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Pesticide Use Culture among Food Crop Farmers: Implications for Subtle Exposure and Management in Barbados

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Abstract: Globally, there is a strong interest in on-farm pesticide use culture due to genuine concerns about the individual, public, and ecological health risks posed by pesticides. At farm scale, pesticide use culture can be captured via the assessments of knowledge, attitudes, and practices (KAP) to inform intervention strategy and integrated science-based management. Despite the intensive use of pesticides in agriculture in the Caribbean, there is limited information on pesticide use culture or KAP assessment. This study assessed the pesticide use culture among selected food crop farmers in Barbados. A cross-sectional study of 93 food crop farmers, using a semi-structured instrument, was carried out. The results show that the respondents self-rated their level of knowledge on pesticide handling and application as medium to high but low on waste management. Over 50% of the respondents indicated they determine application rates and could understand and follow information on pesticide labels. The majority of the respondents relied on the Internet for information on pesticides, and less than half had received formal training on pesticide use in the three years preceding this study. On attitude, there was overwhelming support for the encouragement of pesticide usage to reduce losses in yield and quality of harvest. Knowledge did not always imply positive attitudes toward safe practices. While 86% agreed that pesticides posed considerable risks to the personal health of users, 60% agreed that one did not need to have all the recommended personal protective equipment (PPE) before using a given pesticide. Due to gaps in the knowledge–attitude–practice continuum, some respondents applied pesticides when necessary, and there was low adherence to the use of recommended PPE when handling/applying pesticides or cleaning/repairing pesticide application equipment, and some respondents indicated a tendency to eat, drink, or smoke during or immediately after pesticide application. These suggest subtle exposure. It was concluded that the low use of recommended PPE, high reliance on the Internet for pesticide guidance, and, particularly, pesticide waste disposal practices require urgent attention from policy, regulatory, and practical levels to improve the pesticide use culture.

Keywords: occupational health; food safety; acute and chronic exposure; knowledge; attitude; practice; Caribbean; integrated pest management

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1. Introduction

Pesticide use in agriculture is increasing rapidly in developing countries due to perceived or actual benefits of avoided reductions in yield and quality of the harvest index. Globally, annual use of pesticides in agriculture is estimated at about two million tons [1], and this is likely to increase due to expanded use of existing pesticides in old and new geographies, as well as the development of new products [2]. Use of pesticides makes agriculture one of the most hazardous human activities. This is because, by design and mode of action, pesticides are poisons to their target organisms [3] and can be lethal to humans, other non-target organisms, and environmental matrices [4]. In humans, acute (short-term) health effects of exposure to pesticides include headaches, abdominal pains, irritation, nausea and vomiting, dizziness, blurred vision, and diarrhoea. Chronic (long-term) effects include cancer, diabetes, respiratory diseases, foetal or congenital diseases, impotence and reproductive disorders, depression, genetic and other neurological disorders, and even death [4,5]. Evidence suggests that occupational exposure to pesticides and the attendant ill-health conditions in farm workers are becoming widespread globally (e.g., [3,6–10]. As a result, human and ecological health concerns about use of pesticides in agriculture remain topical in the policy, practice, and research communities [11–13], especially in developing countries where there are weak structures for integrated science management of pesticide use and the attendant public and ecological health issues from exposure.

One of the fundamental steps towards an integrated science-based pesticide management is understanding the culture surrounding pesticide use in agriculture. At farm scale, pesticide use culture can broadly be captured via assessment of knowledge, attitudes, and practices (KAP) related to pesticide use. The KAP assessment was conceived as instrumental to effecting a cultural change towards healthy behavioural practices. The underlying motivation or theory is that increased knowledge about a given behaviour generates or improves favourable attitudes which drive positive behaviour. In other words, knowledge and positive attitudes underpin behavioural change. Farmers' knowledge, attitudes, and beliefs have been reported to underpin pesticide use practices and occupational exposure in developing countries [14–17]. For pesticide workers, the risk of exposure arises from handling, application, cleaning or maintenance of pesticide equipment, and use of recommended personal protection equipment (PPE). Crop and ecological exposure arises from application and waste disposal practices. Globally, there is a strong interest in identifying opportunities for policy and management interventions aimed at altering pesticide use culture to limit the risks of both human and ecological exposure. Globally, KAP assessment has been fundamental to intervention strategy in several disciplinary and practice domains. To this end, assessment of KAP related to pesticide use (handling, application, and use of PPE) is crucial to identifying gaps and opportunities for intervention.

Ordinarily, knowledge of the dynamic interactions in the continuum of crop-pest-pesticide would influence attitudes, practices, and overall safe use culture. Positive attitudes towards safeguarding personal and ecological health would inform or be reflected in safe practices. Thus, adoption of measures to limit the risk of personal and ecological exposure to pesticides hinges on the personal knowledge, beliefs, attitudes, or choices of workers who interact with pesticides, as well as the socio-economic context of production [18]. Recent KAP assessments in developing countries, however, provide interesting revelations on gaps in pesticide culture and related health consequences of exposure. For example, research evidence shows that good knowledge about safe handling or application of pesticides does not always translate into positive attitudes or safe practices, resulting in adverse health outcomes [14,16,19,20]. Adverse health outcomes of pesticide exposure due to gaps in the knowledge–attitude–practice continuum have been reported in developing countries such as Ghana [3], Iran [21], China, Kuwait, Tanzania [22], Nepal [7], and Pakistan [23]. The results of these studies suggest that use of appropriate PPE when handling and applying or cleaning pesticide application equipment is as important as not smoking, eating, or drinking while handling or applying pesticides [15,23]. Often, the gap between knowledge and practice regarding the risk of personal exposure and environmental pollution on one hand, and pesticide handling or application on the other, is considerably influenced by the perceived scale of threat and consequences of exposure and the benefit–cost ratio of preventive actions to oneself or the production enterprise [7,24]. Periodic KAP assessment of pesticide use culture, is, therefore, critical for identifying gaps and potential risks of personal and ecological exposure within the framework of integrated science-based pesticide management.

In the Caribbean, pesticides have been widely used for a long time and continue to be used in agriculture [25–27], with residues found in agricultural commodities, environmental media, and human populations [25,28–31]. Pesticide use and public health have become a topical issue in the Caribbean. However, few recent studies on pesticide use culture in agriculture or KAP assessments exist in the Caribbean, covering Suriname [32], Jamaica [33–35], and St. Lucia [36], where substantial gaps were found in adherence to safe practices. Mansingh et al. [26] suggested that pesticides have been injudiciously used since their introduction in the Caribbean. Barbados has been reported to have more intensive use of pesticides, with a relatively higher pesticide load compared to other Commonwealth Caribbean Island States [26]. However, there is limited information on pesticide use culture in the agricultural sector, and potential risks for human and ecological exposure in Barbados. Such information is useful for designing policy, regulatory, and management interventions within a broader framework of integrated science-based pesticide management. This study, therefore, assessed the pesticide use culture (via KAP) among selected farmers in key food crop production areas of Barbados.

2. Materials and Methods

2.1. Study Area

Barbados (13°10′ N, 59°30′ W) is the easternmost island in the eastern Caribbean, with a total land area of 166 m^2 or 430 km^2. Total cropland area is about 8000 ha, as estimated in 2017 according to the FAOSTAT. According to the most recent census in 2010 [37], Barbados has a population of 277,821. With population density of about 663 persons per km^2, Barbados is one of the most densely populated countries in the world [38]. Barbados is divided into 11 parishes (see Figure 1), with Bridgetown as the main city and the national capital. The eastern parishes are more rural and contain most of the farmlands compared to the urbanized western parishes. The parishes of St. Philip (southeast) and St. Lucy (northernmost) host the two government-supported irrigation schemes.

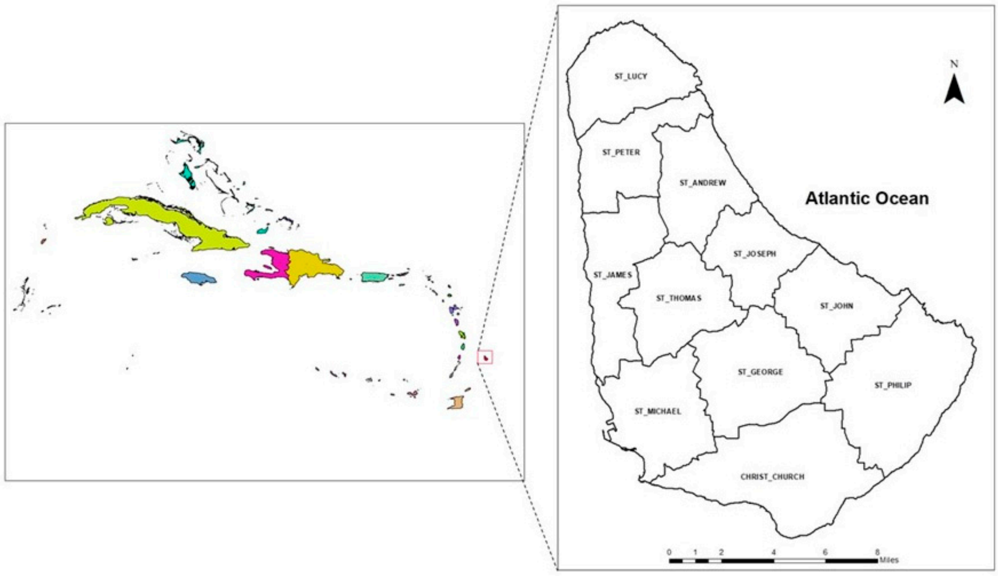

Figure 1. Barbados and its parishes (**right**) in the context of the Caribbean (**left**).

2.2. Data Collection and Analysis

A cross-sectional survey, complemented with field observations, was carried out to assess the KAP or pesticide use culture of respondents. Because the parishes of St. Philip and St. Lucy host the two government-supported irrigation schemes, with a concentration of farmers growing diverse food crops, the study was focused on these two locations. To broaden the survey, however, some farmers in other parishes were also recruited via a snowball approach or oral references by farmers and willingness of prospective farmers to participate. In addition, the fresh produce market in Bridgetown, called the Cheapside Market, was used as a source of information to identify the geographic scope of food sources and thereby support further recruitment of willing farmers in other parishes using multistage and proportional assignment approach with respect to crop production mix.

In the end, a total of 93 farmers were surveyed from October 2018 to July 2019. Data were collected using a semi-structured instrument (though with more close-ended than open-ended items) in a face-to-face interview mode with farmers. The instrument was structured to keep a balance between general pesticide survey requirements and the objectives of the study. Broadly, the KAP assessment was focused on pesticide handling, application, waste disposal, use of PPE, and impacts of exposure. Most interviews were conducted on the farms, providing opportunities for observation of pesticide handling, application, waste management, and use of PPE in some cases. Appointments were normally made with farmers over the phone. Prior to each interview, a letter of consent, explaining the purpose of the study, assuring confidentiality of their data or privacy, and the ultimate use of the information to be gathered, was given to the respondent. In addition, respondents read these letters and agreed to be interviewed before each interview began. Again, all respondents had to indicate in the affirmative that they either owned or worked on the farm holding in relation to pesticide use, otherwise the interview was terminated. In addition to the KAP data on pesticide handling, application, waste disposal, use of PPE, and potential impacts of exposure, other information collected included the demography of respondents, years of farming experience, average duration of pesticide application, land tenure, crops grown, and perspectives on ecological impacts of pesticides, among others. Most of the closed-ended items were assessed using a dichotomous response item, a 5-point Likert type scale, or self-rating scale ranging from 1 to 5 (very low to very high, respectively). Where necessary, open-ended questions were used or further questions were asked to elicit more information or clarify a response.

The data collected were coded and analysed in SPSS (version 19) and Microsoft Excel. The data were mainly described using frequencies or cross-tabulation of the response variables. Bivariate associations were explored using the Pearson chi square, or group differences were determined using the t-test. To this end, some relevant moderator variables (e.g., age or education) were decomposed into two groups to meet the minimum expected frequencies or requirements of the analytical technique in relation to the sample size. Responses to open-ended questions were grouped according to similarity and frequency.

3. Results

3.1. General and Demographic Information of Respondents

About 40% and 31% of the respondents or farms surveyed were located in the parishes of St. Philip and St. Lucy, respectively. The remaining respondents were located in St. George (13%), St. Michael (10%), St. Andrew (3%), and Christ Church (3%). Of the total respondents, 89 (96%) applied pesticides in an outdoor environment or open field, while 4 applied pesticides in both outdoor and indoor (protected) environments. All respondents had applied pesticides on the surveyed farms in the three years prior to this study. Forty respondents had worked for 10 or more years on the surveyed farm holding, while 25 and 24 had worked for one to three years and four to six years, respectively, on the farms surveyed (data not shown).

There were 88 (95%) male respondents, of whom more than half had completed secondary education, while 17 (19%) had achieved a university degree or higher (Table 1). The educational qualifications of the female respondents were fairly spread out from secondary through diploma/certificate to a university degree or higher. In all, 57 (61%) of the respondents had completed secondary education, with only 19 (20%) having achieved a university degree or higher qualification. Most of the respondents (63 or 68%) were older than forty years, while a total of 30 (32%) respondents were 40 years or younger (Table 2). Only 12 respondents were 30 years or younger, while 13 were 61 or older. All the female respondents were more than 40 years old. A large proportion of the respondents had a wealth of experience in farming. About 78% of all respondents had 10 years or more of experience in farming, with only 12% having 1–3 years of experience in farming (Table 2).

Table 1. Highest level of education of respondents by sex.

Sex of Respondent	Highest Level of Education				
	Secondary	**Degree or Higher**	**Diploma/Certificate**	**Polytechnic**	**Total**
Male	55	17	11	5	88
Female	2	2	1	0	5
Total	57	19	12	5	93

Table 2. Age and years of experience of respondents in farming.

Age (Years)	Years of Experience in Farming				
	1–3	**4–6**	**7–9**	**10 or More**	**Total**
19 or younger	9	0	0	0	9
20–30	0	3	0	0	3
31–40	2	0	0	16	18
41–50	0	0	4	24	28
51–60	0	0	0	22	22
61–70	0	2	0	5	7
71 or older	0	0	0	6	6
Total	11	5	4	73	93

3.2. Pesticide Use Culture (Knowledge, Attitudes, and Practices)

3.2.1. Knowledge

Frequencies of responses to a selection of knowledge items are summarized in Table 3. The source of information is an important input to knowledge on pesticides. The majority of the respondents relied on their own research (mainly from the internet or other unspecified sources) for information or guidance on pesticides, with agricultural officers being the least frequently used source of information or guidance. While 37 (or 40%) of the respondents had received formal training in pesticide use (mainly handling and application) in the three years preceding this study, most of them (56 or 60%) indicated they had not received such training. More than half of the respondents rated their ability to determine application rates as 3, with few self-ratings at 4 or 5. Nearly half of the respondents indicated they had knowledge of pesticide hazard classification, while 52 (56%) did not. The majority of the respondents (47) agreed that they can understand and follow information on pesticide labels. Key information that the majority of the respondents liked to extract from pesticide labels included application rate (84%), target organism (89%), and specified crops (96%). Few were interested in recommended PPE, waste disposal, or action on exposure. The majority of the respondents self-rated their understanding of how pesticides work or pesticide selection for target organisms as average (3) or high (4). Nasal (91) and oral (77) exposure pathways were widely known among the respondents, but about half indicated dermal pathway. Respondents indicated mainly symptoms of acute exposure, including headache and dizziness. Though most respondents were unaware of existing regulations on pesticide usage, they were aware of registered (formal) pesticide sellers. About 52 (or 56%) of the respondents indicated they needed further training on pesticide usage in agriculture. Overall, the respondents self-rated their knowledge on pesticide handling and application as average to high but considerably very low to low on appropriate pesticide waste disposal methods.

Table 3. Frequencies of responses to knowledge items.

Item	Response (Frequency)					
Main source of information or guidance on pesticides	Agric. Officers (8)	Fellow farmers (15)	Pesticide supplier (19)	Internet or own research (26)	Other (25)	-
Previous formal training	Yes (37)	No (56)	-	-	-	-
Ability to determine application rates	1 (very low) (11)	2 (13)	3 (51)	4 (13)	5 (very high) (4)	
Know pesticide hazard classes	Yes (39)	No (52)	-	-	-	-
Able to understand/follow pesticide label information	Unsure/ no response (9)	Agree (47)	Strongly agree (11)	Disagree (15)	Strongly disagree (11)	-
Key information of interest from labels	Application rate/ Directions for use (78)	Recommended PPE * (17)	Active ingredient (21)	Target organism (83)	Specified crops (89)	PHI * (32)
Understand how pesticides I use work	1 (7)	2 (12)	3 (39)	4 (28)	5 (5)	
Know the pesticide to use for specific pests or crop conditions	1 (5)	2 (21)	3 (31)	4 (29)	5 (7)	
Known exposure pathways	Nasal (91)	Dermal (39)	Oral (77)	-	-	-
Exposure symptoms/effects	Dizziness (86)	Nausea (58)	Red, watery eyes (71)	Headache (92)	Itchy/sore skin (17)	-
Know existing pesticide regulations	Yes (31)	No (58)	Unsure (4)	-	-	-
Aware of registered sellers	Yes (56)	No (29)	Unsure (8)	-	-	-
Require further training?	Yes (52)	No (39)	-	-	-	-
Overall rating of knowledge (appropriate handling)	1 (12)	2 (24)	3 (23)	4 (29)	5 (5)	
Overall rating of knowledge (appropriate application)	1 (2)	2 (4)	3 (45)	4 (33)	5 (9)	
Overall rating of knowledge (appropriate waste disposal)	1 (33)	2 (24)	3 (17)	4 (10)	5 (9)	-

* PPE denotes personal protective equipment; PHI denotes preharvest interval.

3.2.2. Attitudes

Frequencies of responses to items on attitude are presented in Table 4. About half of the respondents did not agree that one needs to know the toxicity class of a pesticide prior to using it, although the overwhelming majority agreed that pesticides pose risks to personal and public health. On the importance of adherence to instructions on pesticide labels, 58 respondents strongly agreed and 21 agreed, while 9 respondents disagreed. Yet, more than half of the respondents (strongly) agreed that not all the recommended PPE was necessary prior to handling or applying pesticides. Regarding adverse health effects of chronic exposure, respondents' attitudes were varied. While the majority (strongly) agreed that pesticides can affect their nervous system, most disagreed about their effect on their reproductive system (43), respiratory system (32), and circulatory system (39), as well as their role in promoting non-communicable diseases (33). Again, a large number of respondents disagreed about the need to have all recommended PPE regardless of the cost (37) and eating, drinking, or smoking while applying or handling pesticides. The respondents overwhelmingly supported the promotion or continued use of pesticides (though with training and precautions) and disagreed about the risk of long-term adverse health effects of pesticide usage on individual users, the public, non-target organisms, and environmental matrices. None of the respondents indicated they or a family member had ever experienced illnesses related to acute or chronic exposure to pesticides.

Table 4. Frequencies of responses to items on attitude.

Item	Agree	Strongly Agree	Disagree	Strongly Disagree	Neutral/Not Sure
It is extremely important to know the toxicity or hazard class of a pesticide before using it	21	8	33	14	17
Pesticides pose risks to personal and public health	48	32	8		5
Following label instructions is always absolutely necessary for my health and safety	21	58	7	2	5
One does not require all the recommended PPE before handling/applying a pesticide	29	27	17	8	12
Pesticides I use can affect my nervous system	28	41	11	5	8
Pesticides I use can affect my reproductive system	14	9	43	16	8
Pesticides I use can affect my respiratory system	21	21	32	11	8
Pesticides I use can affect my circulatory system	16	11	39	19	8
Pesticides I use can cause other non-communicable diseases	31	3	33	18	8
I must always use all the required PPEs regardless of the cost	26	21	37	9	-
It is okay to eat, drink, or smoke while handling or applying pesticides	9	5	32	38	9
Without pesticides, I will incur huge losses in yield or revenue	19	72	-	-	2
Pesticides I use can have long-term health effects on me	23	13	29	21	7
Pesticides I use can be harmful to non-target organisms	31	9	26	20	7
Pesticides I use can contaminate soil and water	17	16	16	21	23
Pesticides I use can harm consumers through residues in food	21	8	31	13	20
I have suffered short- or long-term pesticide-related illness in the past	Never (93)	-	-	-	-
A family member has suffered known short- or long-term pesticide-related illness in the past	Never (93)	-	-	-	-
Overall, pesticide use should be encouraged	38	43	2	2	8

3.2.3. Practices

Frequencies of responses to items on practices are presented in Table 5. The respondents mostly stored pesticides at home (53) and on the farm (33). Similarly, storage of pesticide application equipment was split between home and on the farm/elsewhere. However, pesticides were largely mixed on the farm (75 respondents), and about half of the respondents mixed different chemicals to increase potency or effectiveness. Only 24 respondents stored spray solution leftovers, but the majority (62) maintained or repaired their pesticide application equipment. Pesticide application equipment was largely cleaned at home (41) or the farm (29). Only 34 respondents cleaned their pesticide application equipment after each spray event, and the majority seldomly cleaned their equipment or did so when necessary. The majority of the respondents (78%) indicated they read and adhered to the instructions on the labels in relation to application rates, while 22% read it only once. In contrast, experience or memory constituted the main source of information on the application rate (48), followed by pesticide labels (31). Pre-harvest interval (PHI), or the number of days allowed between the last spray event and harvest, is an important proxy for consumer exposure to pesticides. While 37 respondents allowed 1–5 days of PHI, 34 allowed 11–14 days, and 6 indicated that the PHI depended on several other factors or conditions. The majority of the respondents (56) never ate, drank, or smoked during or immediately after pesticide application or handling; the remaining respondents engaged in this behaviour occasionally or frequently. Most of the respondents indicated they bathed or washed themselves immediately after pesticide handling or application. Pesticide retailing was found to be highly concentrated between three companies, but most respondents (57) changed pesticides occasionally once more potent products become accessible. Importantly, on pesticide waste disposal, while the majority (49) tried to spray all the spray solution, about 30 respondents disposed of the leftover spray solution in the environment, while 14 kept it to add to the next spray solution. Similarly, about 70 of the respondents discarded their rinsate in the environment in a diluted or other form.

Table 5. Frequencies of responses to items on practices.

Item	Response (Frequency)					
Where pesticides are stored	Home (53)	On farm (33)	Elsewhere (7)			
Where pesticide application equipment stored	Home (46)	On farm or elsewhere (47)	-	-	-	-
Where pesticides are mixed	Home (4)	On farm (75)	Other (14)	-	-	-
Mix different types of pesticides in one application?	Yes (47)	No (46)	-	-	-	-
Store spray solution leftover?	Yes (24)	No (69)	-	-	-	-
Maintains/repairs own pesticide equipment	Yes (62)	No (31)	-	-	-	-
Where equipment is cleaned?	On farm (29)	At home (39)	Elsewhere (23)	-	-	-
Frequency of cleaning equipment	Never (8)	Occasionally (23)	At least after 2–3 spray rounds (13)	After each spray round (34)	When there is a need to spray different chemicals (4)	Separate sprayer for each chemical (11)
Read and follow direction on pesticide labels	Always (73)	Only once (20)	Sometimes (0)	Never (0)	-	-
Main source of information on application rate	Pesticide label (31)	Experience/Memory (48)	Supplier (5)	Others (9)	-	-
Crop growth stage considered for application rate?	Yes (11)	No (68)	Not necessary (14)	-	-	-
Number of days between last spray and harvest	1–5 (37)	6–10 (16)	11–14 (34)	Other (depends) (6)	-	-
Eat, smoke, drink during or immediately after pesticide handling or application	Never (56)	Sometimes or occasionally (28)	Frequently (6)	Always (3)	-	-
Bathe immediately after application/handling	Yes (76)	No (17)	-	-	-	-
Changes in pesticide brand	Same pesticide continuously (36)	Change pesticide occasionally (57)	-	-	-	-
Main source of pesticide	Carters [1.] (21)	Massy [1.] (63)	BADMC [1.] (4)	Two or more or other sources (5)	-	-

Table 5. *Cont.*

Item	Response (Frequency)					
Disposal of spray solution leftover	No leftover (spray the entire solution) (49)	Discard it prior to washing equipment (15)	Transfer to a container to add to next spray (12)	Dilute and throw away (9)	Spray on nearby bush (6)	Keep in the equipment for next spray (2)
Disposal of rinsate	Transfer into a container and seal it (15)	Around the cleaning site (40)	Throw away into nearby bush (17)	Throw away and wash it off with more water (14)	-	-

[1.] Carters is a private company that sells hardware and general goods, including agricultural products such as pesticides, seeds, fertilizers, and equipment. Massy is a private conglomerate that distributes and retails general goods, including pesticides, seeds, seedlings, and equipment. BADMC (Barbados Agricultural Development and Marketing Corporation) is a government entity under the Ministry of Agriculture and Food Security.

Whereas only 7 (11%) of the respondents with non-tertiary education disposed of used pesticide containers by triple-rinsing and then burning the bottles, 13 (42%) of respondents with tertiary education used this method of disposal (Table 6). Similarly, 35 (57%) of respondents with non-tertiary education dumped the used pesticide container in the garbage, while 12 (39%) of respondents with tertiary education used this practice. In all, 47 (51%) of all respondents dumped the used pesticide bottles in the garbage, while 20 (22%) triple-rinsed and then burnt the bottles. Only seven respondents (six of whom were in the non-tertiary education category) indicated that their bottles were collected by designated persons such as agricultural officers. A chi-square Test showed a significant association between respondents' education and the methods used to dispose of pesticide containers. The chi-square test for education and method of pesticide container disposal was χ^2 (3) = 11.876, $p = 0.008$. The strength or effect of the association was large and highly significant (Cramer's V = 0.357, $p = 0.008$). Similarly, there was a significant association between respondents' age category and method of pesticide container disposal (χ^2 (3) = 20.006, $p < 0.01$), and the effect size was large and highly significant (Cramer's V = 0.464, $p < 0.001$). Regarding this, the respondents who were 40 years or younger either burnt the pesticide bottles (11 or 37%) or dumped them in the garbage (19 or 63%) (Table 6). However, the respondents above 40 years commonly triple-rinsed and then burnt the bottles (20 or 32%) or dumped the bottles in the garbage (28 or 44%). Here, all the respondents whose bottles were collected were above 40 years.

Table 6. Association between respondents' education or age and disposal of pesticide containers.

Category	**Pesticide Bottle Disposal Method**				
Education	**Triple-Rinse and Burn Bottle**	**Burn Bottles**	**Dump in Garbage**	**Bottles Collected**	**Total**
Non-tertiary	7	14	35	6	62
Tertiary	13	5	12	1	31
Total	20	19	47	7	93
Age					
40 years or younger	0	11	19	0	30
Above 40 years	20	8	28	7	63
Total	20	19	47	7	93

Additionally, frequency of pesticide application is a good proxy for understanding the potential exposure. Respondents generally handled or applied pesticides regularly. The majority of the respondents applied pesticides when necessary (34%), or weekly (22%) or every two weeks (Figure 2), indicating scope for discretionary application practices when they felt the observed conditions warranted the application. This discretionary application was independent of whether a single crop or multiple crops were grown on the farm. Only 3% of the respondents applied pesticides at six-week intervals, with few applying pesticides only once during the growth cycle of the crops (mostly close to harvest to protect the visual appeal or physical integrity of the harvested produce). Typically, most respondents spent an estimated average of one to two hours (26%) or three to four hours (47%) in a day handling and applying pesticides or more than 40 days per year working with pesticides (data not shown).

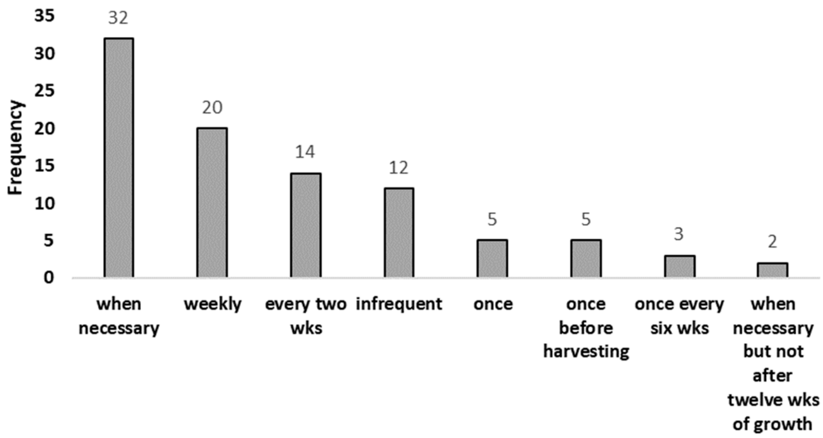

Figure 2. Self-reported frequency of pesticide application.

Personal protective equipment (PPE) is the first line of defence between pesticide users and adverse exposure. Regarding the use of PPE, 55 (63%) of the 88 male respondents used up to two recommended PPEs when handling (mixing, loading, or offloading) pesticides and 12 (14%) used no PPE at all, while 5 (6%) used up to three recommended PPEs (Table 7). However, all the female respondents used only one recommended PPE (generally gloves). A similar pattern is shown for the application of pesticide, with negligible variation. In all, 56 (60%) of all respondents used up to two PPEs when applying pesticides, with 8 respondents (only males) using up to three recommended PPEs. The use of PPEs for pesticide application among the female respondents was the same as for when handling pesticides as, generally, others applied the pesticides for them. The main PPEs indicated were boots and gloves, in combination with a respirator or face shield. Long pants (pair of trousers) and long-sleeved shirts were considered and used as their normal farm workwear. Few respondents used face shields as most normally wore sunglasses or consumer market eyeglasses when applying or handling pesticides.

Because a highly significant Pearson correlation was found between use of recommended PPE when handling and when applying pesticides (r = 0.93, $p < 0.01$), the t-test was run for only when applying pesticides. A statistically significant difference was found between tertiary and non-tertiary educated respondents in terms of use of recommended PPEs (t = −3.112, df = 60.721, p = 0.003) (Table 8). Respondents with tertiary education (mean = 2, SD = 0.775) had significantly higher use of recommended PPEs compared to respondents with non-tertiary education (mean = 1.47, SD = 0.783). The effect size (magnitude of the difference in the mean overall use of PPEs), however, was moderate (eta-squared = 0.096) according to Cohen's guide. However, age differences had no statistically significant effect on the use of recommended PPEs when applying pesticides (Table 8).

Table 7. Respondents' sex and use of recommended PPEs when handling or applying pesticides.

Sex of Respondent	Number of Recommended PPEs When Handling Pesticides				
	0	1	2	3	Total
Male	12	16	55	5	88
Female	0	5	0	0	5
Total	12	21	55	5	93
	Number of recommended PPEs when applying pesticides				
Male	12	12	56	8	88
Female	0	5	0	0	5
Total	12	17	56	8	93

Table 8. Effect of age and education on use of recommended PPEs when applying pesticides.

Grouping Variable	Levene's Test (Equality of Variances)	F	Sig.	t	df	Sig. (2-Tailed)	Mean Diff.	Lower and Upper Confidence Limit (95%)	
Education	assumed	5.097	0.026	−3.100	91	0.003	−0.532	−0.873	−0.191
	Not assumed			−3.112	60.721	0.003	−0.532	−0.874	−0.190
Age	assumed	0.321	0.572	0.717	91	0.475	0.130	−0.230	0.491
	Not assumed			0.733	60.369	0.467	0.130	−0.225	0.486

4. Discussion

4.1. Pesticide Use Culture (KAP)

This study proceeded on the belief that perceived benefits, risks, and adherence to regulations or safety standards drive a pesticide use culture that is manifested by practices. The pesticide attraction is driven by perceived or actual favourable outcomes from crop–pest–pesticide interactions. However, the potential risks of exposure and adverse impacts are not perceived at the same level as the attraction to use pesticides. The KAP assessment can reveal this gap and attendant unsafe practices to support intervention strategy designs. The current study assessed the pesticide use culture (via a KAP survey) of selected Barbadian food crop farmers. The results show that most of the respondents had completed secondary and post-secondary education, were old, and had considerable years of experience in farming (Table 1). This phenomenon of a male-dominated and aging farming population is consistent with previous studies across the Caribbean [32,33,35,36,39,40] and perhaps globally [10,17,41]. However, in these other Caribbean studies, the respondents largely had a primary level of education. Barbados is one of the most economically advanced countries in the eastern Caribbean, and it is possible that economic diversification has made crop production less attractive to young persons.

A culture of effective and safe use of pesticides requires knowledge on the dynamic interactions in the crop–pest–pesticide nexus, the use of PPE, pesticide waste disposal, main exposure pathways, and attendant consequences. This requires training (beyond formal education) and credible information services. A key finding in the current study is that the majority of the respondents relied on their own research (mainly from the Internet or other unspecified sources) for information or guidance on pesticides. This could be risky in an era of misinformation and information explosion and should raise concerns about the authenticity of the information and its adaptability or applicability to the Barbadian conditions. Knowledge based on erroneous information or improper interpretation of information from the internet or pesticide labels can lead to, for example, the incorrect rate of application and choice of crop or growth stage, which can contribute to personal, public, and ecological exposure [42]. While this finding suggests a critical need for dedicated, authentic information services to improve and update farmers' knowledge, it is consistent with those from studies in other developing countries [17]. A study in St. Lucia [36] revealed that 53% of the respondents did not understand the instructions on the pesticide labels. In general, the current study shows that, at least, half of the respondents had a good level of knowledge on application rate, hazard classification, pesticide functionality in relation to the target crop and pest, exposure pathways, and symptoms of acute exposure, and could use information on pesticide labels. Knowledge of the hazard class of a pesticide can generate positive attitudes toward safe use practices. Labels on pesticide containers are the first source of information for minimizing the risk of exposure to pesticides. It is therefore worrisome that, despite this decent level of knowledge, few respondents were interested in recommended PPE on pesticide labels. Additionally, the respondents' low self-ratings on their knowledge on appropriate pesticide waste disposal methods need urgent attention. These, together with the desire for training, could be the main entry points for interventions to enhance knowledge.

Knowledge and attitudes generate practices. However, as an intermediary between knowledge and behaviour, attitudes alone can promote or undermine practice. The expectation would be that knowledge on pesticide toxicities and impacts of exposure would generate positive attitudes towards safe practices. Farmers' knowledge, attitudes, and beliefs have been reported to underpin pesticide use practices and occupational exposure in developing countries [14–17,19]. Though the majority of the respondents in the current study agreed that pesticides posed personal and public health risks and it is important to adhere to instructions on labels, this contrasted with the finding that about half of the respondents had a negative attitude towards knowledge of pesticide toxicity class and having all the recommended PPE prior to using pesticides. Additionally, the respondents overwhelmingly supported the idea that use of pesticides should be encouraged and disagreed to adverse health outcomes from chronic exposure. This gap between a decent level of knowledge and attitudes could undermine adherence to safe practices [7]. Indeed, there was low adherence to the use of recommended PPE (55 respondents used only two PPE).

Use of recommended PPE is the first line of defence or barrier between pesticide users and adverse exposure to the chemical. These PPEs normally include foot protection (boots), hand protection (gloves), body protection (long-sleeved shirts or overalls and long pants or trousers), eye protection (safety glasses, goggles, or face shield), and mouth protection (respirator or mouth cap or mask). In the current study, while there is evidence for frequent and discretionary pesticide application (Figure 2), gloves and boots were indicated as the recommended PPE most frequently used even though some respondents used the same boots and body protection for on-farm work. Mouth protection was hardly used (though some used face scarves), and some respondents wore consumer-grade sunglasses as safety glasses. The results suggest potential for subtle exposure to pesticides. Some of the reasons given for not using the recommended PPE included '*not available, the weather being too hot, not accustom to, face mask too stifling or suffocating, or just don't use it'*. Similar studies in the Caribbean have reported overall low adherence to the use of recommended PPE. For example, only 23% and 17% of 130 respondents in St. Lucia used boots and gloves, respectively, when applying pesticides, with a substantial number using no PPE [36], or 90% and 44%, respectively, in Jamaica [34,35]. Low adherence to use of mouth protection has been reported in previous studies: 43% in Jamaica [34,35] and 13% in St. Lucia [36]. Findings from a study in Suriname show that the use of PPE there is relatively higher than in the other Caribbean countries. Low use of all recommended PPE seems to be common in developing countries [3,7,17]. Education, age, and sex are generally known to differentiate groups in the use of pesticides and related PPE practices and associated health effects [3,10]. The results of the current study indicate that the level of formal education is an important mediator in the use of PPE, and responsible disposal of pesticide containers by respondents with higher education correlated with more frequent use of PPE and relatively safer methods of disposing of containers compared to those with lower levels of education. However, there was no significant difference between older respondents (over 40 years) and younger respondents regarding use of PPE. It seems that as one becomes older and gains more experience, complacency sets in regarding the use of adequate PPE [34]. This suggests a need for targeted PPE use intervention.

4.2. Implications for Exposure and Pesticide Use Management

Pesticide use culture is underpinned by a combination of knowledge (on crop–pest—pesticide interactions) and attitudes (to regulation, health and safety standards, and productivity or profit), which drive practices. Arguably, knowledge might influence attitudes and then practices. However, culture is both reproductive and dependant. This implies a feedback relationship between practices on one hand and knowledge and attitudes on the other. Knowledge of the effectiveness of pesticides creates a pesticide attraction. However, farm workers who handle and apply pesticides are at risk of exposure [43], and unsafe practices can create ecological and public health risks. Adherence to safe practices depends considerably on the recognition of or belief in the scale of threat to one's health from occupational exposure [7,24] and the health of consumers and the environment. In the current study, there were instances of unsafe practices that could have implications for personal, public, and ecological exposure to pesticides. These practices, which reflect on the pesticide use culture, require further investigations to inform management interventions. For example, a substantial number of respondents stored pesticides and application equipment at home, cleaned and repaired application equipment at home, and had poor pesticide waste disposal practices. Others included the discretionary application frequency of pesticides, variable observance of pre-harvest interval (PHI), and some respondents eating or drinking or smoking when applying or handling pesticides. Most importantly, low adherence to adequate use of recommended PPE when handling and applying pesticides or cleaning application equipment generates a serious cause for concern regarding potential exposure. It is interesting that none of the respondents, nor any of their family members, had ever shown symptoms of acute or chronic exposure to pesticides. Further studies are required to validate this opinion. Notwithstanding, analysis of registered pesticides in Barbados would show that over 20% are banned in other Caribbean or EU countries or are classified as hazardous, and about 15% are potentially carcinogenic. In contrast, previous studies in the Caribbean showed that nearly a third of the respondents in St. Lucia [36] and two-thirds of respondents in Jamaica [33] had encountered adverse health effects from pesticide exposure. From these studies, several ill-health experiences were reported.

The observed lapses in adherence to safe practices might have been nurtured or consolidated by stronger pesticide attractivity and experience over time. The majority of the respondents indicated strong support for the continued use of pesticides. There is a strong belief that, without pesticides, they might suffer significant yield penalties. This strong attraction ought to be balanced with a recognition of and a strong interest in the human and ecological health risks posed by pesticides. Such a balance could improve willingness to seek training and knowledge from authentic sources and adherence to safe practices. The instances of unsafe practices, together with the main findings of this study, suggest a need for intervention at the levels of policy, regulation, and practice. At the policy and regulation level, for example, it could be made mandatory for only certified workers to handle and apply pesticides. At the practical level, an example intervention could be the establishment of appropriate waste management systems (e.g., bottle collection), and authentic information sources could be promoted. The current study advances the idea that further studies are required to understand pesticide attraction in different contexts and how this can be explored and balanced with interest in the health risks posed by pesticides. This should be the starting point for intervention designs aimed at improving adherence to safe practices and sustainable use of pesticides. The current study, however, is limited to a small-island developing state with a limited sample size, and it is a cross-sectional study.

5. Conclusions

A culture of safe and effective use of pesticides remains an active debate globally due to the public and ecological health hazards posed by pesticides. Pesticide usage is increasing in the Caribbean, and there is an urgent need for integrated science-based management. Mapping the knowledge, attitudes, and practices regarding pesticide use can provide insights into gaps, potential risks, and entry points for intervention at varying scales to support sound management. This study assessed the pesticide use culture (KAP) of selected Barbadian food crop farmers to support sound management of pesticides in agriculture. Within the limits of the study, it can be concluded that the farmers surveyed were confident about their level of knowledge on pesticide application and handling but not on waste management. However, there was a gap between aspects of knowledge and attitudes, potentially resulting in the partial practical adherence to the edicts of knowledge. Consequently, the gap in knowledge and practice could potentially underlie the low use of recommended PPE and the relatively high discretionary application. The respondents believed that use of pesticides in agriculture should be encouraged as, without pesticides, they could incur large yield losses or quality degradation. The excessive reliance on the Internet for guidance on pesticides could be risky and requires an authentic information service and training to enhance farmers' knowledge, shape attitudes, and guide practices. Apart from low use of recommended PPE, pesticide storage and waste disposal practices require urgent attention to limit the risk of public and ecological health hazards. Unsafe practices identified suggest a potential for subtle exposure of some respondents to pesticides. There is a need to work on farmers' perception and acknowledgement of the chronic and acute effects of pesticide exposure to improve adherence to safe practices. Given the increasing intensity of agriculture and wider use of pesticides in Barbados and the Caribbean, it is important to undertake a robust and wider assessment of pesticide use culture, exposure, and health impacts among farmers as a component of a sound pesticide management framework. The key to intervention is understanding pesticide attraction and balancing this with a strong interest in the health hazards posed to users, consumers, and the environment.

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References

1. Sharma, A.; Kumar, V.; Shahzad, B.; Tanveer, M.; Sidhu, G.P.; Handa, N.; Kohli, S.; Yadav, P.; Bali, A.; Parihar, R.; et al. Worldwide pesticide usage and its impacts on ecosystem. *SN Appl. Sci.* **2019**, *1*, 1446. [CrossRef]
2. FAO; ITPS. *Global Assessment of the Impact of Plant Protection Products on Soil Functions and Soil Ecosystems*; The Food and Agriculture Organization (FAO) of the United Nations: Rome, Italy, 2017; 40p.
3. Quansah, R.; Bend, J.R.; Armah, F.A.; Bonney, F.; Aseidu, J.; Yawson, D.O.; Adu, M.O.; Luginaah, I.; Essumang, D.K.; Abdul-Rahaman, A.; et al. Respiratory and non-respiratory symptoms associated with pesticide management practices among farmers in Ghana's most important vegetable hub. *Environ. Monit. Assess.* **2019**, *191*, 716. [CrossRef]
4. Tago, D.; Andersson, H.; Treich, N. Pesticides and health: A review of evidence on health effects, valuation of risks, and benefit-cost analysis. *Adv. Health Econ. Health Serv. Res.* **2014**, *24*, 203–295. [PubMed]
5. Lessenger, J.E. (Ed.) *Agricultural Medicine: A Practical Guide*; Springer Science+Business Media, Inc.: New York, NY, USA, 1996; 557p.

6. Lerro, C.C.; Beane Freeman, L.E.; DellaValle, C.T.; Kibriya, M.G.; Aschebrook-Kilfoy, B.; Jasmine, F.; Koutros, S.; Parks, C.G.; Sandler, D.P.; Alavanja, M.C.R.; et al. Occupational pesticide exposure and subclinical hypothyroidism among male pesticide applicators. *Occup. Environ. Med.* **2018**, *75*, 79–89. [CrossRef] [PubMed]
7. Bhandari, G.; Atreya, K.; Yang, X.; Fan, L.; Geissen, V. Factors affecting pesticide safety behaviour: The perceptions of Nepalese farmers and retailers. *Sci. Total Environ.* **2018**, *631–632*, 1560–1571. [CrossRef] [PubMed]
8. Shrestha, S.; Umbach, D.M.; Beane Freeman, L.E.; Koutros, S.; Alavanja, M.C.R.; Blair, A.; Chen, H.; Sandler, D.P. Occupational pesticide use and self-reported olfactory impairment in US farmers. *Occup. Environ. Med.* **2021**, *78*, 179–191. [CrossRef]
9. Shrestha, S.; Kamel, F.; Umbach, D.M.; Freeman, L.E.B.; Koutros, S.; Alavanja, M.; Blair, A.; Sandler, D.P.; Chen, H. High pesticide exposure events and olfactory impairment among U.S. farmers. *Environ. Health Perspect.* **2019**, *127*, 017005. [CrossRef]
10. Fix, J.; Annesi-Maesano, I.; Baldi, I.; Boulanger, M.; Cheng, S.; Cortes, S.; Dalphin, J.C.; Dalvie, M.A.; Degano, B.; Douwes, J.; et al. Gender differences in respiratory health outcomes among farming cohorts around the globe: Findings from the AGRICOH consortium. *J. Agromed.* **2020**, *26*, 97–108. [CrossRef]
11. Ippolito, A.; Kattwinkel, M.; Rasmussen, J.J.; Schafer, R.B.; Fornaroli, R.; Liess, M. Modeling global distribution of agricultural insecticides in surface waters. *Environ. Pollut.* **2015**, *198*, 54–60. [CrossRef]
12. Huang, Y.; Luo, X.; Tang, L.; Yu, W. The power of habit: Does production experience lead to pesticide overuse? *Environ. Sci. Pollut. Res.* **2020**, *27*, 25287–25296. [CrossRef]
13. Schreinemachers, P.; Grovermann, C.; Praneetvatakul, S.; Heng, P.; Nguyen, T.T.L.; Buntong, B.; Le, N.T.; Pinn, T. How much is too much? Quantifying pesticide overuse in vegetable production in Southeast Asia. *J. Clean. Prod.* **2020**, *244*, 118738. [CrossRef]
14. Bagheri, A.; Emami, A.; Allahyari, M.S.; Damalas, C.A. Pesticide handling practices, health risks, and determinants of safety behavior among Iranian apple farmers. *Hum. Ecol. Risk Assess.* **2018**, *24*, 2209–2223. [CrossRef]
15. Gesesew, H.A.; Woldemichael, K.; Massa, D.; Mwanri, L. Farmers knowledge, attitudes, practices and health problems associated with pesticide use in rural irrigation villages, Southwest Ethiopia. *PLoS ONE* **2016**, 0162527. [CrossRef]
16. Fan, L.; Niu, H.; Yang, X.; Qin, W.; Bento, W.P.M.; Ritsema, C.J.; Geissen, V. Factors affecting farmers' behaviour in pesticide use: Insights from a field study in northern China. *Sci. Total Environ.* **2015**, *537*, 360–368. [CrossRef] [PubMed]
17. Matthews, G.A. Attitudes and behaviours regarding use of crop protection products–a survey of more than 8500 smallholders in 26 countries. *Crop Prot.* **2008**, *27*, 834–846. [CrossRef]
18. Brisbois, B.W.; Spiegel, J.M.; Harris, L. Health, environment and colonial legacies: Situating the science of pesticides, bananas and bodies in Ecuador. *Soc. Sci. Med.* **2019**, *239*, 112529. [CrossRef] [PubMed]
19. Bagheri, A.; Emami, N.; Damalas, C.A.; Allahyari, M.S. Farmers' knowledge, attitudes, and perceptions of pesticide use in apple farms of northern Iran: Impact on safety behavior. *Environ. Sci. Pollut. Res.* **2018**, *26*, 9343–9351. [CrossRef] [PubMed]
20. Kongtip, P.; Nankongnab, N.; Tipayamongkholgul, M.; Bunngamchairat, A.; Yimsabai, J.; Pataitiemthong, A.; Woskie, S. A cross-sectional investigation of cardiovascular and metabolic biomarkers among conventional and organic farmers in Thailand. *Int. J. Environ. Res. Public Health* **2018**, *15*, 2590. [CrossRef]
21. Sharafi, K.; Pirsaheb, M.; Maleki, S.; Arfaeinia, H.; Karimyan, K.; Moradi, M.; Safari, Y. Knowledge, attitude and practices of farmers about pesticide use, risks, and wastes; a cross-sectional study (Kermanshah, Iran). *Sci. Total Environ.* **2018**, *15*, 509–517. [CrossRef]
22. Wang, J.; Chu, M.; Ma, Y. Measuring rice farmer's pesticide overuse practice and the determinants: A statistical analysis based on data collected in Jiangsu and Anhui Provinces of China. *Sustainability* **2018**, *10*, 677. [CrossRef]
23. Khan, M.; Damalas, C.A. Farmers' knowledge about common pests and pesticide safety in conventional cotton production in Pakistan. *Crop Prot.* **2015**, *77*, 45–51. [CrossRef]
24. Raksanam, B.; Taneepanichskul, S.; Robson, M.G.; Siriwong, W. Health risk behaviors associated with agrochemical exposure among rice farmers in a rural community, Thailand: A community-based ethnography. *Asia Pac. J. Public Health* **2014**, *26*, 588–595. [CrossRef] [PubMed]
25. Wahid, A.F.; Wickliffe, J.; Wilson, M.; Van Sauers, A.; Bond, N.; Hawkins, W.; Mans, D.; Lichtveld, M. Presence of pesticide residues on produce cultivated in Suriname. *Environ. Monit. Assess.* **2017**, *189*, 303. [CrossRef] [PubMed]
26. Grossman, L.S. Pesticides, caution, and experimentation in St. Vincent, Eastern Caribbean. *Hum. Ecol.* **1992**, *20*, 315–336. [CrossRef]
27. Mansingh, A.; Robinson, D.E.; Dalip, K.M. Use, fate, and ecotoxicity of pesticides in Jamaica and the Commonwealth Caribbean. In *Pesticide Residues in Coastal Tropical Ecosystems: Distribution, Fate, and Effects*; Taylor, M.D., Klaine, S.J., Carvalho, F.P., Barcelo, D., Everaarts, J., Eds.; Taylor & Francis: London, UK, 2003; pp. 425–463.
28. Dewailly, E.; Forde, M.; Robertson, L.; Kaddar, N.; Laouan Sidi, E.A.; Côté, S.; Gaudreau, E.; Drescher, O.; Ayotte, P. Evaluation of pyrethroid exposures in pregnant women from 10 Caribbean countries. *Environ. Int.* **2014**, *63*, 201–206. [CrossRef] [PubMed]
29. Forde, M.S.; Robertson, L.; Laouan Sidi, E.A.; Côté, S.; Gaudreau, E.; Drescher, O.; Ayotte, P. Evaluation of exposure to organophosphate, carbamate, phenoxy acid, and chlorophenol pesticides in pregnant women from 10 Caribbean countries. *Environ. Sci. Process. Impacts* **2015**, *17*, 1661–1671. [CrossRef]
30. Landau-Ossondo, M.; Rabia, N.; Jos-Pelage, J.; Marquet, L.M.; Isidore, Y.; Saint-Aime, C.; Martin, M.; Irigaray, P.; Belpomme, D. Why pesticides could be a common cause of prostrate and breast cancers in the French Caribbean Island, Martinique: An overview on key mechanisms of pesticide-induced cancer. *Biomed. Pharmacother.* **2009**, *63*, 383–395. [CrossRef]
31. Wood, B.P.; Gumbs, F.; Headley, J.V. Distribution and occurrence of atrazine, deethylatrazine, and ametryne residues in groundwater of the tropical island Barbados. *Commun. Soil Sci. Plant Anal.* **2007**, *33*, 3501–3515. [CrossRef]

32. Mahabali, S.; Spanoghe, P. Risk assessment of pesticide usage by farmers in Commewijne, Suriname, South America: A pilot study for the Alkmaar and Tamanredjo regions. *Environ. Monit. Assess* **2015**, *187*, 153. [CrossRef]
33. Feola, G.; Henry, D. Pesticide-handling practices of smallholder coffee farmers in Eastern Jamaica. *J. Agric. Rural. Dev. Trop. Subtrop.* **2013**, *114*, 59–67.
34. Abebe, A.C.; Jolly, M.; Ngqabutho, N.; Jolly, P.E. Pesticide handling and pesticide container disposal measures in Northeastern Jamaica. In Proceedings of the 29th West Indies Agricultural Economics Conference, Saint Vincent, West Indies, 17–21 July 2011.
35. Ncube, N.M.; Fogo, C.; Bessler, P.; Jolly, C.M.; Jolly, P.E. Factors associated with self-reported symptoms of acute pesticide poisoning among farmers in North-western Jamaica. *Arch. Environ. Occup. Health* **2011**, *66*, 65–74. [CrossRef] [PubMed]
36. McDougall, L.; Magloire, L.; Hospedales, J.; Tollefson, J.E.; Ooms, M.; Singh, C.; White, F.M.M. Attitudes and practices of pesticides users in Saint Lucia, West Indies. *Bull. PAHO* **1993**, *27*, 43–51.
37. Barbados Statistical Service. *2010 Population and Housing Census*; The Report of the Fifteenth Population Census; The Barbados Statistical Service: Bridgetown, Barbados, 2013.
38. UNEP. National Environmental Summary: Barbados 2010. Available online: http://www.pnuma.org/publicaciones/FINAL%20Barbados%20NES%20Nov%202010-%20edited.pdf (accessed on 28 December 2018).
39. Bynoe, P.; Simmons, D. Use or mis-use of pesticides: Analysis of knowledge, attitudes and practices of farmers in the Caribbean. In Proceedings of the FNS First International Conference on Sustainable Development, Georgetown, Guyana, 12–14 August 2013.
40. Woodsong, C. Old farmers, invisible farmers: Age and agriculture in Jamaica. *J. Cross-Cult. Gerontol.* **1994**, *9*, 277–299. [CrossRef]
41. Issa, Y.; Sham'a, F.A.; Nijem, K.; Bjertness, E.; Kristensen, P. Pesticide use and opportunities of exposure among farmers and their families: Cross-sectional studies 1998-2006 from Hebron governorate, occupied Palestinian territory. *Environ. Health* **2010**, *9*, 63. [CrossRef] [PubMed]
42. Helps, J.C.; Paveley, N.D.; van den Bosch, F. Identifying circumstances under which high insecticide dose increases or decreases resistance selection. *J. Theor. Biol.* **2017**, *428*, 153–167. [CrossRef] [PubMed]
43. Damalas, C.A.; Koutroubas, S.D. Farmers' exposure to pesticides: Toxicity types and ways of prevention. *Toxics* **2016**, *4*, 1. [CrossRef]