0.35 kg/ha, closely followed by the USA, which records a rate of 0.33 kg/ha.

Colombia also shows significant usage at 0.29 kg/ha.

These figures suggest a higher reliance on chemical herbicides in these countries, potentially reflecting more intensive agricultural practices or greater challenges with weed control.

On the other end of the spectrum, countries like Spain, Turkey, Israel, and India display minimal herbicide use, each with rates of 0.01 kg/ha or less, indicating either lower dependency on chemical controls or possibly more stringent pesticide regulations.

The overall average is 0.08 kg/ha, indicating diverse HHH use globally.

HIGHLY HAZARDOUS INSECTICIDES (HHIs)

Table 13. Temporal trends in the usage of highly hazardous insecticides (HHIs) in agriculture (all crops) by cotton growing countries. Data represent the quantity of active ingredients in tonnes over a five-year period (2018-2022).

Crops	2018	2019	2020	2021	2022	Average
Rice	16,499	16,700	15,568	4,598	4,788	11,631
Vegetables and Flowers	10,675	10,237	9,786	8,049	7,916	9,333
Cotton	9,361	10,324	10,935	6,268	6,467	8,671
Corn/maize	6,370	6,627	6,039	3,751	4,838	5,525
Wheat	5,404	5,408	5,423	5,000	4,856	5,218
Fruits and Nuts	4,415	4,582	4,456	3,965	4,185	4,321
Citrus	5,437	6,370	6,640	1,143	1,216	4,161
Other Crops	5,434	3,655	3,596	3,751	4,027	4,093
Plantation	4,915	5,111	3,524	2,803	2,427	3,756
Soybeans	3,865	2,808	3,116	3,933	4,160	3,576
Sugar Cane	4,147	2,672	2,121	2,778	2,830	2,910
Potatoes	1,770	1,704	1,259	1,582	1,760	1,615
Grapes/Vines	1,435	1,616	1,636	590	519	1,159
Bananas	1,016	1,150	1,124	980	989	1,052
Forage Crops	362	365	332	325	342	345
Cereals	317	332	334	356	354	339
Rapeseed/Canola	325	284	298	298	301	301
Beets	196	212	192	15	42	131
Environmental Markets	18	62	40	233	250	121
Barley	59	58	65	63	64	62
Grand Total	82,019	80,276	76,484	50,480	52,332	68,318

The dataset in table-13 illustrates the trends in the use of HHIs in active ingredients, measured in tonnes, across various crops from 2018 to 2022. Rice demonstrates the highest overall usage, with an average of 11,631 tonnes annually, despite a sharp decline from 16,499 tonnes in 2018 to 4,788 tonnes in 2022.

Vegetables and flowers follow, with a relatively consistent pattern averaging 9,333 tonnes, peaking at 10,675 tonnes in 2018.

Cotton is another major user of HHIs, averaging 8,671 tonnes over the five years, with a notable peak of 10,935 tonnes in 2020 and a decrease to 6,467 tonnes in 2022. Cotton's HHI usage indicates its substantial reliance on these chemicals compared to many other crops, reflecting its vulnerability to pest infestations and the necessity for intensive pest management strategies.

Corn/maize shows significant use, averaging 5,525 tonnes, with a decline from 6,370 tonnes in 2018 to 4,838 tonnes in 2022. Wheat maintains steady usage, averaging 5,218 tonnes annually, with slight variations between 5,000 tonnes and 5,423 tonnes during the period.

Comparison of Cotton with Other Crops

When comparing HHIs usage in cotton with other crops, cotton shows a moderate to high level of dependency.

Cotton averages 8,671 tonnes of HHIs use annually, with a peak of 10,935 tonnes in 2020 and a decline to 6,467 tonnes in 2022.

This usage is higher than that of crops like corn/maize (5,525 tonnes), wheat (5,218 tonnes), and fruits and nuts (4,321 tonnes), but significantly lower than rice (11,631 tonnes) and vegetables and flowers (9,333 tonnes).

It is indeed alarming that edible crops such as rice, corn, wheat, and vegetables rank among the top five in the use of HHIs.

While the use of HHIs in cotton is certainly a major concern, their usage in major edible crops such as rice, wheat, corn, and vegetables is even more serious due to the potential health risks from consuming food exposed to these chemicals. Many HHIs can be carcinogenic or life-threatening, making this issue a significant public health threat.

Figure-19. Average annual usage (active ingredients in tonnes) of HHIs across various crops. Data represent the average of the five-year period from 2018 to 2022.

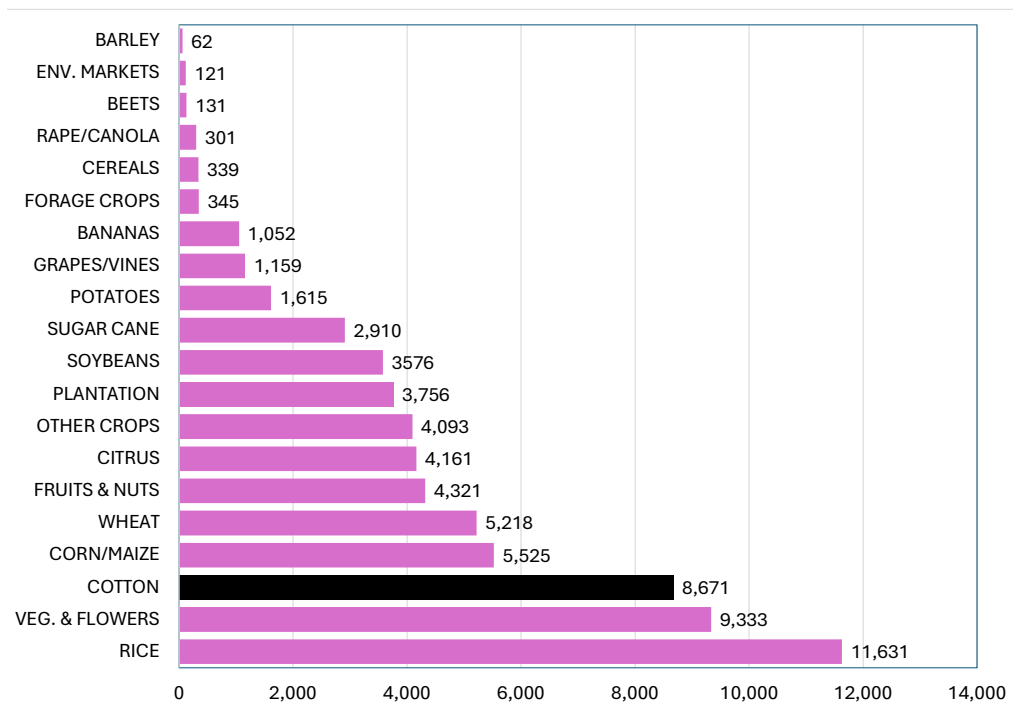


Figure-19 shows the average usage of HHIs across crops. Data shows that rice emerges as the leading crop in HHIs usage, with an average of 11,631 tonnes, followed by vegetables and flowers (9,333 tonnes) and cotton (8,671 tonnes).

Corn/maize and wheat also exhibit significant usage, averaging 5,525 and 5,218 tonnes, respectively.

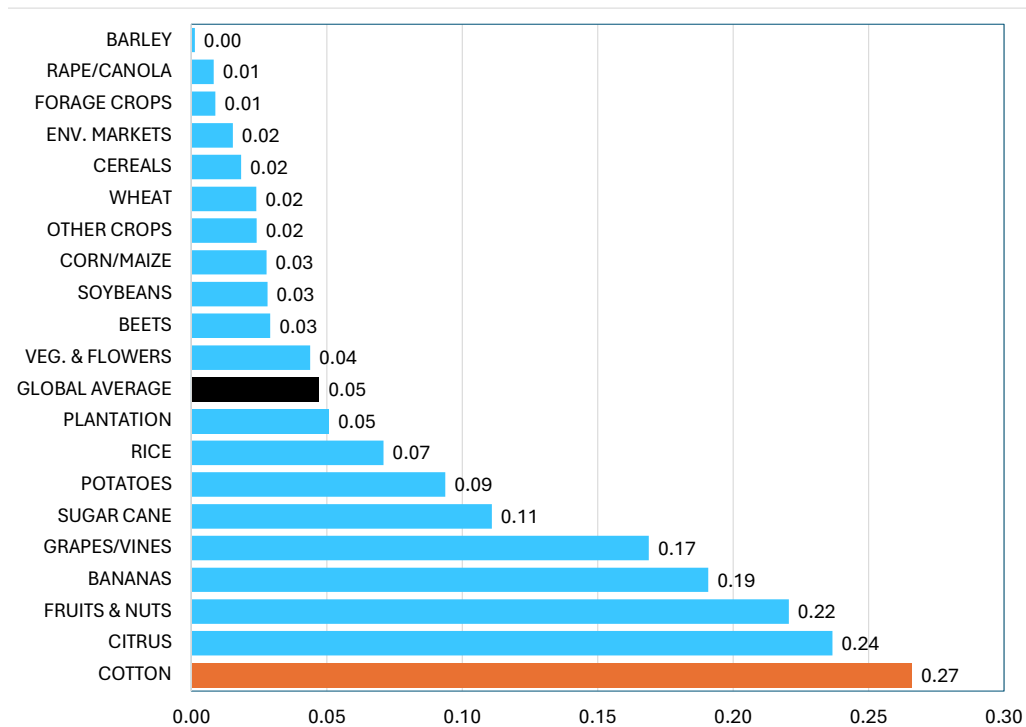
Fruits and nuts and citrus display moderate HHIs utilization, with averages of 4,321 and 4,161 tonnes, respectively.

Other crops such as plantation, other crops, and soybeans demonstrate notable usage ranging from 3,576 to 4,093 tonnes on average.

Conversely, crops like barley, environmental markets, beets, and cereals exhibit minimal HHIs application, with quantities ranging from 62 to 339 tonnes on average.

The use of HHIs in staple and edible crops like rice, corn, wheat, fruits, and vegetables presents a significantly greater concern than their application on fiber crops such as cotton.

Figure-20. Average annual usage of HHIs as kg/ha in various crops over five years (2018-2022)



The data presents the kilograms per hectare (kg/ha) of HHIs utilized across various crops over a five-year period (2018-2022).

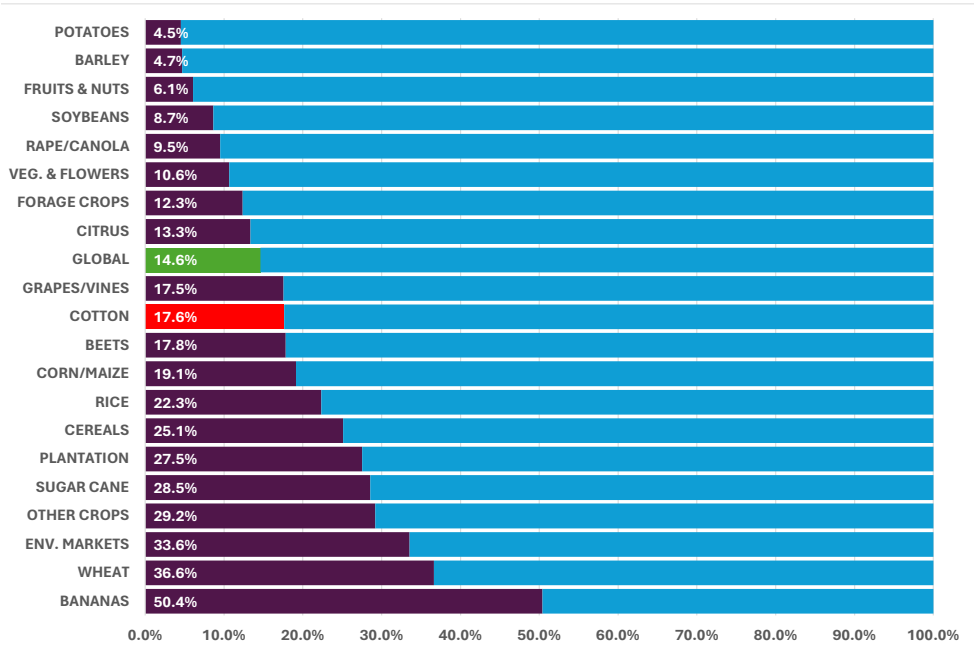
Among the top five crops with the highest HHI usage are cotton (0.27 kg/ha), citrus (0.24 kg/ha), fruits and nuts (0.22 kg/ha), bananas (0.19 kg/ha), and grapes/vines (0.17 kg/ha).

Cotton stands out with the highest usage of HHIs among the listed crops.

With a usage of 0.27 kg/ha, cotton demonstrates a higher reliance on HHIs compared to crops like citrus, fruits and nuts, bananas, and grapes/vines.

This suggests the critical need to continue exploring integrated pest management (IPM) and insecticide resistance management (IRM) approaches to reduce dependence on HHIs in cotton and other major fruit crops, mitigate environmental impacts, and promote sustainable agriculture across cotton and all crops.

Figure-21. Proportion of HHIs in the total insecticides used in each individual Crop over five years from 2018 to 2022.



The data in figure-21 provides insights into the percentage share of HHIs within the total insecticide usage across different crops.

Notably, bananas demonstrate the highest reliance on HHIs at 50.43%, followed by wheat at 36.62% and environmental markets at 33.56%.

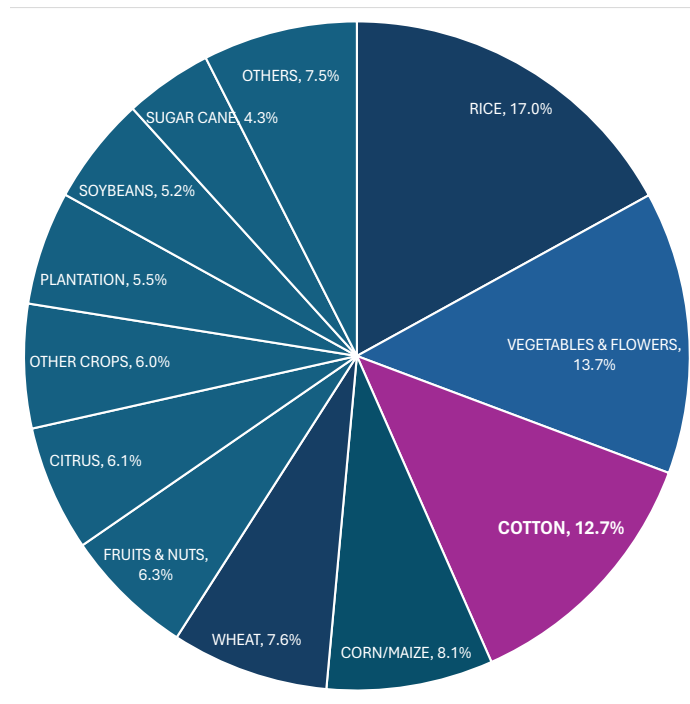
Other crops with substantial proportions of HHI usage include sugar cane (28.54%), plantation crops (27.52%), and cereals (25.10%).

Conversely, crops like potatoes (4.54%), barley (4.68%), and fruits and nuts (6.08%) exhibit relatively lower percentages of HHIs use compared to the top-ranking crops.

Comparison of Cotton with Other Crops

In comparison to cotton, which registers 17.64% of HHIs within its total insecticide usage, several other crops, notably bananas, wheat, and environmental markets, demonstrate significantly higher reliance on HHIs.

Figure-22. Global distribution of HHIs used across crops.



Data in figure 22 shows the percentage distribution of different crops in the overall global use of HHIs and their usage patterns in agriculture.

Rice emerges as the leading crop in terms of HHI usage, accounting for a substantial 17.02% of the global share.

Vegetables and flowers and cotton follow closely, with shares of 13.66% and 12.69% respectively, underscoring significant reliance on HHIs in these sectors for pest management.

Corn/maize and wheat secure notable shares at 8.09% and 7.64% respectively, reflecting the widespread use of HHIs in staple cereal crops.

Fruits and nuts and citrus also exhibit considerable shares, highlighting the dependence on HHIs in fruit cultivation.

Other crops collectively contribute 5.99% of the global HHI usage, demonstrating the diverse application of HHIs across various agricultural sectors.

Conversely, crops such as barley, environmental markets, and beets demonstrate minimal usage, collectively accounting for less than 1% of the global HHI usage during the specified period.

Comparison of Cotton with Other Crops

Cotton ranks third in the global usage of HHIs, with a share of 12.69%. While substantial, this share places cotton behind rice and vegetables and flowers, indicating a significant reliance on HHIs in these sectors compared to cotton cultivation.

This comparison underscores variations in HHI usage across different crops, with some food crops requiring more intensive HHI application for pest control which, apart from causing environmental concerns, could have serious health implications to humans and animals when such food and feed are consumed.

Table 14. Temporal trends in the usage of HHIs in cotton. Data represent the quantity of active ingredients in tonnes over a five-year period (2018-2022)

Countries	2018	2019	2020	2021	2022	Average
China	4,603	4,652	4,742	492	446	2,987
Brazil	1,616	2,268	2,484	2,427	2,840	2,327
India	2,112	2,116	2,349	1,990	1,763	2,066
USA	475	559	491	631	757	583
Pakistan	430	608	755	526	544	573
Zimbabwe	32	32	39	32	0	27
Mexico	7	7	0	58	57	26
Argentina	22	22	22	32	35	27
Egypt	20	20	21	21	8	18
Australia	2	0	0	34	2	8
South-Africa	16	16	19	6	4	12
Israel	16	16	11	11	8	12
Others	8	6	4	6	2	5
Grand Total	9,361	10,323	10,935	6,267	6,466	8,671

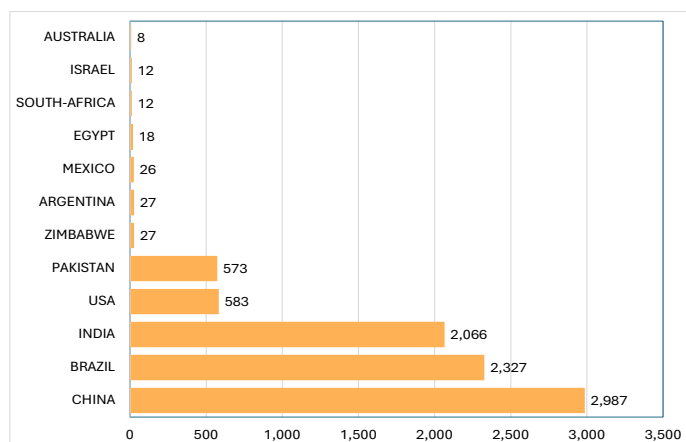
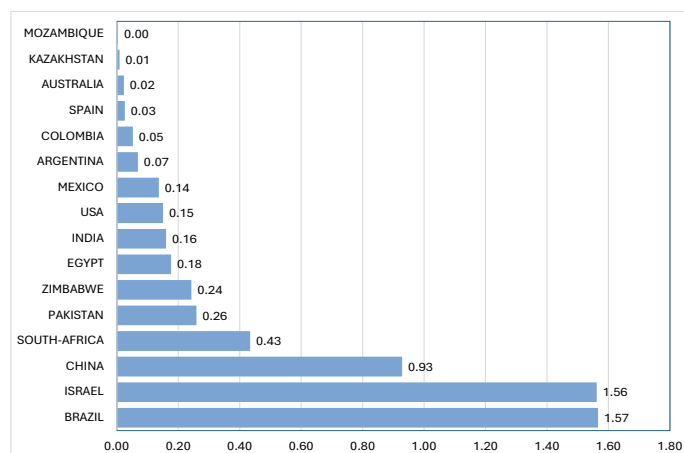
Figure-23. Usage of HHIs on cotton across countries. data represent average of five years (2018-2022) of active ingredients in tonnes.

Table-14 and figure-23 show the trends in use of HHIs in cotton cultivation across various countries from 2018 to 2022.

China leads in usage, starting at 4,603 tonnes in 2018 and dramatically decreasing to 446 tonnes in 2022, with an average of 2,987 tonnes per year. Brazil shows a consistent increase, from 1,616 tonnes in 2018 to 2,840 tonnes in 2022, averaging 2,327 tonnes annually. India maintains a relatively stable usage, with an average of 2,066 tonnes per year.

In the USA, HHI use varies, peaking at 757 tonnes in 2022 and averaging 583 tonnes annually. Pakistan's usage remains steady, with an average of 573 tonnes per year. On the lower end, countries like Zimbabwe, Mexico, Argentina, and Egypt report minimal usage, each with averages well below 50 tonnes annually, indicating limited reliance on HHIs.

Figure-24. Average annual usage of HHIs as kg/ha on cotton from 2018 to 2022.

The HHI application rates (HHP-kg/ha) indicate Brazil (1.57 kg/ha) and Israel (1.56 kg/ha) as the highest users, followed by China at 0.93 kg/ha.

South Africa, Pakistan, and Zimbabwe report moderate usage between 0.24 and 0.43 kg/ha. Many countries, such as Mozambique, Turkey, and Greece, show negligible or zero usage. The overall average stands at 0.33 kg/ha, reflecting significant disparities in HHI use globally.

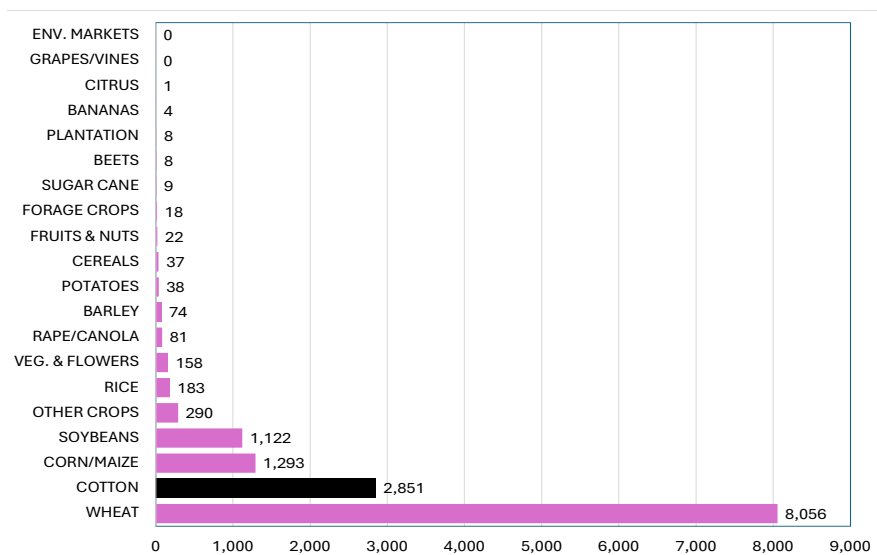
Cotton ranks first in the application rate of HHIs at 0.27 kg/ha, followed by citrus (0.24 kg/ha), fruits and nuts (0.22 kg/ha), bananas (0.19 kg/ha), and grapes/vines (0.17 kg/ha). More than 80% of HHPs in agriculture are used by four countries: China, Brazil, the USA, and India. These four countries, together with Pakistan, account for 99% of the global use of HHPs in cotton cultivation.

HIGHLY HAZARDOUS PLANT GROWTH REGULATORS (HH-PGRs), HIGHLY HAZARDOUS SEED DRESSING CHEMICALS (HH-SDCs) AND OTHERS (HHOs)

Table 15. Temporal trends in the usage of highly hazardous chemicals used as HH-PGRs, seed dressing chemicals (HH-SDCs) and others (HHOs) in agriculture (all crops) by cotton growing countries. Data represent the quantity of active ingredients in tonnes over a five-year period (2018-2022).

Crops	2018	2019	2020	2021	2022	Average
Wheat	12,416	12,814	13,184	998	868	8,056
Cotton	4,628	4,766	4,834	14	16	2,851
Corn/maize	1,945	2,039	1,784	416	281	1,293
Soybeans	1,330	1,331	1,307	911	732	1,122
Other Crops	277	320	377	340	283	320
Rice	118	68	59	525	145	183
Vegetables and Flowers	267	93	99	152	179	158
Rapeseed/Canola	244	1	95	19	47	81
Barley	149	49	46	78	45	74
Potatoes	43	33	30	36	48	38
Cereals	23	50	47	49	15	37
Fruits and Nuts	60	47	1	3	1	22
Forage Crops	28	13	15	16	17	18
Grand Total	21,530	21,624	21,877	3,559	2,677	14,253

Figure-25. Average annual usage (active ingredients in tonnes) of PGRs, seed dressing and other HHPs across various crops. data represent the average of the five-year period from 2018 to 2022.



Corn and soybeans display moderate usage, with averages of 1,293 and 1,122 tonnes, respectively.

Other crops, including rice, vegetable and flowers, and rapeseed/canola, demonstrate relatively lower utilization, ranging from 81 to 290 tonnes on average.

Conversely, crops like barley, potatoes, and cereals exhibit minimal application, with quantities ranging from 37 to 74 tonnes on average.

Fruits and nuts, forage crops, sugar cane, beets, plantation, bananas, and citrus show negligible usage, indicating minimal reliance on HH-PGRs, seed dressing chemicals and other HHPs.

The average usage of other HHPs and HH-SDCs in different crops from 2018 to 2022 illustrates diverse application trends (Figure-19 and Table-15).

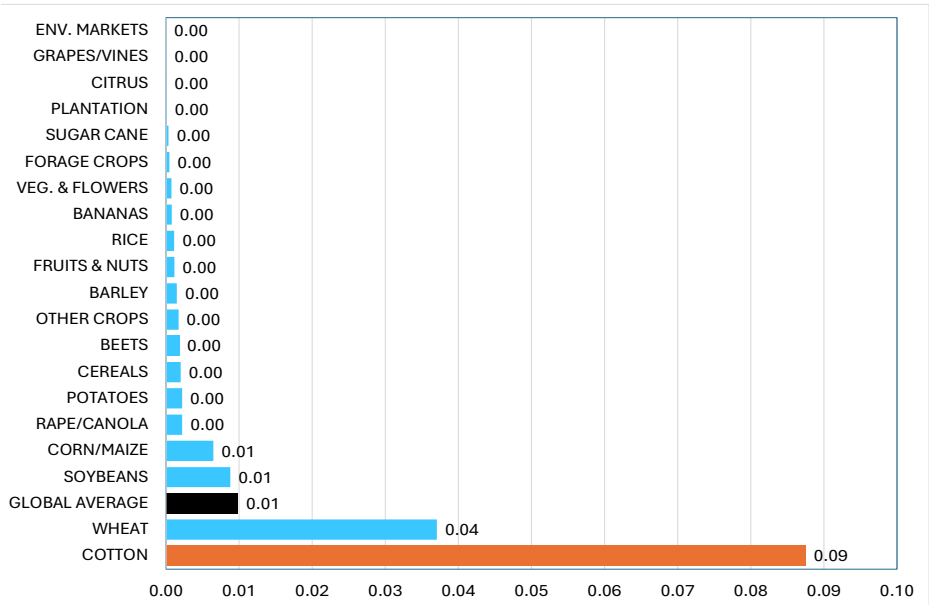
Wheat emerges as the predominant crop in this category, with an average utilization of 8,056 tonnes.

Cotton follows, although with notably lower usage compared to wheat, averaging 2,851 tonnes.

Comparison of Cotton with Other Crops

Cotton ranks second in this category with an average usage of 2,851 tonnes. However, its usage is significantly lower compared to wheat, which dominates this category with an average utilization of 8,056 tonnes. Corn/maize and soybeans also exhibit moderate usage, surpassing cotton with averages of 1,293 and 1,122 tonnes, respectively.

Figure-26. Average annual usage of highly hazardous HH-PGRs, seed dressing chemicals and other HHPs as kg/ha in various crops over five years (2018-2022).



Notably, cotton exhibits the highest usage of HHPs in this category with 0.09 kg/ha, reflecting the importance of seed treatments and other specialized applications in cotton cultivation. Conversely, several crops, including wheat, soybeans, corn/maize, and rapeseed/canola, register minimal to no usage of HHPs in this category, underscoring potential differences in agronomic practices and pest management strategies across crop types.

Comparison of Cotton with Other Crops
Cotton emerges as the primary crop with notable usage of HHPs in the others and seed dressing category, indicating the significance of seed treatments and specialized applications in cotton production systems. With a usage of 0.09 kg/ha, cotton demonstrates a higher reliance on HHPs in this category compared to major staple crops like wheat, soybeans, and corn/maize, each registering minimal usage (0.04 kg/ha or less).

Highly hazardous others (HHOs) and HH-SDCs encompass various agricultural chemicals beyond HHFs, HHHs, and HHIs, including highly hazardous chemical seed treatments and other specialized formulations. The data provides insights into the kilograms per hectare (kg/ha) of 'HHOs and HH-SDCs' utilized across different crops over a five-year period (2018-2022).

Figure-27. Proportion of highly hazardous HH-PGRs, HH-SDCs and HHOs within the respective groups of pesticides used on various crops (2018-2022).

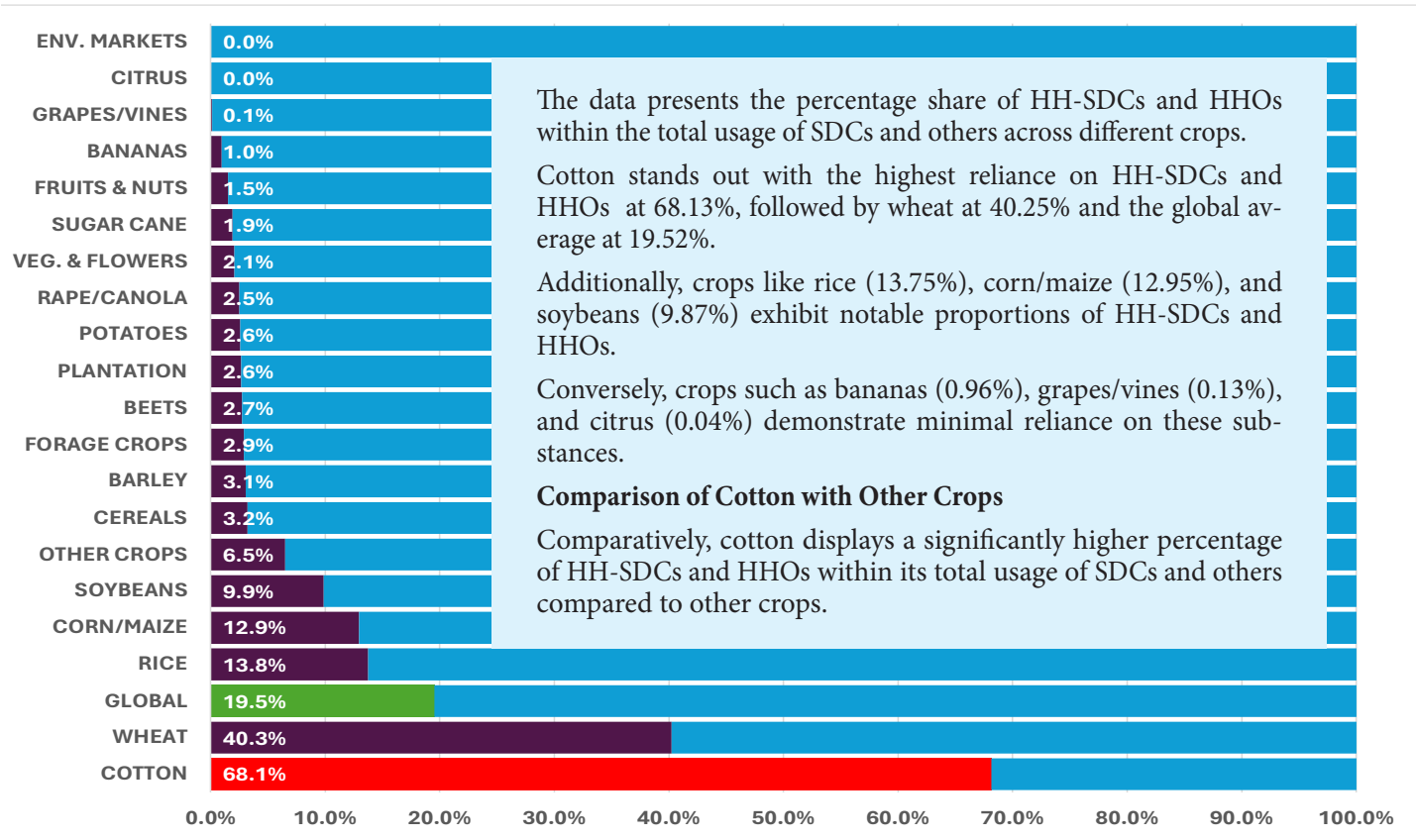
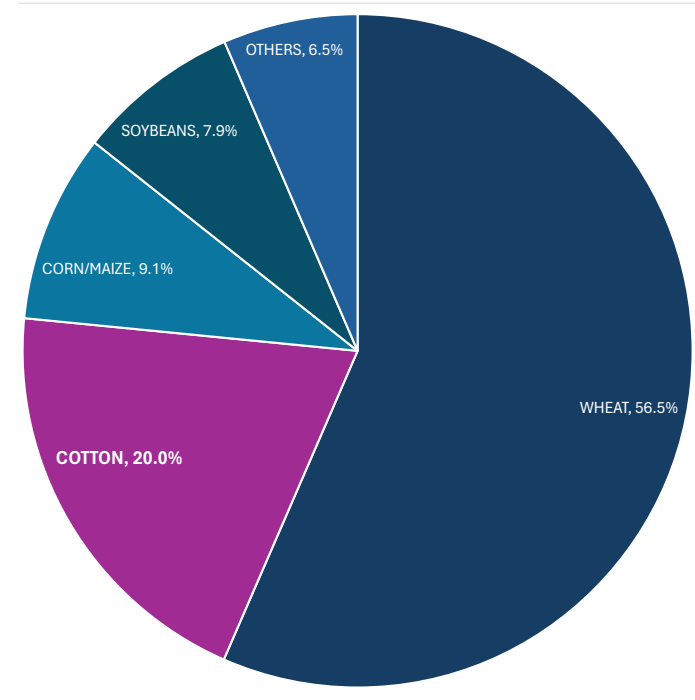


Figure-28. Global utilization of HH-PGRs, HH-SDCs and HH-others.



The distribution of HHPs in the category of HH-PGRs, HH-others and HH-SDCs across various crops unveils insights into their global usage patterns in agriculture.

Wheat dominates the global utilization of HHPs in this category, accounting for a substantial 56.52% share.

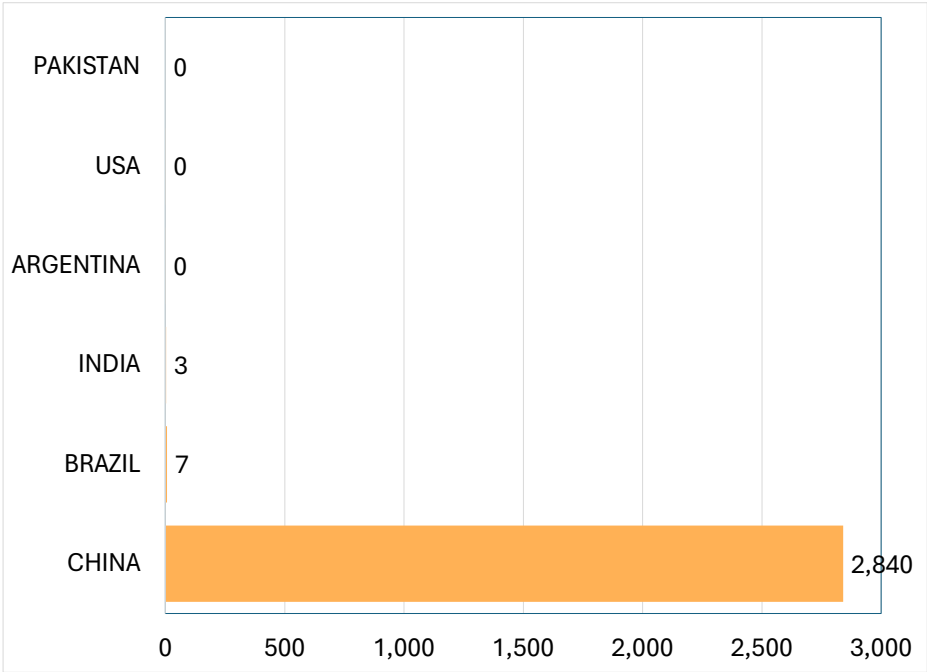
Cotton follows with a significant share of 20.01%, reflecting the intensive application of HHPs in cotton cultivation for seed dressing and other purposes.

Corn/maize and soybeans secure notable shares at 9.07% and 7.87% respectively, underscoring their reliance on HHPs for seed treatment and dressing.

Other crops collectively contribute to 2.03% of the global HHP usage in this category, signifying diverse applications across various agricultural sectors.

Conversely, crops such as citrus and grapes/vines exhibit minimal usage, highlighting their comparatively lower dependence on HHPs for seed dressing and other purposes.

Figure-29. Usage of highly hazardous HH-PGRs, HH-SDCs and HHOs on cotton across countries. Data represent average of five years (2018-2022) of active ingredients in tonnes.



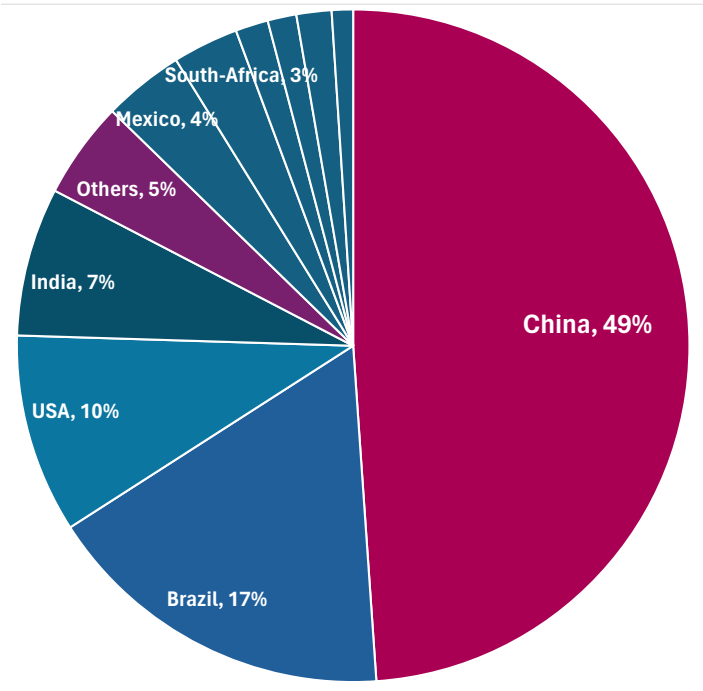
The dataset in figure-29 highlights the average usage of HH-PGRs, HH-SDCs and HH-others across various countries. China stands out with a substantial average of 2,840 units, indicating heavy reliance on such chemicals. In contrast, Brazil and India show minimal usage with 7 and 3 tonnes, respectively. Many countries, including the USA, Argentina, and several others, report zero usage, suggesting diverse agricultural practices and potential shifts towards less hazard-

ous pest management strategies.

The data on HH-SDC application rates (kg/ha) shows that China is the sole significant user with a rate of 0.88 kg/ha. All other countries, including Brazil, Argentina, the USA, and India, report negligible or zero usage. The overall average is 0.11 kg/ha, indicating that highly hazardous seed treatment practices are predominantly limited to China.

SUMMARY GRAPHS

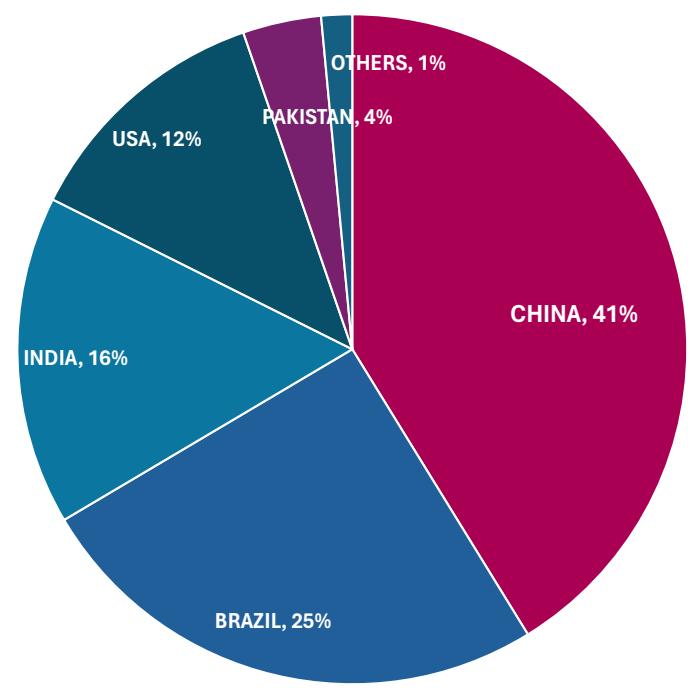
Figure-30. Country-wise share of HHP usage in agriculture.



China accounts for about half of the global HHP usage in agriculture. The data in figure-30 illustrates the distribution of HHPs usage in crop production across various countries.

China leads significantly, accounting for 49% of the total usage of HHPs in agriculture across various countries. Brazil follows with 17%, while the USA and India use 10% and 7%, respectively. Other notable countries include Mexico (4%), South Africa (3%), Australia and Russia (2% each), and Argentina and Colombia (1% each). More than 80% of HHPs in agriculture are used by four countries, namely, China, Brazil, USA, and India.

Figure-31. Country-wise share of HHP usage in cotton.

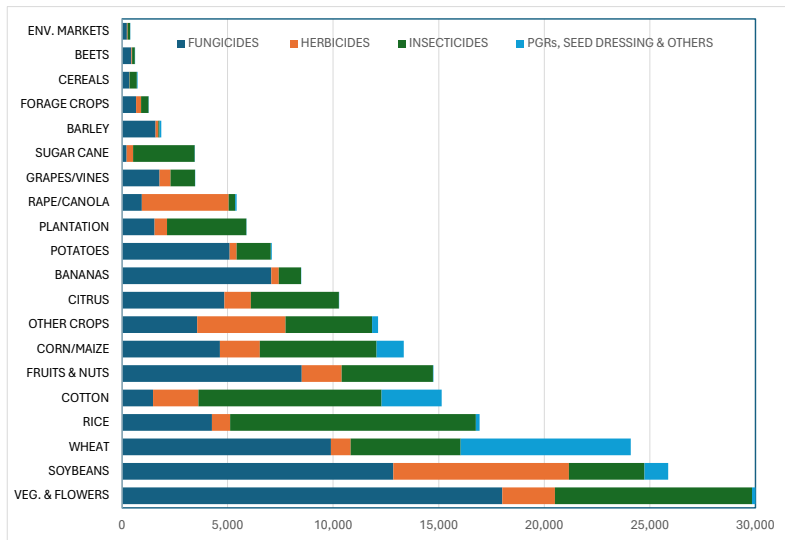


China uses more than 40% of the global HHP usage in cotton. The data indicates the distribution of HHPs in cotton production by country.

China leads with 41% of the total usage of HHPs in cotton production by country, followed by Brazil at 25%.

India accounts for 16%, while the USA contributes 12%. Pakistan uses 4%, and other countries collectively make up the remaining 1%. The above five countries account for 99% of the global use of HHPs.

Figure-32. Annual average usage (tonnes) of different types of HHPs in agriculture



The distribution of HHPs across various crops reveals significant variations in usage patterns.

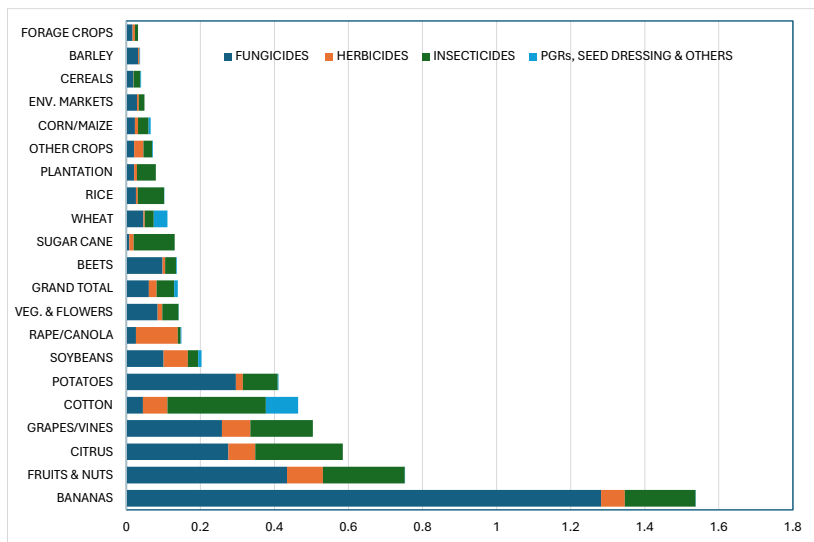
Vegetables and flowers lead with the highest usage of HHFs at 18,011 tonnes and HHIs at 9,333 tonnes, while soybeans dominate in HHHs at 8,321 tonnes.

Cotton, often scrutinized for its pesticide use, shows substantial HHI usage at 8,671 tonnes, but lower figures for HHFs at 1,475 tonnes and HHHs at 2,144 tonnes.

Fruits and nuts follow with considerable HHF at 8,507 tonnes and HHH at 1,899 tonnes usage.

Wheat shows high utilization in both HHFs at 9,898 tonnes and HH-PGRs, HH-SDCs and HHOs at 8,056 tonnes.

Figure-33. Annual average usage (kg/ha) of different types of HHPs in agriculture



The use of HHPs varies widely among different crops, highlighting distinct agricultural practices and pest management strategies.

Bananas exhibit the highest application rate of HHFs at 1.28 kg/ha and significant HHI use at 0.19 kg/ha.

Fruits and nuts also show high HHF at 0.43 kg/ha and HHIs at 0.22 kg/ha usage.

Cotton stands out for its high HHI application rate of 0.27 kg/ha and notable use in HH-PGRs, HH-SDCs and HHOs at 0.09 kg/ha.

Comparatively, soybeans and rapeseed/canola use substantial HHHs at 0.07 kg/ha and 0.11 kg/ha, respectively.

Figure-34. Annual average usage (tonnes) of different types of HHPs in cotton

The average usage of HHPs in cotton cultivation varies significantly across countries.

China leads with substantial amounts of HHIs at 2,987 tonnes and HH-SDCs at 2,840 tonnes, reflecting intensive pest management practices.

Brazil follows with notable use in HHFs at 968 tonnes and HHIs at 2,327 tonnes.

India's usage is also significant, particularly in HHIs at 2,066 tonnes.

In contrast, the USA shows high HHH use at 1,287 tonnes but no HHFs or HH-SDCs. Other countries like Pakistan, Zimbabwe, and Mexico exhibit minimal HHP usage across all categories.

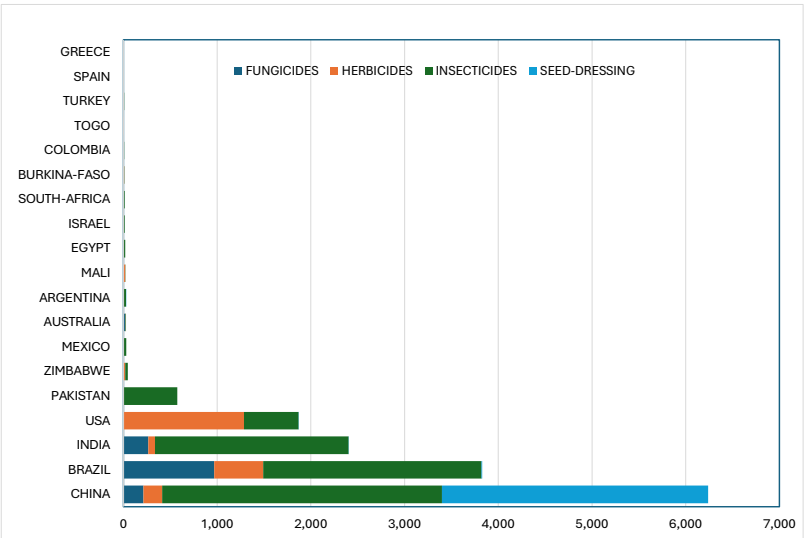
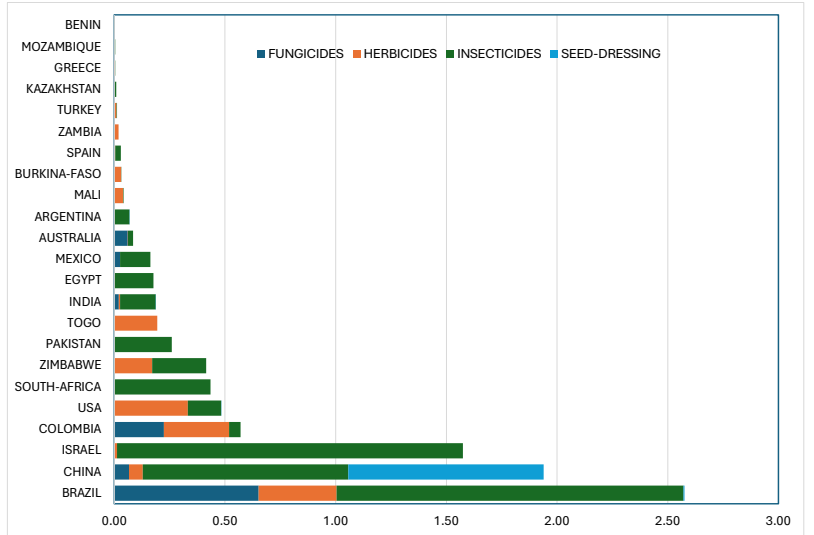


Figure-35. Annual average usage (kg/ha) of different types of HHPs in cotton



The application rates of different types of HHPs per hectare in cotton cultivation reveals varied practices across different countries.

Brazil exhibits the highest HHI use at 1.57 kg/ha and significant HHF at 0.65 kg/ha and HHH at 0.35 kg/ha applications.

China also shows considerable use of HHIs at 0.93 kg/ha and seed dressing (HHP) at 0.88 kg/ha. In Israel, HHI use is notably high at 1.56 kg/ha.

Conversely, countries like the USA and Australia demonstrate moderate to low HHH and HHI usage, while many African nations, including South Africa, Zimbabwe, and Mali, report minimal to negligible HHP applications across all categories.

SUMMARY: HHP USAGE - COMPARISON OF COTTON WITH OTHER CROPS

HIGHLY HAZARDOUS PESTICIDES

- **Cotton Ranks Fifth:** Cotton, with an average usage of 15,141 tonnes of HHPs from 2018 to 2022, ranks lower compared to several crops. For instance, vegetables and flowers, soybeans, wheat, and rice exhibit notably higher HHP usage, averaging 29,998 tonnes, 25,865 tonnes, 24,099 tonnes, and 16,938 tonnes, respectively.
- **Cotton Ranks Fifth:** With respect to the application rate (kilograms per hectare) of HHPs used in various crops, cotton demonstrates a moderate level of usage at 0.47 kg/ha compared to crops like bananas, with an average of 1.54 kg per hectare, fruits and nuts at 0.75 kg/ha, citrus at 0.58 kg/ha, and grapes/vines at 0.51 kg/ha.
- **Cotton Ranks Second:** Cotton, accounting for 13.04% of its total pesticide use, shows a significant share of HHPs. In contrast, bananas exhibit the highest proportion of HHPs at 26.74%, almost double that of cotton. Additionally, the share in HHP usage in the total pesticide used in crops like wheat (12.09%), citrus (10.98%), and vegetables and flowers (10.69%) is also significant.
- **Cotton Ranks Fifth:** In the global usage of HHPs, cotton, with a 7.52% share, falls behind vegetables and flowers, soybeans, wheat, and rice. While it maintains a significant share, cotton's percentage is notably lower compared to the top four crops.

HIGHLY HAZARDOUS FUNGICIDES

- **Cotton Ranks Below 14 Crops:** Cotton's usage of HHFs averages at 1,475 tonnes, representing a smaller share compared to other crops, such as vegetables and flowers, soybeans, wheat, fruits and nuts, and bananas, which exhibit higher usage, ranging from 7,068 to 18,011 tonnes on average.
- **Cotton Ranks Below 9 Crops:** Cotton, with an HHF usage of 0.05 kg/ha, demonstrates a relatively moderate level of HHF application compared to crops like bananas (1.28 kg/ha), fruits and nuts (0.43), potatoes (0.30), citrus (0.28), and grapes/vines (0.26).
- **Cotton Ranks Eighth:** The share of HHFs out of the total fungicides used in the crop is highest at 44.61% in trees and turf (environmental markets), followed by corn/maize at 32.27%, bananas at 29.63%, forage crops at 27.39%, wheat at 27.15%, barley (24.54%), soybeans (23.43%), and cotton (20.93%).
- **Cotton's Share in Global HHF Use is Very Low:** Cotton, with a mere 1.68% share in the global usage of HHFs, falls behind several other crops such as vegetables and flowers with a significant 20.48%, followed by soybeans (14.60%) and wheat. Fruits and nuts exhibit notable shares at 11.25% and 9.67%, respectively, and bananas securing the fifth position with an 8.04% share.

HIGHLY HAZARDOUS HERBICIDES

- **Cotton Ranks Fifth:** The average quantities of HHHs used in various crops show that soybeans emerge as the leading crop, with an average usage of 8,321 tonnes, followed by other crops (4,183 tonnes), rapeseed/canola (4,110 tonnes), and vegetables and flowers (2,496 tonnes). While cotton ranks fifth with an average usage of 2,144 tonnes, it exhibits lower reliance compared to soybeans and several other crops.
- **Cotton Ranks Tenth:** Data on the kilograms per hectare (kg/ha) of HHHs utilized across various crops shows that rapeseed/canola leads in HHPs usage with 0.11 kg/ha, followed closely by fruits and nuts (0.10 kg/ha), grapes/vines (0.08 kg/ha), citrus (0.07 kg/ha), and cotton (0.07 kg/ha).
- **Cotton Ranks Eighth in the Proportion of HHPs Within the Total Herbicides Used in the Crop:** The data on the percentage share of HHHs within the total herbicide usage in a crop showed that rapeseed/canola leads in HHH utilization at 10.89%, followed by grapes/vines at 8.23%, citrus at 7.12%, bananas at 6.76%, fruits and nuts at 5.16%, and cotton (4.29%).
- **Cotton Ranks Fourth:** Soybeans constitute a substantial 27.13% of the global share of HHHs, followed by rapeseed/canola (13.40%), vegetables and flowers (8.1%), and cotton (6.99%).

HIGHLY HAZARDOUS INSECTICIDES

- **Cotton Ranks Third:** Rice is the leading crop in HHI usage, with an annual average of 11,631 tonnes, followed by vegetables and flowers (9,333 tonnes), and cotton at 8,671 tonnes.
- **Cotton Ranks First:** The top five crops with the highest HHI usage are cotton (0.27 kg/ha), citrus (0.24 kg/ha), fruits and nuts (0.22 kg/ha), bananas (0.19 kg/ha), and grapes/vines (0.17 kg/ha).
- **Cotton Ranks Low in the Proportion of HHPs Within the Total Insecticides Used in the Crop:** Bananas demonstrate the highest reliance on HHIs at 50.43%, followed by wheat at 36.62% and environmental markets at 33.56%. Other crops with substantial proportions of HHI usage include sugar cane (28.54%), plantation crops (27.52%), cereals (25.10%), and cotton, which registers 17.64% of HHIs within its total insecticide usage.
- **Cotton Ranks Third in the Share of Global HHIs:** Rice is the leading crop in terms of HHI usage, accounting for a substantial 17.02% of the global share. Vegetables and flowers and cotton follow closely, with shares of 13.66% and 12.69%, respectively, underscoring significant reliance on HHIs in these sectors for pest management.

DISCUSSION

Cotton cultivation has often been at the center of debates concerning the environmental impact of pesticide use. There is a prevailing belief that cotton consumes a disproportionately high amount of pesticides, particularly HHPs, compared to other crops.

This narrative is supported by organizations like the Environmental Justice Foundation (EJF), which claims that despite cotton occupying only about 2.3% of global arable land, it uses over 16% of global insecticides and a significant share of HHPs. The World Counts states that cotton is a very pesticide-intensive crop, grown on 2.5% of the world's agricultural land but consuming 16% of all the insecticides and 7% of all herbicides used worldwide—more than any other crop. However, a closer examination of the data and scientific literature reveals a more nuanced picture.

Pesticide Usage in Cotton

According to the International Cotton Advisory Committee (ICAC), cotton is indeed cultivated on 2.3% of the world's arable land. However, during the period from 2018 to 2022, cotton accounted for 4.0% of global pesticide use and 10.51% of the total insecticides used in agriculture worldwide, and not 16.0% often cited by advocacy groups.

The World Counts website also mentions that cotton consumes 7.0% of all herbicides used worldwide, but ICAC data shows that cotton's share of the global herbicide usage stands only at 3.1%, behind several crops such as soybeans (20.9%), maize (20.0%), wheat (7.3%), rice (5.3%), and sugar cane (4.2%), which exhibit higher percentages.

These figures, while indicating a higher-than-average use of pesticides relative to its land area, suggest that some claims about cotton's pesticide use might be exaggerated.

Proportion of HHPs in Total Pesticide Use

The proportion of HHPs within the total pesticide use in cotton is another area of contention. The EJF states that cotton uses the highest quantity of pesticides among all crops, with a particularly high proportion of HHPs.

They assert that globally, 69.1% of pesticides used on cotton are classified as HHPs, compared to 25.8% on cereals and 43.5% on rice. In contrast, ICAC data shows a more modest yet significant share of HHPs in cotton's pesticide use at an average of 13.04% over five years from 2018 to 2022, ranking behind bananas which have a share of 26.74% HHPs in the pesticides used.

Additionally, the share in HHP usage in the total pesticides used in crops like wheat (12.09%), citrus (10.98%), and vegetables and flowers (10.69%) was also significant. This discrepancy highlights the need for critical evaluation of various data sources and methodologies.

Comparison with Other Crops

When comparing cotton to other crops, several key points emerge. Cotton's pesticide usage, though significant, is not the highest in every category. For example, vegetables and flowers, soybeans, wheat, and rice exhibit higher overall pesticide usage. Specifically, vegetables and flowers averaged 18,011 tonnes of HHHs annually from 2018 to 2022, significantly more than

cotton's 1,475 tonnes. Similarly, soybeans and wheat also show higher HHH usage.

In terms of HHHs, soybeans lead with an average usage of 8,321 tonnes, followed by other crops and rapeseed/canola. Cotton ranks fifth, with an average of 2,144 tonnes, indicating lower reliance on HHHs compared to these crops. The narrative that cotton uses an inordinately high amount of HHHs is therefore not entirely supported by the data.

HHI Usage in Cotton

Cotton's use of HHIs is notably high, which aligns with some of the claims made by organizations like EJF. During 2018-2022, cotton ranked third in global HHI usage, averaging 8,671 tonnes annually. This positions cotton behind rice and vegetables and flowers but still reflects significant usage. The application rate of HHIs in cotton (0.27 kg/ha) is higher than that of other crops, including citrus, fruits, and nuts, and bananas. Cotton's share of the global HHI use is 12.69%, which suggests that while cotton does use a significant portion of global HHIs, the figures presented by some sources may be overstated.

CONCLUSION

In summary, while cotton does use a higher proportion of pesticides and insecticides relative to its cultivated area, the extent of this usage is often exaggerated in public discourse. The ICAC data provides a more balanced view, showing that while cotton's pesticide usage is significant, it is not as disproportionately high as some sources suggest. Understanding these nuances is crucial for developing balanced and effective agricultural policies that address environmental concerns without resorting to hyperbole.

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Annexure-1 LIST OF HIGHLY HAZARDOUS PESTICIDES (Jepson et al., 2020)

	WHO 1a	WHO 1b	GHS Cancer 1A, 1B	GHS Muta 1A, 1B	GHS Repro 1A, 1B	Montreal Protocol	Rotterdam Convention	Stockholm Convention
Acrolein								
Alachlor								
Aldicarb								
alpha-BHC/HCH								
Alpha-chlorohydrin								
Aluminum phosphide								
Anthracene oil								
Arsenic compounds								
Atrazine								
Azafenidin								
Azinphos-ethyl								
Azinphos-methyl								
Benomyl								
Beta-cyfluthrin;								
beta-HCH/BCH								
Blasticidin-S								
Borax; disodium tetraborate decahydrate								
Boric acid								
Brodifacoum								
Bromadiolone								
Bromethalin								
Butoxycarboxim								
Cadusafos								
Captafol								
Carbendazim								
Carbetamide								
Carbofuran								
Chlordane								
Chlorethoxyphos								
Chlorfenvinphos								
Chlormephos								
Chlorophacinone								
Chlorothalonil								
Clothianidin								
Coumaphos								
Coumatetralyl								
Creosote								
Cyproconazole								
DDT								
Demeton-S-methyl								
Dichlorvos; DDVP								
Dicrotophos								
Difenacoum								
Difethialone								
Dinocap								
Dinoterb								
Diphacinone								
Disulfotonne								
DNOC and its salts								
Edifenphos								
Endosulfan								
Endosulfan I (alpha)								
E-Phosphamidon								
Epichlorohydrin								
EPN								
Epoxiconazole								
Ethiofencarb								
Ethoprophos; Ethoprop								
Ethylene dibromide; 1,2- dibromoethane								
Ethylene dichloride; 1,2- Dichloroethane								
Ethylene oxide								
Ethylene thiourea								
Famphur								
Fenamiphos								
Fenchlorazole-ethyl								
Fipronil								
Flocoumafen								
Fluazifop-butyl								
Flucythrinate								
Flumioxazin								
Fluoroacetamide								
Flusilazole								
Formetanate								
Furathiocarb								
Glufosinate-ammonium								
Heptenophos								
Hexachlorobenzene								
HCH/BHC mix isomers								
Imidacloprid								
Iprodione								
Isoxathion								
Lindane								
Linuron								
Magnesium phosphide								
Mecarbam								
Mercury compounds								
Methamidophos								
Methidathion								
Methiocarb								
Methomyl								
Methyl bromide								
Mevinphos								
Monocrotophos								
Nicotine								
Nitrobenzene								
Omethoate								
Oxamyl								
Oxydemeton-methyl								
Paraquat dichloride								
Parathion								
Parathion-methyl								
PCP; Pentachlorophenol								
Pentachlorobenzene								
Phorate								
Phosphamidon								
Phosphine								
Propetamphos								
Propiconazole								
Propylene oxide, Oxirane								
Silafluofen								
Sodium fluoroacetate (1080)								
Spirodiclofen								
Strychnine								
Sulfuramid								
Sulfotep								
Tebupirimifos								
Tefluthrin								
Terbufos								
Thiamethoxam								
Thiofanox								
Thiometonne								
Thiram in formulations with benomyl and carbofuran only								
Triadimenol								
Triazophos								
Trichlorfon; metrifonate								
Tridemorph								
Triflumizole								
Vamidothion								
Vinclozolin								
Warfarin								
zeta-Cypermethrin								
Zinc phosphide								
Z-Phosphamidon								



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