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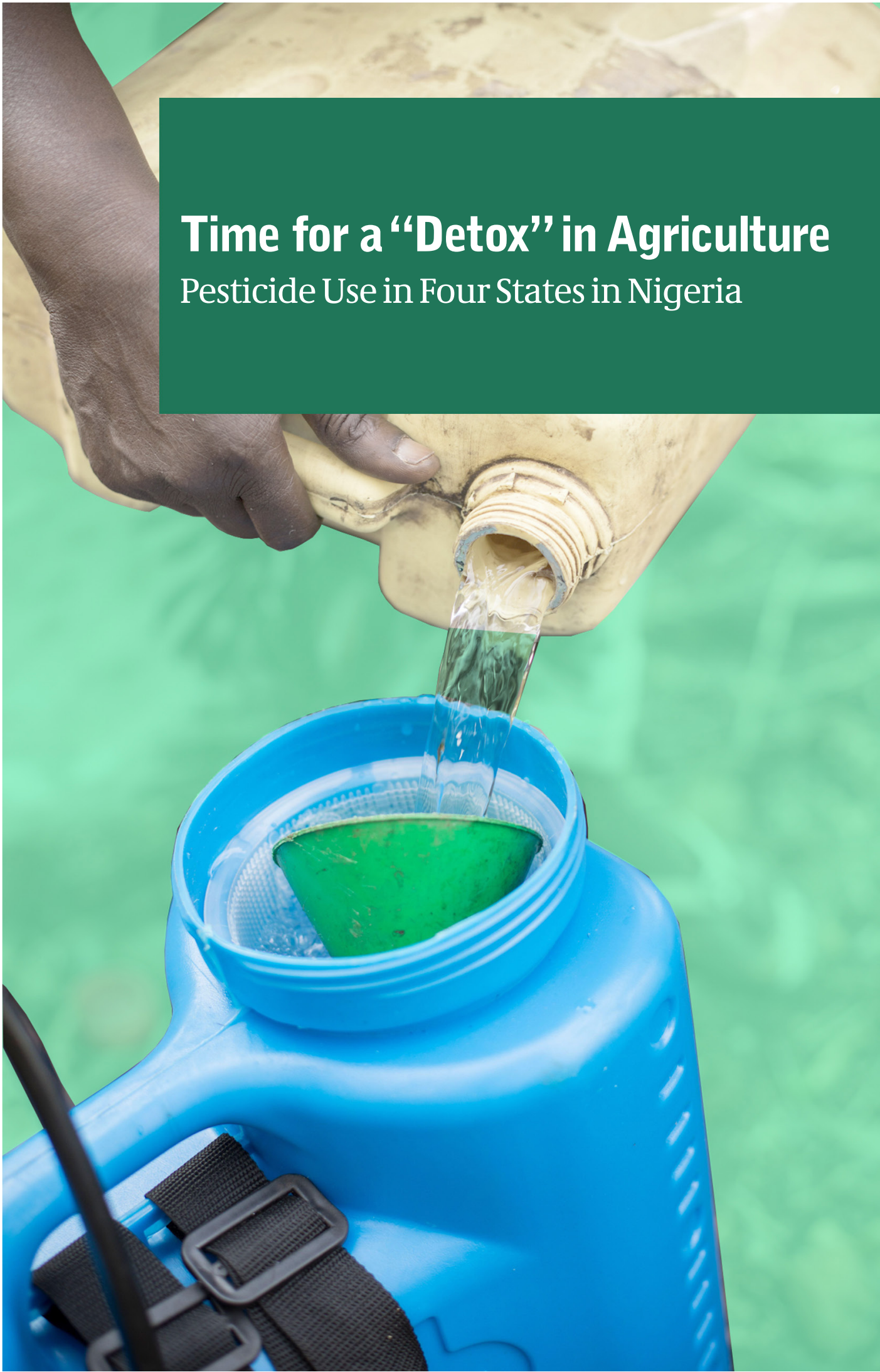
Time for a "Detox" in Agriculture

Pesticide Use in Four States in Nigeria



The Author

Dr. Silke Bollmohr is an ecotoxicologist, risk assessor of pesticides and expert for sustainable agriculture. She has worked for twenty years in various countries in Africa to establish strategies for a reduction in the use of highly hazardous pesticides. In the last four years, she worked in Kenya on strategies on how to phase out pesticides that are banned in Europe, among other issues.

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Chris Kaka and his team at the Trade Network Initiative (TNI) provided conceptual and review input to this study. They also managed and oversaw the data collection process, working with field officers recruited from across the four selected target states.

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Pesticide Use in Four States in Nigeria

Contents

Introduction

Nigeria's agricultural sector is a major pillar of the country's economy and accounts for about 22% of GDP, compared to oil and gas (9.5%), manufacturing (9.7%) and trade (16.1%). Over 75% of the active labour force is employed in agriculture, directly or indirectly.[1] Agriculture in Nigeria faces many challenges, including the loss of soil fertility, conflicts related to land use and access to the means of production, pressure on natural resources, and climate change. This has left the country unable to meet the demand of domestic and export markets. Government policies have therefore focused on increasing productivity. However, these mainly promote conventional industrial agriculture that requires high external inputs, such as pesticides and artificial fertilizers.

Yet the proper registration of pesticides, their sustainable management and the promotion of alternatives are clearly lacking, as a 2020 report by the Heinrich Böll Foundation Abuja Office has highlighted.[2] Many pesticides still registered in Nigeria are proven to cause chronic health effects and show very high environmental toxicity. About 40% of the registered pesticides in Nigeria have been withdrawn from the European market, partly due to toxicity, persistence or lack of data. Some of these, including carbofuran and diazinon, have been found in high levels in green vegetables. Nigeria has no comprehensive policies in place to fund, implement or promote research into organic farming, agroecology or any other sustainable agricultural strategy. The First Draft of the Integrated Pest Management Plan focuses on the "safe use" of pesticides and lacks clear advice on alternative, scientifically sound pest-control strategies.

Building on the 2020 report, and to capture issues beyond the registration status of pesticides and the policy environment in Nigeria, this field survey sought to find out from farmers, extension officers and local pesticide dealers the types of pesticide in use across the country and to bring to the fore on-the-ground challenges related to pesticide use. Specifically, the objectives of the rapid assessment survey were to:

1. assess the extent and types of pesticide use
2. determine the influence of agro-dealers and extension officers on pesticide use
3. identify challenges related to safety measures
4. identify crops that should be prioritized for better pest and disease management.

The general purpose of this study is to provide evidence to support a process of withdrawing highly hazardous pesticides from the Nigerian market, based on their toxicity to human health and the environment, and to promote safer alternatives to chemical pesticides for crop and pest management. The study provides guidance for policymakers to prioritize the pesticides and crops that require attention.

Methodology

The survey was conducted in June 2021. The four target states – Benue, Oyo, Ebonyi and Kano – were selected for three reasons. First, agriculture is the main economic activity in each state; second, they are among the highest producers of crops and therefore rely heavily on pesticides; third, they represent four of the six geopolitical zones in Nigeria.

Using a purposive random-sampling methodology, three groups were interviewed for the survey. The first group included 597 smallholder farmers with an average farm size of 5.3 acres. The second group featured 69 extension-service providers and the final group comprised 78 local agro-dealers who retail agrochemical products to farmers.

STATE	FARMERS	EXTENSION OFFICERS	AGRO-DEALERS	AVERAGE FARM SIZE (ACRES)
Benue	149	20	20	2.29
Ebonyi	149	18	20	2.34
Kano	149	20	20	3.51
Oyo	150	11	18	12.96
TOTAL	597	69	78	AV. 5.3

Table 1. Number of farmers, extension officers and agro-dealers who took part in the survey.

Information was collected about the use of insecticides, herbicides and fungicides, managed crops, and training, awareness and safety measures.

Additionally, a pesticide-residue analysis of yam and tomatoes sourced from farms in Kano and Oyo states was conducted in July 2021.

Pesticide Hazards

In terms of chronic health effects, pesticides are classified as carcinogenic, mutagenic/genotoxic, toxic to reproduction and neurotoxic.[3] Additionally, many pesticides are classified as endocrine disrupters, which means that they interfere with the hormonal system, causing adverse effects such as increasing or decreasing the activity of male or female hormones. This is not surprising as most pesticides are specifically designed to act on the hormone systems of plants and insects.

Since pesticides are designed to kill insects, many have an impact on the broader ecosystem, including fish, pollinators, earthworms and other important soil organisms. These effects are aggravated if directions for proper use, including recommended spraying times and spraying rates for target crops, are not followed or if mitigation measures such as buffer zones are not in place.

The survey confirmed that Nigerian smallholder farmers use a variety of pesticides. The active ingredients in each pesticide were identified and their toxicity data checked in the Pesticide Properties Database (PPDB), which provides toxicity information on all active ingredients worldwide.[4]

WILDLIFE TOXICITY (BEES, FISH) [mg/L]		CHRONIC HUMAN HEALTH EFFECTS	
Very toxic	< 0.1	Yes	Carcinogenicity
Toxic	0.1–1.0	Possible	Mutagenicity
Moderately toxic	1.0–10	No	Reproduction Toxicity
Low toxic	10–100	No Date	Neurotoxicity
Not toxic	>100		Endocrine disruption

Table 2. Categories of environmental toxicity according to PPDB.

What are highly hazardous pesticides?

According to the World Health Organization, highly hazardous pesticides (HHPs) are especially dangerous for human health, animals and the environment. They can lead to serious or irreversible harms, including cancer, problems with the hormone system, fertility and fetal harm, and environmental damage to the ozone layer and to animal species, water, soil and biodiversity. They are especially dangerous for farmers and land workers who use them. In many countries, HHPs are found in food, which puts the health of consumers at risk. This study uses the list of HHPs categorized by Pesticide Action Network International.[5]

Pesticide Use in the Surveyed States

General pesticide findings

A total of 40 active ingredients in 74 product formulations were used in the four surveyed states of Nigeria. They were used on 31 different crops to control pests and diseases. The most-used pesticides were insecticides (50%), with 20 active ingredients, followed by herbicides (26%), with 14 active ingredients, and fungicides (24%), with 6 active ingredients.

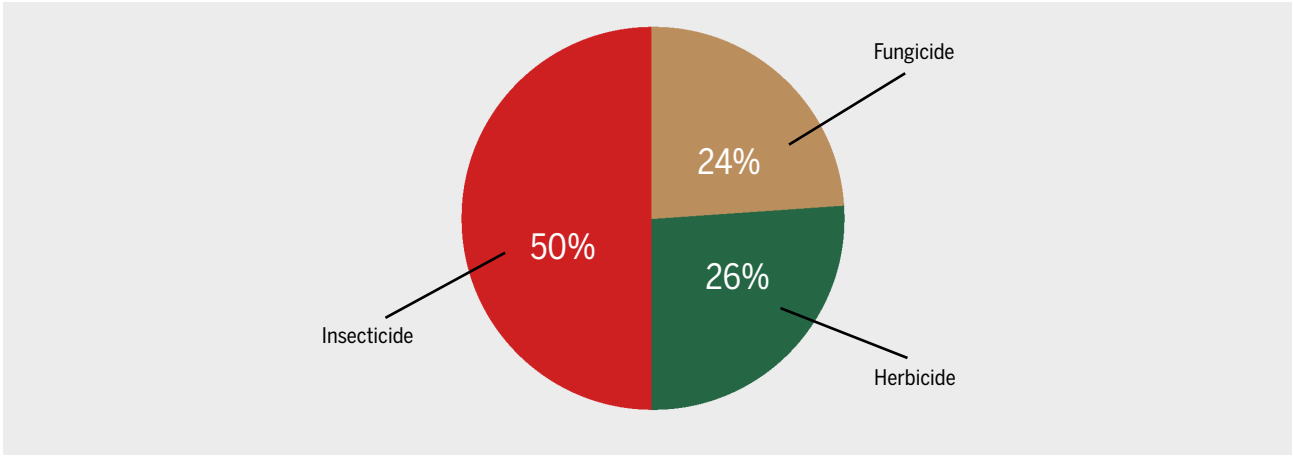

Figure 1. Type of pesticides in use in the study.

Sixty-five percent of all active ingredients used by the farmers in the four target states are categorized as HHPs.

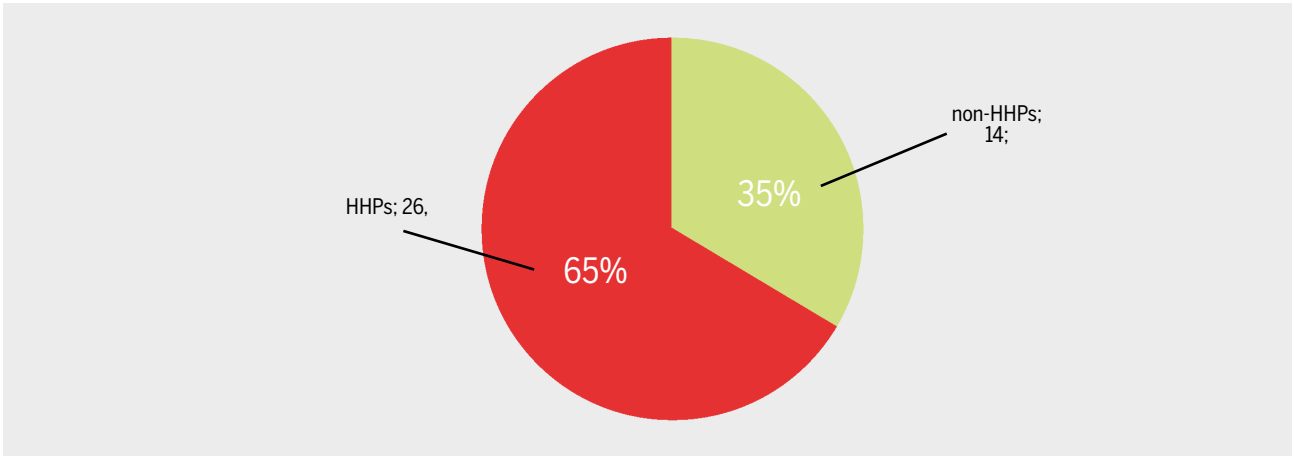

Figure 2. Highly hazardous pesticides in use in the study.

Pesticides are generally used 1–3 times per growing season (normal frequency), but some are used 4 –6 (elevated frequency) or even 7–10 times per growing season (high frequency). It is important to identify the reasons for these differences, which could relate to different pest pressures or the development of resistance to the pesticide in use.

Most of the farmers spend at least N10,000 per season on agrochemicals, while 26% spend more than N50,000.

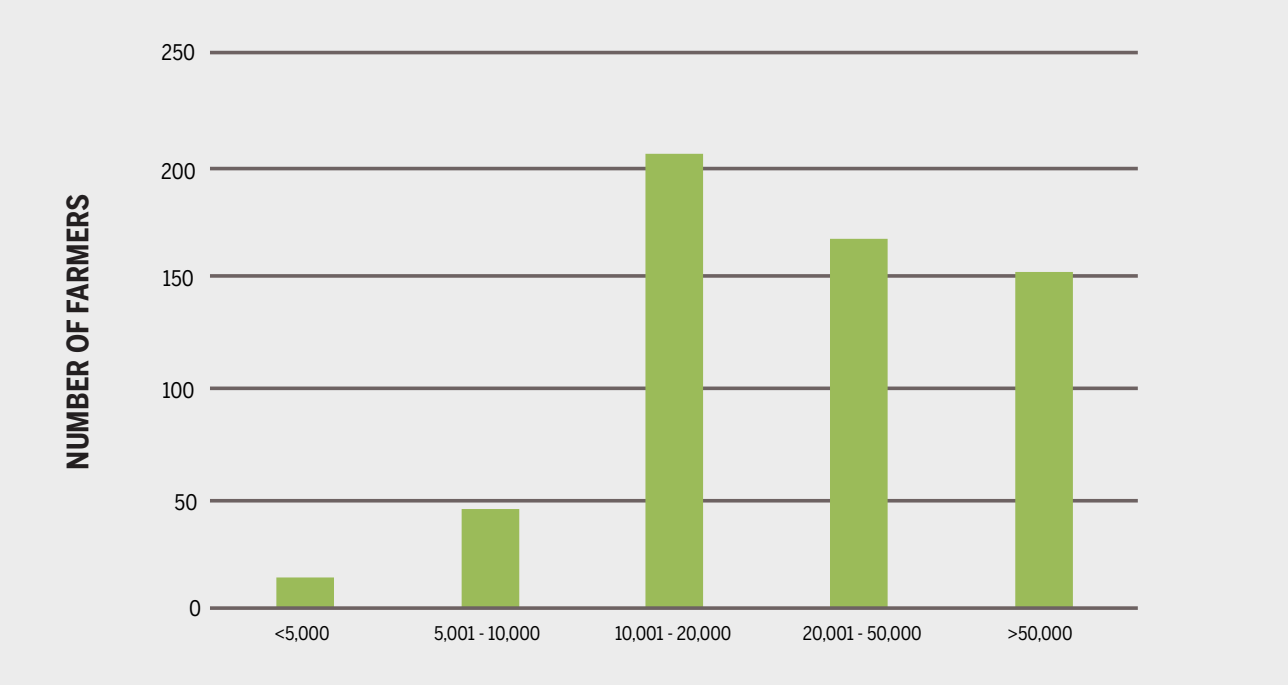

Figure 3. Amount spent on agrochemicals by farmers per season in Naira.

Health and environmental hazards of pesticides in use

Of the total of 40 active ingredients, more than half (26, 65%) are HHPs, with high toxicity hazards for human health and/or the environment. Two pesticides are carcinogens and two are mutagens, five are known endocrine disruptor compounds (EDCs), 11 are proven to be neurotoxic and 12 are proven to affect the human reproduction system.

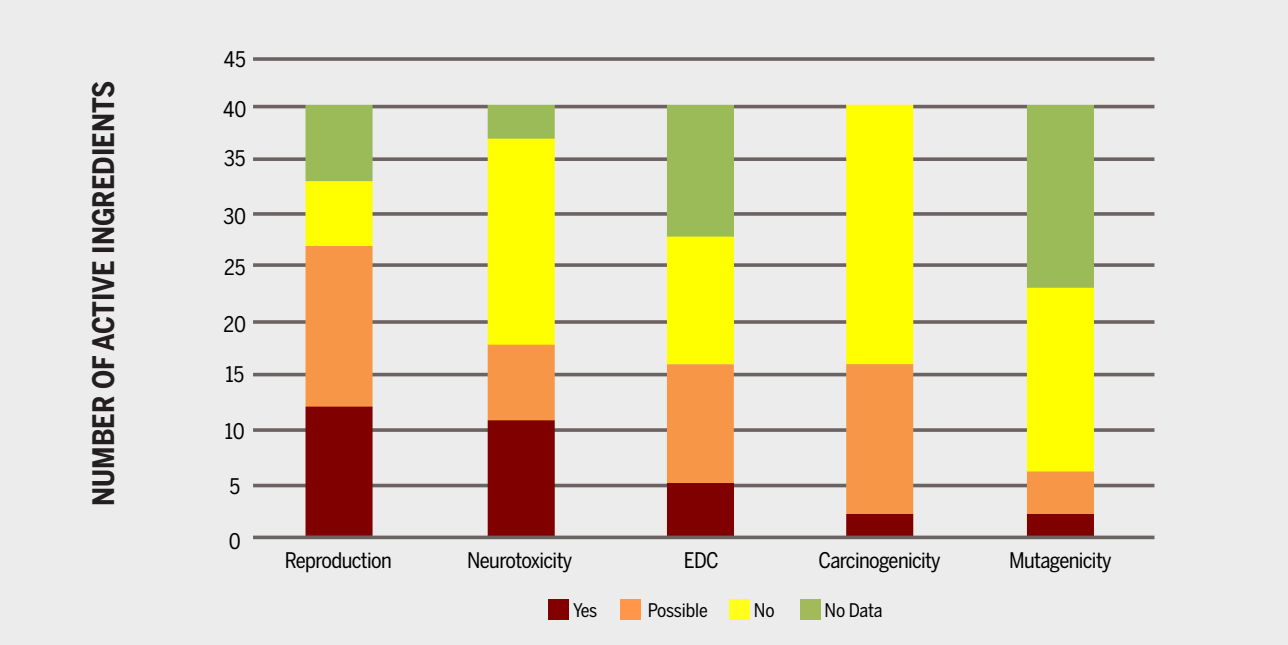

Figure 4. Chronic health risks of pesticides used in the study.

The use of pesticides that are toxic to fish and bees is very high: 58% of the pesticides used show high or very high toxicity for fish and 33% show high or very high toxicity for bees. As 41% of the farmers had received no training on the use and potential hazards of pesticides or on mitigation measures to reduce their impact,[6] one can expect the use of these pesticides to result in a negative impact on the aquatic system and pollinators.

Type of pesticide use

The most frequently used active ingredients by far are the insecticide chlorpyrifos, the fungicide mancozeb and the herbicide glyphosate, which all have been classified as highly hazardous.

Chlorpyrifos was recently withdrawn in Europe and Canada and is under discussion to be banned in the US. Mancozeb was withdrawn in Europe due to its developmental toxicity.[7] The International Agency on Research on Cancer found glyphosate to be "probably carcinogenic" in 2015. There are also worldwide claims of chronic diseases caused by exposure to this ingredient.[8]

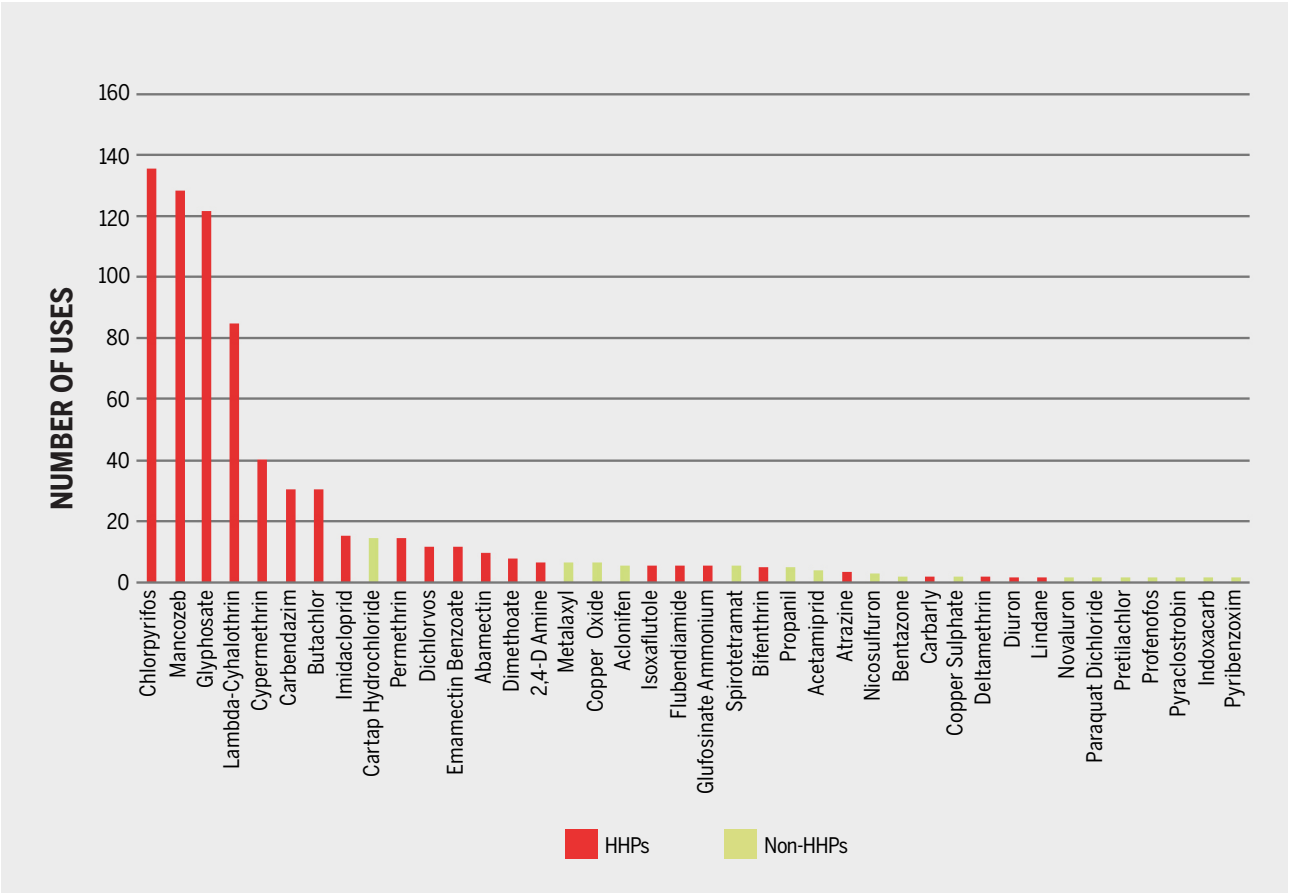

Figure 5. Frequency of use of active ingredients within the study.

Highly hazardous pesticide use in the different states

The share of HHPs is very high in the pesticide use in all four target states. Farmers in Kano State used pesticides most frequently (90% of these were HHPs), followed by Oyo State (84% HHPs), Ebonyi State (100% HHPs) and Benue State (97% HHPs).

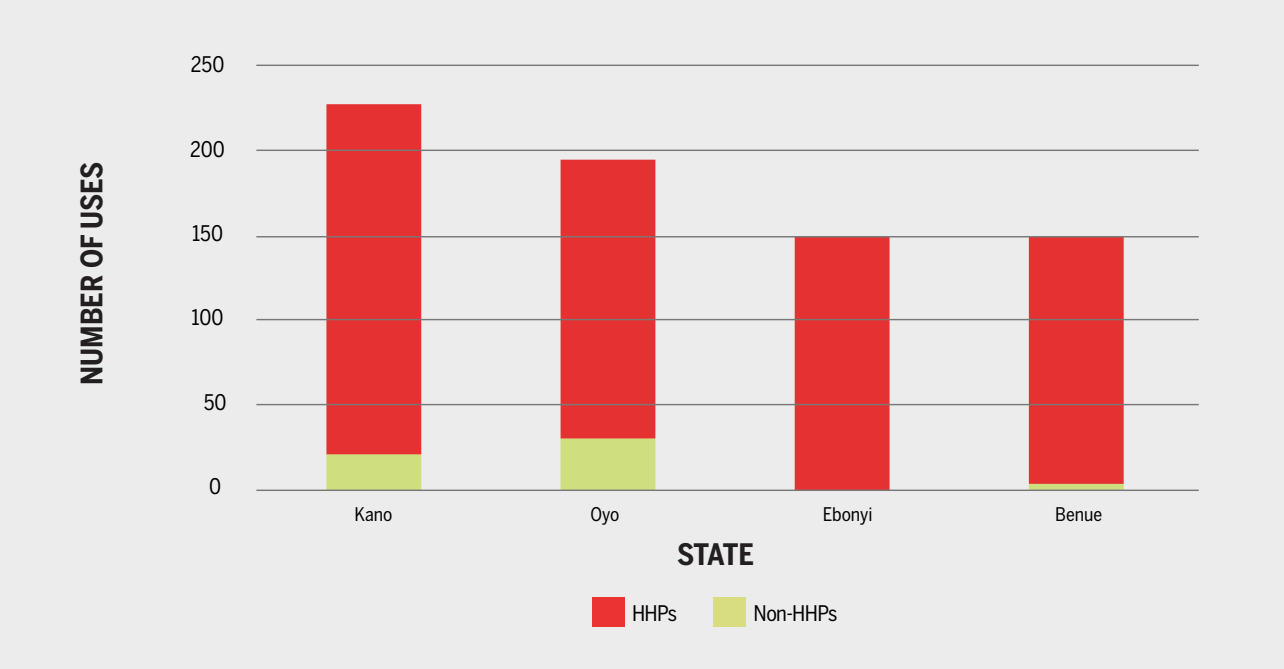

Figure 6. Frequency of use of pesticides in Kano, Oyo, Ebonyi and Benue states.

The number of active ingredients in use is highest in Kano (20) and Oyo states (21). However, the number of HHPs is very similar across the four, ranging from 9 in Benue State to 13 for both Kano and Oyo states.

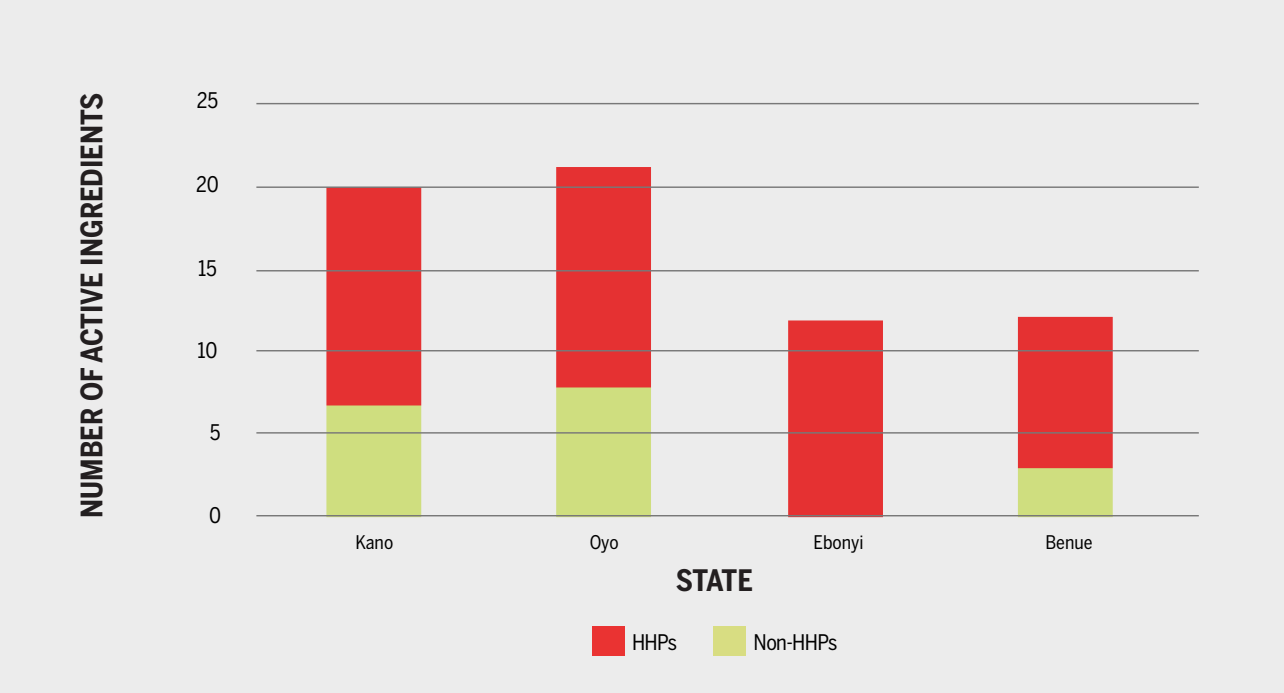

Figure 7. Number of active ingredients used in Oyo, Ebonyi and Benue states.

In Kano State, lambda-cyhalothrin is the most-used insecticide, glyphosate and butachlor are the most-used herbicides and mancozeb the most-used fungicide.

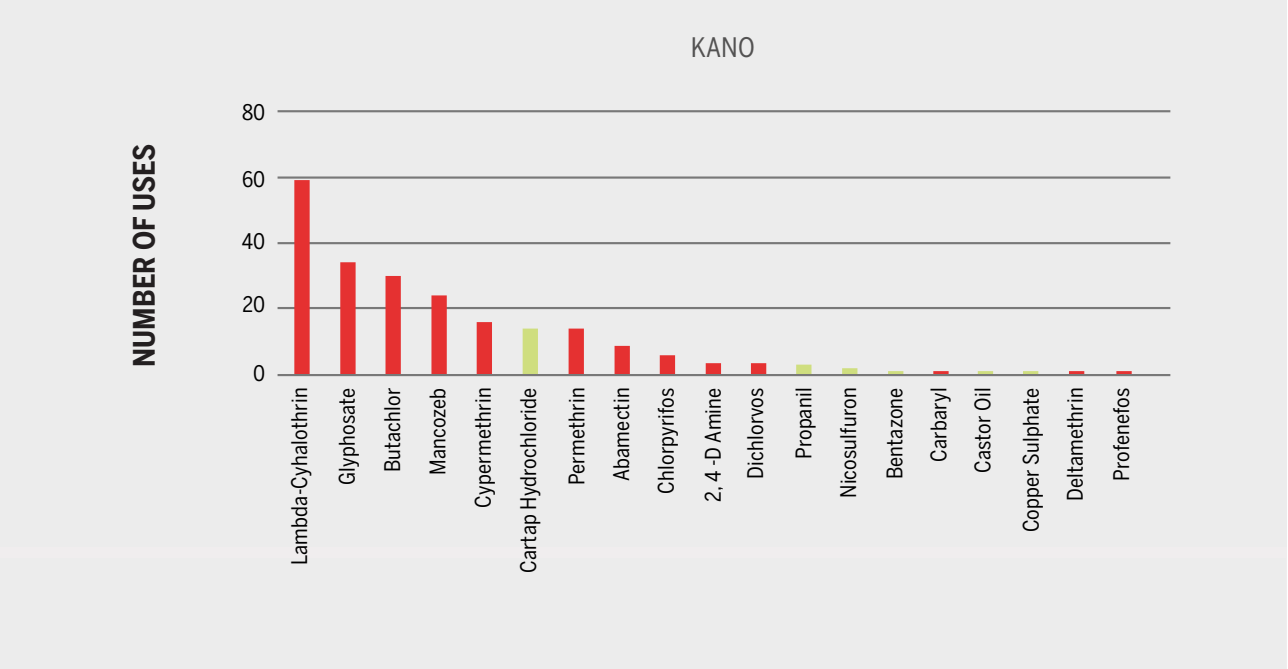

Figure 8. Number of uses for each active ingredient in Kano State.

In Oyo State, fungicides and herbicides are mostly used; the most-used fungicide is mancozeb and the most-used herbicide is glyphosate.

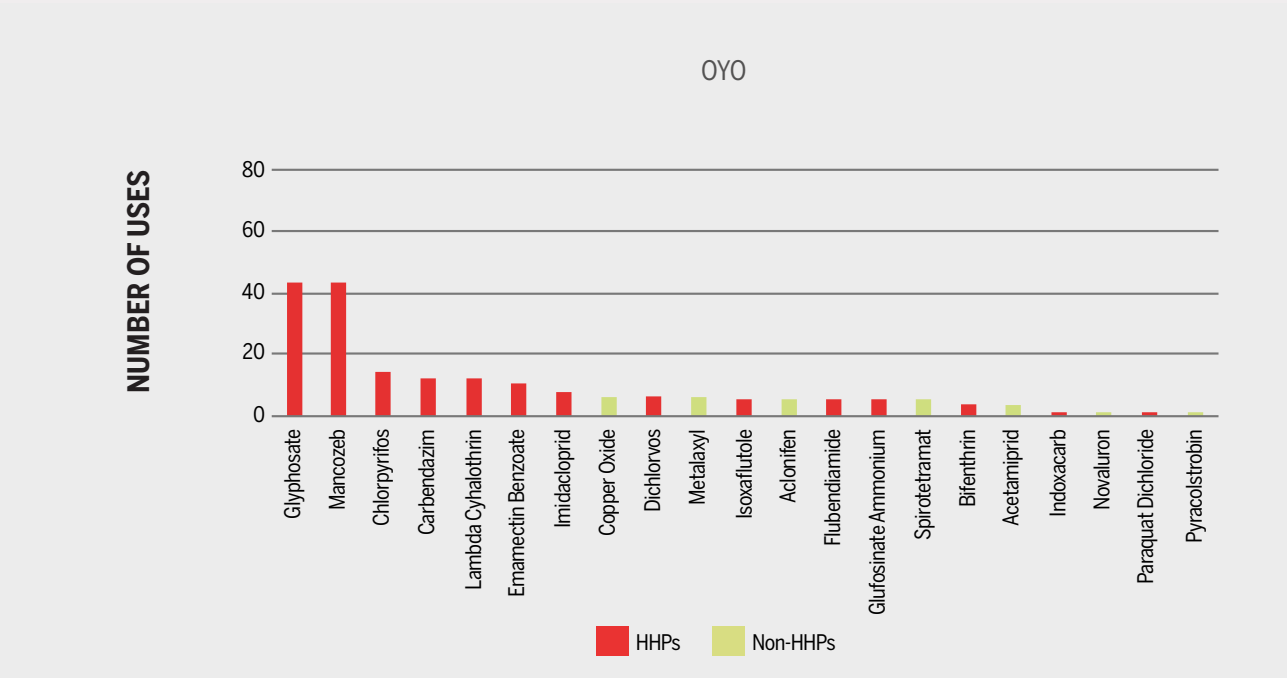

Figure 9. Number of uses for each active ingredient in Oyo State.

In Ebonyi State, mostly fungicides are used, and mancozeb is the most used. Chlorpyrifos is the most-used insecticide and herbicides are hardly used.

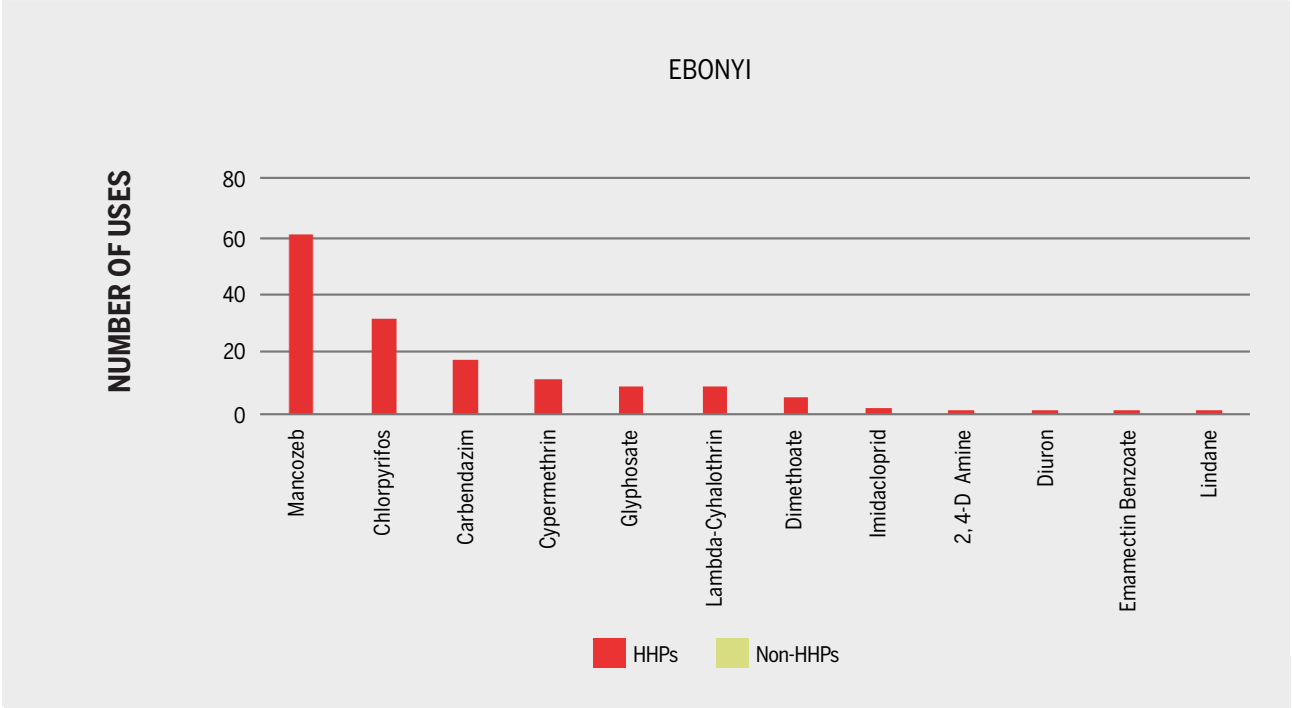

Figure 10. Number of uses for each active ingredient in Ebonyi State.

In Benue State, chlorpyrifos is by far the most-used insecticide, glyphosate the most-used herbicide and fungicides are hardly used.

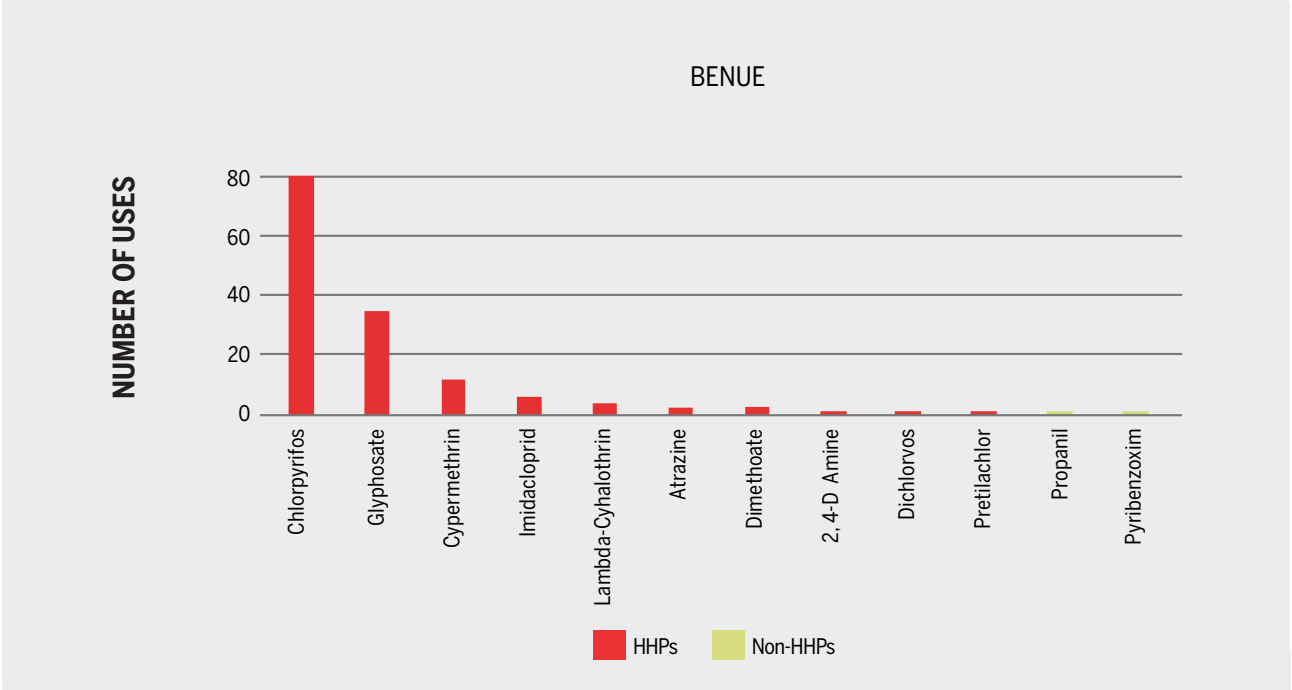

Figure 11. Number of uses for each active ingredient in Benue State.

Priority Crops for Integrated Pest Management

All in all, the interviewed farmers grow 34 different crops, of which staples – cassava, maize, rice, yam and millet – are the most important. Only a few farmers grow vegetables such as tomatoes, pepper, cabbage, beans or spinach and even fewer grow fruit, such as bananas.

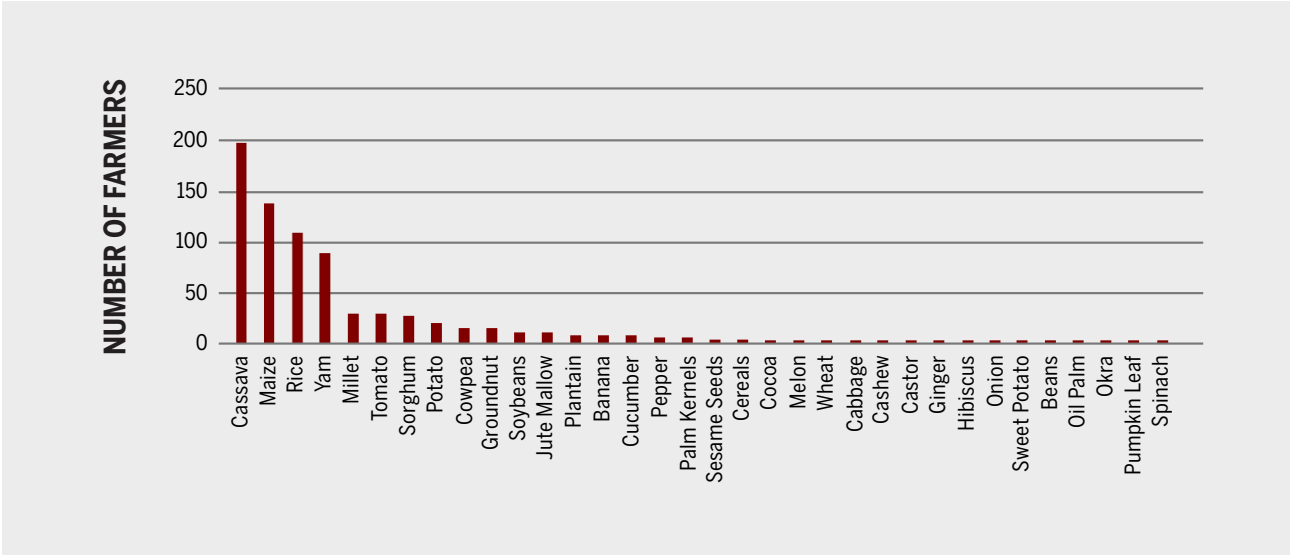

Figure 12. Crops grown by farmers in the study.

A total of 30 different crops were treated with pesticides. It is clear that pesticides are most frequently used on cassava (205 uses), where 18 different active ingredients were identified. This was followed by maize (with 25 active ingredients), rice (17) and yam (13).

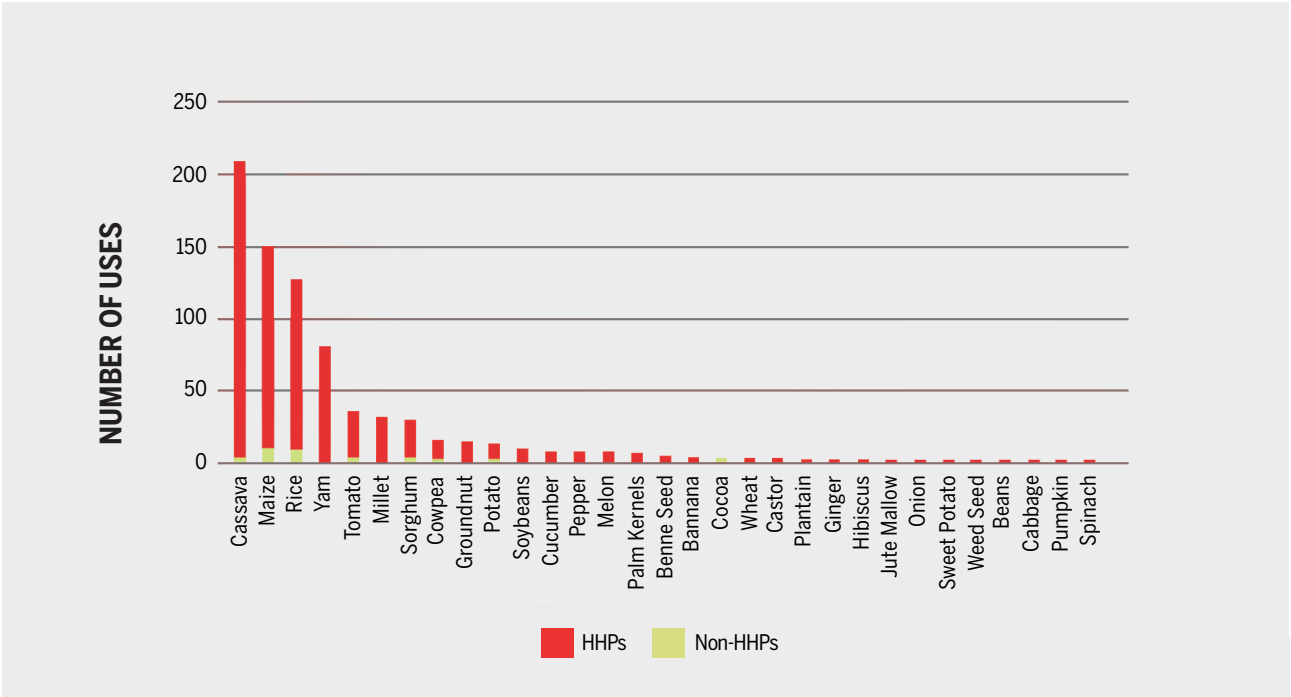

Figure 13. Number of uses of pesticides on various crops in the study.

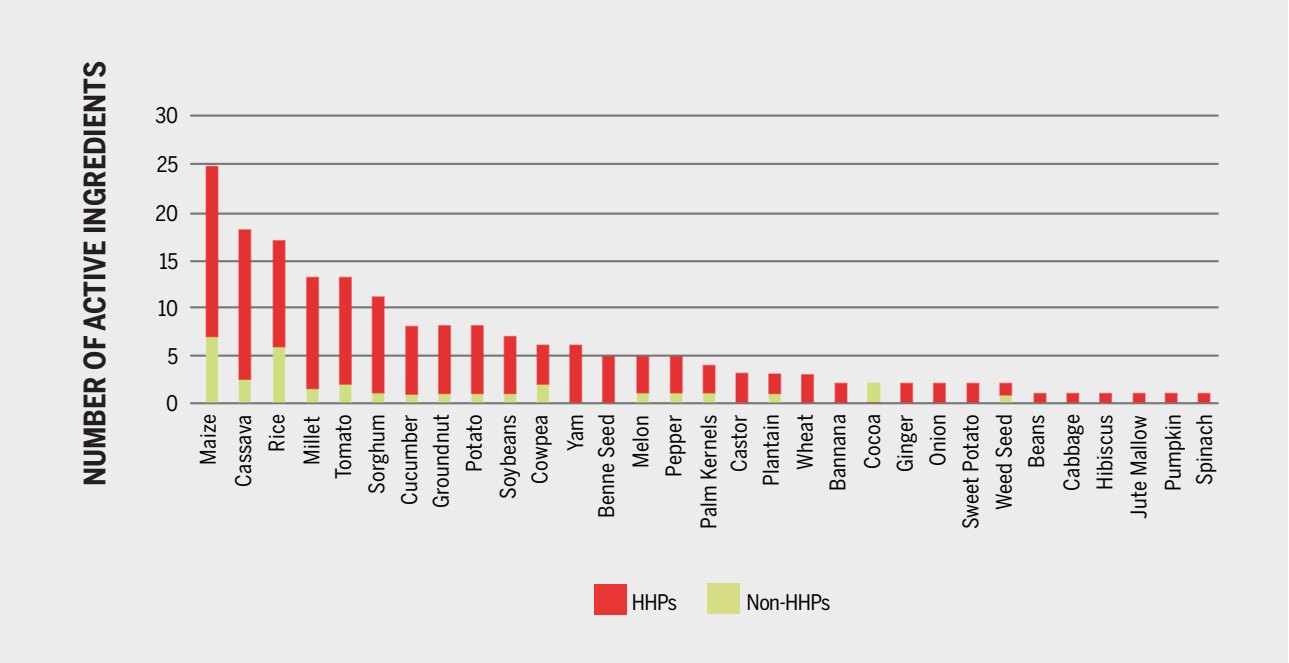

Figure 14. Number of active ingredients applied on various crops in the study.

Priority crops in the different states

Surveyed farmers in Oyo and Kano states grow the greatest diversity of crops, probably because of the bigger average land size (12.96 and 3.51 acres respectively). The farmers in Benue grow only six crops and in Ebonyi only five, with average farm sizes of 2.29 and 2.34 acres respectively.

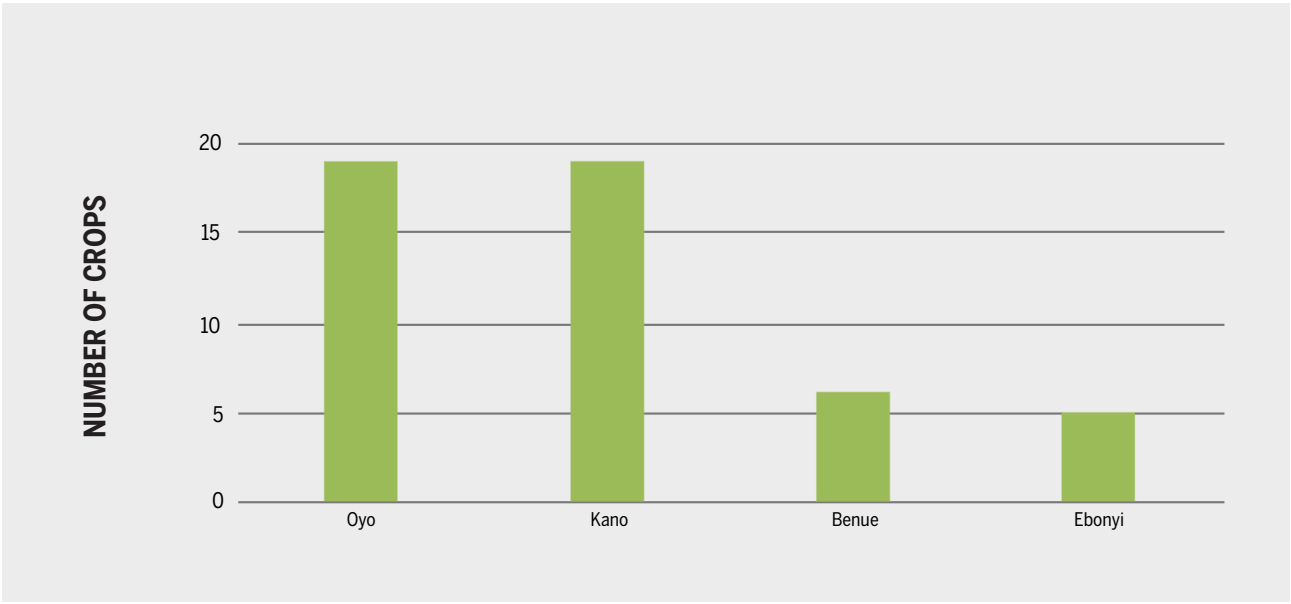

Figure 15. Number of crops grown by farmers in Oyo, Kano, Benue and Ebonyi states.

In Oyo State, farmers applied the highest variety of pesticides among all states as they also grow the greatest variety of crops. Pesticides are applied mostly on cassava, maize and tomatoes.

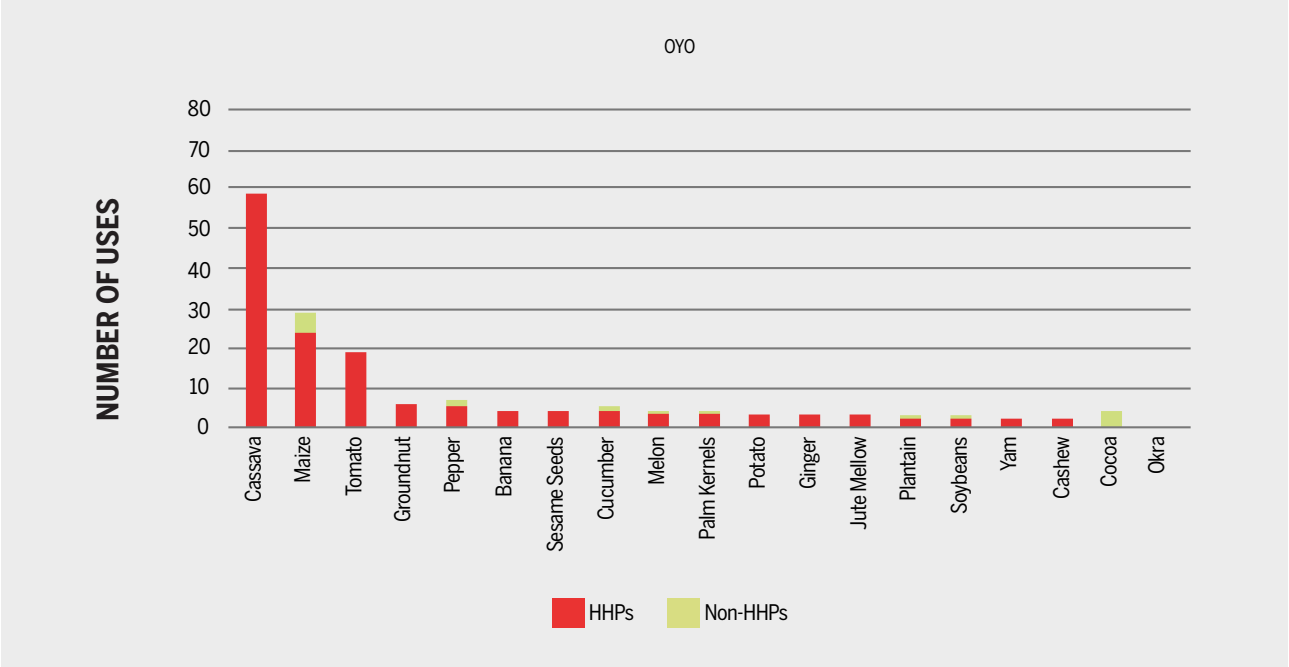

Figure 16. Number of uses of pesticides on various crops in Oyo State.

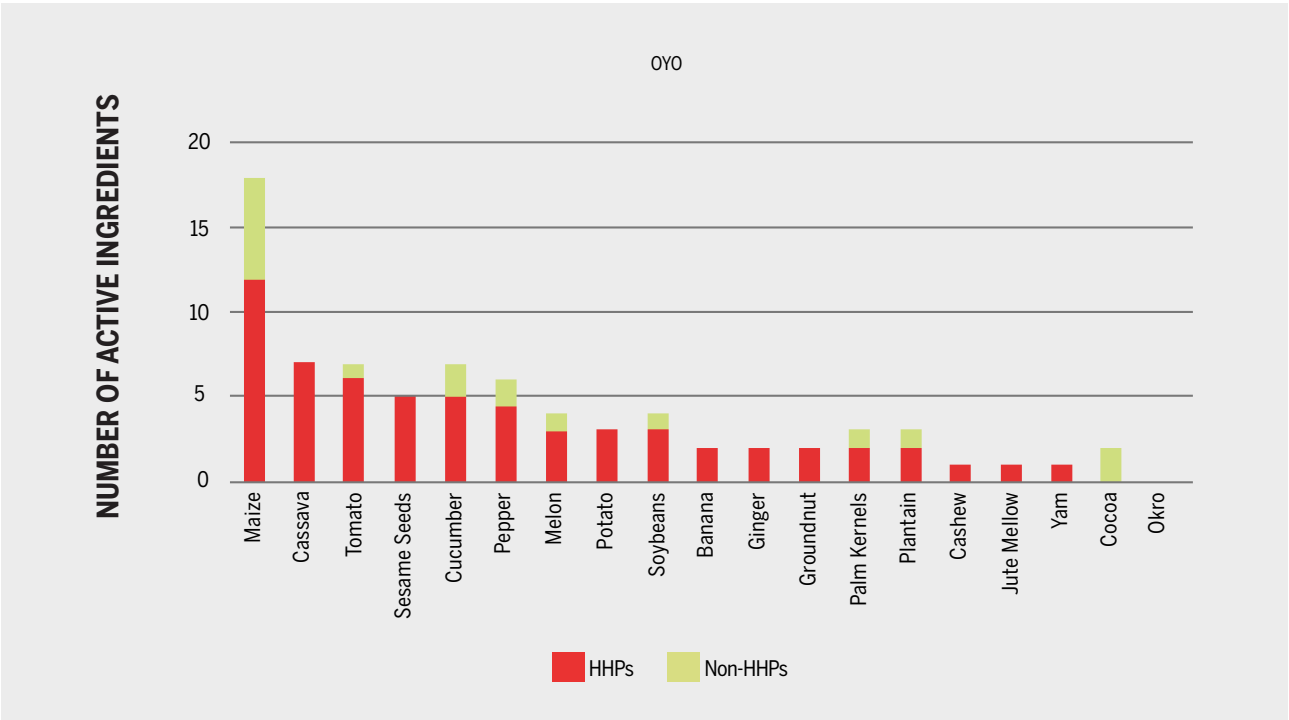

Figure 17. Number of active ingredients applied on various crops in Oyo State.

Farmers in Kano State grow a high variety of crops and therefore apply a higher variety of active ingredients. Pesticides are mainly applied on maize, cassava, millet, sorghum and rice.

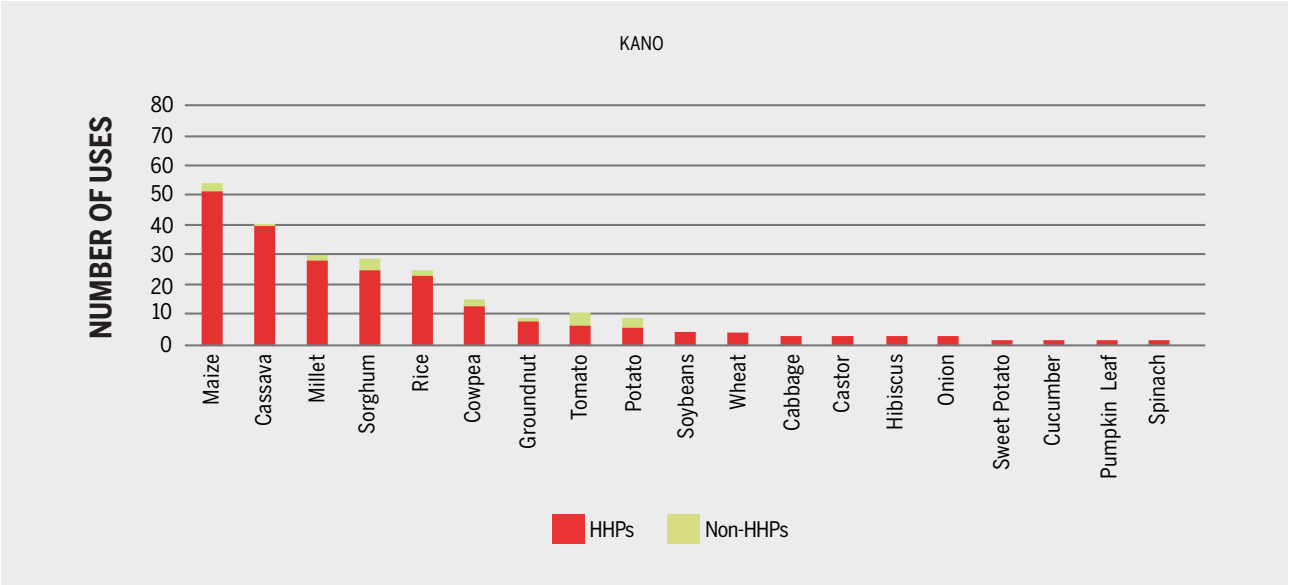

Figure 18. Number of uses of pesticides on various crops in Kano State.

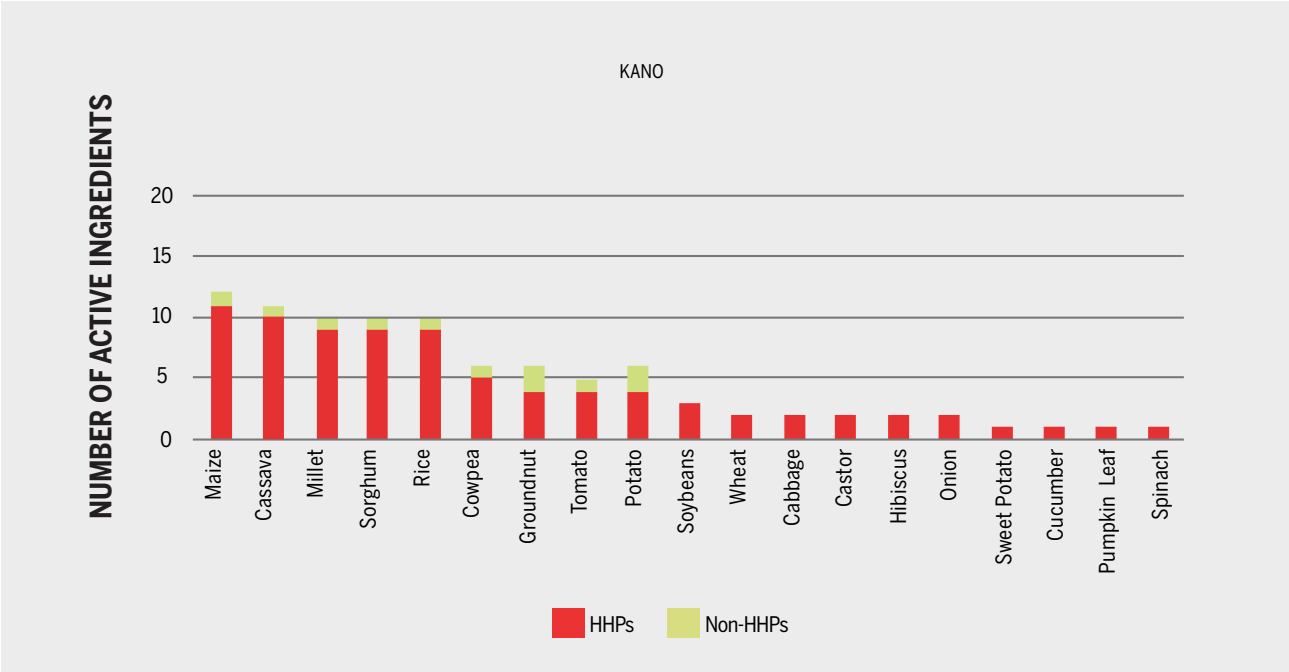

Figure 19. Number of active ingredients applied on various crops in Kano State.

In Benue State, mostly yam is treated with pesticides, followed by cassava and maize. The variety of pesticides is also not very high and ranges from two active ingredients to six.

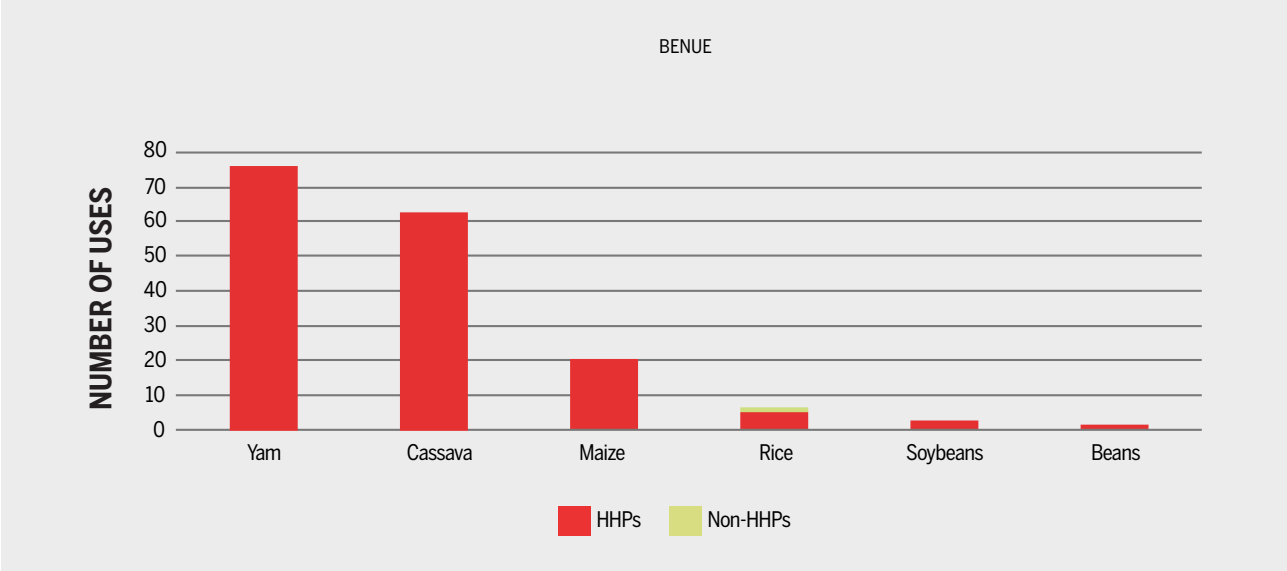

Figure 20. Number of uses of pesticides on various crops in Benue State.

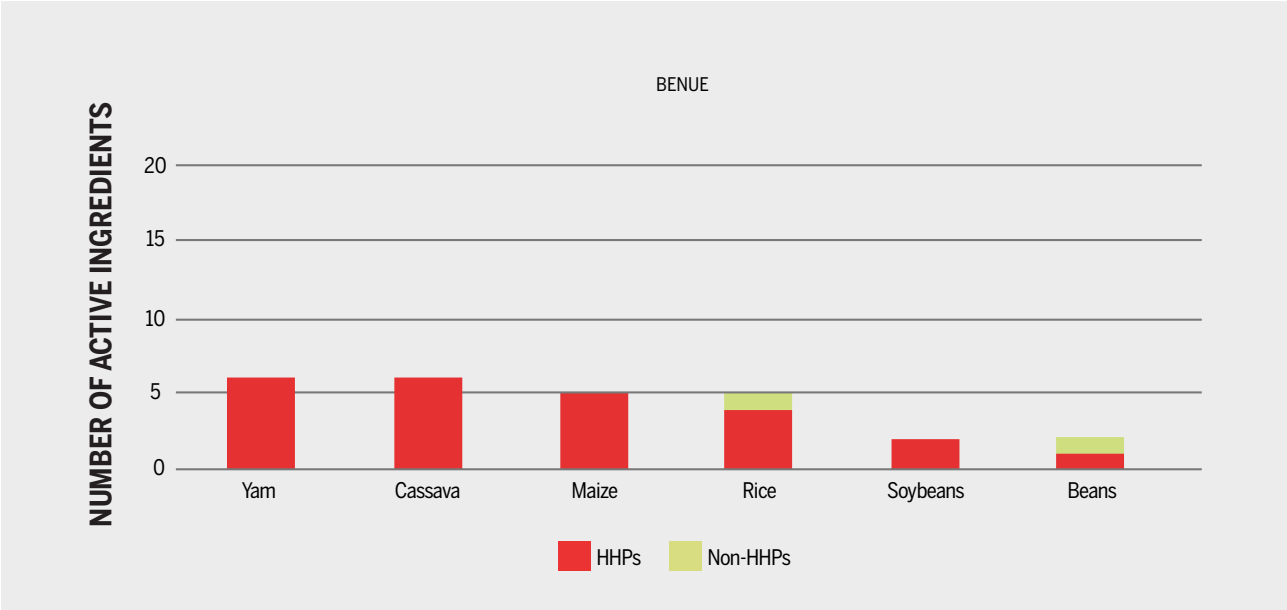

Figure 21. Number of active ingredients applied on various crops in Benue State.

Although only a few crops are grown by sampled farmers in Ebonyi State, they apply pesticides with the highest frequency of all four states. Most of the applications are for rice, with 6 different active ingredients, followed by cassava and maize.

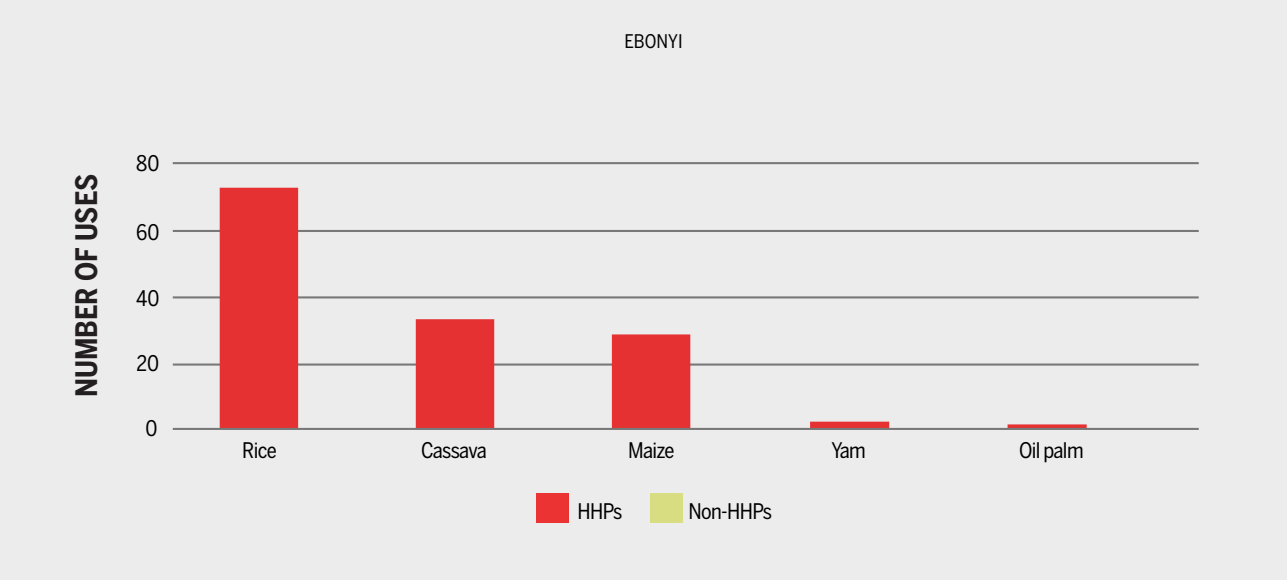

Figure 22. Number of uses of pesticides on various crops in Ebonyi State.

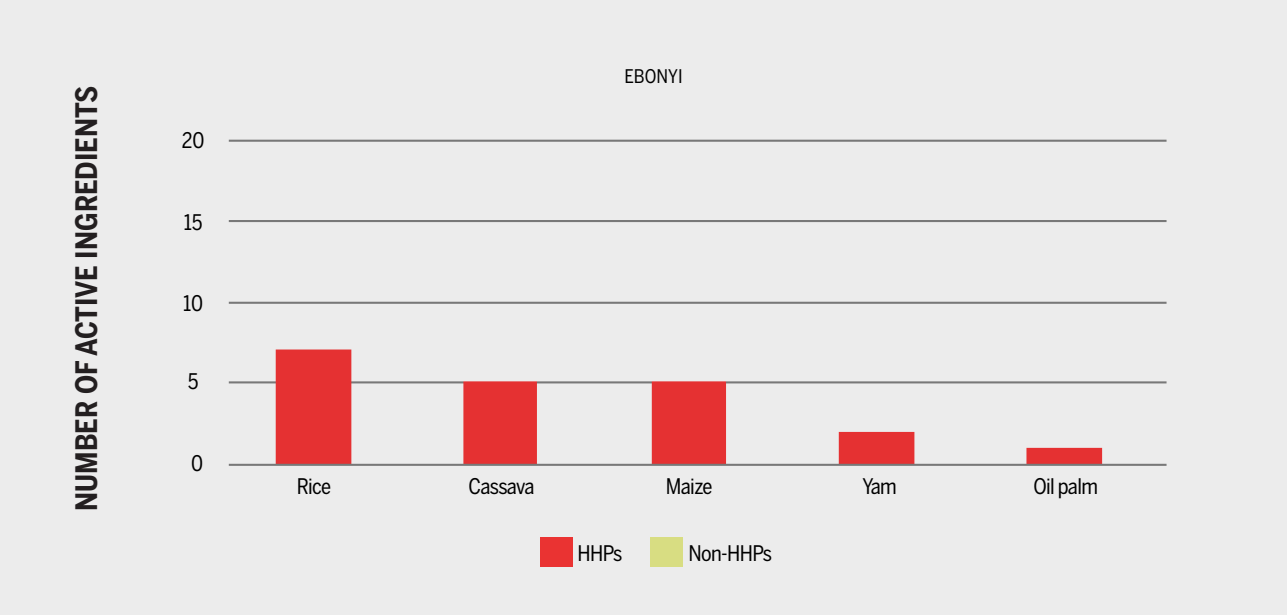

Figure 23. Number of active ingredients applied on various crops in Ebonyi State.

Only Kano and Oyo farmers use some non-HHP active ingredients for pest management. Farmers in Ebonyi and Benue state rely almost only on HHPs.

Awareness and Safety of Pesticide Use

Although 65% of all pesticide applications are of HHPs, many farmers do not use any personal protection equipment (PPE), such as face masks, gloves, boots and eye protection. Twenty-four percent of all farmers do not use any PPE at all. Many cannot afford PPE or it is not available.

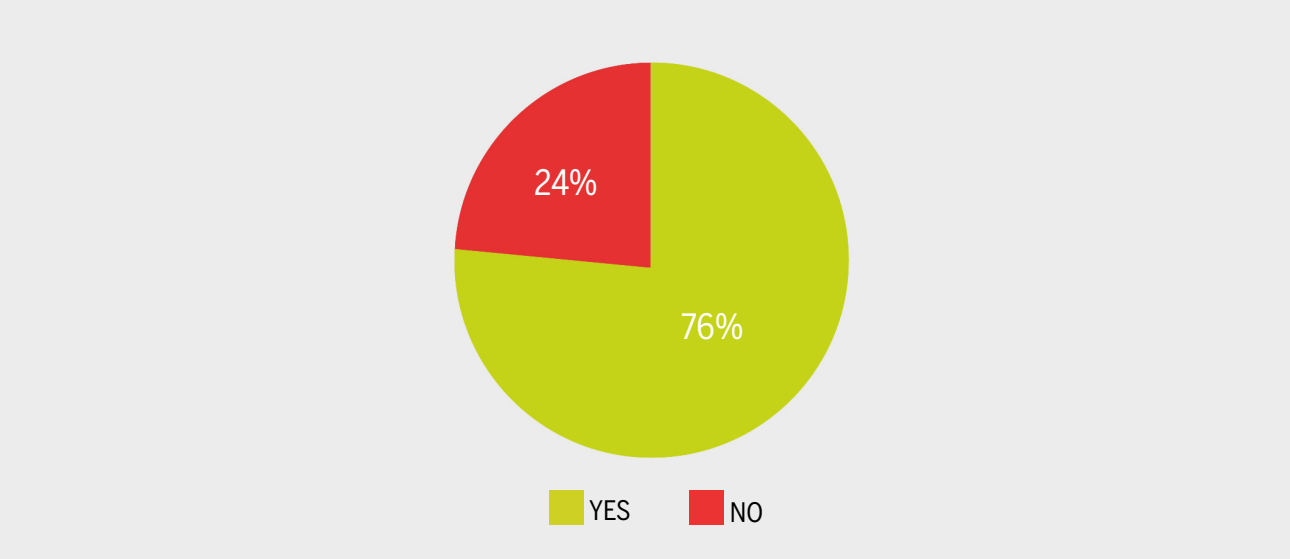

Figure 24. Use of personal protection equipment by farmers in the study.

The most common protective items worn during pesticide applications are face masks (20%), gloves (29%) and boots (13%). Very few protect their eyes (4%) or use an overall to shield their clothes (5%).

One reason that farmers do not wear PPE could be that they are not aware of the potential toxicity of the pesticides and related health effects. Indeed, the study showed that 32% of the farmers are not aware of any health effects of the pesticide they use. However, every farmer should know that pesticides can impact their health if used incorrectly.

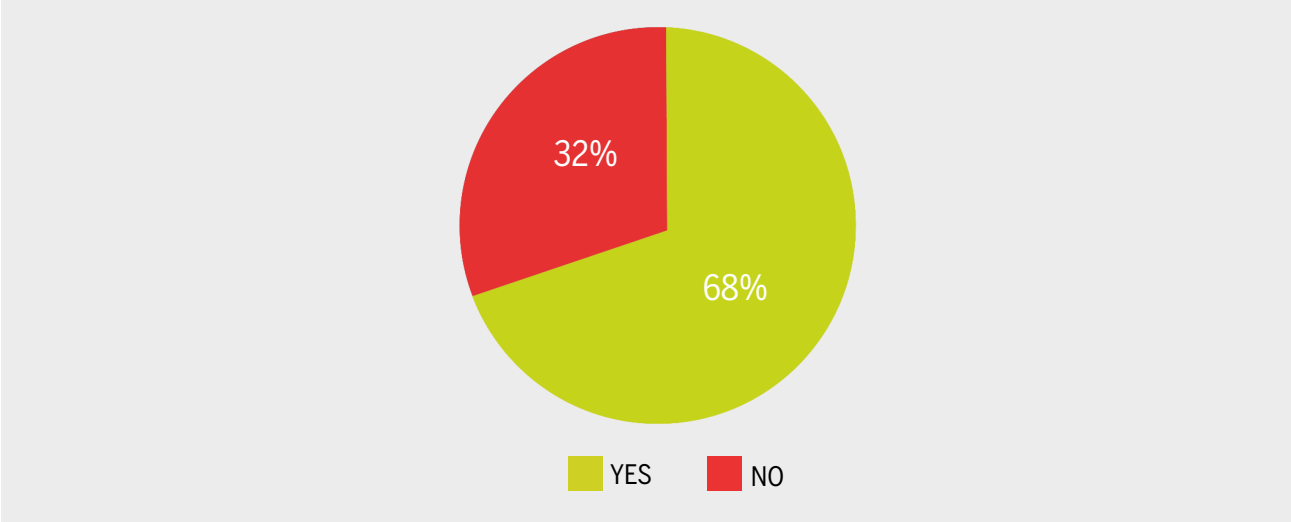

Figure 25. Awareness of farmers in the study about negative health effects of pesticides.

The relatively high percentage of farmers not being aware of health effects could be because they were never informed. The study revealed that 41% of all farmers never received any training on the safe use of pesticides.

Most of the farmers who had training received it from farmers' associations, followed by agro-dealers. Only a few received the training from the state, indicating low coverage by public extension officers.

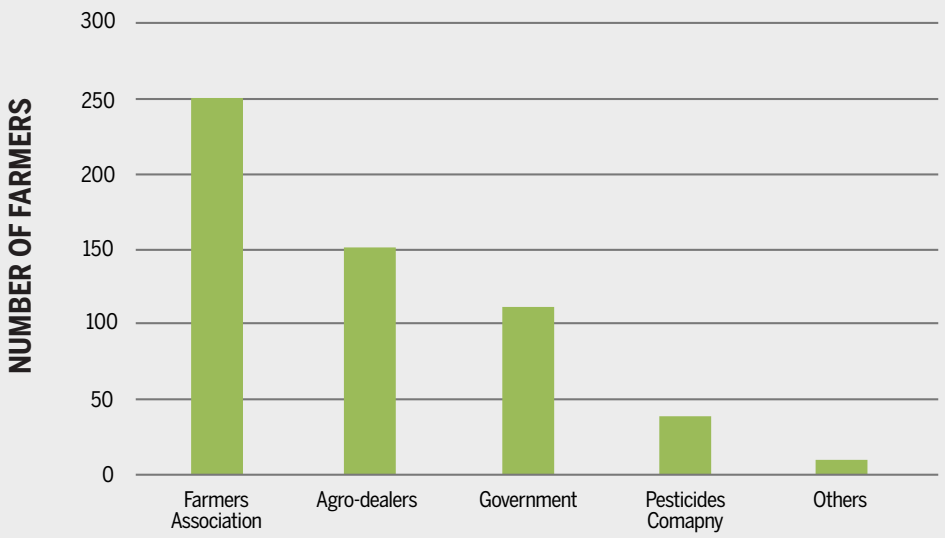

Figure 26. Institutions that offer training on pest management and pesticide use in the study.

Advice on Pesticide Use

Extension officers

Most of the extension officers are male (74%), work for the government (87%) and have received a university degree (64%).

Extension officers specified 20 different pesticides that they recommended for use, of which 85% belong to the highly hazardous group. Glyphosate is the most frequently suggested herbicide, followed by the insecticides lambda-cyhalothrin and cypermethrin. Fungicides were not recommended very often, with mancozeb the most common one.

GENDER	(%)
Female	26
Male	74
EMPLOYER	**(%)**
Government	87
Private Company	3
NGO	7
Others	3
HIGHEST LEVEL OF EDUCATION	**(%)**
Primary School	2
Secondary School	2
College	32
University	64

Table 3. General characteristics of extension officers who completed the questionnaire.

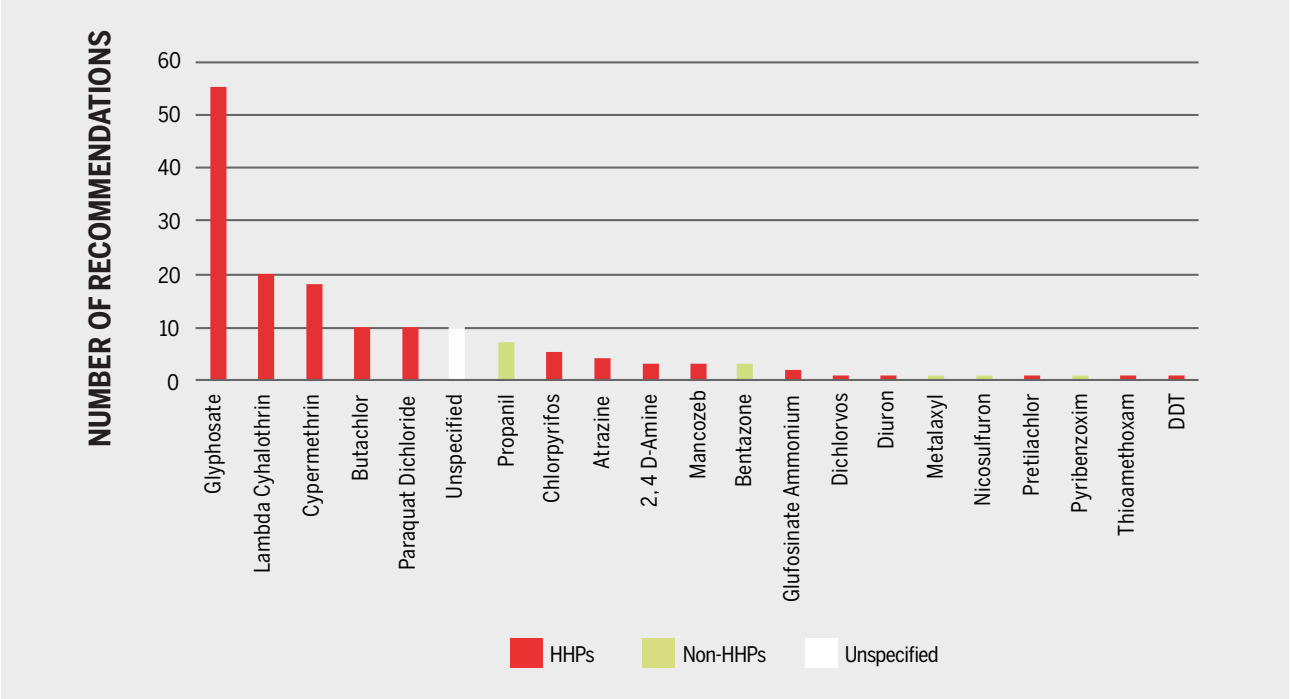

Figure 27. Active ingredients recommended by extension officers.

Agro-dealers

Most of the agro-dealers are male as well (81%). Only 23% received higher education at college or university. Although almost all agro-dealers (98%) offer product advice to farmers, only 57% had received training in pesticide management.

Agro-dealers recommended 22 different pesticides, of which 94% were HHPs. The most recommended were the herbicides glyphosate, paraquat and 2,4-D amine, followed by insecticides lambda-cyhalothrin, cypermethrin and carbofuran. Only a few recommended fungicides like mancozeb. All in all, their recommendations were similar to those of the extension officers.

GENDER	(%)
Female	19
Male	81
HIGHEST LEVEL OF EDUCATION	**(%)**
Primary School	1
Secondary School	76
College	15
University	8
PESTICIDE MANAGEMENT TRAINING	**(%)**
Yes	57
No	43

Table 4. General characteristics of agro-dealers who completed the questionnaire.

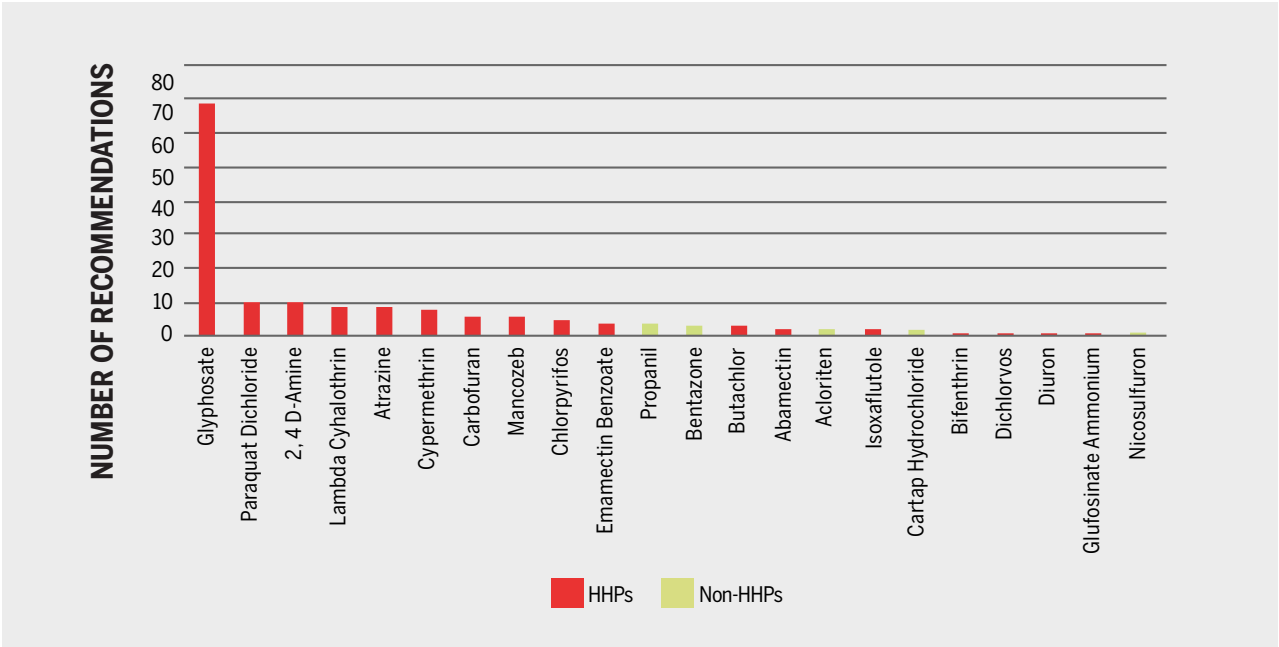

Figure 28. Active ingredients recommended by agro-dealers.

Generally, the pesticides recommended by extension officers and agro-dealers are similar to the ones the farmers are using. This means that most of the farmers follow the advice.

Alternatives to Pesticide Use

Farmers are generally unaware of alternatives to pesticide use and 31–45% of those surveyed would continue to use agrochemicals to control pests, diseases and weeds. This could be because few of them have received training in integrated pest management (IPM) and not many agro-dealers and extension officers recommend efficient sustainable methods. Also, not many biopesticides are commercially available and there is no government policy and little information on IPM in general.

The survey revealed that only 1% of the agro-dealers recommended biopesticides for pest control.

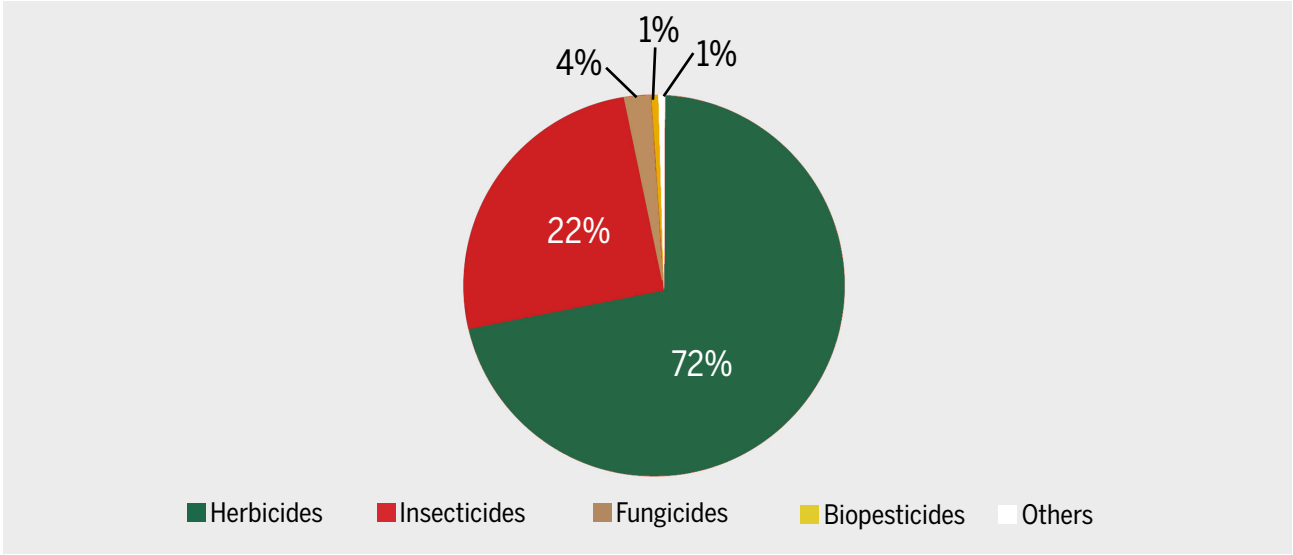

Figure 29. Advice on pest management by agro-dealers.

Extension officers mostly recommended good agricultural practice (GAP) as an alternative to pest control. Only 1% recommended commercially available biopesticides.

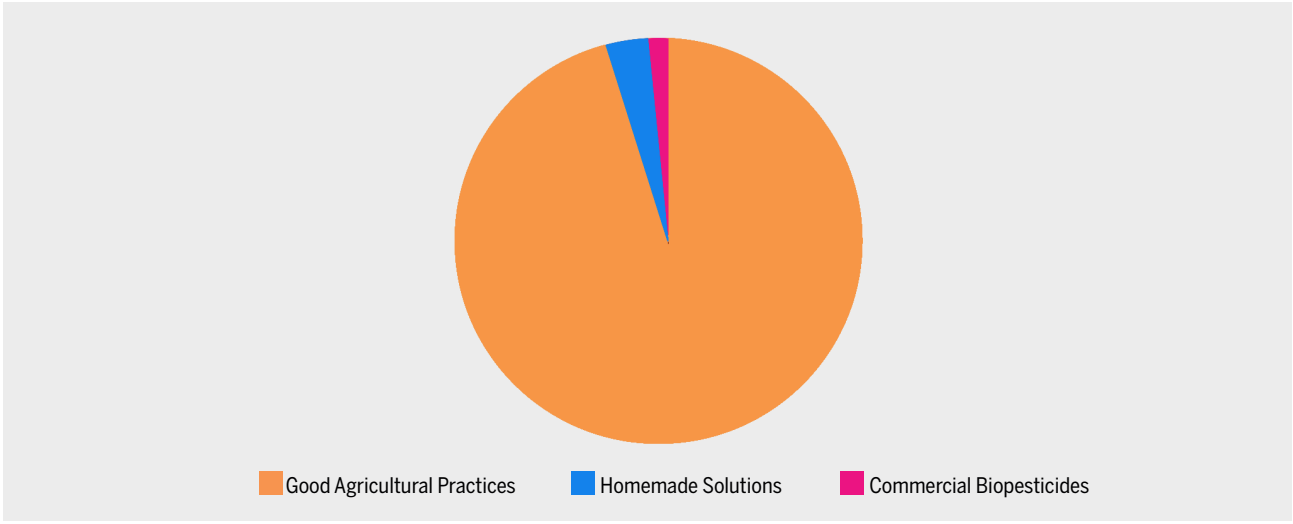

Figure 30. Advice on alternative pest management strategies by extension officers.

The good agricultural practices recommended by extension officers included the use of resistant crop varieties, crop rotation, mechanical and biological control and early planting to reduce pest pressure. Important strategies like attracting beneficial insects, intercropping and implementing biodiversity were neglected.

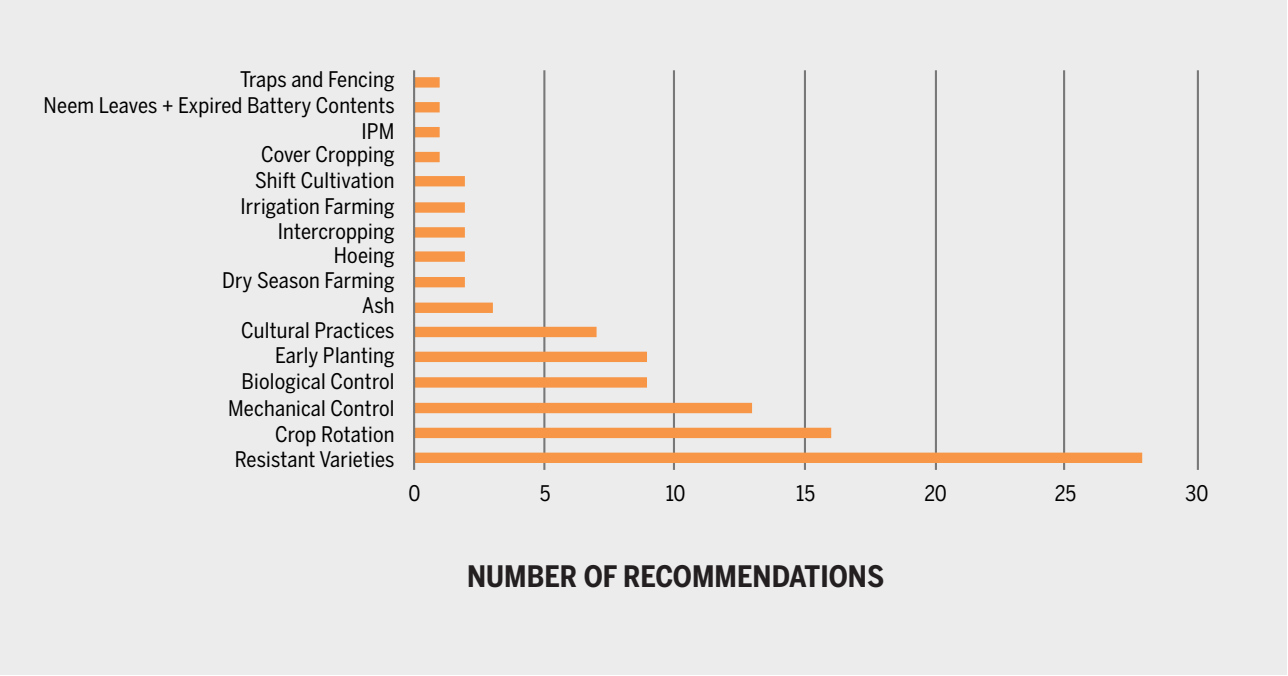

Figure 31. Good Agricultural Practices recommended by extension officers.

Pesticide Residues in Food

Methodology

Since the results showed that many farmers were using pesticides with high frequency and a high number of different active ingredients on yam and tomatoes, these crops were analyzed for pesticide residues. The maximum residue level (MRL) is the maximum amount of pesticide residue that is expected to remain on food products when a pesticide is used according to label directions that will not be a concern to human health.

In July, the produce was collected from randomly selected farms in Kano and Oyo states (four different farms for each crop in each of the states). The samples were prepared by Cropnuts for analysis by Groen Agro Control in the Netherlands.

Analysis

The analytical sample (homogenate) is prepared by fine grinding using a blender and deled in two fractions, A and B. Fraction A can be directly used for the analysis; fraction B is immediately stored in closed glass flasks at -18°C. Laboratory samples are homogenized so that the relatively small (10–25 g) test portion taken for analysis is representative of the entire sample.

A portion of homogeneous portion A and representative sub-sample is extracted using the QuEChERS methodology. A fraction of the final extract can be directly analyzed using GC-MS/MS (gas chromatography) and LC-MS/MS (liquid chromatography) for the identification and quantification of pesticides.

Validated analytical methods and quality assurance/quality control procedures were adapted for the determination of the active-ingredient content of a number of pesticides. The results presented are statistically evaluated. If the concentration of the determined pesticide exceeds the MRL, a second portion of the sample is analyzed and another fraction is spiked with the appropriate pesticide for a correction of the recovery of the extraction.

Results

Yam

Four different pesticides were detected in yam from Kano State. All of them are HHPs and one, permethrin, is a carcinogenic insecticide and should not be applied on yam. The fungicides metalaxyl and tebuconazole were above the MRLs and therefore may pose a risk to human health. Furthermore, the mixture of the four pesticides may have unknown impacts on human health.

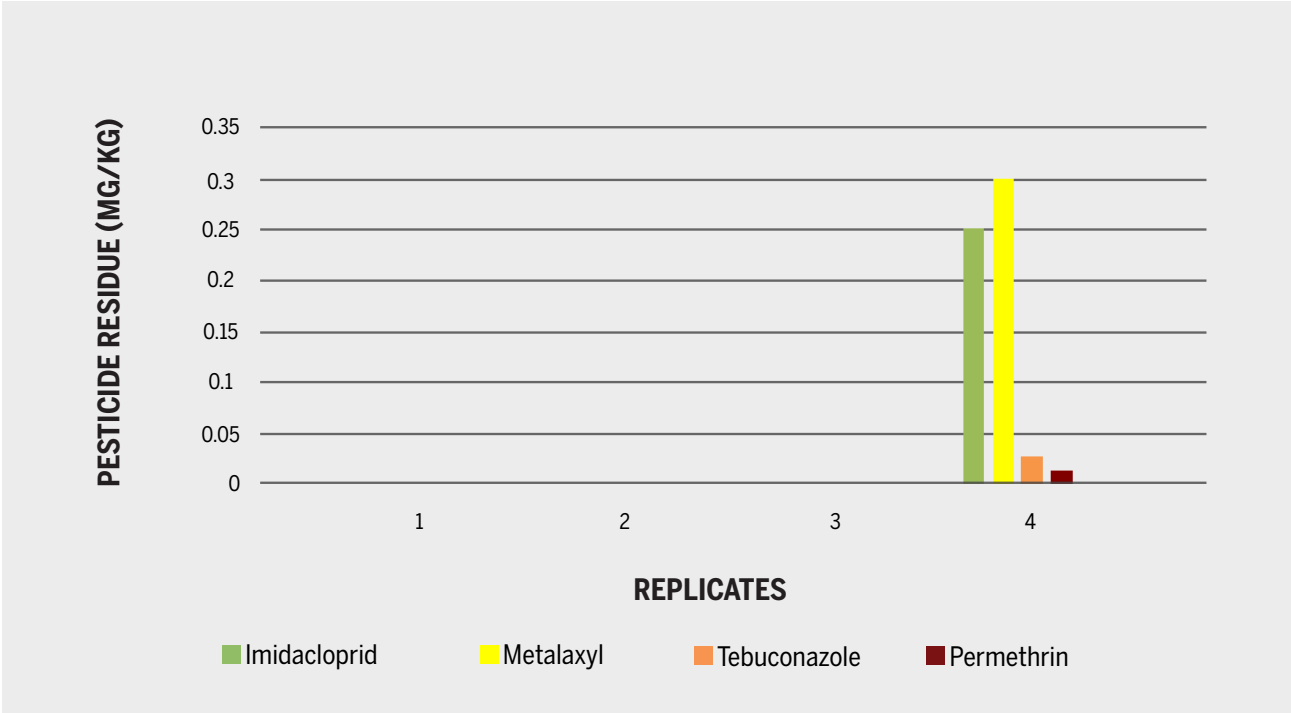

Figure 32. Pesticide residues in yam from Kano State.

Tomatoes

Cypermethrin levels were detected in tomatoes grown in Kano State and three different insecticides were detected in tomatoes grown in Oyo State. Again, permethrin was detected, which may pose a carcinogenic risk to human health, especially as one sample even exceeded the MRL. However, all other residues were below their MRLs. Pesticide levels in tomatoes grown in Oyo State are clearly higher and similar levels were found in all four replicates. The mixture of cypermethrin, profenofos and permethrin may pose an unknown risk to consumers.

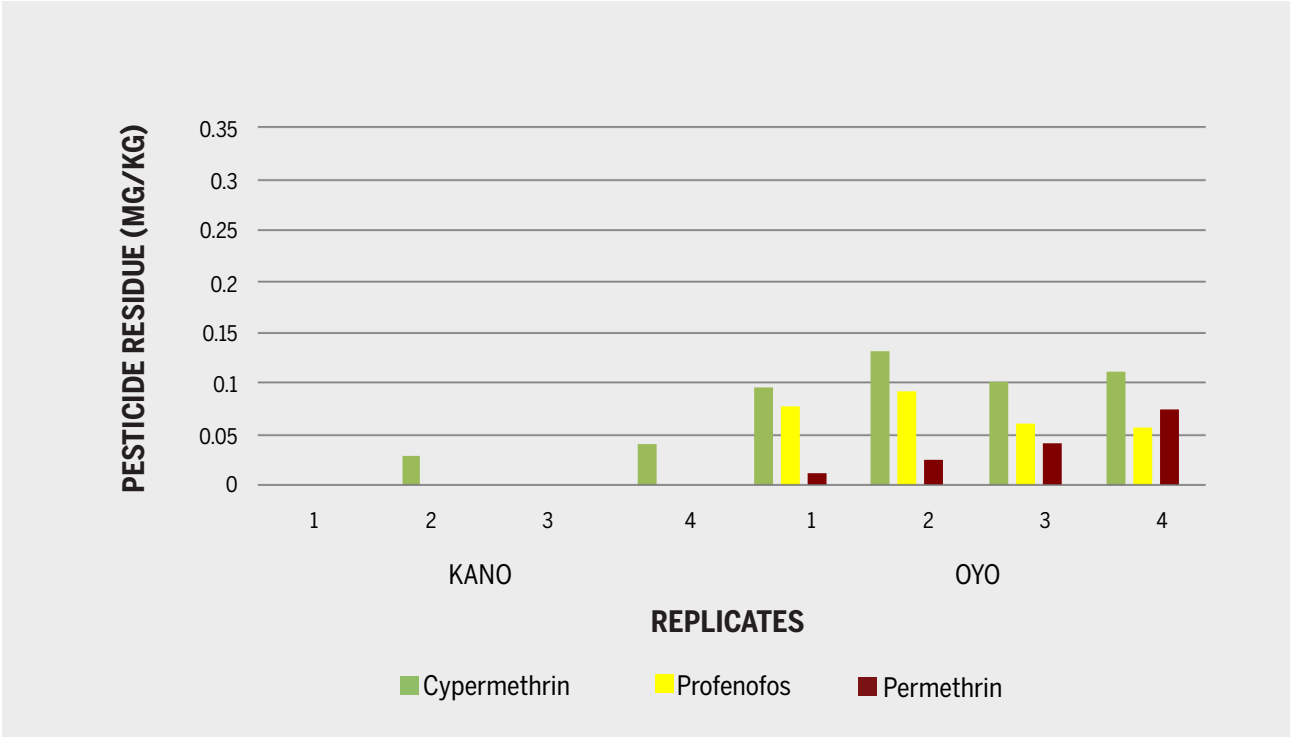

Figure 33. Pesticide residues in tomatoes from Kano and Oyo states.

Key Insights and Solutions

Farmers' awareness and knowledge

Only a limited variety of pesticides is used by the farmers in the four states and recommended by advisors. Herbicides like glyphosate, insecticides like cypermethrin, chlorpyrifos and lambda-cyhalothrin, and fungicides like mancozeb are predominant. This could lead to the development of resistance in pests, diseases and weeds, especially if the farmers use them with high frequency and incorrect dosages.

Most of the pesticides used are HHPs and toxic to human or environmental health, but there is a clear lack of knowledge among the farmers about their potential health or environmental effects. Many did not even wear PPE.

Solutions

This indicates an urgent need for better training of extension officers and an increased budget for extension services. Extension officers should predominantly provide information on sustainable agricultural practices. This should include, firstly, mitigation measures to prevent environmental and human health effects and, secondly, IPM strategies to replace toxic pesticides with biocontrols and biopesticides – or even less-toxic pesticides – and, ultimately, agroecology principles.
Crops like cassava, maize, rice, yam and tomatoes should be targeted first, as they receive the most HHPs and greatest frequency of applications. Regular monitoring of these crops would ensure food safety for Nigerians.

Agro-dealers' awareness and knowledge

As the main source of farmers' information about pest and disease management, the advice given by agro-dealers is very important. Almost all the pesticides that appear in this study are HHPs. The "precautionary principle" in law states that precautionary measures should be taken when there is a reasonable threat of harm, even if it has not yet been scientifically confirmed. In accordance with this principle, some of these pesticides have already been withdrawn from the European market. Yet agro-dealers recommend pesticide products that are proven to have certain chronic health effects and are toxic to bees and fish.

Solutions

The "principle of sustainability" guides meeting the needs of the present without compromising the needs of future generations. Agro-dealers should advise farmers on sustainable pest-management practices to reduce the likelihood of negative impacts on human health and the environment.

Agro-dealers should receive training on the registration status of the products they recommend, as well as the potential human health and environmental effects of these products. They should also have the knowledge to advise farmers on proper mitigation measures to avoid harmful effects. Governmental incentives should be provided to farmers for the promotion of sustainable pest-

control solutions, including biocontrol and biopesticides.

Sales of unregistered pesticide products (e.g. DDT) to farmers should be monitored and penalized.

Protection and safety

Highly hazardous pesticides are sold and used in all four target states in Nigeria. Despite their toxicity to human health, farmers are either not protecting themselves fully or not wearing any PPE at all. This could be because they are unaware of the hazards and/or PPE is too expensive or otherwise not available. Farmers are also unaware of environmental effects and the necessary mitigation measures. The pesticide industry is selling these products while knowing their toxicity.

Solutions

It is the industry's responsibility, together with government, to ensure that all mitigation measures are in place and to protect human health and the environment. If required mitigation measures cannot be implemented, these pesticides should not be used any more and be restricted from the market.

Promotion of alternatives

Generally, there is still a lack of knowledge among farmers and extension officers about sustainable farming systems that use less or no pesticides. The most common staple crops are treated with a high frequency of pesticides. Agro-dealers and extension officers are not recommending biopesticide or biocontrol. Only a few recommend good agricultural practice to avoid pest infestation. However, the methods recommended (crop rotation, resistant varieties and mechanical control) are very limited.

Solutions

Agroecological farming systems prevent pesticide exposure, enhance biodiversity, help to improve air, soil and water quality and mitigate climate change. Farming systems need to be redesigned or adjusted based on the available knowledge of this.

Farmers and policy-makers in local governments should be encouraged and supported to understand and transition to agroecological practices like crop rotation, soil fertility management and crop selection adapted to local conditions.

Measures can include training, direct payments and market development for agroecological products.

Pesticide residues in food

In the study, yam showed elevated levels of tebuconazole and metalaxyl, and tomatoes showed a mixture of cypermethrin, profenofos and permethrin. Permethrin, a carcinogenic substance, was detected in yam and tomatoes. Some pesticide residues in tomatoes (permethrin) and yam (metalaxyl and tebuconazole) exceeded the MRLs, making the sample produce unsuitable for consumption.

However, there are no adequate monitoring and reporting systems for pesticide residues in local food. Consumers are mostly not aware of pesticide residues in food and the danger of chronic exposure to pesticides.

In addition, the calculation of MRLs is based on consumption patterns, and the Nigerian diet contains much more yam than do European diets.

Solutions

The implementation of monitoring and reporting strategies for pesticide residue in food and the environment requires an increased budget and political will.

MRLs need to be adapted to Nigerian diets, which should result in lower MRLs for pesticides that are applied on yam crops.

There should be routine updates of the MRLs allowed in Nigeria as well as dissemination of pesticide safety information based on the most up-to-date global and local scientific literature.

Conclusion

The results of this study show that Nigerian smallholder farmers regularly use highly hazardous pesticides that are toxic to human health and the environment. They do so with the advice of agro-dealers and extension officers but without being provided with the necessary information and training in protection and mitigation practices or alternative sustainable and integrated pest management.

Although this survey only provides a snapshot of four states and focuses on local crop production, it documents the need for urgent changes in pest-management strategies in the country. The Nigerian government needs to re-assess the pesticides that are currently registered and should phase them out while sourcing less-toxic alternatives.

When proposed mitigation measures are not applicable to small-scale farming or are too expensive, human and environmental health will not be protected from the effects of these highly toxic pesticides. This entails the urgent design and implementation of integrated pest management, with a focus on crops like cassava, maize, rice, yam and tomatoes, and the promotion of an agroecological approach. Only through more sustainable strategies can the Nigerian government assure a safe national food market and a growing export market.

Notes

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