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ORIGINAL RESEARCH ARTICLE

Farmers' Perception on Herbicide Usage and Impact on Health: an Overview of Status Quo in Parts of Benue South, Nigeria

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ABSTRACT
Herbicide usage has increased significantly. Its irrational use has adverse side effects. These side effects threaten the environment and human health. This study aimed to evaluate farmers' knowledge and perception on the health effects of herbicide usage in some parts of Benue South. Quantitative and qualitative data were collected through questionnaires from farmers. A total of 252 farmers were interviewed from three selected local government areas in the state. Amongst farmers interviewed, 56% were males, 44% were females and all between 20-50 years. Some farmers had secondary education and few tertiary education, while the majority had primary or non-formal education. Most respondents reported non-use of personal protective equipment during applications. Commonly used herbicides were Paraforce, Sarosate, Force-off, Fitscosate, Actraforce, Dsitop, and Weed off. Paraforce and force off were the most commonly used. Some farmers (68.7%) reported that they read and adhered to application instructions on the herbicide pack, while (77.4%) as suggested by their co-farmers. Only 38.5% reported to have got their information from workshops. A fraction of the respondents reported different symptoms of ill-health after herbicide application. Farmers had a high level of ignorance of the impact of inappropriate herbicide usage and biosafety especially on the use of protective clothing. Inappropriate herbicide application has great side effects on health. We recommend farmers' training programs on safe and appropriate herbicide usage measures and urge strict regulation and control of herbicide availability in the country

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INTRODUCTION
Herbicides are chemicals that manipulate or control undesirable vegetation or eradicate them. Its use in agriculture is increasing globally due to the high labor cost and decreasing labor force (Ustuner *et al.*, 2020). Farmers in Africa have been reported to have an increasingly high dependency on agricultural pesticides/herbicides (Boll, 2023). Recent and increasing dependency on these herbicides has been attributed to high farm labor costs, pressure to intensify production, and greater availability of exported inexpensive products (Moss, 2019). Reports indicate herbicide importation into Africa has increased significantly in the last five years. Statistics indicate that the importation of these chemicals into West Africa has doubled in five years, from 218,948 tonnes in 2015 to 437,930 tonnes in 2020. Another report showed that Nigeria's imports alone (147,446 tonnes) exceeded the total imports of Southern Africa (87,403 tonnes) and North Africa (109,561 tonnes) in 2020 (Boll, 2023).

Unfortunately, there is a marked lack of resources to monitor the negative impacts of herbicides on human health and the environment in Africa. The observation of increased use of herbicides implies that millions of smallholder farmers are exposed to potential risks associated with these chemicals (Boll, 2023).

Due to significant losses caused by weeds in agriculture, herbicides are used increasingly to increase productivity (Ustuner *et al.*, 2020). They selectively remove or eradicate undesirable vegetation/weeds in competition with cultivated crops for nutrients (Obiri *et al.*, 2021). However, their excessive, uncontrolled, and inappropriate usage has been shown to negatively affect the environment, especially on the soil (Balderrama *et al.*, 2020). These effects have been attributed to the slow nature of degradation of these chemicals, hence their accumulation in the soil and the environment (Balderrama

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et al., 2020). Its accumulation in the soil implies dissemination into rivers, lakes, oceans, and other water bodies. One of the negative impacts of the growing chemical herbicide usage is the deposition of toxic elements in the soil (Saskia, 2019). This also represents detrimental effects on living organisms in these environments, hence potential risk to non-target ecosystems. Most herbicides can eradicate both target and non-target organisms as they are broad spectrum, hence, destroy important ecosystem components (Obiri *et al.*, 2021). The detrimental effects of these chemical substances on the environment and human life have raised concerns (Matias *et al.*,2021). There is a growing concern about the potential risks associated with synthetic herbicide usage on the environment, especially in developing countries such as sub-Saharan Africa (Adewuyi and Offar, 2022) and human health. Herbicide usage represents global risks with impacts in sub-Saharan African countries like Nigeria, where agriculture constitutes a major part of the economy. Being an agrarian country, it provides business for various agrochemicals (Kehinde and Tijani, 2021).

The detrimental effects of herbicides are measured largely in toxicity and persistence (Adewuyi and Offar, 2022). Its toxicity is classified into acute and chronic toxicity. They are grouped with varied toxicity levels based on their chemical structure and composition as organophosphates, organochlorines, carbamates, and pyrethroids (Balderrama et al., 2020). These chemical substances selectively remove or kill non-economic plant species competing with crops for light, water, space, and nutrients (Obiri *et al.*, 2021). They are being used increasingly to increase productivity in agriculture, but their excessive usage has been shown to lead to adverse effects on the environment, especially on the soil, and, by extension, ecological problems with repercussions on the health of animals and humans (Filimon *et al.*, 2021).

Although herbicide usage has been associated with improved and increased agricultural yield, its potential risk to human health has been well-established and demonstrated in numerous scientific studies. Aldosari *et al.*, 2019 stated that human exposure to pesticides results in a number of harmful effects depending on the type of herbicide and duration of exposure. Elsewhere, studies on farmers' occupational herbicide exposure and health impacts exist (Balderrama *et al.*, 2020). Some of the diseases reported to have resulted from herbicide exposure include impaired neurobehavioral function (e.g., cognitive and behavioral disorders), Alzheimer's and Parkinson's diseases, hormone disruption, asthma, allergies, hypersensitivity, obesity, diabetes, hepatic lesions, kidney failure, multiple sclerosis, and cancer (Fuhrimann, 2019).

Chemical weed control is playing an increasing role in Nigerian agriculture due to the increasing cost and widespread unavailability of labor required to carry out traditional weed management (Imolame *et al.*, 2021). This study aimed to evaluate farmer's knowledge and perception on the health effects of herbicide usage in some parts of Benue State.

MATERIALS AND METHODS

Study Area

Benue State, Nigeria, is termed 'The Food Basket of the Nation'. It is highly agrarian, with most of its populace engaging in one form of agriculture. The study was conducted in three (Otukpo, Okpokwu and Agatu) local government areas out of the nine local governments (Figure 1) of Benue South senatorial zone. The study locations were selected based on its prominence in food production in Benue South.

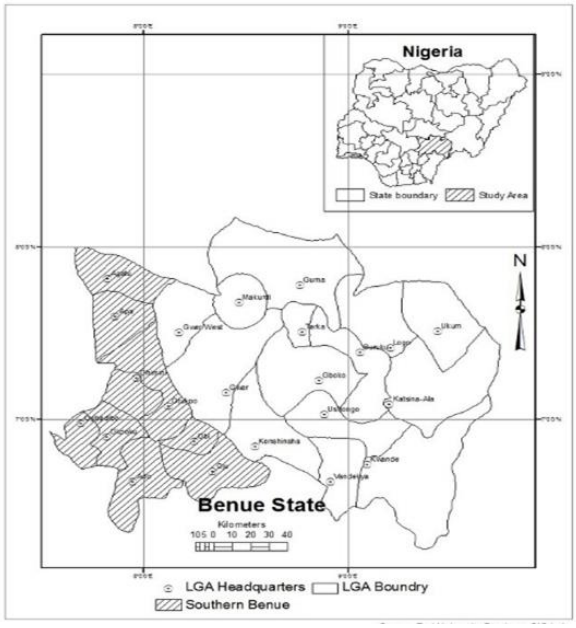

Figure 1: Map of showing Local Governments in Benue South.

Research Design

An exploratory research design was adopted as a baseline study due to a lack of previous research/information on herbicide usage from the study area. The researcher gathered preliminary data and problems were identified.

Sampling Procedure.

A pilot study of the target local governments was undertaken, and contact was established with field extension workers. The purpose of the study was discussed, and study areas were selected from each local government area. The selection was based on areas with farmers who used herbicides and consented to participate

in the study. A cluster sampling technique was used to obtain the cross-sectional data for this study. Farmers from fifteen selected villages, i.e., Five villages from each selected local government area, formed study areas. A total of three hundred questionnaires were distributed in each local government area (20 farmers in each of the five villages selected in a local government). A validated and structured questionnaire with open and closed-ended questions from related research done elsewhere (Aldosari *et al.*, 2019) was adopted for this study. Information on socio-demographic characteristics, level of education, types of herbicides they use, method of application, and use of protective clothing formed part of the information sourced.

The survey was conducted from September 2022- January 2023.

Statistical Analysis

Quantitative and qualitative data was collected through cluster sampling technique and one interview using structured questionnaires. Questionnaires were distributed to 300 farmers, although only 252 cooperated and returned their questionnaires. All variables regarding knowledge level, sources of information, reasons for herbicide usage, and farmers' perception of safe herbicide usage were clearly defined. The demographic characteristics of the respondents were assessed using descriptive statistics, frequency distributions, and percentages. While students' T-test was used to compare variables on socio demographic characteristics. The data obtained were coded, entered into Epi Data info version 3.1, and then analyzed using the Statistical Package for Social Sciences version 21.

RESULTS AND DISCUSSION

Demographic Characteristics of the Farmers

The socioeconomic characteristics studied are the farmers' age, education level, main occupation, annual income, and farming experience (in years) using herbicides.

Age and education level of the respondents.

Table 1 shows that the highest percentage of the respondents (48.0%) belonged to the 26-30 age group, followed by 23% in the 21-25 age group.

Regarding educational level, most respondents had primary education (31.3%). This means at least most of the sampled population have basic education and are expected to understand and adhere to instructions on safe herbicide applications. Obiri *et al.*, 2021 stated that literate farmers had a high potential to understand and apply safe herbicide application procedures. On the other hand, some farmers (17.9%) in the study area had no formal education. A similar report by Babarinsa *et al.*, 2018 also observed that education level impacted farmers' understanding. Farmers with little or no formal education might be at higher risk when using herbicides, possibly due to difficulties reading and understanding the instructions and safety procedures on the product labels. Hence, need for proper training and enlightenment.

Income of Respondents

Captioned as 'the food basket of the nation', farming is a major occupation of the population in Benue South. It was noted to be the main occupation of most of the sampled population, with 60.3% having farming as their sole source of livelihood. Table 1 shows that though some of the respondents are engaged in business (22.6%), hold government jobs (13.5%), and some artisans (2.9%), the majority are involved in agriculture directly or indirectly for their livelihood.

On the income level of respondents, most had an income level of N100,000 (46.4%) and above N100,000 (40.5%) from farming. This is far above the minimum wage in the country, hence, an important revenue generating source. Our findings align with Ramankutty *et al.*, 2018 who stated that agriculture represents an important income source in developing countries. Hence, farming is an important income-generating occupation in the country and requires great interest and promoting safe agricultural practices.

Most of the sampled population had more than 11 years of farming and herbicide use experience (52.8%). These years of experience indicate prolonged herbicide application in the study area.

Farmers' Perception on the advantage of herbicide usage

An inquiry on farmers' perception on the advantages of herbicide usage revealed that 91.6% of the respondents used herbicides to save energy (Table 2). Most respondents (97.6%) used herbicide as a fast method of weed control, 80.9% claimed it promoted high yield and 67.8% said it positively impacted their income level from the yield. This research supports the previous report by Haggblade et al., 2017 that these chemicals are well adapted for rural workers due to their affordability, replacement of manual weeding, and perceived increased yields.

In a related study, Moss, 2019 stated about 16 reasons farmers prefer the use of herbicides, including economic factors due to the less labor demand and rapid results. In addition to its ease of use without training, even if inappropriate and less technological demand, among other points. Our results are in tandem with these reports.

TABLE 1: Socioeconomic characteristics of respondents (N=252)

	Number = 252	Percentage (%)
Age of the respondents (years)		
≤ 20	16	6.3
21-25	57	22.6
26-30	121	48.0
≥ 31	58	23.0
The education level of respondents		
Informal	45	17.9
Primary	79	31.3
Secondary	51	20.2
Tertiary	77	30.5
The main occupation of respondents		
Business	57	22.6
Farming	152	60.3
Civil servant	34	13.5
Artisan	9	2.9
Income per annum of the respondents		
≤ 50,000	33	13.1
100,000	102	40.5
≥ 100,000	117	46.4
Farming experience of respondents (years)		
≤ 5	31	12.3
6-10	88	35.0
≥ 11	133	52.8

TABLE 2: Farmers' perception of the advantages of herbicide usage

Herbicides usage	**N=252 (%)**
Herbicide usage involves less energy	231 (91.6)
Herbicide application is a fast method of weed control	246 (97.6)
Herbicides control insects	210 (83.3)
Herbicide usage improves yield	204 (80.9)
Herbicide usage affects farmers' income	171 (67.8)
Knowledge of herbicides killing non-targeted organisms	205 (81.3)
Reuse of herbicide containers	30 (11.9)
Children's assistance in the application of herbicides	88 (34.9)

TABLE 3: Respondent's knowledge and practices regarding safe pesticide usage

Practices	**N=252 (%)**					
	Frequently	**Rarely**	**Never**	**Mean**	**Standard Deviation**	**P-value**
Read instructions on the label of herbicides	56.9	14.7	27.3	28.4	21.6	
Usage of head mask	31.4	38.4	30.2	33.1	4.4	1.664
Usage of overall apron	29.4	34.1	36.5	33.2	3.6	
Wear boot only	57.1	21.0	21.8	28.7	20.6	2.197
Wear protective glasses	25.0	40.1	34.9	32.7	7.6	
Usage of hand gloves	31.0	42.4	26.5	32.7	8.1	0.0003
Use nose protector	40.9	33.3	25.7	32.7	7.6	
Bathe after herbicide application	49.6	12.6	13.9	20.6	20.9	5.490
Wash hands after applying herbicides	70.2	16.2	13.4	24.8	32.0	
Regular medical check-up	20.2	43.6	36.1	31.7	11.9	2.875

Respondent's knowledge and practices regarding safe pesticide usage

Farmers' knowledge and practices regarding safe pesticide usage are assessed using 10 questions/statements (Table 3). Answers were evaluated against three levels (frequently, never, and rarely). The results show that 38.4% of the respondents rarely or never (30.2%) wore head masks during herbicide application, 36.5% never used aprons, and 34.1% rarely put overall aprons during herbicide application. On wearing protective glasses, 40% rarely wore protective glasses, while 34.9% of the respondents never did. Regarding hand gloves, 42.4% rarely wore hand gloves, while 26.5% never used hand gloves during herbicide applications. Inquiry on using a nose protector/nosemask showed that 33.3% rarely wore a nose protector, while 25.7% never wore a nose mask. Though 70.2% washed their hands after application, only 49.6% took a full bath after application. Questions to respondents regarding medical checkups showed that only 20.2% of the sampled population ever went for a medical checkup. On reading of instruments on the herbicide label, 56.9% said they read instructions before use, and 27.3% reported they never bothered to read the instructions on the herbicide label before use.

Ignorance of safe herbicide application is detrimental, and some farmers in the study area lack awareness of the importance of reading its instructions before use. This could also be why most farmers never or rarely protected themselves during herbicide application. Previously, Damalas and Khan (2016) noted that most farmers do not read the instructions printed on bottles/containers of pesticides.

TABLE 4: Percentage of herbicide usage across different locations

Herbicides/	(%) (N=252)				
LGAs	Agatu	Otukpo	Ohimini	Okpokwu	P-value
Paraforce	30.6 (45)	16.2(41)	30.7(4)	19.3(60)	
Force off	29.3 (43)	22.2 (56)	7.7(1)	12.3(38)	0.932
Weed off	1.3 (2)	5.6 (14)	0 (0)	12.6(39)	
Sarosate	32.7 (48)	24.6 (62)	38.5(5)	20.0(62)	1.381
Fitcosate	0.7 (1)	0 (0)	0(0)	1.3(4)	
Bush fire	3.4 (5)	6.7(17)	0(0)	10.6(33)	2.749
General	0.7 (1)	2.8(7)	0 (0)	12.6(39)	
Altra force	1.4 (2)	9.9(25)	15.4(2)	6.1(19)	0.905
Select	0(0)	7.5(19)	7.7(1)	3.9(12)	
Verstaline	0(0)	0.8(2)	0 (0)	0.3(1)	5.435
Xtravest	0(0)	0.8(2)	0 (0)	0.6(2)	
Diutop	0(0)	3.2(8)	0 (0)	0.6(2)	1.000

Health-related issues resulting from the exposure of agricultural workers to herbicides are a serious concern, especially in developing countries. This concern is because herbicide usage in this region is indiscriminate and without personal protective equipment, as observed in the study. Occupational health hazards encompass materials and processes with the potential to cause injury, sickness, and impaired health and affect the well-being and efficiency of workers (Ramankutty *et al*., 2018). Herbicides have been noted to be potentially toxic to organisms and humans and need to be used safely and their cans disposed of properly (Tudi *et al*., 2021). This study revealed that 49.2% of farmers in the study area leave herbicide containers unwashed after use, 56.9% ate during application, and 42,8% allowed children's assistance in herbicide application. These represent potential public health risks in the area.

Occupational health issues may occur long after exposure to occupational hazards, including contaminants from air, chemical, biological, physical, and ergonomic hazards, including psychosocial factors (Landrigan *et al*., 2017). Farmers are exposed to varied agricultural environment aerosols, including herbicides, in agricultural trade. They can be directly exposed to herbicides by inhalation, ingestion, and contact with skin and eyes. Hence, farmers in the studied population risk the potential detrimental effects of direct exposure to these herbicides.

On assessment of farmers' knowledge about hazards associated with herbicide application, although 82.9% of the respondents took note of the expiry date of herbicides, 27.3% used expired herbicides (Table 5). A good number of respondents were noted to eat during herbicide application (56.3%), drink liquid during application (38.0%), and even scoop herbicides with bare hands (36.5%), and some made phone calls during herbicide application (53.9%).

TABLE 5: Knowledge assessment of environmental hazards associated with herbicide application

Practices	Percentage (%) (N=252)
Knowledge of herbicide expiry date	82.9 (209)
Usage of expired herbicides	27.3(69)
Leave containers unwashed after usage	49.2 (124)
Regular water treatment	13.4(34)
Adherence to re-entry time after herbicides application	13.1 (33)
The action of herbicides on non-targeted organisms	19.4 (49)
Reuse of herbicides containers	15.0 (38)
Children's assistance in the application of herbicides	42.8 (108)
Make phone calls during herbicides application	34.5 (87)
Receive phone calls during herbicides application	53.9 (136)
Receive visitors during herbicides application	47.2 (119)
Eating during herbicide application	56.3 (142)
Drink liquid during herbicides application	38.0 (96)
Smoke during herbicides application	10.7 (27)
Scoop herbicides with bare hands	36.5 (92)
Stir herbicides with bare hands	17.4 (44)

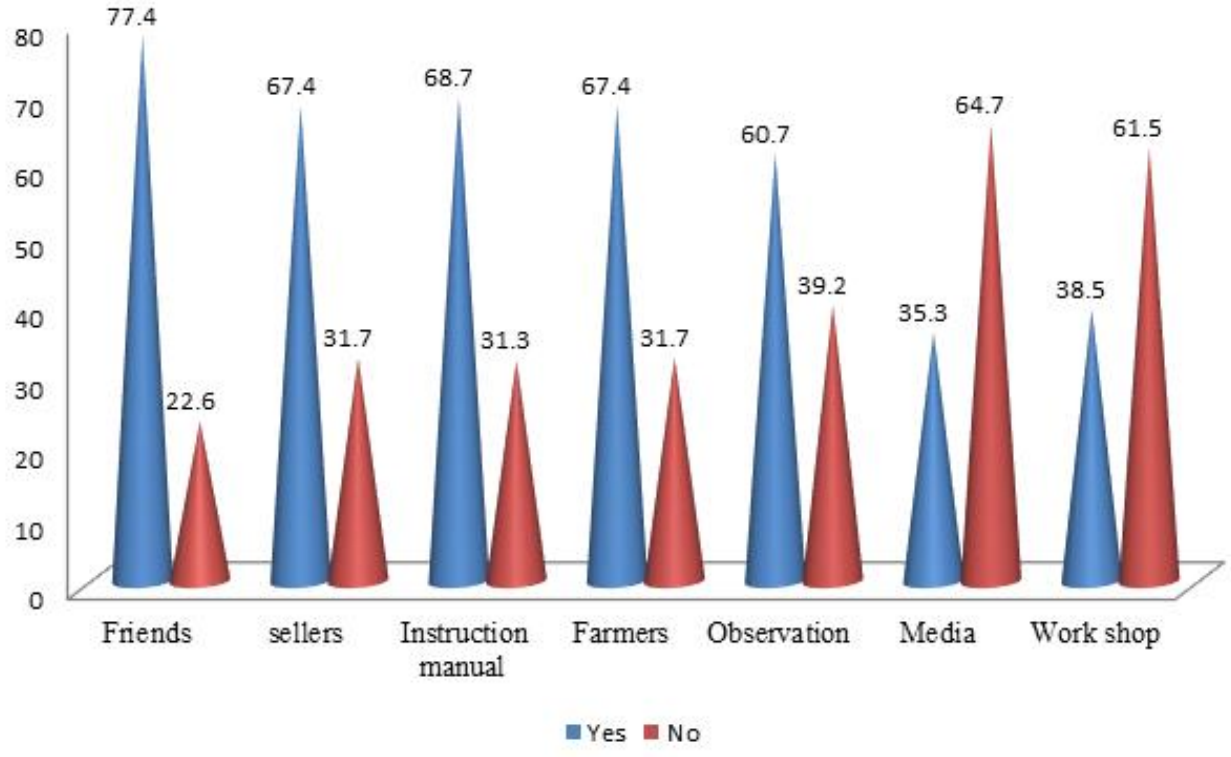

Figure 2: Farmers' information source on how to use herbicide

Assessing the respondents' source of information on herbicide usage, it was observed that the highest percentage (77.4%) relied on friends for information/guidance on herbicide usage/application. While, 67.4% got informed through sellers.

About 68.7% got knowledge of its usage guide through an instruction manual, and 67.4% got informed through co-farmers. Knowledge gained through the media and workshop was the least, with 35.3% and 38.5%, respectively.

In a related study, training of farmers on safety measures during herbicide usage significantly affected farmers' knowledge, attitude and practice (Aldosari *et al*., 2019). Hence, there is a need for extensive information dissemination and training through media and workshops by agricultural extension professionals.

CONCLUSION

The study indicates high herbicide usage among farmers in Benue South, Nigeria. Farmers in the study area used herbicides indiscriminately and without personal protective equipment. Many lack awareness of the potential effect of unguided herbicide usage.

RECOMMENDATION

The findings of this study suggest that it is necessary to reduce possible health and environmental risks associated with herbicide use by documenting risk perceptions and developing ways to address them. The application of safety measures is of utmost importance. We recommend enlightenment and training workshops by agricultural extension professionals on safe herbicide usage and biosafety measures. Training workshops, which are formal and informal are recommended in herbicide usage and ways of safety measure adoption. The government should also adhere to strict regulation of the import of herbicides into the country. Further studies are warranted to generate appropriate data on which to base policies. Using natural and safe pesticides is advocated, and we recommend researching bioactive materials with herbicide effects.

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REFERENCES

Adewuyi K. A. and Offar G. (2022). Analysis of the determinants of adoption of bio-herbicide technology for sustainable food production in the North-Eastern Region of Nigeria. *African Journal of Agricultural Research* Vol.18 (6), pp. 464-469 **[Crossref]**

Aldosari, F. O. , Mubushar, M., Mirza, B. Bader, B., Alotaibi, M. and Abdul Qader, K. (2019). Assessment of farmers on their knowledge regarding pesticide usage and biosafety Muhammad *Saudi Journal of Biological Sciences* 26: 1903-1910. **[Crossref]**

Babarinsa, S.O., Ayoola, O., Fayinminnu, O. and Adedapo, A. A. (2018). Assessment of the Pesticides Usage in Selected Local Government Areas in Oyo State, Nigeria. *Journal of Experimental Agriculture International* 21(1): 1-13. **[Crossref]**

Balderrama-Carmona A.P., Silva-Beltrán, N., P., Alvarez, L., A., Z., Bante, N. P. A. and Palacio, E. F. M. (2020). Consequences of Herbicide Use in Rural Environments and Their Effect on Agricultural Workers. Sustainability Concepts in Developing Countries. **[Crossref]**

Boll, H.S. (2023) Pesticide Use in Africa: Increasingly Vulnerable. https://ng.boell.org/en/2023/04/19/pesticide-use-africa-increasingly-vulnerable

Damalas, C.A., Khan, M., 2016. Farmers' attitudes towards pesticide labels: Implications for personal and environmental safety. *International Journal of Pest Management* 62: 319-325. **[Crossref]**

Filimon, M.N., Roman, D.L., Caraba, I.V. and Isvoran, A. (2021). Assessment of the Effect of Application of the Herbicide S-Metolachlor on the Activity of Some Enzymes Found in Soil. *Agriculture* 11; 469. **[Crossref]**

Fuhrimann, S., Winkler, M.S., Staudacher, P., Weiss, F.T., Stamm, C. and Eggen, R.I. (2019). Exposure to pesticides and health effects on farm owners and workers from conventional and organic agricultural farms in Costa Rica: Protocol for a cross-sectional study. *Journal of Medical Internet Research* 8(1):e10914. **[Crossref]**

Haggblade, S., Minten, B., Pray, C., Reardon, T., Zilberman, D. (2017). The herbicide revolution in developing countries: Patterns, causes, and implications. *The European Journal of Development Research*. 29:533-559. **[Crossref]**

Imoloame, E.O. Ayanda, I.F. and Yusuf, O.J. (2021). Integrated weed management practices and sustainable food production among farmers in Kwara State, Nigeria. *Journal of Open Agriculture* . **[Crossref]**

Kehinde, A.D. and Tijani, A.A. (2021). Effects of access to livelihood capitals on adoption of European Union (EU) approved pesticides among cocoa-producing households in Osun State,

Nigeria. *Agric Tropica Subtropica*, 54 (5) (2021), pp. 57-70 **[Crossref]**

Landrigan, P.J., Fuller, R., Acosta, N.J.R., Adeyi, O., Arnold, R., Basu, N. (2017). The lancet commission on pollution and health. *The Lancet*, 391:462-512. **[Crossref]**

Matias, H., Antonio, H. and Jose, L.R. (2021). Perception and adoption of new agricultural technologies in a Northern Inland Mozambique. *African Journal of Agricultural Research*, 17(2):310- 315. **[Crossref]**

Moss, S (2019). Integrated weed management (IWM): Why are farmers reluctant to adopt nonchemical alternatives to Herbicides. *Pest Management Science*.75:1205- 1211. **[Crossref]**

Obiri, B.D., Obeng, E.A., Oduro, K.A. , Apetorgbor, M.M., Peprah, T., Duah-Gyamfi, A., Mensah, J.K. (2021). Farmers' perceptions of herbicide usage in forest landscape restoration programs in Ghana. *Scientific African* II e00672. **[Crossref]**

Ramankutty, N., Mehrabi, Z., Waha, K., Jarvis, L., Kremen, C., Herrero, M. (2018). Trends in global agricultural land use: Implications for environmental health and food security. *Annual Review of Plant Biology*, 69:789-815. **[Crossref]**

Saskia, F., Beckers, L.,Busch, W., Carmona, E., Dulio, V., Kramer, L., Krauss, M., Posthuma, L., Schuze, T., Slootweg, J., Peter, C. and Brack, V. (2019). A risk based assessment approach for chemical mixtures form wastewater treatment plant effluents. *Academic Journals*, 164:107234. **[Crossref]**

Tudi, M., Daniel, R. H., Wang, L., Lyu, J., Sadler, R., Connell, D., Phung, D.T. (2021). Agriculture development, pesticide application and its impact on the environment. *International Journal of Environmental Research and public health* 18(3): 1112. **[Crossref]**

Ustuner, T., Al sakran, M. and Almhemed K. (2020). Effect of Herbicides on Living Organisms in the Ecosystem and Available Alternative Control Methods. *International Journal of Scientific Research*; 10:(8)633 **[Crossref]**