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Assessment of pesticides residue in selected arable farm lands in Ogbomoso South local government area of Oyo state, Nigeria

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Abstract. *Pesticide residues in soils and farmlands have long been an important concern in agricultural safety. In developing countries, ignorance and illiteracy among untutored farmers have greatly contributed to this issue, as several pesticides (herbicides, insecticides, etc.) can leave residues in the soil. The study was carried out in selected arable farms in Ogbomoso South Local Government Area of Oyo state to evaluate and determine the possibility of pesticide residues in the soils of farmers who are fond of using pesticides in crop production. Questionnaires were administered to farmers in the study area and soil samples were collected from some of the farms owned by farmers interviewed and found to have relevant pesticide usage history. Additionally, soil samples were collected from farms with no records of pesticide usage which served as control. Subsequently, these soil samples were then taken to the laboratory for analysis of pesticide residue. The average pH was 5.56 mg/kg for farmlands with pesticide usage and 5.63 mg/kg for those with no pesticide usage, respectively. The average level of metabolites of d-BHC, Chlorothalonil, Alachlor, Aldrin, Dacthal, Heptachlor epoxide, g-Chlordane, and Trans-nonachlor for arable lands where there was pesticide usage and where none were used were 32.41 mg/kg and 39.27 mg/kg, 0.62 mg/kg and 1.05 mg/kg, 1.39 mg/kg and 2.14 mg/kg, N.D and 1.5 mg/kg, 3.91 mg/kg and 10.65 mg/kg, 5.43 mg/kg and 7.62 mg/kg, 6.68 mg/kg and 7.47 mg/kg, and 4.78 mg/kg and 6.4 mg/kg, respectively.*

The results showed that pesticide usage left residues in the soil and the standard of measuring the amount (whether low or high) is still unavailable in the literature and most importantly for many herbicides in use within the study area. Since there is a leftover chemical residue in the soil, there is therefore the need for a quality assurance body to evaluate what is placed on the table of consumers from the markets and this is currently lacking in the food supply chain in Nigeria and if not in Africa. In conclusion, there is a need for public awareness and education among farmers to know the dangers inherent in the use of pesticides so that precautionary measures will be taken in the application of pesticides.

Keywords: soil, plant protection, regulation

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Introduction

Food is of utmost importance to man, and the demand for it has been progressively increasing. In Nigeria, agriculture is one of the most significant sectors accountings for around 30% of the gross domestic product (Sertoğlu et al., 2017; Dioha and Kumar, 2020). The production of food, however, has been stalled and affected by other living competitors referred to as pests. Numerous studies revealed that pest effects have been leading to reduced production and decimation of crops, thereby, affecting the available supply of food to meet the increasing human population (García-Barrios et al., 2016; Baweja et al., 2020; Muluneh, 2021). In an effort to mitigate pest effects on crop production, pesticide application has been utilized. Contrarily, the contamination of the environment and food by chlorinated organic pesticides has become a topical issue of considerable concern in many parts of the world and has led to a lot of fatal and non-fatal cases (Rasool et al., 2022; Stuart et al., 2023). In 2020, a systematic review of the scientific literature published between 2006 and 2008, supplemented by mortality data from WHO was carried out. The result showed that approximately 740,000 annual cases of Unintentional Acute Pesticide Poisoning (UAPP) were reported, resulting from 7446 fatalities and 733,921 non-fatal cases. On this basis, it is estimated that about 385 million cases of unintentional acute pesticide poisoning occur annually worldwide including around 11,000 fatalities (Boedeker et al., 2020; Davies et al., 2023). An estimated 44% of the global farming population of 860 million, or 378 million farmers, are poisoned by pesticides annually (World Health Organization, 2012).

Raimi et al. (2020) noted that Nigeria is ranked below its peers on the continent, such as Kenya and Ethiopia, with pesticide application rates of 19 kg/hectare. This is compared to the stipulated 16 kg/hectare per average. Previous studies have revealed that annually in Nigeria, over 135 chemical pesticides are imported and applied, approximately 125,000-130,000 metric tons in preparation volume. Furthermore, in a 2011 study carried out in Borno state, Ogah (2012) pointed out that Lindane, Diazinon, and Aldrin were present in the pre-storage bean samples, while DDT, Dichlorvos, and Endrin were present in both pre-storage and post-storage samples. Similarly, in accordance with the reports by the National Agency for Food and Drugs Administration and Control (NAFDAC, 2008), following the ingestion of a meal including beans, 120 pupils from Government Girls Secondary School, Doma in the Gombe area of Nigeria were immediately brought to Gombe Specialist Hospital. This occurrence caused some to worry about possible pesticide residues in the beans. Following analysis, it was discovered that samples of both cooked and uncooked beans had abnormally high levels of an organochlorinated pesticide. Due to their immediate effectiveness, these chemicals, which have been studied to contain strong toxicity, are frequently used in both domestic and industrial settings. On the other hand, several chemical pesticides, most notably Otapiapia, are locally made and sold in urban areas across Nigeria by people who are economically challenged lack certification, and have passed their expiration dates (Maduako, 2009; Musa et al., 2010).

Emphatically, it is very important that the primary goal of pesticide application is to manage and mitigate the effect of weeds, insects, mites, and other harmful animals and plant pathogens during the pre-planting, planting, and post-harvesting stages of crops (USEPA, 2017). However, it is therefore expedient that the pesticides used by farmers and pesticide residues in the agricultural soils be assessed, farmers grow food to eat and sell to others. Ben Khadda et al. (2021) and Belluco et al. (2023) further reported that public health experts have described that pesticide use is usually accompanied by deleterious environmental and public health effects. Evidently, pesticides hold a unique position among environmental contaminants due to their high biological activity and toxicity (acute and chronic) (Ore et al., 2022; Tarfeen et al., 2022).

Although some pesticides are described to be selective in their modes of action, their selectivity is only limited to test organisms. Thus, pesticides can be best described as biocides (capable of harming all forms other than the target pest). Obviously, the contamination of water bodies with pesticides can pose a significant threat to aquatic ecosystems and drinking water resources (Hojjati-Najafabadi et al., 2022). Evidently, Whelan et al. (2022) added that pesticides can enter water bodies via diffuse or via point sources. Importantly, point-source pollution comes from a specific, localized source and enters a body of water at a discrete location or the limited number of locations. Examples of point-source pollution include agricultural runoff from farms, wastewater from sewage treatment plants, combined sewer overflows, and accidental chemical spills. (Schönenberger et al., 2022). Also, there are point sources of pesticides from non-agricultural use, e.g., from application on roads, railways, or urban sealed surfaces such as parking lots (Reichenberger et al., 2007). Unfortunately, few studies have been carried out on farmers' usage of pesticides in the selected farm settlement within the Ogbomosho local government.

Therefore, the specific objectives are to evaluate the extent to which farmers use pesticides in the selected farm settlement, identify types of pesticides being used on the farms in the study areas, and evaluate the level of pesticide residue in the soil of selected farms within the study area.

Material and methods

Description of the study area

Oyo state is situated in the southwestern geopolitical zone of Nigeria encompassing a total land area of 28,454 km^2 (Babayemi et al., 2014). Agriculture continues to be the state's principal sector, employing a considerable part of its people. Cocoa, kolanut, cashew nuts, citrus fruits, palms, and rubber are the principal tree crops cultivated in the southern forest zones of the state, yam and cassava are the important root crops, and maize is the dominating cereal cultivated in the savannah areas of the State (Babayemi et al., 2014).

Study Area

The samples were collected from Ogbomoso south local government area of Oyo state, Nigeria, with its administrative headquarter located at Arowomole. As shown in Figure 1 below, it is bounded by Surulere, Oriire and Ogo-Oluwa town. Soil samples were taken from farms in Agric, Atoba, Abede, Ibapon, and Abe-Emin areas of Ogbomoso South local government.

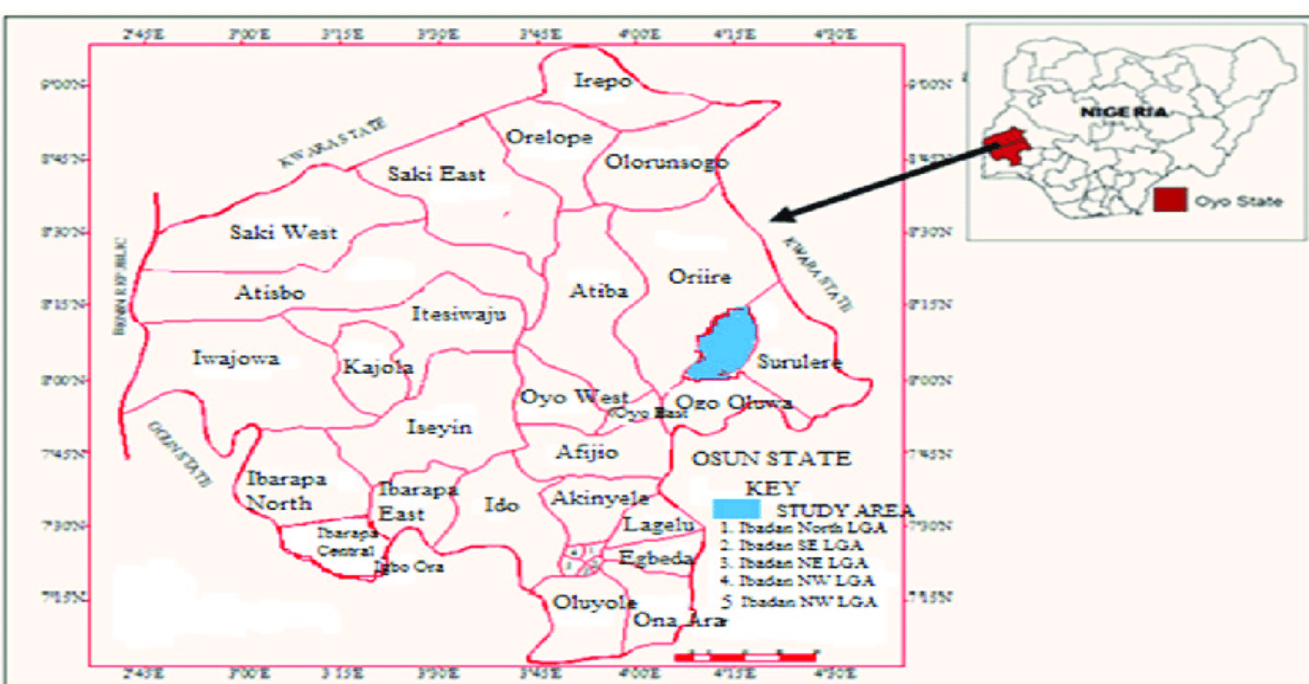

Figure 1. Map of Oyo state showing the study area (Ogbomoso South Local Government)

Questionnaire Administration

Structured questionnaires were administered to a sample of 30 farmers in order to collect data on farm management practices and inputs. The questionnaires gathered information on:

Farm use history (number of years under cultivation, crops grown, rotation practices, etc.);

Pest pressures - specifically identification of problematic weeds, insects, or diseases;

Pesticide usage - trade names and/or active ingredients of insecticides, herbicides, fungicides, and other pesticides used, as well as source(s) obtained;

Soil amendment and fertilizer inputs - types, and frequencies of synthetic and organic nutrient inputs.

The questionnaire used predefined response categories and closed-ended questions to allow for quantitative analysis of results. Data collected through the structured questionnaires aimed to provide insights into pest management practices that may influence soil health parameters under investigation.

Soil Sampling

Soil sampling was conducted at each of the selected sites using a bucket auger to collect samples from 0-30 cm depth. Four replicate soil samples were collected systematically in a diagonal pattern within each plot to capture within-plot spatial variability. Approximately 2 kg of soil was collected per sampling point. Samples were stored in labeled paper bags for transportation to the laboratory for analysis. In addition to the cultivated farm sites, control samples were collected from an uncultivated area outside the farmlands. These samples served as experimental controls. Sampling followed the same diagonal pattern and depth increments as the farm site samples. Control samples were stored in labeled polythene bags.

In the laboratory, pesticide residues were extracted from both the farm soil samples (treated) and control samples following published methods by Khan et al. (2007) and Riazuuddin et al. (2011) with minor modifications. The soil sample extracts were filtered, concentrated, and subjected to pesticide residue analysis via gas chromatography-mass spectrometry (GC-MS). Quantification was performed against standard calibration curves of target analytes. Appropriate quality control samples were processed alongside the experimental samples to evaluate extraction efficiency and matrix effects. By collecting replicated treated and control samples and using a validated analytical method, this study was designed to provide robust, quantitative data on pesticide contamination in soils across the sampled farm sites.

Data Analysis

The recorded data were further subjected to statistical analysis using Statistical Package for Social Sciences (SPSS) version 20.

Results

Types of soil amendment/fertilizer used by the respondents

Figure 1 presents the frequency distribution of respondent farmers categorized by the various soil amendment and fertilizer types self-reported to be applied to arable crops in the study area. The majority (79.2%) of respondents preferred the application of the synthetic fertilizer NPK 15:15:15 as a soil amendment, followed by urea (59.4%). In addition, the results of the soil amendment applications revealed that 23.4% of the respondents applied pig dung, while 19.8% utilized poultry manure and cow dung. The amendment least applied by respondents was ammonia (16.7%). Furthermore, this indicated that all farmers in the study area utilized fertilizers in order to compensate for nutrient deficiencies in the soil, consequently increasing yield. Most of the farmers used NPK 15:15:15, which is an inorganic fertilizer.

Name and type of pesticides used by the respondents

The usage of pesticides reported by the arable crop farmers surveyed in the study area is displayed in Table 1. The majority of the respondents (92.4%) identified Paraforce and Force-up as the pesticide products most frequently utilized on their farmland, while 79.2% and 52.8%, respectively, noted that Atrazine and Karate pesticides were used on their cropland. Furthermore, weed crusher (39.6%), Nwurawura (19.8%), and Laraforce (6.7%) pesticide products are reported to be least utilized by the farmers on their croplands. Similarly, the table also shows that Herbicides and Insecticides are the only types of pesticides used by the farmers in the study area.

Table 1. Names and types of pesticides used by the respondents

Name of Pesticide	Chemical name	Class	Pesticide Type	Frequency*	Percentage
Paraforce	N, N'-dimethyl-4,4'-bipyridinium dichloride	Bipyridylium	Herbicide	28	92.4
Force Up	Glyphosate – Isopropylamine	Glyphosate	Herbicide	28	92.4
Atrazine	diamino-1,3,5-triazine	Triazine	Herbicide	24	79.2
Karate	Lambda Cyhalothrin	Pyrethroid	Insecticide	16	52.8
Round up	Glyphosate, isopropylamine	Glyphosate	Herbicide	3	10
Laraforce	Lambda-cyhalothrin	Pyrethroid	Insecticide	2	6.7
Weed crusher	Paraquat dichloride	Rimsulfuron	Herbicide	12	39.6
Nwurawura	Isopropylamine	Glyphosate	Herbicide	6	19.8
Total No. of Respondents				**30**	**100**

Field survey, 2022
Multiple response

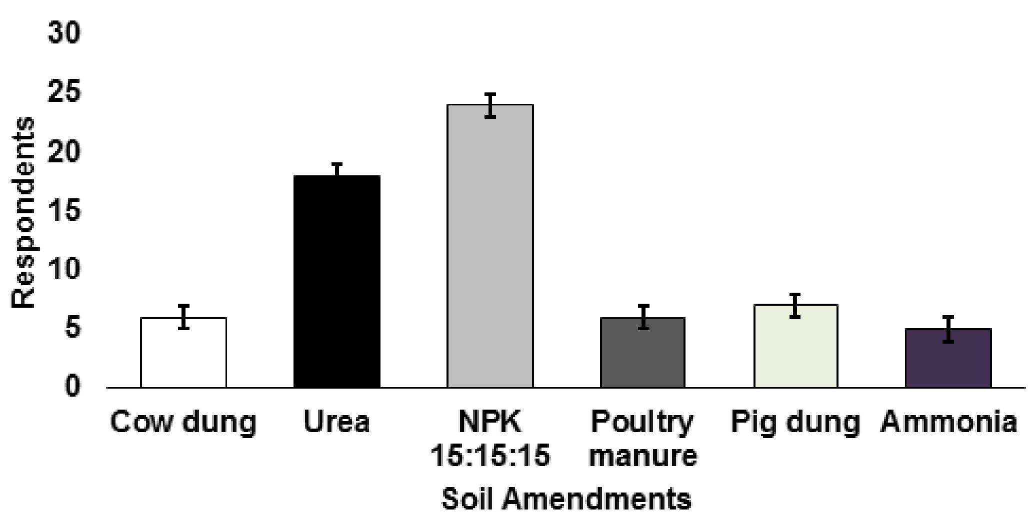

Figure 2. Type of soil amendments/fertilizers used by the respondents.

The concentration of pesticide residue in the selected farmlands

A total of eight (8) organochlorine pesticide residues in the soil samples collected were analyzed which include d-HBC, Chlorothalonil, Alachlor, Aldrin, Dacthal, Heptachlor epoxide, g-Chlordane, and Trans-nonachlor, respectively. Based on the result of the analysis of the pesticide residues on the soil samples collected as shown in Table 2 below, d-BHC concentration was found to be abundant in soil samples of uncultivated farm area of Atoba (Atoba Control) (87.59 mg/kg), followed by samples of uncultivated Abe-Emin (Abe-Emin control) (74.11 mg/kg) and Abede farm (70.76 mg/

kg). On the other hand, the lowest concentration of d-BHC was found in soil samples collected in an uncultivated Ibapon farm (Ibapon control) (4.25 mg/kg). Furthermore, the detected levels of chlorothalonil in soil samples collected from uncultivated Ibapon farm area (Ibapon control, 1.92 mg/kg) and Atoba farm (1.11 mg/kg) were relatively higher than other sampled locations. On the other hand, chlorothalonil was not detected in Abe-Emin and Agric farmlands while there was no detection of this concentration also of uncultivated soil samples collected from Atoba and Agric farmlands. Likewise, Alachlor concentration was not detected in most of the uncultivated lands except for the uncultured farmland of Atoba (2.25 mg/kg) and Agric (2.03 mg/kg), which were relatively higher than that of cultivated lands.

Similarly, the detected levels of Aldrin were found in uncultured farm areas of Abe-Emin (1.64 mg/kg) and Agric (1.19 mg/kg) only. In addition, Dacthal concentration found in uncultivated farm areas of Atoba (28.29 mg/kg) was depicted to be higher than in other locations for soil sampled both in uncultivated and cultivated farmland areas. Meanwhile, Dacthal concentration was found to be very low in the uncultivated area of Abede (Abede control, 0.91 mg/kg), Agric farmland (1.54 mg/kg), Ibapon uncultivated land area (2.65 mg/kg) and Abe-Emin (Abe-Emin control, 2.72 mg/kg), respectively. Importantly, the detected level of Heptachlor epoxide in the soil samples collected from uncultivated areas of Atoba (Atoba control) and Abede (Abede control) were 15.55 mg/kg and 9.76 mg/kg, respectively. On the other hand, Heptachlor epoxide was found to be low in soil samples from Ibapon farmland (2.18 mg/kg). Furthermore, the g-Chlordane compound was detected to be higher in Agric farmland (13.77 mg/kg) and the uncultivated land area of Abede (Abede control, 11.61 mg/kg). Meanwhile, it was found to be limited in Abe-Emin farm (2.83 mg/kg), uncultivated area of Agric (Agric control, 4.14mg/kg), and Ibapon farmland (4.91 mg/kg), respectively. Additionally, Trans-Nonachlor was detected to be abundant in the uncultivated land area of Atoba (10.82 mg/kg), Ibapon farmland (5.26 mg/kg), the uncultivated land area of Agric (5.31 mg/kg), and Abe-Emin (3.07 mg/kg), respectively.

Discussion

The use of pesticides and synthetic fertilizers in the Agricultural sector has increasingly become an important aspect of Agricultural technology and innovation, critical for agricultural development, economic growth, and poverty reduction. Globally, the use of synthetic inputs such as fertilizer and pesticides in food production is common with many farmers using commercial pesticides for pest control to increase yield and improve quality (Monteiro and Santos, 2022). The result of this research depicted that most of the farmers rely heavily on chemical fertilizers for their crop production. These findings align with the study by Niréti et al. (2017), which revealed that inorganic fertilizers, NPK, and urea specifically are the most used fertilizer in the study area. Similarly, Ba et al. (2016) revealed that Urea and NPK application is a widespread practice in some parts of Dakar, Senegal. However, several researchers have reported that excessive use of chemical fertilizer has been leading to undesired effects such as greenhouse gas emissions because of nitrogenous fertilizer (Wang and Lu, 2020; Byrne et al., 2020). Also, chemical fertilizer strongly affects the microbial diversity in the soil which helps in the breakdown of chemical compounds and organic matter (Gupta et al., 2022; van Rijssel et al., 2022). On the other hand, the application of organic manure increases soil quality and plant productivity (He et al., 2022; Hashimi et al., 2020); increases saturated hydraulic conductivity, total water retention capacity of the soil (Abid et al., 2020; Jamal et al., 2023).

Furthermore, pesticides are indispensable in agricultural production, they have been used by farmers to control weeds and insects in agricultural cultivation, and remarkable increases in agricultural products have been reported because of pesticide use (Lamichhane, 2017). These findings corroborate these reports, as the farmers in our study applied various synthetic pesticides on their farmlands. These included pesticides have been documented as effective for protecting crops against weeds and pest effect on crop production (Guleria et al., 2022; Rowen et al., 2022; Khan et al., 2023). According to several reports, preference among these pesticides is because of different factors such as efficacy, ease of purchase, effectiveness, longevity of efficacy, fast response, availability, and long time of use and popularity (Dawodu et al., 2020; Matova et al., 2020; Priya et al., 2022). However, most of the farmers have been using their land for a very long time and continuously use pesticides. Consequently, several pesticides have become infamous for their detrimental impacts on human health and the environment, leading to restrictions or outright bans on their use (Parish et al., 2020; Cohen et al., 2022; Anagnostopoulou et al., 2022).

In addition, the presence of some residues in the collected soil samples across all locations in the study area is an indication that they have been used or are still being used. Previous studies have detected different types of pesticide residuals in soil, crops, and water (Khan et al., 2020; da Silva Sousa et al., 2020). The levels of aldrin detected in soil samples from uncultivated areas in Abe-Emin (Abe-Emin Control) and Agric (Agric control) exceeded the European Union Maximum Residue Limit (EU MRL) of 0.02 mg/kg. Aldrin was also detected in cucumber samples at concentrations ranging from 0.0995-0.0215 mg/kg (Odewole et al., 2020). Aldrin is known to have caused neurotoxic, reproductive, and carcinogenic effects on human health, leading to nausea and vomiting (USEPA, 1975; Rani et al., 2021). A further study by Babayemi (2016) revealed that a direct application of pesticides can lead to hazardous levels of aldrin. Furthermore, it was discovered that all the compounds tested and detected left residues in the soil since they are active ingredients in synthetic pesticides which can find their way into water and food and can adversely affect human health (Hvězdová et al., 2018).

Conclusion

It can be deduced from this research that farms have pesticide residues of different levels. The detected pesticides like aldrin and d-BHC exceeded European regulatory limits, posing risks for farmers, consumers, and ecosystems. On average, each level is directly proportional to the duration of land use. This can be attributed to the build-up of pesticide residues in the soil due to the continuous usage of these pesticides over the years. Also, quite a number of the farmers lack formal education, and this deprives them of the ability to read and understand important instructions on the pesticide label. Farmers in this category tend to misuse the pesticides, apply them in unhealthy proportions, or use them too frequently (using wrong intervals between each application). In addition, most of the farmers obtain their pesticides from the marketplace, which in Ogbomosho South, has no regulation and allows for all sorts of pesticides (registered and unregistered, banned, and unbanned). Farmers, therefore, gain access to these pesticides, some of which are highly chlorinated and persist in the soil for long.

Lastly, the results underscore the urgency of implementing integrated pest management, organic practices, and agroecological approaches to reduce reliance on hazardous synthetic pesticides. Stronger policies and enforcement are needed to regulate pesticides and safeguard food safety and public health in this major farming region. Further research should continue monitoring pesticide residues across agricultural areas and analyse their impacts. Transitioning to sustainable agriculture can help secure food production while protecting human and environmental health in Ogbomosho South and beyond.

Table 3. Pesticide residues in soil (mg/kg)

S/N	COM-POUND	Abede Farm	Abede Control	Abe-Emin Farm	Abe-Emin Control	Ibapon Farm	Ibapon Control	Atoba Farm	Atoba Control	Agric Farm	Agric Control	Farm Mean	Control Mean	T	Tcal	
1	d-BHC	70.76	17.81	31.49	74.11	23.93	4.25	19.09	87.59	16.79	12.58	32.412	39.27	0.25	1.86	3.36
2	Chloro-thalonil	0.43	0.58	ND	0.64	0.33	1.92	1.11	ND	ND	ND	0.62	1.05	0.63	2.13	4.6
3	Alachlor	ND	ND	1.64	ND	1.02	ND	1.54	2.25	1.39	2.03	1.39	2.14	3.05	2.13	4.6
4	Aldrin	ND	ND	ND	1.8	ND	ND	ND	ND	ND	1.19	-	1.495	4.91	-	-
5	Dacthal	2.53	0.91	7.27	2.72	6.04	2.65	2.17	28.29	1.54	18.68	3.91	10.65	1.02	1.86	1.86
6	Hepta-chlor epoxide	6.2	9.76	5.89	3.24	2.18	3.73	6.82	15.55	6.06	5.83	5.43	7.62	0.7	1.86	1.86
7	g-Chlor-dane	6.59	11.61	2.83	8.97	4.91	7.6	5.31	5.07	13.77	4.14	6.68	7.47	0.25	1.86	1.86
8	Trans-Nonachlor	ND	ND	ND	3.07	5.26	ND	4.3	10.82	ND	5.31	4.78	6.4	4.02	2.35	5.84

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