



Agrochemical use Patterns among Fresh Produce Farmers in Nakuru County, Kenya: Examining the Instigators

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ABSTRACT

Agriculture is the most important economic activity in Kenya, despite only 10.2% of the total land cover being arable. The agriculture sector contributes 51 percent of Kenya's GDP, 26 percent directly and 25 percent indirectly, accounting for 60 percent of employment and 65 percent of exports (KNBS, 2024). To achieve optimal production in the agricultural sector, agrochemicals play a significant role. On average 12,983 tons of agrochemicals are imported in to the country annually with a total value of KES 10.7 billion.

More agrochemical volumes are required over time resulting in a vicious cycle between agrochemical use dependency and worsening health and climatic conditions. This study sought to determine the agrochemical use practices among Fresh Produce Farmers in Nakuru County, Kenya and their drivers. The study design was a community based cross-sectional analytic and descriptive study. The target population included Fresh Produce Farmers residing in Nakuru County for at least two years routinely applying agrochemicals in their daily occupational activities. A two-stage sampling technique, using probability proportional to size (PPS), was applied to select four sub-counties: Njoro, Kuresoi North, Molo, and Bahati. A total of 388 respondents were sampled using Cochran's formula with a 10% non-response adjustment. Quantitative data were collected using structured questionnaires, while qualitative insights were gathered through focus group discussions and key informant interviews. Data were analyzed using SPSS v28 for descriptive and inferential statistics, and NVivo for thematic analysis. The findings revealed a significant association between awareness of pest pressure and resistance of agrochemicals and decision-making on volume and frequency of agrochemical usage. 87% of respondents who used recommendations from experts were aware of the potential environmental impacts of agrochemicals. 72% and 48% of those who used previous experience and those using recommendations from other farmers were also aware of the potential environmental impacts of agrochemicals, respectively. Fresh produce farmers who have realized extreme weather patterns use fewer methods of applying agrochemicals. The Ministry of Agriculture and the Ministry of Environment, Climate Change, and Forestry need to work collaboratively to support fresh produce farmers in Nakuru County in public extension services, which will play a critical role in increasing the protective use of agrochemicals. Public extension services will shift the decision-making habits of the farmers to ensure that they use recommendations from the extension services in all their farming practices.

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Introduction

Agriculture remains the most important economic activity in Kenya, despite only 10.2% of the total land cover being arable. The agriculture sector contributes 51 percent of Kenya's GDP, 26 percent directly and 25 percent indirectly, accounting for 60 percent of employment and 65 percent of exports (KNBS, 2024). To achieve optimal production in the agricultural sector, agrochemicals play a significant role. On average 12,983 tons of agrochemicals are imported in to the country annually, in various forms including insecticides (27%), fungicides (45%), herbicides (14%), and other products such as acaricides, fumigants, plant growth regulators, miticides and biocontrol agents (14%), with a total value of KES 10.7 billion (approximately 100 million US\$) (Clausing et al., 2021). Remarkably, the volume of imported insecticides, herbicides, and fungicides has more than doubled within four years from 6,400 tons in 2015 to 15,600 tons in 2018, with a growth rate of 144% (UNEP, 2022). Agrochemical use is increasing globally despite growing evidence of its adverse environmental and human health impacts. This is driven in part by climate change, which is exacerbating several factors that compel farmers to rely more heavily on agrochemicals: Worsening environmental conditions like erratic rainfall, prolonged drought, and soil depletion are making it harder for farmers to grow crops without agrochemicals. New crop varieties that are more susceptible to pests and diseases are being promoted, necessitating greater agrochemical use. Agrochemicals are seen as a reliable and cost-effective solution compared to labor-intensive traditional farming methods, especially as labor becomes scarcer.

Agrochemicals are known to have adverse impacts on human health and the environment. They have been shown to propagate environmental degradation and cause negative health effects to the consumers and the Fresh Produce Farmers (Pathak et al., 2022). However, there are limited studies on the effects of climate change on agrochemicals use practices, occupational health and safety, as well as the lifestyle of fresh produce farmers in Low- and Medium-Income Countries (LMICs), Kenya included.

Chemical technologies are essential for modern societies, with more than 95% of all manufactured goods and articles relying on chemistry. While chemicals provide many desired benefits, they may be

released during their lifecycle and cause adverse effects on human health and the environment (Tudi et al., 2021). The unwanted waste of human origin released to air, land, and water is an existential threat to human health and planetary health, and jeopardizes the sustainability of modern societies. Agrochemicals propagate contamination of air by fine particulate matter, ozone, oxides of sulphur and nitrogen, freshwater pollution, and poisoning of the soil by accumulation of lead, mercury, and other heavy metals. The needs and demands of a growing population and urbanization shape the production, trade and consumption of crops and other goods and services for which agrochemicals and fertilizers are used in significant quantities (Wang et al., 2020).

Problem Statement

Rising numbers of cases of non-communicable diseases, such as cancer, have been linked to air pollution and agrochemical exposure in commercial large-scale farming rural areas. In global terms, trying to find solutions to minimize incidences of ill health and mortality is urgent. It is important to determine whether Fresh Produce Farmers and farm workers, who are predisposed to agrochemical exposure, take precautions in agrochemical handling and adhere to agrochemical use regulations (Singer, 2024). Proper use and handling of agrochemicals is also significant as it involves adopting good agricultural practices such as the selection of agrochemicals that have less impact on human health and the environment (UNEP, 2020).

The use of agrochemicals among Fresh Produce Farmers has been associated with negative health effects. Existing data link agrochemical exposure to endocrine disruption, genetic mutations, neurological dysfunction, and other metabolic disorders, apart from the myriad of acute effects. Despite the risks, farmers continue to use agrochemicals due to various factors such as lack of knowledge, inadequate protective equipment, and limited access to alternative pest control methods (Anaduaka et al., 2023). The evaluation of climate change, agrochemical use and health effects among Fresh Produce Farmers is crucial to identify the factors that motivate or compel farmers to use agrochemicals, assess the safety challenges of agrochemicals and their impacts on climate change and human health, and ascertain the determinants of farmers' decisions on agrochem-

ical use in Fresh Produce Farming. This research is necessary to develop strategies to promote the adoption of safe agrochemical use practices, to safeguard food quality, mitigate negative health effects, and promote climate change resilient fresh produce farming practices.

According to the National Cancer Institute of Kenya (NIC-Kenya) report released in 2023, the most common cancer types reported in the National Cancer Registry for the period 2021/2022 were breast (15.9%), cervix (13.3%), and esophagus (11.8%). The report showed that the Central and Eastern regions of Kenya demonstrated a higher rate of cancer cases reported on the National Cancer Registry. Nakuru County was reported as the second among the top ten counties, accounting for 63% and 62% of the total cancer burden among females and males, respectively, after Nairobi County (Okumu Lynet, 2023). This study sought to determine the agrochemical use practices among Fresh Produce Farmers in Nakuru County, Kenya.

Literature Review

Theoretical review

The Social Cognitive Theory (SCT) was proposed by Albert Bandura (1986) to predict how social and cognitive factors influence health behavior (Luszczynska & Schwarzer, 2015). In principle, Bandura postulated that observations of the social norms had a significant impact on learning and that learning, ultimately, influenced the health behaviors that were practiced by individuals. The SCT is underscored by a three-dimensional relationship among cognitive, environmental, and supportive behavior factors. These three factors were postulated as determinants of health promotion and disease prevention (Martin & Guerrero, 2020), which makes the SCT an appropriate theory to support the investigation of the relationship between individual characteristics of farmers, agriculture practices/behaviors, and potential health outcomes.

The relationship between the personal cognitive factors, socioeconomic or environmental factors, and supportive behavior is referred to as reciprocal determinism, emphasizing the interplay between the components of the theory and the effect on health outcome (Martin & Guerrero, 2020). In relation to cognitive influences on behavior, the constructs of the SCT are self-efficacy (belief that one

can perform a behavior that will lead to a particular outcome), outcome expectation (assessment of the consequences of an action), and knowledge (information about how to act and the risks and benefits (Glasgow, 2019).

In relation to environmental influences on health, the constructs of the theory include observational learning (learning behaviors through cultural norms in a society), normative belief (belief about the normalcy and acceptability of a cultural norms), social support (support that is provided through interaction with peers, colleagues, family and other members of the society), and barriers and opportunities (external factors that facilitate or hinder a behavior) (Martin & Guerrero, 2020). With regard to supporting behaviors, the constructs of the SCT are behavioral skills (personal capacity to perform a behavior), intentions (considerations about adding or modifying behaviors), and reinforcement and punishment (providing or removing incentives for acting).

Empirical review

Agrochemicals remain an integral part of agricultural activities worldwide. They are often used to increase productivity and the quality of agricultural products. Pesticides are chemical compounds that are used to kill, repel, or control pests to protect plants before and after harvest. Pesticides work by causing damage to target organisms, but the mechanisms by which pesticides work are not specific to one species. The most widely used pesticides are organophosphate, carbamate, and pyrethroid insecticides (Anaduaka et al., 2023). The impact of pesticide exposure has become a globally developing environmental health problem. Increased vulnerability of farmers to pesticide poisoning is caused by a lack of knowledge about handling pesticides safely and appropriately. Agrochemical poisoning is one of the greatest problems in the world (Tudi et al., 2022). The World Health Organization reports that there are at least 18.2 per 100,000 agricultural workers who experience pesticide poisoning related to their work. Pesticides can enter the body through inhalation, dermal absorption, and ingestion during the preparation to application of pesticides (European Union, 2021). To reduce exposure to pesticides and protect health, farmers are encouraged to practice the use of PPE during the application of pesticides by the International Labor Organization (ILO) and

the World Health Organization (WHO). Acute pesticide poisoning is generally underdiagnosed among farmers. This is often more common in developing countries (Joko et al., 2020).

The extensive and improper use of chemical inputs in agriculture has triggered various non-point source pollution and accelerated carbon emissions. This has been deteriorating the ecological environment, compounding negative climate change effects, and endangering public physical and mental health. Overuse of inorganic fertilizers during farming is linked to the accumulation of contaminants in agricultural soils, including arsenic, cadmium, fluorine, lead, and mercury. Agrochemicals, including but not limited to pesticides, fungicides, and herbicides, are frequently found in stream water in agricultural areas (Hoque et al., 2022). Studies have found that many farmers use agrochemicals, but their knowledge of safety precautions is often limited, and they may fail to appreciate the health and environmental effects of agrochemicals. The major sources of agrochemical information for farmers include agricultural extension workers, agrochemical dealers, farmer colleagues, and the farmers' self-intuitions. Unsafe chemical use practices are high among farmers in Africa, posing serious health and environmental consequences (Demi & Sicchia, 2021).

In a study by Mengistie et al. (2017) on agrochemical use practices among vegetable farmers in Ethiopian Central Rift Valley, it was revealed that farmers apply agrochemicals in violation of the recommendations: they use unsafe storage facilities, ignore risks and safety instructions, and do not use protective devices when applying agrochemicals, and dispose containers unsafely. By applying a social practice approach, they showed that these agrochemical-handling practices are steered by the combination of the system of provision, the farmers' lifestyle, and the everyday context in which agrochemicals are being bought and used (Argüelles & March, 2023). Bringing in new actors such as environmental authorities, suppliers, NGOs, and private actors, as well as social and technological innovations, may contribute to changes in the actual performance of these agrochemical buying and using practices. They argue that a practice approach can represent a promising perspective to analyze agrochemical handling and use and to systematically identify ways to change these practices (Soriano et al., 2023).

Istriningsih et al. (2022) in a study done in Indonesia posit that the gap between knowledge and practice, particularly in pesticide usage, has been underlined by several scholars. They state that the importance of using personal protection equipment (PPE) when handling pesticides is recognized by agricultural workers. Nevertheless, not all of them wear safety equipment. A similar finding is described by Joko et al. (2020). Poor pesticide usage practices, such as a lack of disposal management and the use of PPE, are common among farmers even when they have a good level of knowledge about the potential dangers of pesticides. Glasgow (2019) found that although farmers are aware of the adverse effects of pesticides on human health, they continue to neglect the use of PPE when applying them.

The gap between Fresh Produce Farmers' knowledge and practice of good agricultural practices for safe pesticide usage in Nakuru County has not been adequately discussed in the scientific literature, and empirical evidence is lacking. This study aims to address this gap. However, an analysis of the gap between knowledge and practice might not be sufficient to formulate recommendations for the improvement of implementation at the farmers' level. This study, therefore, employs an Importance-Performance Analysis (IPA) approach to enrich the discussion. IPA can generate insights into critical aspects that require more attention and identify potential resources that could be allocated effectively (Martilla & James, 1977). The IPA model can help to identify areas where resources should be allocated appropriately (McLeay et al., 2017).

This study aims to investigate the gap between Fresh Produce Farmers' knowledge and practice of Agrochemical use practices to identify potential problems that should be considered and help formulate appropriate recommendations. The results of this study are expected to contribute to the development of interventions to promote safe agrochemical use. This will help to increase awareness of the phenomenon among Fresh Produce Farmers and reduce the potential environmental and health-related risks of inappropriate agrochemical use (Istriningsih et al., 2022).

Methodology

This study employed a community-base cross-sectional analytic and descriptive design. The target

population comprised fresh produce farmers residing in Nakuru County for at least two consecutive years, who routinely applied agrochemicals as part of their daily occupational activities.

A two-stage sampling approach was adopted. In the first stage, four sub-counties—Njoro, Kuresoi North, Molo, and Bahati—were selected using probability proportional to size (PPS) sampling. In the second stage, respondents were randomly selected from farmer lists obtained from local agricultural offices and cooperative societies. The sample size of 388 farmers was determined using Cochran's formula, incorporating a 10% adjustment for potential non-response. The participants were distributed proportionally across the sub-counties as follows: Njoro (102), Kuresoi North (96), Molo (94), and Bahati (96).

Quantitative data were collected using structured questionnaires, which captured demographic characteristics, occupational practices, and exposure to agrochemicals. Qualitative data were gathered through focus group discussions (FGDs) with farmer groups in each sub-county, as well as key informant interviews with agricultural extension officers and community health workers. Additionally, an observation guide was used to record on-site handling and storage practices for agrochemicals.

Quantitative data were analyzed using SPSS version 28, employing descriptive statistics (frequencies, percentages, means) and relevant inferential tests to explore associations. Qualitative data were

transcribed verbatim and analyzed using thematic analysis in NVivo, allowing for the identification of patterns and themes relating to farmer experiences, perceptions, and safety practices.

Ethical Considerations

Ethical approval was obtained from the Meru University of Science and Technology Institutional Scientific and Ethics Review Committee (MIRERC), accredited by NACOSTI, which also issued the research license. Permission was granted by the Nakuru County Government Department of Agriculture. Informed consent, confidentiality, voluntary participation, and adherence to national research ethics guidelines were strictly observed.

Results and Discussion

Agrochemical use practices among Fresh Produce Farmers in Nakuru County, Kenya.

Factors influencing the decision to use agrochemicals on farms.

98.5% of the respondents' decisions on the use of agrochemicals on their farms are influenced by pest infestation. Climate change was the second factor influencing their decision, which was mentioned by 85.3% of them. The least factor was government regulations, which was selected by 0.5% of the respondents.

Factor	Yes n(%)	No n(%)	Total
Pest infestation	382 (98.5)	6 (1.5)	388 (100%)
Weed control	202 (52.1)	186 (47.9)	388 (100%)
Disease management	278 (71.6)	110 (28.4)	388 (100%)
Cost effect	15 (3.9)	373 (96.1)	388 (100%)
Gov regulations	2 (0.5)	386 (99.5)	388 (100%)
Climate change	331 (85.3)	57 (14.7)	388 (100%)

Table 1: *Distribution of respondents by factors influencing the use of agrochemicals*

The majority of the respondents make decisions about agrochemicals based on what they see working around them. If a neighbor gets a good harvest after using a certain chemical, they'll likely use the same one. Many don't have formal training, so they rely on advice from fellow farmers, agrovet sellers, and sometimes even Google or farming apps. But not all information is reliable—some agrovet sellers just want to make a sale, and without proper guidance, farmers may end up using the wrong chemicals or even overdosing, thinking it will work better.

The type of crop and stage of growth also determine what chemicals they use. For example, potatoes need different sprays at different times, and if crops start to look unhealthy, farmers have to find quick solutions to save them. Some take samples of sick plants to the agrovet for recommendations, while others simply guess based on past experiences.

A major challenge is the lack of agricultural officers to guide them. Many farmers say they've never attended training, and when meetings are called, people are often too busy trying to make a living to attend. Even when training happens, no one follows up to see if the farmers are applying what they learned. Some believe that if there were model farms to demonstrate best practices, more farmers would adopt safer and more effective methods.

Economic pressure also plays a huge role—farmers need results fast, and sometimes that means using stronger chemicals or applying more than recommended. The push for higher yields makes it hard to consider organic alternatives, which many see as too slow or labor-intensive. Even technology, which could help with better decision-making, isn't fully utilized. While some farmers use their phones for research, many still see them as tools for M-Pesa and calls, not for learning.

"We do it the local way, when you go to the farm and realise that your beans are getting burnt, you uproot like 2-3 pieces and you take them to the agro vet, they will discuss about the possible disease and they will give you some chemical to use" A farmer from Mau Narok.

"You just consult with other farmers on the agro chemicals they used and buy what they have used. You just copy from other farms that have had good harvests and use the agrochemicals they used on their farms." A farmer from Njoro.

Types of agrochemicals

Majority of the respondents (96.4%) use pesticides as agrochemicals on their fresh produce farms, and the least preferred type of agrochemical was herbicides, which is used by 41.5% of the respondents. 0.8% of the respondents who selected other types of agrochemicals mentioned organic.

Type	Yes n(%)	No n(%)	Total
Pesticides	374 (96.4)	14 (3.6)	388 (100%)
Herbicides	161 (41.5)	227 (58.5)	388 (100%)
Fungicides	245 (63.1)	143 (36.9)	388 (100%)
Insecticides	231 (59.5)	157 (40.5)	388 (100%)
Other	3 (0.8)	385 (99.2)	388 (100%)

Table 2: Distribution of respondents by Type of agrochemicals used

During the Focus group discussions, farmers mentioned using a variety of agrochemicals to protect their crops and enhance yields, including herbicides for weed control, insecticides for managing pests like aphids, and fungicides to prevent diseases such as rust in peas and groundnuts. Some commonly mentioned brands include Thunder, Alfakill, Zetanil, Mistress, Oshogene, and Zidomil. To further support plant growth, they apply foliar feeds, boosters like Quick and Fallier, and top-dressing fertilizers. While many rely on synthetic chemicals, some farmers are turning to organic alternatives like rabbit urine and Super Grow, which are considered effective and more affordable.

“If it is for peas and groundnuts, there is this illness called ...Rust, which affects peas and not potatoes, but aphids attack all potatoes, peas, and cabbages; one will use the same chemical to kill those pests. Though it depends on one’s pocket, there is one for 200 and another for 700, that is the only difference, though it is used on one plant.” A farmer from Kuresoi

“Nowadays, people opt for rabbit urine instead of spending money buying agrochemicals. It is very effective. If you use it correctly, your potatoes can burst.” A farmer from Nyoro.

Frequency of use

In the study, 60.8% of the respondents used agrochemicals every week on their farms, with the least, 0.3% never having used agrochemicals.

From the discussions with farmers, it was reported that farmers rely heavily on agrochemicals, using them regularly to protect their crops and ensure

good yields. Most chemicals are applied every two weeks, but this can change depending on the weather. When it’s dry, crops like potatoes don’t need as many chemicals, but during rainy or cold periods, farmers have to spray more often, sometimes every week. They also keep a close eye on their farms, checking for pests and diseases so they know when to spray again. Some crops, like spinach and kale, attract a lot of insects, so farmers use chemicals whenever infestations appear. For maize, spraying happens about three to four times over a season, especially when new pests like armyworms show up. Many farmers say they can’t grow anything without agrochemicals anymore. A decade ago, there were no agro-vets nearby, and food was grown without many chemicals, but now, almost every crop—from carrots to peas—needs fertilizers and pesticides to thrive.

“No, they are different. Differently, let us say for instance potatoes, when it is sunny, you don’t use too many chemicals to control, but when it is rainy or cold, instead of after two weeks, you use it in a week, you go spray. The weather changes control you. That is why, as he has said, you have to do scouting, and the weather controls you by the way.” A farmer from Bahati

Methods of application

All the respondents (100%) used spraying as a method for application of agrochemicals, followed by 27.1% that used foliar application, and the least used methods were fertigation and drenching, used by 1% and 0.8% of the respondents, respectively.

Method	Yes n(%)	No n(%)	Total
Spraying	388 (100)	0 (0)	388 (100%)
Drenching	3 (0.8)	385 (99.2)	388 (100%)
Foliar Application	105 (27.1)	283 (72.9)	388 (100%)
Fertigation	4 (1.0)	384 (99.0)	388 (100%)

Table 3: Distribution of respondents by method of application of agrochemicals

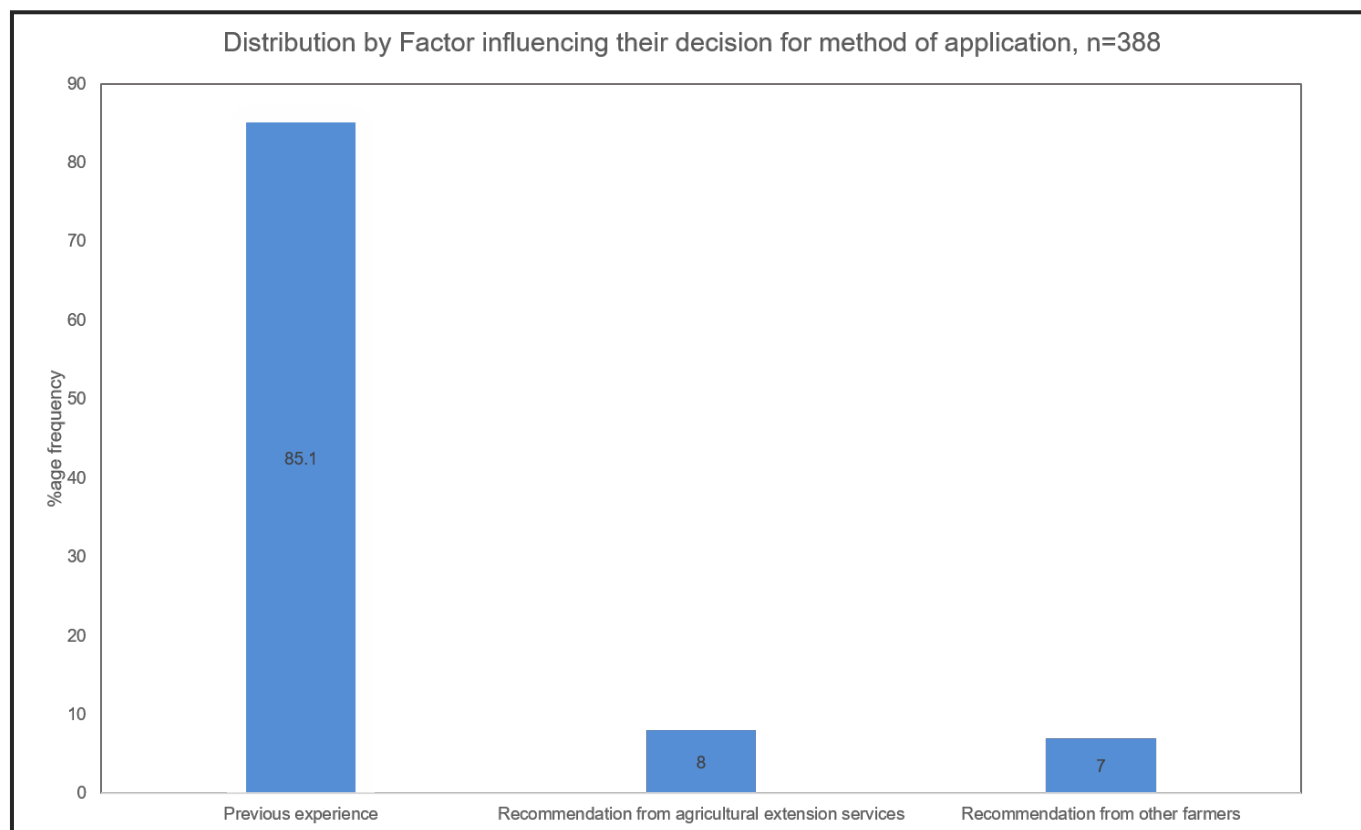


Figure 2: Distribution of respondents by Decision for method of application

Decision on method of application

Majority (85.1%) of the respondents consider their previous experience when deciding the method of application, they use in applying agrochemicals.

All of the respondents agreed that farmers primarily use pumps to apply agrochemicals, with different types suited for various scales of farming. The most common method involves knapsack sprayers, which are carried on the back and come in sizes ranging from 15 to 20 liters. Some of these pumps are manual, while others have engines to make spraying easier. For large-scale farming, tractor-mounted sprayers are used to cover bigger areas efficiently. In some cases, especially with fertilizers, farmers apply them directly by hand.

“The pumps, like for fertilizer, we use our hands directly...For large-scale farming, there is a pump for tractors.” A farmer from Mau Narok

“There is a pump that we carry on our backs, though it is dangerous, and there is the other hand pump that we also use to spray the crops...They use the pump that is carried on the back, and it has an engine.” A farmer from Njoro .

Pre-Harvest Interval (PHI)

Majority of the respondents do not consistently follow the pre-harvest interval (PHI)—the recommended time between applying agrochemicals and harvesting crops. Several key themes emerge from the discussions across different regions, highlighting the reasons for non-compliance and the mixed attitudes towards PHI adherence.

Economic Pressures and Market Demand

One of the most significant factors influencing farmers’ decisions is financial pressure and fluctuating market prices. Farmers often find themselves in a dilemma—if a buyer arrives soon after spraying chemicals, they are likely to sell the produce despite the PHI recommendations. A farmer from Bahati noted, *“Maybe the one buying comes today, and you had used the chemicals yesterday... the one buying won’t know you used chemicals because maybe you won’t tell them.”* This underscores how immediate financial needs override safety concerns.

Similarly, in Mau Narok, a participant explained, *“You’d hear like today carrots or potatoes per kilogram were selling at 35 shillings, and you get rumors that by*

next week the price will drop... You can't wait. You will harvest before the recommended time."

This highlights how fear of market price fluctuations leads farmers to compromise on safety.

Lack of Enforcement and Follow-ups

Farmers acknowledge that there was better adherence to PHI when strict follow-ups were done by agricultural officers or companies, especially in export-oriented crops like French beans. A farmer from Bahati explained, "The time we planted French beans, GAP (Good Agricultural Practices) was followed a lot... But nowadays, there are no follow-ups from the company." Without enforcement, adherence becomes inconsistent, leaving the decision solely in the hands of farmers, many of whom prioritize profits over regulations

Knowledge Gaps and Literacy Barriers

While some farmers are aware of the pre-harvest intervals, others lack the necessary knowledge. A participant from Njoro stated,

"Knowledge is needed here in the farming area because what goes around comes around... we need one another to coexist."

Farmers in Kuresoi also highlighted that agrochemical instructions are often printed in small font and English, making them difficult to read, particularly for older farmers. They suggested,

"If they can enlarge the writings and not write too much English, it will be better."

Ethical Dilemmas and Dishonesty

Many farmers recognize the ethical implications of their actions but still choose to ignore PHI for financial gain. In Njoro, a participant admitted,

"People living in towns are the great consumers of

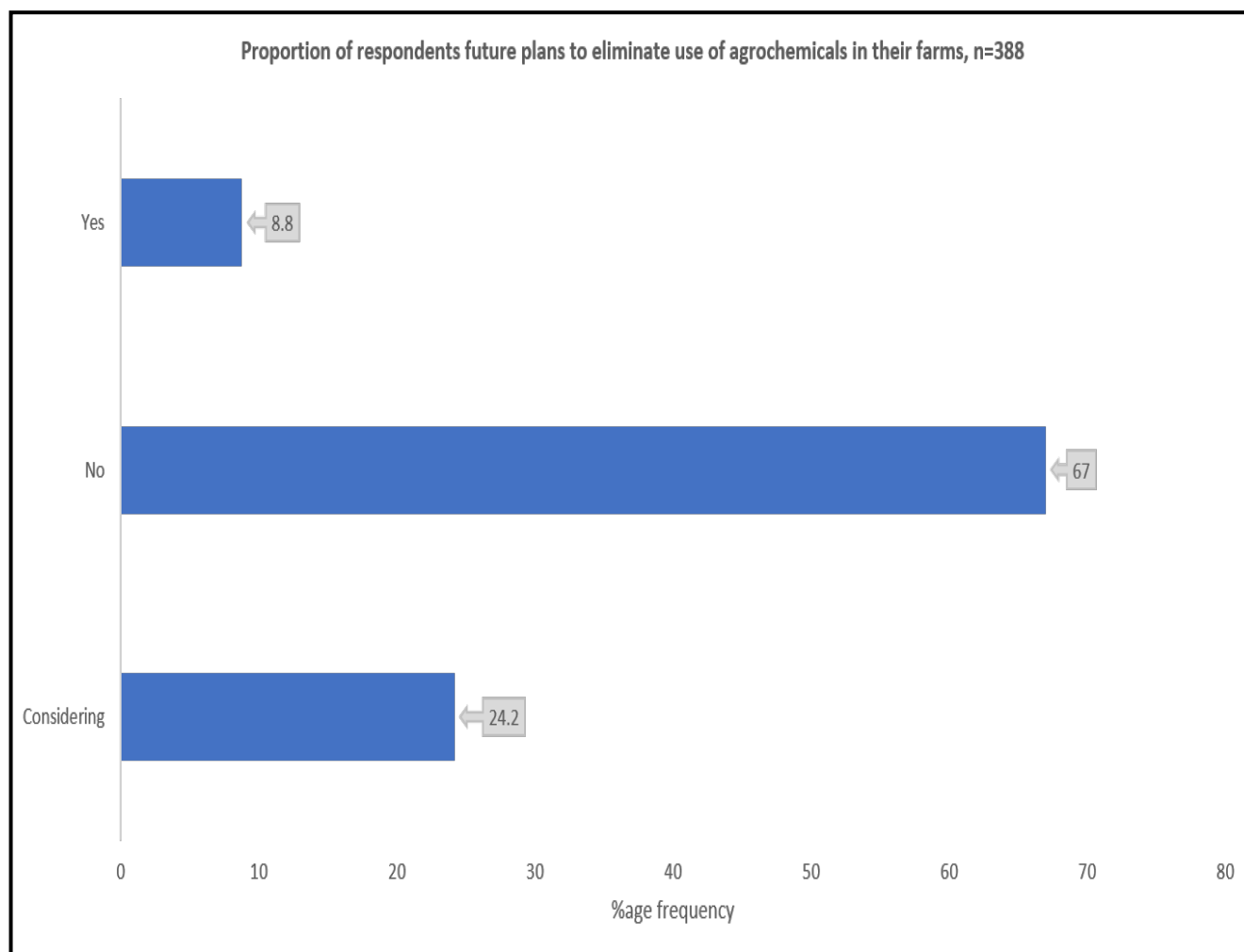


Figure 4: Distribution of respondents by Future plans to eliminate agrochemical use

this food because people are interested in money... those vegetables have a lot of foam, and those are just chemicals."

Future plans

In the study, 67% of respondents don't have any plans to eliminate the use of agrochemicals in their fresh produce farms, with only 8.8% having the plan. However, 24.2% would consider eliminating agrochemical usage.

Majority of the respondents recognize the need to reduce their reliance on agrochemicals, but many feel they have no viable alternatives, especially for commercial farming. While organic methods like crop rotation and residue retention have been suggested as ways to minimize chemical use, the transition has been slow, and many farmers are hesitant to embrace change. Some believe that with better education and support, including access to soil testing services and training on organic farming, they could gradually reduce their dependence on synthetic chemicals. Others have started experimenting with traditional and natural solutions, such as using rabbit urine or making homemade fertilizers and pesticides from leaves. However, challenges remain, as market demand often favors chemically grown produce, making it difficult for farmers to fully shift to organic practices.

"Some farmers have become innovators. They invent new things. There are some leaves that they boil, and it becomes fertilizer, and it also serves as a pesticides because these pests have become resistant to the manufactured pesticides because they are now used to it. It is like the rats. Nowadays, if you use the manufactured chemicals, the rats will just smell the trap and leave it there." A farmer from Mau Narok

"In addition, I would like to disagree with what my colleague has said, we aim to plant and have a good harvest. You can farm your crops nicely without the use of fertilizer and other agrochemicals, but the ones that come to buy from us will not buy your produce. So there is a challenge, you may decide to use the farm yard manure, but your potatoes won't be bought." A farmer from Njoro.

Discussion

On agrochemical use practices the study showed that 98.5% of the respondents' decision on use of agrochemicals on their farms is influenced by pest in-

festation, 85.3% because of climate change, 71.6% because of disease management, 52.1% because of weed control, 3.9% because of cost, and government regulations that was selected by 0.5% of the respondents. This is in agreement with a study by Anaduaka et al. (2023), which found that in Africa, use of agrochemicals continues to dominate fresh produce farms, which farmers consider the best insurance for protecting their crops from pest infestation. Globally, it is estimated that 35% of crop yield is lost because of preharvest pest attack, supporting extensive use of agrochemicals, as stated by Pathak et al. (2022). The findings also revealed that economic pressure played a critical role in the use of agrochemicals for fast results or growth and maturity acceleration of fresh produce. The study findings also agree with a study by Duchenne-Moutien and Neetoo, which posits that climate change is characterized by extreme increases in temperature and alterations in weather patterns that affect food security, which makes most farmers use agrochemicals as a fast alternative for securing their produce (Duchenne-Moutien & Neetoo, 2021).

The study revealed that there is widespread high use of agrochemicals among fresh produce farmers. The findings showed that 96.4% of the respondents used pesticides on their fresh produce farms, 63.1% used fungicides, 59.5% used insecticides, and 41.5% used herbicides. This is congruent with the findings of other studies that have shown a drastic increase in the use of agrochemicals over time, with a growth of 261% in recent years in Africa (Gnanaprakasam & Vanisree, 2022; Sharma et al., 2019). Pesticides are the most commonly used agrochemicals, whose tremendous benefits are when different types are used (Tudi et al., 2022). Herbicides, fungicides, and insecticides are commonly used globally, with insecticides majorly in low- and middle-income countries (LMICs) (Ssemugabo et al., 2022). In modern agriculture, farmers continue to use herbicides, insecticides, and fungicides because they have become effective agrochemicals for increasing agricultural productivity, controlling weeds, diseases, and extending the shelf life of farm produce (Akpan et al., 2023; Maino et al., 2023; Mukah et al., 2023). The study findings differed from a study by Owemigisha and others done in Uganda, where the researchers found that insecticides were the most commonly used, closely followed by pesticides, while herbicides were the least

used (Owemigisha et al., 2024).

The study revealed that 60.8% of the respondents used agrochemicals every week on their farms, with the least, 0.3% never having used agrochemicals. Another study done in Nigeria showed that all its farmers applied agrochemicals every week, confirming the commonness of weekly application as seen in Nakuru county (Ademola et al., 2024). Overuse of agrochemicals is considered to be a contributor to the loss of soil fertility and a major cause of health effects to human beings and disruption of environmental conditions (Anjaria & Vaghela, 2024; Ahmad et al., 2024). Inaccurate application schedule of agrochemicals may lead to adverse effects because of residue leakage, deposit of toxic chemicals, and air pollution (Koka et al., 2022).

The study showed that all the respondents (100%) used spraying as a method for application of agrochemicals, followed by 27.1% that used foliar application, and the least used methods were fertigation and drenching, used by 1% and 0.8% of the respondents, respectively. Foliar application of agrochemicals can improve growth and seed yield, especially by mitigating nutrient stress at reproductive stages (Haakenstad et al., 2022). Fertigation is a modern agro-technique capable of minimizing environmental pollution while maximizing yield (Pibars et al., 2022). Application of agrochemicals through drenching is an effective and economically acceptable method for management of pests (Mao et al., 2022). However, from the study findings, fertigation and drenching were the least used methods of application of agrochemicals in Nakuru County.

The study revealed that the majority (85%) of the respondents considered their previous experience when deciding the method of application of agrochemicals, 8% used recommendations from agricultural extension services, and 7% considered recommendations from other farmers. The findings align with one done in Ghana by Demi and Sicchia, where they found out that most farmers use personal experience to influence their agrochemical use practices (Demi & Sicchia, 2021). The findings also showed that it matters from whom the farmers receive recommendations on the use of agrochemicals, since this influences their knowledge and social learning. Receiving recommendations from extension services is especially critical when farmers' choices not only affect themselves but have a direct impact on their

neighbors and the public (Wuepper et al., 2023). Farmers who specifically get advice from public extension services are more likely to engage in protective use of agrochemicals.

From the study, 67% of respondents did not have any future plans of eliminating the use of agrochemicals in their fresh produce farms, with only 8.8% having such plans. However, 24.2% would consider eliminating agrochemical usage. The findings concur with the argument that agrochemical use may increase over the years, especially for crop protection, because of pest abundance and behavior caused by climate change (Punniyakotti et al., 2024). However, farmers are prioritizing sustainability in their markets as well as their environment (AGRA, 2022), which explains the motivation of 24.2% of the respondents who considered the elimination of agrochemical use.

Conclusion

In Nakuru county, the most significant climate change characteristic is extreme weather patterns, showing an association between climate change and agrochemical use practices of fresh produce farmers. The most affected agrochemical use practices are methods of application and decisions on agrochemical usage. Fresh produce farmers who have realized extreme weather patterns use fewer methods of applying agrochemicals. More so, fresh produce farmers who have realized extreme weather patterns are more likely to seek recommendations from experts about agrochemical usage. Notably, the decision on use of agrochemicals is largely influenced by pest infestation, climate change, disease management, and weed control. There is widespread high use of agrochemicals among fresh produce farmers, with farmers preferring spraying as a method for application of agrochemicals. Farmers consider their previous experience when deciding the method of application of agrochemicals. Moreover, most farmers expressed no future plans of eliminating the use of agrochemicals in their fresh produce farms.

Recommendations

The Ministry of Agriculture and the Ministry of Environment, Climate Change, and Forestry need to work collaboratively to support fresh produce farmers in Nakuru County in public extension services, which will play a critical role in increasing the protective use of agrochemicals. Public extension services

will shift the decision-making habits of the farmers to ensure that they use recommendations from the extension services in all their farming practices.

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