Macrothink Institute™

Journal of Biology and Life Science
ISSN 2157-6076
2025, Vol. 16, No. 1

Students', Teachers' and Farmers' Mastery of Knowledge on the Use and Benefits of Herbicides in Four Communities in Birim South District, Ghana

G. O. Boatey & W. H. K. Hordzi

Department of Biology Education, Faculty of Science Education; University of Education, Winneba, B. O. Box 25, Winneba. Ghana

Received: October 17, 2024 Accepted: November 18, 2024 Published: November 25, 2024

doi:10.5296/jbls.v16i1.22421 URL: https://doi.org/10.5296/jbls.v16i1.22421

Abstract

Rampant farmer application of herbicides involving students in agriculture in Ghana, especially in Birim South District is a major concern for stakeholders. This problem can be reversed if stakeholder knowledge about appropriate ways of application and usefulness of herbicides is known. Hence, this study determined views of Junior High School students, their teachers and farmers in Birim South District of Ghana about the usefulness and appropriate application of herbicides. Ninety students, 30 teachers and 60 farmers randomly and conveniently selected participated in a cross-sectional survey in the District. Expert validated questionnaire with Cronbach alpha reliability coefficient of .0.75 was used. There were eight close-ended items. Questionnaires were personally administered and analysed descriptively. Students (mean =2.3), teachers (mean = 2.7) and farmers (mean = 3.6) were all familiar with herbicides but farmers were most familiar. All teachers and farmers and 93.33% of students agreed that herbicides are primarily used to control weeds. Opinions about cost-effectiveness of herbicides were highly varied. There were also varied opinions about practices farmers could adopt to minimize risks associated with herbicide application. All respondents had some misconceptions about usefulness and appropriate ways of herbicide application. The implication is that there should be education programmes to help stakeholders to consolidate the right information and empower them with more knowledge to do away with the misconceptions.

Keywords: herbicides, application, familiarity, knowledge, farmers, lower toxicity, protective cloths

1. Introduction

Farming generally involves clearing of bush before sowing. Even after sowing there is the

need for weed control. Over the years, in Ghana, pre-planting weed clearing and weed control in farms were mainly through slash and burn, ploughing or use of hand hoes. This happens especially on small farms of peasant farmers where tillage is typically manual, using the hand hoe or a single-furrow, animal-drawn moldboard plow (Gianessi, 2014). The manual weeding is environmentally friendly. However, it is very involving and labour driven (Rahman, 2016). In the actual fact manual pre-plant tillage using the hand hoes requires a lot of time up to about 8-10 days of labour per hectare (Gianessi, 2014). Thus, such labour-intensive weed control agriculture was too tiring and less appealing to farmers. As a result, majority of farmers in Ghana including those from Birim South District have shifted to the use of herbicides in pre-planting and post-planting weed control.

According to Mesnage *et al*. (2021), herbicides are agrochemicals applied to prevent or interrupt normal plant growth and development. In Ghana the use of herbicides has gained grounds and it is a common phenomenon to see many farmers applying it to control weeds. This is due to the fact that the farmers have come to the realization that the use of these agrochemicals is less laborious and more economical. In any case, herbicides decrease the manual labour required to control weeds and thereby freeing farmers for other tasks (Mesnage *et al*., 2021). The use of herbicides can conserve the soil, soil water ((Munawar *et al*, 1990; Gianessi & Williams, 2012) and energy resources (Gianessi & Williams, 2012). If herbicides, especially non-selective herbicides are applied in a single operation at planting time it makes weeding easier and all weeds can be removed. This drastically reduces labour requirements (Gianessi, 2014).

What makes herbicide use in Ghana alarming is that school children are involved in the application. Meanwhile, herbicides cause unintentional problems such as off-target movement to sensitive crops (spray drift) and small amounts persisting in the soil and disrupting future crops. Also, weed populations can shift in response to herbicides and other production practices, and the establishment of new weeds can lead to crop loss (Mesnage.et al., 2021).

Herbicide application can also cause eye irritation (Rahman, 2016). There are also concerns about herbicide resistance and environmental pollution (Nath *et al*., 2024). According to Sondhia (2018), non-judicious use can cause high buildup of residues in crops, soil surface contamination, and groundwater contamination. If different herbicides are used inappropriately such as high dose, improper methods of application, wrong calibration of equipment, wrong spray volume, these can lead to alteration in plant growth, physiology, and metabolism and eventually results into phytotoxicity and impaired crop productivity (Sondhia, 2018). Continuous use of same type of herbicides over and over again can cause accumulation in the produce, soil, and groundwater, resulting in health hazards (Sondhia & Singh, 2018). Furthermore, repeated use of herbicide(s) having similar mode of action can result in the development of resistance in weed biotypes (Nath *et al*., 2024).

Despite all the negative effects of herbicides espoused above, its use continues in Ghana, for that matter Birim South District among farmers and sometimes school children (students). The question that can be asked is whether those involved in the herbicide application have the

necessary knowledge about herbicides, their use and methods of application? It is said that one major problem of weed control including use of herbicide among peasant farmers in Africa is paucity of knowledge (Simiyu, 2021**)**. Meanwhile, the adage goes that knowledge is power.

Karlsen and Gottschalk (2004) defined knowledge as information combined with experience, context, interpretation, reflection, intuition and creativity. Likewise, Davenport and Prusak (1998) see it as a fluid mix of framed experience, values, contextual information, and expert insight that provides framework for evaluating and incorporating new experiences and information. Knowledge can be seen at work by the way people make decisions, by a certain peculiar way people do their jobs, and through people's creativity in completing their work (Davenport & Prusak. 1998).

It is expected that students, farmers and Junior High school teachers from Birim South District who are stakeholders in herbicide use in the area might possess some useful information regarding the use and application of herbicides that would promote agricultural activities in the area. Thus, respondents would have possessed knowledge such as information combined with experience, values, contextual information, and expert insight and the way decisions related to herbicide use are made. However, there is paucity of research findings about such knowledge from the three categories of respondents in Ghana, and specifically, Birim South District. Hence, this study aimed at ascertaining the views of Junior High School students, their teachers and farmers in the Birim South District of Ghana on the beneficial use and mode of application of herbicides in the District. The Birim South District was used simply as a case study because it is a typical rural District fully involved in agricultural activities.

Purpose of the study

The purpose of the study was to assess the opinions of junior high school students, teachers and farmers about the usefulness and ways of application of herbicides.

Objectives

The specific objectives of the study were to ascertain the:

1. views of students, teachers and farmers about the usefulness of herbicides,
2. knowledge of respondents on the ways of application of herbicides,

Research questions

The study was guided by the following research questions:

1. What are the views of students, teachers and farmers about the usefulness of herbicides?
2. What is the knowledge being held by students, teachers and farmers about the ways of application of herbicides?

Hypothesis

Null hypothesis 1(H_{01}): There is no statistically significant difference in the views of respondents on their familiarity with herbicides.

Null hypothesis 2 (H_{02}): There is no statistically significant difference in the views of respondents on best ways to apply herbicides.

Alternate Hypothesis

Null hypothesis 1(H_{a1}): There is statistically significant difference in the views of respondents on their familiarity with herbicides.

Null hypothesis 2 (Ha_2): There is statistically significant difference in the views of respondents on best ways to apply herbicides.

2. Methodology

Study area

The study was conducted in four communities in Birim South District, Eastern Region of Ghana. The Birim South District is one of the 33 districts in the Eastern Region of Ghana. It is located **5°53′39.98″N 1°0′55.22″W**. The District covers an estimated land area of 725.99 square kilometers. It shares boundaries with Birim Central in the North East, Assin North (West) and Asikuma Odoben-Brakwa and Agona to the South (Ghana Statistical Service, 2014). The District Capital is Akim Swedru. The study was conducted in four communities, Akim Swedru, Akim Awisa, Akim Apaaso and Akim Asawase. There is a total of 25 public Junior High Schools in the District.

Study Design: Cross-Sectional survey was used. This was to allow for systematic collection of data (Babbie, 2016) on students', teachers' and farmers' opinions and experiences related to weed control methods, and the usefulness of herbicides.

Population: The target population comprised all junior high school students (8,293), all junior high school teachers (295) and all famers in the Birim South District in 2023. The accessible population consisted of all junior high school students (891), all junior high school teachers (60) and all farmers in the four selected communities in 2023.

Sample and sampling: The total number of junior high schools (JHS) in the four selected communities is six. For students, the study covered forms two and three because they were more matured. In order to get a representative sample, 15 JHS students were randomly selected from each of the six schools, making it a total of 90. Five JHS teachers were also randomly selected from each of the six schools in the four communities, making a total of 30. The teachers were selected from the same schools from which the students were selected. Sixty (60) farmers, 15 from each of the four selected communities were sampled using convenience sampling. Therefore, in all 180 respondents participated in the study.

Research Instruments

The instrument used to collect data for the study was a researcher–designed questionnaire. The

questionnaire contained eight items in all, covering the usefulness and the ways of applying herbicides. Two of the items were Likert scale whereas six were close-ended with opportunity for the respondents to select more than one option. For the sake of easy comparison, the same questionnaire was administered to students, teachers and farmers.

Three agricultural experts and two researchers went through the questionnaire to ensure its content and face validity. The questionnaires were pilot tested using 10 students, five teachers and 10 farmers making a total of 25 respondents from the area. Those who took part in the pilot test did not take part in the main study. A Cronbach's Alpha reliability coefficient of .0.75 was realized. Reliability refers to the extent to which a measuring instrument measures consistently what it is measuring. It can also be described as internal consistency measure (Uyanah & Nsikhe, 2023). According to George and Mallery (2003) a value greater than or equal to 0.9 is excellent; equal to 0.8 is good; equal to 0.7 is acceptable; equal to 0.6 is questionable; equal to 0.5 is poor and less than 0.5 is unacceptable. Therefore, by George and Mallery (2003) rule, 0.75 is acceptable, suggesting that there was internal consistency for the items, thereby rendering the instrument reliable for use.

Data collection

The questionnaires were personally administered to the sampled students, teachers and farmers by the researchers. Students and teachers were allowed one hour to complete filling out the items after which the questionnaires were immediately collected. For farmers also efforts were made to reach out to those of them who could read and write English to respond to the items in the questionnaire. They were allowed to complete the questionnaires for immediate collection. In each case there was hundred percent retrieval.

Data analysis

Data collected were coded and subjected to statistical analysis using Statistical Package for the Social Sciences (SPSS) analysis software version 27. Weighted (rated) means were calculated for the Likert-Scale items and decision points determined. The means for students, farmers and teachers were compared using one way analysis of variance at a significance level of $p = 0.05$. For multiple choice items allowing more than one option to be selected, frequencies and percentage frequencies were used to compare responses from the three groups of respondents.

Ethical considerations

Before data collection, participants were provided with detailed information about the study's purpose, procedures, and potential risks, aligning with the ethical principle of informed consent as emphasized by Resnik (2020). Informed consent was obtained from all participants or head teachers in the case of teachers and students. Participation in the study was voluntary and participants had the right to withdraw without any adverse consequences. Responses collected from participants were anonymised to protect their identity. This is to ensure confidentiality and data protection (Resnik, 2020). All data collected were securely stored to prevent unauthorized access and ensure participants' privacy.

3. Results and Discussions

Research question 1: What are the views of students, teachers and farmers about the usefulness of herbicides?

Views expressed by respondents on their familiarity with herbicides have been presented in Table 1. The results showed that majority of students, teachers and farmers were slightly (mean of 2.3), moderately (Mean of 2.7) and very familiar (3.6) with herbicides. The differences among their familiarity were significant (F = 33.95) at 0.05 level of probability (Table 2). On the other hand, the differences in the levels of awareness between students and teachers were not significant, between students and farmers were significant and between teachers and farmers were significant. Furthermore, farmers exhibited the highest level of awareness. This may be due to the fact that farmers are the people mostly involved in the use of the herbicides.

The current findings provide data for building knowledge that will foster consciousness, and can be applied for the development of mankind in the agriculture sector. After all, knowledge is created in the human mind and increases when people are involved in its acquisition and dissemination (Mohajan, 2016). This would eventually lead to more knowledge and advancement (Nasimi *et al*., 2013) in the agricultural sector. It can be said that students were in the position to learn from farmers and teachers. This is so as the students would have acquired knowledge from books, agriculture science lessons, knowledge gained when they are sent to buy herbicides and from their parents who are farmers. Hence, it is not surprising that the students exhibited similar knowledge about herbicides just as their teachers.

Table1. Respondents' familiarity with herbicides

Item	**Students** (N=90)			**Teachers** (N=30)			**Farmers** (N=60)		
	Mean	**SD**	**Decision**	**Mean**	**SD**	**Decision**	**Mean**	**SD**	**Decision**
How familiar are you with herbicides?	2.3a	1.08	Slightly familiar	2.7a	0.88	Moderately familiar	3.6b	0.5	Very familiar

Decision point for means: *NF = Not familiar = 1-1.4; SF = slightly familiar = 1.5-2.4; MF = moderately familiar = 2.5-3.4; VF = Very familiar = 3.5-4.0*

NOTE: Same letters attached to means signifies no significant difference.

Table 2. Results of ANOVA on respondents' viws about their familiarity with herbicides

Source of variation	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Groups	54.222	2	27.111	33.95	0.00
Error	141.356	177	0.799		
Total	195.578	179			

From Figure 1, both responses that the primary use of herbicides is for weed and pest control are acceptable. Kumar *et al*. (2023) established that any organism, whether plant or animal causing damage to other plants or plant products is called pest. Actually, all weeds can be

pests and deserve to be treated so. Therefore, weed removal from crops minimises competition between crops and weeds for resources (Rahman, 2016). This ensures that crops make use of available resources to the fullest and thus enhancing crop yield. Consequently, it is less expensive and can result in tripling or quadrupling profit than manual weed control (Rahman, 2016).

Interestingly, all teachers (100%) and farmers (100%) as well as 93.33% of students agreed that herbicides are primarily used to control weeds. However, while 63.33% of teachers and 10% of students agreed that herbicides can be primarily used to control pests in agriculture, all the farmers disagreed (0%). The position of the famers may be linked to their probable level of education because, generally, majority of farmers in rural Ghana have low levels of formal education or no formal education and might only be aware that herbicides can be used to control weeds not knowing that weeds can be pests when they cause economic damage to crops in terms of denying them nutrients and enough air to grow. So, despite the fact that farmers used for this study could read and write English, they still lacked knowledge that herbicides can be primarily used to control pests in agriculture.

A study conducted by Bosu *et al*. (2008) showed that 55% of farmers used herbicides in controlling weeds on their farms. Obiri, *et al.* (2021) in their study covering three study areas in Ghana discovered that 74–85% of farmers used herbicides in land preparation before planting of forest trees and crops, indicating its use for weed control until canopy closure in the third year. The results of the current study confirm the findings of Bosu *et al*. (2008) and Obiri *et al*. (2021).

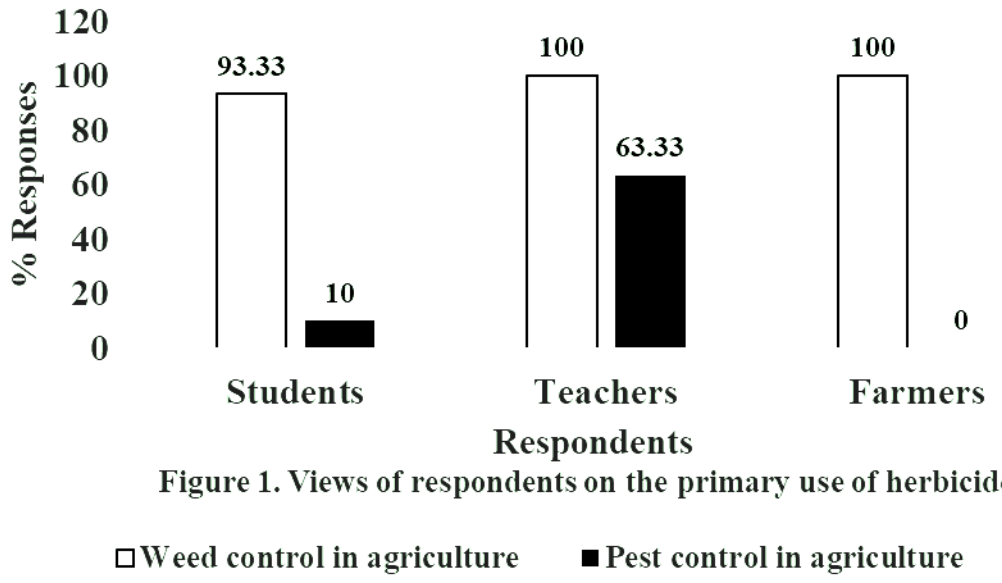

Figure 1. Views of respondents on the primary use of herbicides

From Figure 2, one important response is that herbicides in agriculture are useful in reducing competition among crops and weeds for resources. It has been observed by Simiyu (2021) that herbicide weed control is more effective than hand weeding resulting in weed control in the critical periods of crop growth prior to establishment of canopy. This leads to avoidance of physical damage to crops due to hand weeding and thereby resulting in higher yield, higher

income and reduced time for peasant farmers to undertake other work **(**Simiyu, 2021**)**. No doubt, in this study, it is clear that farmers exhibited the highest level of awareness (90%), followed by teachers (76.67%) and then students (64.44%) for this response. Thus, the farmers were aware that the use of herbicides eliminates weeds from the farm and this to large extent will contribute to increased crop yield as espoused by majority of them (88.33%), teachers (86.67%) and students (37.78%). This is in tandem with Abakpa *et al.*, (2024) who asserted that herbicides are chemicals that manipulate or control undesirable vegetation or eradicate them. It also agrees with Moss (2019) who stated that increasing dependency on herbicides is due to the quest to reduce high farm labour costs in order to intensify production, and also as a result of greater availability of the herbicides. Ustuner *et al*. (2020) also observed that herbicides use is extensively increasing because of high losses caused by weeds in agriculture. Therefore, herbicides are increasingly used to increase productivity. Such developments ensure that herbicides selectively remove or eradicate undesirable vegetation/weeds in competition with cultivated crops for nutrients (Obiri *et al*., 2021).The results of this study once again point to the fact that farmers were leading in opinion. These findings are not very surprising because farmers were using the herbicides and would have been responding from their experience. Similarly, some of the teachers themselves would have been applying herbicides in their farms over the years and this coupled with academic knowledge would definitely put them above students in terms of knowledge of the benefits that herbicides offer to agriculture.

Elimination of weeds from farms may also contribute to enhanced quality of crops in the field, all things equal. In Africa, some weeds are poisonous and can harm humans and livestock with their toxins (Simiyu, 2021). Simiyu (2021**)** further intimated that some of such weeds can drastically reduce crop yield, toxic to livestock and render food uneatable. Hence, opinions expressed by respondents that use of herbicides can enhance quality of crops is acceptable because elimination of dangerous weeds would not negatively affect crop quality that can affect animals.

On the other hand responses related to reduction in competition for resources and increased yield are on the lower side. In this case the opinions of teachers toped both farmers and students. Meanwhile, it is not scientifically clear how the use of herbicides can bring about efficient land use. So, it was not expected that respondents would positively respond to it. However, more than half of the teachers and farmers selected it as a benefit of using herbicides in agriculture. This is worrying because having wrong information is detrimental to agriculture in the research area as farmers and teachers can transmit such wrong knowledge to students who are the future potential farmers of the area.

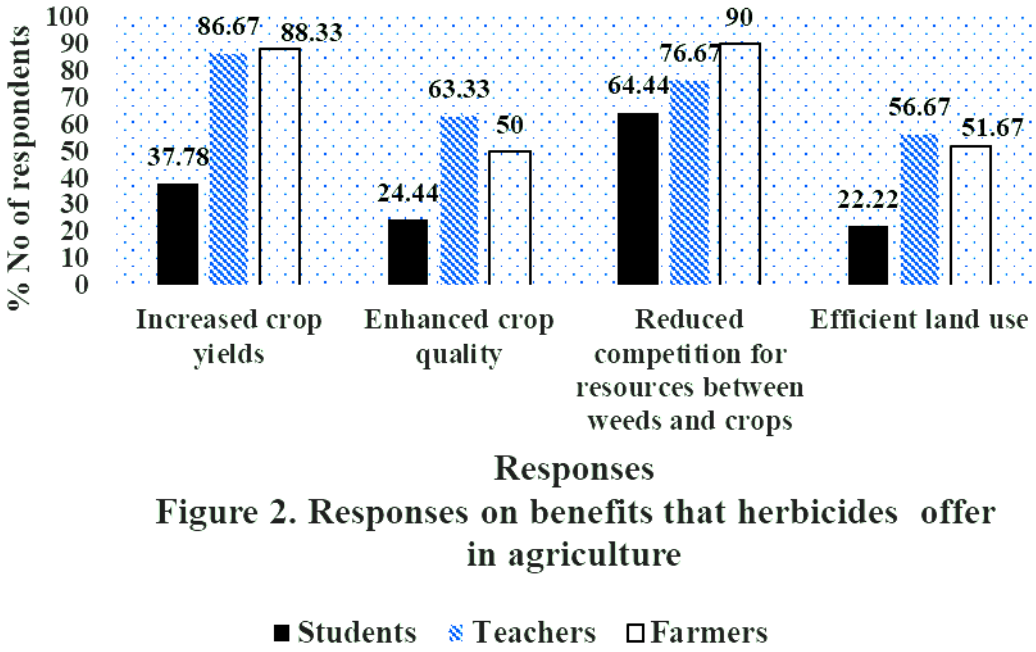

Figure 2. Responses on benefits that herbicides offer in agriculture

In Figure 3, 76.67% of teachers, 28.33% of farmers and 23.33% of students respectively agreed that herbicides are selective. According to Das and Mondal (2014) selective herbicides kill specific weeds and leaves the crop being protected relatively safe. An herbicide is described as selective if it can kill certain plants without injuring others. On the other hand herbicides that can kill most plant species are referred to as nonselective herbicides. However, many herbicides used in crop production are selective (Duke *et al*., 1991). Yakubu *et al.* (2010) also reported similar results when they asserted that majority of farmers (51.11%) used non-selective herbicide, 18% used selective while 30% combined both types in spraying weeds. They further explained that since herbicides are job-specific, they are selective in effectiveness and therefore occur within a given range of concentration under particular conditions. Applying them in excess can cause severe damage to crops.

Rahman (2016) intimated that while manual or mechanical weeding can delay in wet soils, herbicides can be more effectively employed for weed control. In this study, all teachers (100%), 85% of farmers and 80% of students agreed that herbicides are fast in controlling weeds. Since manual weed control is not cost effective, herbicide use becomes the most effective alternative. This is because herbicides control weeds very effectively (Rahman, 2016). Das and Mondal (2014) observed that herbicides provide cost-effective weed control with less labour. In this study also, 65% of farmers, 45.56% of students and 43.33% of teachers agreed that herbicides are more cost-effective compared to manual control. This corroborates the submission by Rahman (2016) that herbicide reduces the cost and drudgery in weed control. Thus, it is three to four times cheaper using herbicides in weed control than manual weed control, pointing to the fact that herbicide weed control is more economical compared to manual and mechanical weed control (Rahman, 2016).

.

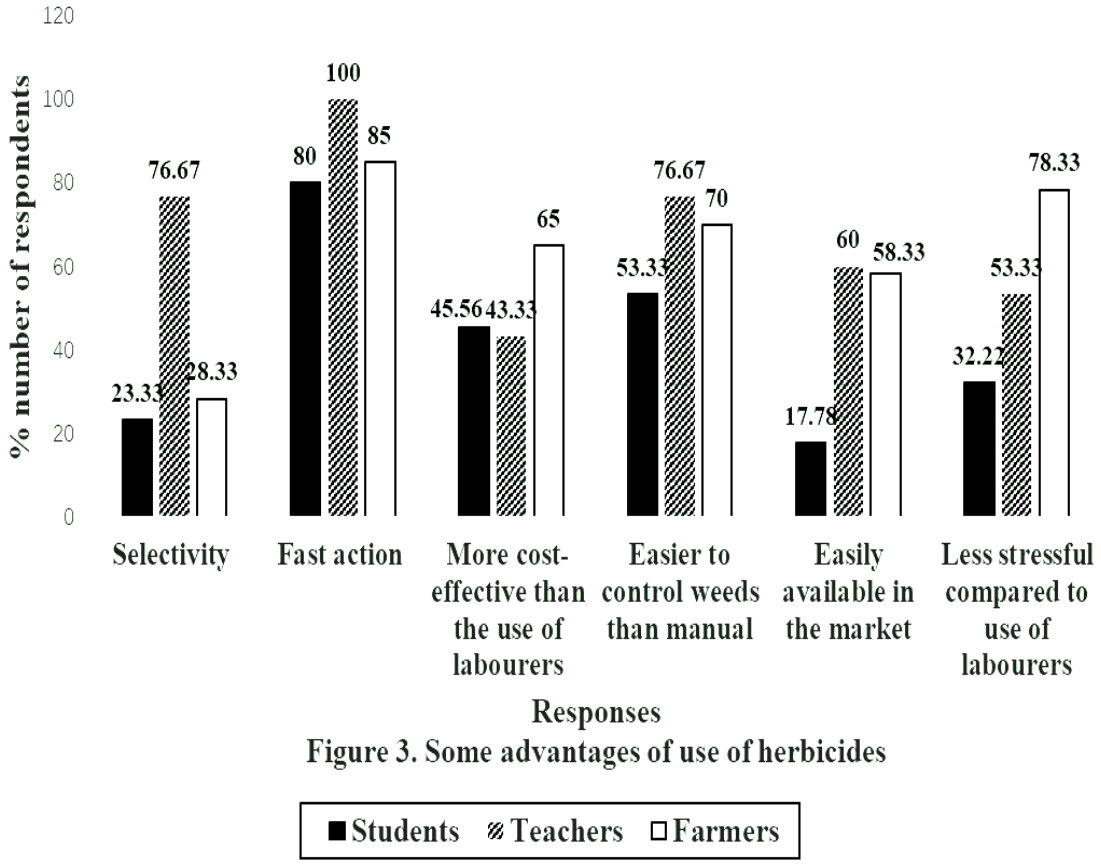

Figure 3. Some advantages of use of herbicides

Simiyu (2021) opined that manual weed control such as hand-hoeing negatively affects the back of farmers and very time consuming. Farmers burn down for long periods of hours and this results in back injuries, sprains and eventual physical deformities. However, when taught how to use herbicides responsibly to reduce manual labour, farmers show readiness to use it to increase yield and at the same time reduce cost. No doubt, 76.67% of teachers, 70% of farmers and 53.33% of students were affirmative that herbicides are easier in controlling weeds compared to manual control. The use of hoe can result in the cutting of both weeds and plant roots, thereby reducing yields (Simiyu, 2021). Abakpa *et al*. (2024) reported similar findings that most respondents (97.6%) used herbicide as a fast method of weed control, 80.9% claimed it promoted high yield and 67.8% stated that it positively impacted their income level from the yield. Similar report was earlier produced by Haggblade *et al*. (2017) that herbicides are well adapted for rural workers due to their affordability, replacement of manual weeding, and perceived increased yields.

Concerning availability of the herbicides for purchase, 60% of teachers, 58.33% of farmers and 17.78% of students were of the opinion that herbicides are easily available in the local market. This finding corroborates the findings of Imoro *et al*. (2019) who in a survey from the Northern Region of Ghana reported that out of 36 different pesticides sold in the Tamale Metropolis herbicides were the most commonly used in the Metropolis (58.3%), followed by insecticides (41.7%). Thus, the herbicides are available for use and farmers can easily buy if they had the money. When it comes to stress in weed control, 78.33% of the farmers, 53.33%

of teachers and 32.22% of students were of the view that herbicides are less stressful compared to manual labour. In a related study, Moss (2019) stated about 16 reasons why farmers prefer the use of herbicides, including economic factors due to the less labour demand and rapid results.

The results of this study showed that teachers followed by farmers and then students agreed that some herbicides are selective against some crops, they generally provide fast action against weeds, it is easier using them to control weeds compared to manual labour, and they are easily available on the market for purchase and use. One response in which majority of the farmers exhibited low knowledge (28.33%) is the selective nature of some herbicides against specific crops. It should be of tremendous concern when over 70% of the farmers did not know of this because it would prevent them from deriving the ultimate benefit from using the herbicides on their farms. Thus, some may only use the herbicides for clearing the bush for planting but when it comes to removing the weeds from the crops they may use manual labour.

A look at the results suggests that the farmers generally knew that the use of herbicides is beneficial in cutting down cost compared to manual labour. Hence, the farmers exhibited higher knowledge (65%) than students (45.56%) and teachers (43.33%) respectively to the response that herbicide use is more cost effective than manual labour. This should not be surprising because farmers would like to make profit from their farms and would definitely find out if the use of the herbicides would not negatively affect that before they venture into it. The surprise is that here, students performed slightly better (45.56%) than teachers (43.33%). This may be due to the fact that the study was done in a rural area where majority of the students used to help their parents on the farm or are farmers themselves. Thus, the students who used to help their parents on the farm would have learnt it from their parents while those of them who are farmers themselves would have also enquired about that before attempting to use the herbicides. In any case parents can also send their wards to buy the herbicides for them. In the process, the students would have learnt a few things from that. This can be further explained by a finding of Obiri *et al*. (2021) from Ghana that respondents indicated that in some instances school children and other more literate people assist with the reading of labels on bottles of herbicides particularly in Mankrang and Afram Headwaters. This is indicative that the students can equally acquire some knowledge about herbicides through reading labels on the containers.

Another response in which the farmers were in the lead (78.33%), followed by teachers (53.33%) and then students (32.22%) was that the use of herbicides to control weeds is less stressful than the use of manual labour. This also points to the fact that obviously the farmers would have opted to use herbicides as alternative to manual labour after getting to know that it would relief them from the stress they used to go through when doing weed control manually.

Research question 2: What is the knowledge being held by students, teachers and farmers about the ways of application of herbicides?

Respondents' views on the proposition that there should be regulations or guidelines for the

application of herbicides to reduce environmental and health risks have been presented in Table 3. It is clear from the Table that students strongly agreed (Mean of 4.6), whereas teachers and farmers agreed (Mean of 4.3). Analysis of variance points to the fact that there were significant differences among the mean responses (F = 9.62) at 0.05 probability level (Table 4). The differences were between means for students and teachers and between means of students and farmers. The results suggest that students were the group exhibiting highest knowledge for this item. Though it is difficult to explain these differences, it can only be considered refreshing for students to be clamoring for rules and regulations related to herbicide use in the community. In any case, if the young people are in favour of such rules and regulations it can only be hoped that they would obey the rules and regulations.

Table 3. Results on the view that there should be regulations or guidelines for the application of herbicides to reduce environmental and health risks

Students (N=90)			**Teachers** (N=30)			**Farmers** (N=60)		
Mean	**Sd**	**Decision**	**Mean**	**Sd**	**Decision**	**Mean**	**Sd**	**Decision**
4.6a	0.49	Strongly Agree	4.3b	0.61	Agree	4.3b	0.45	Agree

Decision point for means: Strongly Disagree = 1-1.4; D = Disagree= 1.5-2.4; NS = Not Sure= 2.5-3.4; A = Agree = 3.5-4.4; SA = Strongly Agree = 4.5-5.0.

NOTE: Same letters attached to means signify no significant difference; Sd = Standard Deviation.

Table 4. ANOVA results on the view that there should be regulations or guidelines for the application of herbicides to reduce environmental and health risks

Source of variation	Sum of Squares	df	Mean Square	F	Sig.
Groups	4.761	2	2.381	9.62	0.00
Error	43.789	177	0.247		
Total	48.550	179			

With regard to the best time to apply herbicides for effective control, 54.44% of students, 86.67% of teachers and 100% of farmers opted for pre-planting/sowing period. Again, 30% of students, 13.33% of teachers and zero percent of farmers favoured post-emergence period. Worst of all, 15.56% of students and no teacher or farmer opted for pre-harvest period. Generally, pre-emergent herbicides are applied to the soil before the crop emerges. These types of herbicides prevent germination or early growth of weed seeds. On the other hand post-emergent herbicides are applied after the crop has emerged, whereas contact herbicides destroy only the plant tissue in contact with the chemical (Das & Mondal, 2014). Therefore, it can be said that in this study greater number of the respondents exhibited high knowledge about pre-planting/sowing spray of herbicides though farmers lead followed by teachers. As usual, farmers have been doing the spraying as part of their profession while teachers and students might be part time farmers or people using academic knowledge. Hence, it is

acceptable that the farmers demonstrated such high level of knowledge about pre-planting application of herbicides. Currently, it is common that many farmers, especially non-commercial farmers have resorted to using herbicides to clear the bush before planting. However, after the emergence of the seedling from the soil, weed control is more manual than herbicide application. This is because majority of the farmers are yet to come into terms with the use of selective herbicides that are mostly used to control weed after planting. Furthermore, it is not surprising that teachers and farmers rejected outright application prior to harvest because that would have been a wasteful exercise and unnecessarily increase cost.

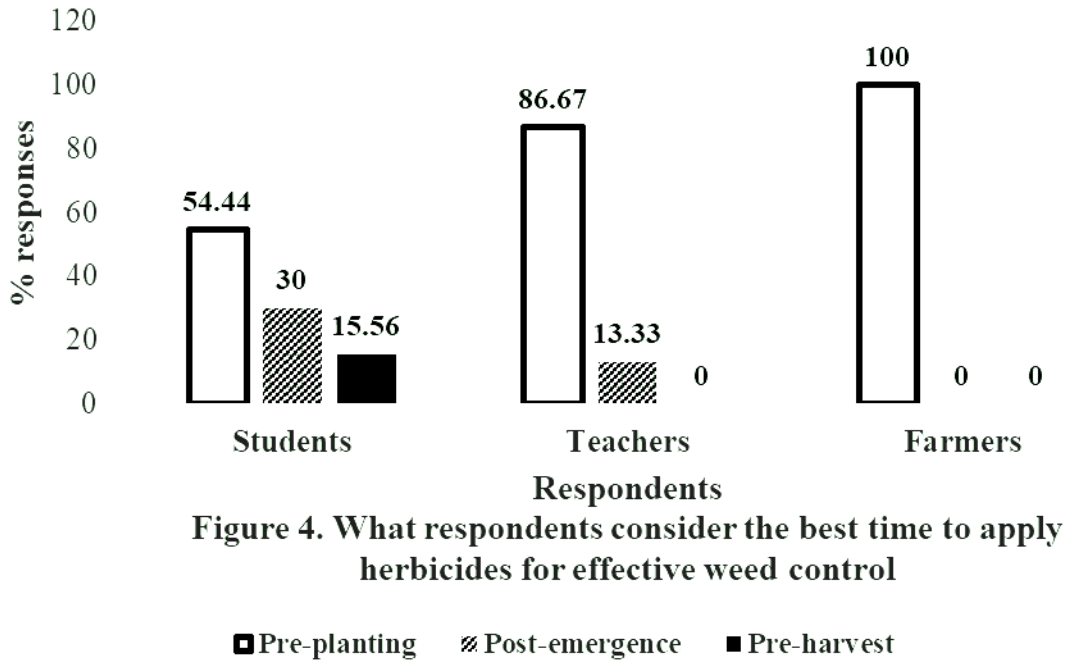

Figure 4. What respondents consider the best time to apply herbicides for effective weed control

In Figure 5, spot treatment was popular with students (76.67%), broadcast spraying was popular with farmers (58.33%) and teachers (43.33%). Rana (2018) explained that herbicide application can be soil (fumigation) before planting or foliar. The foliage application can be broadcast where the chemical is applied uniformly on the entire area or directed where it targets individual plants. The chemical can also be applied as concentrated sprays or granular formulations, broadcasted, diluted with water or diesel, and applied with sand/soil. However, the aerial herbicide application is the quickest, most economical, and highly efficient delivery system to control broad areas of field in a given time (Rana, 2018). Actually, the hand application for small areas was very unpopular with all categories of respondents. This could be due to the fact that it is rarely used in the research area. In any case the broadcast spray method is very common with farmers in Ghana, for that matter the research area. Hence, majority of the farmers opted for that though not too encouraging. Interestingly, it is very surprising that students massively opted for spot treatment which involves targeting spots or plants. It is difficult to deduce the source of such information. However, it can be speculated that they might be combining practical and academic knowledge.

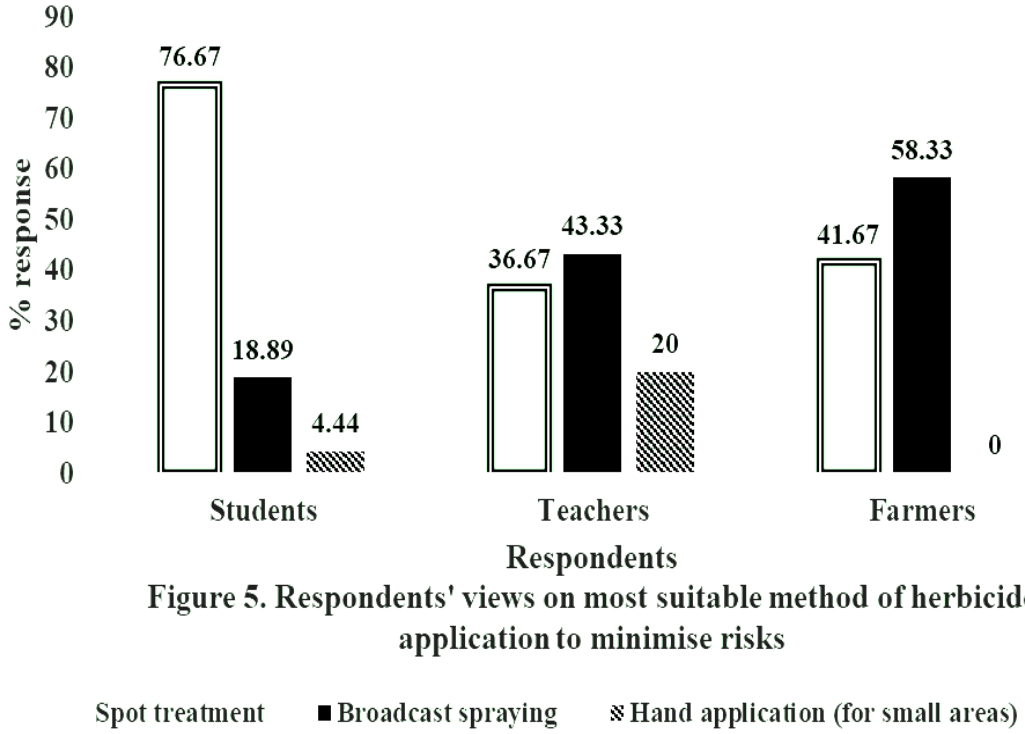

Figure 5. Respondents' views on most suitable method of herbicide application to minimise risks

Concerning practices that farmers can adopt to minimize risks associated with herbicide use/application, farmers' response in almost all cases apart from rotation of herbicides with different modes of action and use of integrated weed management practices, responses were above 75%, and in some cases up to 90 and 100%. For teachers also, apart from response for rotation of herbicides with different modes of action, all responses were from 60% to 93.33%. On the other hand for students, use of protective clothes during the application; use of nose mask, hand gloves and safety goggles when spraying; and following the recommended dosage and application rates that they scored above 50%.

According to Hossain *et al*. (2018) majority of chemical pesticides pose long term danger to the environment and humans through their persistence in nature or in body tissues. This calls for more bio-friendly alternative. Therefore, teachers (60%) and farmers (76.67%) who agreed that use of herbicides with lower toxicity in weed control are right by thinking so. In any case, much as humankind wants easy way to survive does not mean that anything goes. Our health is very important and stakeholders in herbicide use such as farmers, teachers and school children must be concerned. These assertions resonate with responses such as "Use of integrated weed management practices", and "Rotation of herbicides with different modes of action". Nath *et al.* (2024) among others put up a number of alternative measures that can be adopted in effective weed control in agro-ecosystems. These include incorporating principles of ecological weed management; preventive measures rather than eradication; weed surveillance; use of economic threshold of weeds; weed seed bank depletion; use of competitive crops; use of weed predation and allelopathy. Also, system based approaches for non-chemical weed management such as good agronomic practices, stale seedbed technique, crop establishment methods, adjusting the crop planting date, adjusting the crop density,

fertilizer management and others can be used. Others include conservation management practices such as minimum soil disturbance/zero tillage (ZT), permanent soil cover/surface residue retention, physical weed management, weed control by hot water and hot foam, weed control by flaming, weed control by abrasive grit, biological control, and artificial intelligence (AI) and robotics application.

It is also important to follow recommended dosage and application rates. Generally, many farmers do not strictly observe these. As a result they either use below dose or above dose which all create problems. Others also apply many times more than expected. Below the recommended dose the chemical will not be effective and may result in weed resistance. Similarly above dose or more than necessary application may lead to high toxin levels in the crop and the soil with negative consequences for biota including humans. Numerous unwarranted applications can also be cost ineffective. Fortunately, majority of the three groups of respondents (81.11% for students, 93.33% for teachers and 100% for farmers) agreed that it is important to follow the recommended dosage and application rates.

Table 5. Reponses to practices that farmers can adopt to minimize risks associated with herbicide use/application

Response	**Students** (N=90)		**Teachers** (N=30)		**Farmers** (N=60)	
	Freq.	**% freq.**	**Freq.**	**% freq.**	**Freq.**	**% freq.**
Use of herbicides with lower toxicity	30	33.33	18	60.00	46	76.67
Following the recommended dosage and application rates	73	81.11	28	93.33	60	100.00
Use of integrated weed management practices	35	38.89	21	70.00	32	53.33
Proper calibration of sprayers for accurate application	27	30.00	19	63.33	54	90.00
Use of protective clothes during the application	53	58.89	24	80.00	55	91.67
Rotation of herbicides with different modes of action	39	43.33	6	20.00	10	16.67
Use nose mask, hand gloves and safety goggles when spraying	61	67.78	24	80.00	60	100.00

Since herbicides can be toxic and can negatively affect the health of the one applying it, it is important that protective measures should be adopted during application. Fortunately, 67.78% of students, 80% of teachers and 100% of farmers agreed that nose mask, hand gloves and safety goggles must be used during application. Similar findings were reported by Abakpa *et al*. (2024). In assessing farmers' perception on herbicide usage and impact on health with regard to overview of status quo in parts of Benue South, Nigeria, Abakpa *et al*. (2024) reported that 38.4% of the respondents rarely or never wore head masks, 36.5% never used aprons, and 34.1% rarely put on overall aprons during herbicide application. Similarly, 40% rarely wore protective glasses while 34.9% never did. Again, 42.4% rarely wore hand gloves while 26.5% never used it. Furthermore, 33.3% rarely wore a nose protector while 25.7%

never wore it. In another study, Mubushar *et al*. (2019) assessed farmers' knowledge and practices regarding safe pesticide usage using 16 different questions/statements. Each statement was evaluated against three levels (Always, Sometimes, and Never). The results showed that more than half of the respondents (54.4%) had low level of knowledge on the safe use of pesticides, while 45.6% possessed high level of knowledge. It is clear from the current study that once again farmers lived up to expectation when they were all positive about this response.

Commenting on recommended guideline by United States Environmental Protection Agency (USEPA) and United States Department of Agriculture (USDA), Ozkan ((2020) stated that the main aim of calibrating spraying equipment is to determine the actual rate of application in gallons per acre, then to make adjustments if the difference between the actual rate and the intended rate is greater or less than 5% of the intended rate. This provides the opportunity to check the accuracy of the sprayer because application of too little pesticide can lead to ineffective pest control, whereas too much pesticide also wastes money or can damage the crop and thereby increasing the risk of herbicide contaminating ground water and the environment (Ozkan, 2020). This emphasizes the importance of calibrating spraying equipment. As expected, in this study, majority of the farmers (90%) confirmed this by indicating that there needs to be proper calibration of sprayers for accurate application, followed by the teachers (63.33%) and the students (30%). The low knowledge of students and to some extent teachers is very worrying suggesting that even their academic knowledge could not help them. This may be a result of the nature of educational curricular of Ghanaian educational institutions where agricultural science is not given priority at any level of education.

4. Conclusions

1. Clearly, all categories of respondents were familiar with herbicides. However, farmers were ahead of students and teachers.
2. Respondents were very knowledgeable that herbicides are used in weed control. However, all farmers and majority of students did not know that weeds can be pests.
3. Teachers and farmers demonstrated very high knowledge about benefits that herbicides offer in agriculture.
4. While both teachers and farmers generally exhibited high knowledge about some advantages of the use of herbicides, majority of the students exhibited low knowledge. In addition, majority of farmers were ignorant of the fact that some herbicides are selective.
5. Though all the respondents were in favour of existence of regulations or guidelines to regulate the application of herbicides to reduce environmental and health risks, students were surprisingly ahead of teachers and farmers in that regard.

6. Whereas pre-planting herbicide application was familiar to respondents, they flatly exhibited ignorance of the fact that post-emergence and pre-harvest application could be done depending on the situation on the ground.
7. With regard to most suitable method of herbicide application to minimise risks, apart from spot treatment where students exhibited high knowledge, respondents generally exhibited either average or low knowledge for all the application options.
8. Whereas responses to practices that farmers can adopt to minimize risks associated with herbicide use/application were generally encouraging, there were still low points of awareness that demand attention.

Recommendations

1. Since respondents exhibited varying levels of awareness for most of the things that they should have known in order to boost agriculture in the District, it is hereby recommended that agriculture extension officers in the District should organize very intensive education programmes for farmers specifically on the use and benefits of herbicides.
2. Similarly, teachers who teach topics in science related to Agriculture Science at the Junior High School level in the District need to upgrade their knowledge in the issues of herbicide use and benefits so that they can help their colleague teachers and their students to have more understanding of the issues concerning the use and benefits of herbicides.
2. It is further recommended that farmers in the District should familiarize themselves more with ways of protecting themselves during the application of herbicides so that they can appropriately protect themselves when doing application.

Recommendation for further research

- It is hereby recommended that this study be replicated in other farming communities throughout the country to gauge the views of more students, teachers and farmers to inform policy decision in the country on use and benefits of herbicides.

Acknowledge

We are grateful to the farmers, teachers and students who willingly responded to the questionnaires. Similarly, we will like to that the headteachers for allowing us use their students and teachers for this study. Finally, will like to register our appreciation for parents who allowed their wards to participate in the study.

Authors' contributions

The two authors took part in conceptualization, design, data collection, data analysis and writing of the paper.

Funding

The study was funded by the authors.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Macrothink Institute.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

Open access

Copyrights

References

Abakpa, G. O., Oludare, A., Ujoh, A. J., & Onyemowo, D. (2024). Farmers' Perception on Herbicide Usage and Impact on Health: an Overview of Status Quo in Parts of Benue South, Nigeria. *UMYU Scientifica, 3*(1), 29-36. https://doi.org/10.56919/usci.2431.003

Babbie, E. R. (2016). *Survey Research Methods* (7th ed.). Cengage Learning. https://doi.org/10.1016/B978-0-08-044894-7.00296-7

Bosu, P. P., Apetorgbor, M. M., Owusu Sekyere, E., Owusu, W., Appiah, K., Nutakor, E., &. Ofori, J. (2008). Strategies for the control of *Broussonetia papyrifera* in the Afram headwaters forest reserve. In: E.G. Foli, (Ed.) *AfDB/MLFM/CFMP On-farm Research Project*.

3rd Annual Progress Report, CSIRFORIG/TR/EF/2008/03. eISSN: 0855-1707

Das, S. K., & Mondal, T. (2014). Mode of action of herbicides and recent trends in development: A Reappraisal. *International Journal of Agricultural and Soil Science, 2*(3), 27-32. https://doi.org/10.5772/intechopen.105356

Davenport, T. H., & Prusak, L (1998). *Working Knowledge.* Harvard Business School Press. https://doi.org/10.1080/13636820000200133

Duke, S. O., Abbas, H. K., Boyette, C. D., & Ghobara, M. (1991). Microbial compounds with potential for herbicide use. In: Brighton Crop Protection Conference, on Weeds, Academic Press. https://doi.org/10.51694/AdvWeedSci/2022;40:seventy-five003.

George, D., & Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and reference*. 11.0 update (4th ed.). Allyn & Bacon. ISBN:978-0-205-75561-5

Ghana Statistical Service (2014). *2010 Population and Housing Census*. Ghana Statistical Service Gianessi, L. P. (2014). *Importance of Herbicides for Conservation Agriculture in Sub*-Saharan Africa. CropLife Foundation. https://croplife.org/wp-content/uploads/pdf_files/Case-Study-102-NoTill-in-Africa.pdf

Gianessi, L. P., & Williams, A. (2012). *The importance of herbicides for natural resource conservation in the U.S. Croplife Foundation*. https://ucanr.edu/blogs/UCDWeedScience/blogfiles/10299.pdf

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. https://doi.org/10.1057/s41287-017-0090-7

Hossain, L., Rahman, R., & Khan, M. S. (2018). *Alternative pesticides*. Springer International Publishing. https://doi.org/10.1007/978-3-319-52683-6_9

Imoro, Z. A., Larbi, J., & Duwiejuah, A. B. (2019). Pesticide Availability and Usage by Farmers in the Northern Region of Ghana. *Journal of Health & Pollution, 9*(3), 1-8. https://doi.org/10.5696/2156-9614-9.23.190906

Karlsen, J. T., & Gottschalk, P. (2004). Factors affecting knowledge transfer in IT projects. *Engineering Management Journal, 16,* 3-10. https://doi.org/10.1080/10429247.2004.11415233.

Kumar, S., Biswas, S. K., Shukla, P., Jaisval, G. K. & Kumar, S. (2023). What is *Pest, Categories of Pests and Causes of Pest Outbreak*. 1st Edition. Integrated Publications. https://doi.org/10.22271/int.book.261

Mesnage, R., Szekacs, A., & Zaller, J. G. (2021). *Herbicides: Brief history, agricultural use, and potential alternatives for weed control.* Elsevier Inc. https://doi.org/10.1016/B978-0-12-823674-1.00002-X.

Mohajan, H. K. (2016). Knowledge is an essential element at present world. *International Journal of Publication and Social Studies, 1*(1), 31-53.

https://doi.org/10.18488/journal.135/2016.1.1/135.1.31.53

Moss, S (2019). Integrated weed management (IWM): Why are farmers reluctant to adopt nonchemical alternatives to herbicides. *Pest Management Science, 75*, 1205-1211. https://doi.org/10.1002/ps.5267

Mubushar, M., Aldosari, F. O., Baig, M. B., Alotaibi, B. M., & Khan, A. Q. (2019). Assessment of farmers on their knowledge regarding pesticide usage and biosafety. *Saudi Journal of Biological Sciences, 26*(7), 1903-1910. https://doi.org/10.1016/j.sjbs.2019.03.001

Munawar, A., Blevins, R. L., Frye, W. W., & Saul, M. R. (1990). Tillage and cover crop management for soil water conservation. *Agronomy Journal, 82*, 773-777. https://doi.org/10.1016/j.still.2020.104896.

Nasimi, M. H., Nasimi, S., Kasmaei, M. S., Kasmaei, H. S., Basirian, F., & Musapour, H. (2013). Knowledge and competitive advantage for organizations. *Kuwait Chapter of Arabian Journal of Business and Management Review, 2*(5), 56–64. https://doi.org/10.12816/0001188

Nath, C. P., Singh, R. G., Choudhary, V. K., Datta, D., Nandan, R., & Singh, S. S. (2024). Challenges and alternatives of herbicide-based weed management. *Agronomy, 14*(126), 1-21. https://doi.org/10.3390/agronomy14010126

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, 11*, 1-16. https://doi.org/10.1016/j.sciaf.2020.e00672

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. https://doi.org/10.1016/j.sciaf.2020.e00672.

Ozkan, E. (2020). *Why should you calibrate your sprayer, and how*? Agronomic Crops Network, Ohio State University Extension. https://agcrops.osu.edu/newsletter/corn-newsletter/2020-11/why-should-you-calibrate-your-sprayer-and-how

Rahman, M. (2016). Herbicidal weed control: benefits and risks. *Advances in Plants & Research, 4*(5), 371-372. https://doi.org/10.15406/apar.2016.04.00153

Rana, S. S. (2018). *Application techniques and equipment*. Department of Agronomy. Retrieved on 8th August 2024 from https://www.researchgate.net/profile/Surinder-Rana/publication339325272_Lecture_14Herbicide_application_techniques_and_equipments/links/5e4b961192851c7f7f43e513/Lecture-14Herbicide-application-techniques-and-equipments.pdf

Resnik, D. B. (2020). *What is Ethics in Research & Why is it Important? National Institute of Environmental Health Sciences.* Retrieved on 14th August, 2024 from https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm

Simiyu, S. N. (2021). *Herbicides Reduce Hand-Weeding in Africa.* Retrieved on 5th August,

2024 from https://pesticidefacts.org/perspectives/herbicides-reduce-hand-weeding-in-africa/

Sondhia, S. (2018). Herbicide residues, persistence and degradation: An Indian viewpoint. In Fifty Years of Weed Science Research in India. Sushilkumar, Mishra, J.S., Eds.; *Indian Society of Weeds Science*: Jabalpur. https://doi.org/10.1007/978-981-13-1038-6

Sondhia, S., & Singh, P. K. (2018). Bioefficacy and fate of pendimethalin residues in soil and mature plants in chickpea *Field Journal Research Weed Science, 1*, 28-39. https://doi.org/10.26655/jrweedsci.2018.6.4

Ustuner, T., Al Sakran, M. & 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. https://doi.org/10.29322/IJSRP.10.08.2020.p10480

Uyanah, D. A., & Nsikhe, U. I. (2023). The Theoretical and Empirical Equivalence of Cronbach Alpha and Kuder-Richardson Formular-20 Reliability Coefficients. *International Research Journal of Innovations in Engineering and Technology (IRJIET*), *7*(5), 17-23. https://doi.org/10.47001/IRJIET/2023.705003

Yakubu, A. A., Singh, A., & Ibrahim, A. A. (2010). Survey of utilization of herbicides on the Sokotorima Flood Plains in Dundaye, Nigeria. *Journal of Agriculture and Environment*, 6 (1&2). eISSN: 2695-236X.