

Full Length Research Paper

A comparative analysis of agrochemical use among agroforestry and non-agroforestry practicing farmers in South west Cameroon: The examples of insecticides, fungicides and herbicides

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The abusive use of toxic agricultural chemicals (insecticides, fungicides and herbicides in particular) by farmers has attracted a lot of attention from environmentalists, scientists and policy makers. The use of these toxic agricultural chemicals not only contributes to environmental deterioration but equally poses major health risks to farmers and the general public. It is therefore incumbent on policy makers to take measures geared towards limiting the use of toxic agricultural chemicals. Some of these measures could be the vulgarization of agro-ecological farming practices like agroforestry. It is in this light that this study comparatively examined the use of toxic agricultural chemicals by agroforestry practicing and non-agroforestry practicing farmers in a bid to identify the most sustainable and viable option. Both primary and secondary data were collected for the study, and analysis was done using the statistical software Microsoft Excel 2007 and SPSS 17.0. It was found that the main crops grown by agroforestry practicing farmers were food and cash crops while non-agroforestry practicing farmers cultivated mainly market gardening crops and to some extent, food crops. Toxic agricultural chemicals (mainly fungicides, herbicides and insecticides) were used in large quantities and frequently by a majority (over 50%) of non-agroforestry practicing farmers, while less than 40% of agroforestry practicing farmers used toxic agricultural chemicals, mostly in small quantities and less frequently. A significant direct non-cause-effect and cause-effect relationship ($p < 0.05$) existed between the non-cause-effect and cause-effect relationship ($p < 0.05$) between the non-practice of agroforestry and the use of toxic agricultural chemicals, while a significant inverse non-cause-effect and cause-effect relationship ($p < 0.05$) was found to exist between the practice of agroforestry and the use of toxic agricultural chemicals. This implies that the practice of agroforestry can play a major role in reducing the use of toxic agricultural chemicals by farmers. It is recommended that policy makers should formulate policies geared towards fast-tracking agroforestry into the mainstream as a sustainable and viable pathway to limiting the use of toxic agricultural chemicals by farmers.

Key words: Farmers, insecticides, fungicides, herbicides, agroforestry, sole cropping, Cameroon.

INTRODUCTION

Agriculture is the mainstay of most economies around the world, especially the economies of developing countries

(FAO, 2016). It is the main employer – employing over 70% of the active population in the developing world

(FAO et al., 2018). However, the agricultural sector is increasingly becoming unsustainable as most farmers resort to the excessive use of toxic agricultural chemicals like insecticides, herbicides and fungicides to combat weed, as well as pests and diseases, all in a bid to improve crop productivity (Gullino et al., 2010; Komarek et al., 2010; Abang et al., 2013, 2014; Rahaman et al., 2018; Onwona et al., 2018; Stadlinger et al., 2018; Asanga-Fai et al., 2019). The abusive use of these toxic agricultural chemicals impacts negatively on the environment as well as human health (Matthews et al., 2003; Matthews, 2008; Jepson et al., 2014; Tandi et al., 2014; Lewis et al., 2016; Manfo et al., 2019).

Studies undertaken across Cameroon, Africa and the world have shown that toxic agricultural chemicals applied on farms, are regularly washed from crop fields into streams, lakes, rivers and oceans, polluting soils, potable water sources, and affecting aquatic life (MINADER, 2013; Abang et al., 2014; Nkemleke, 2019; Tarla et al., 2013, 2015; Asanga-Fai et al., 2017; Kenko et al., 2017; Tarla et al., 2020). The hazardous use of toxic agricultural chemicals on farms has attracted the attention of environmentalists, scientists and policy makers who seek to make agriculture more sustainable and environmental friendly.

The integration of trees within croplands and pasturelands in a system known as “agroforestry” is increasingly seen as a sustainable and viable option (Molua, 2005; Asaah et al., 2011; Bishaw et al., 2013; Smith and Mbow, 2014; Atangana et al., 2013; Atangana et al., 2014; Kiptot et al., 2014; Quandt et al., 2017, 2018; Leakey 2017; Munjeb et al., 2018; Leakey, 2019; Tsufac et al., 2019; Awazi et al., 2019; Noordwijk et al., 2019; Awazi et al., 2020; Awazi and Avana, 2020). Agroforestry systems provide many ecosystem services among which are the provision of fuelwood, fibre, food, finance or income, building materials, soil fertility improvement, fodder, climate regulation, as well as pest and disease control (Jose, 2009; Nair and Garrity, 2012; Environment and Rural Development Foundation – EruDeF, 2013; African Model Forest Network – AMFN, 2017; Trees for the Future, 2019; Bell, 2020; Pumarino et al., 2015; Montagnini, 2017; Staton et al., 2019; Long et al., 2016; Amare et al., 2018; Awazi and Tchamba, 2019). Thus, the practice of agroforestry has huge potentials to limit the use of toxic agricultural chemicals by farmers. However, very limited research has been done showing the role agroforestry can play towards limiting the use of toxic agricultural chemicals by farmers, which was the *raison d'être* for this study. The study was undertaken in essence to fill a knowledge void. The objectives of the study were to: (1) identify the main crops grown by agroforestry and non-agroforestry practicing farmers; (2)

identify the different toxic agricultural chemicals used by agroforestry and non-agroforestry practicing farmers; (3) identify the rate and frequency of use of these toxic agricultural chemicals among agroforestry and non-agroforestry practicing farmers; (4) examine the relationship between the practice/non-practice of agroforestry and the use of toxic agricultural chemicals.

MATERIALS AND METHODS

Description of the study site

Location of Mbelenka

The study was undertaken in the Southwest region of Cameroon, in the district of Mbelenka, found in Lebialem division (Figure 1). Longitudinally and latitudinally, Mbelenka is located between 10° 2'E to 10° 4 E and 5° 37'N to 5° 39 N, respectively. Savannah grassland dominates the landscape with some patches of forested land (Tsufac et al. 2019). Mbelenka is a vast area covering M'muock-Fossimondi right up to the western flanks of the Bamboutus Mountain located in the west region of Cameroon and extends to parts of Alou and Wabane sub-Divisions, that is, parts of Mmuock-Fossimondi, Mmuock-Leteh and Bamumbu chiefdoms, respectively.

Mbelenka has a rolling topography characterized with broad hilltops and gentle slopes reaching an altitude of 2200 m. The area is suitable for market gardening. Landslides are common in the area which can be explained by the very steep slopes dominating the topography of the area (Wabane Council Report, 2013). The main soil types in the area are Mollisols and andosols which resulted from intense weathering activities. From the following studies carried out in Mbelenka by the Institute of Agricultural Research for Development (IRAD) in 2010, it was found that the soils are dark in colour, with deep upper layers, slightly acidic, higher in nitrogen. These soils are good for the cultivation of vegetable crops like potato, cabbage, tomatoes, carrots, leeks and spices. However, the soils have been eroded and leached over time which has led to soil infertility.

The climate of the area is characterized by two seasons – a short dry season that begins in November and ends in April and a long rainy season that commences in May and stretches up to October and early November with a mean annual rainfall of about 300 mm (Figure 2). Here the mean temperatures can go below 18°C in the months of December to January but with a mean annual temperature of 18°C (Wabane Council Report, 2013). The area has characteristics of both the humid forest zone and the grassland zone because it falls within the transition zone between the forest and the grassland – although grassland characteristics dominate. The area used to have a dense hydrographic network. However, owing to the degradation of water catchment areas resulting from deforestation for farming and animal rearing activities, the hydrographical network here has sharply decreased resulting in the scarcity of water resources.

The Bangwa of the M'mock clan are the dominant/indigenous population in the area. They are accompanied by the Bamileke, Mundani and the Mbororos – who are mostly nomads. The Bangwa belong to the M'mock clan that migrated from the forest area to this

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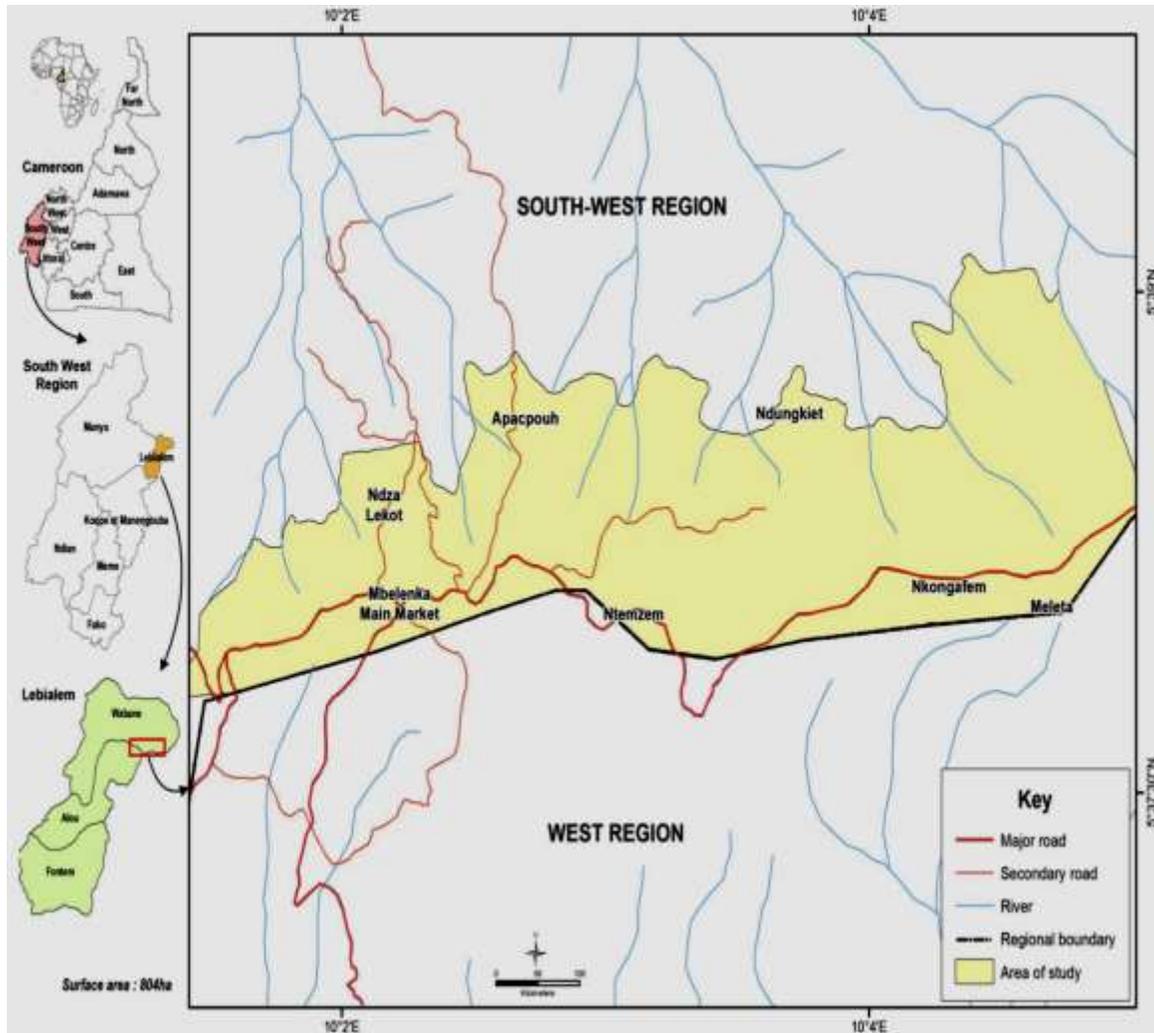


Figure 1. Map of the study area.
Source: Authors.

environment. People from other tribes like the Bamileke, Mundani and Mbororos migrated to Mbelenka because they were attracted by the huge agricultural potentials of Mbelenka. Despite the diversity in cultures and ways of life, all the people inhabiting Mbelenka live in harmony with each other.

Sampling and questionnaire design

There was a purposive selection of M'Muock-Fossimondi and M'Muock-Leteh (two clans), all found in Mbelenka, South west region of Cameroon owing to their high crop productivity and due to the fact that the soils in these communities were rapidly degrading. They were selected after an exploratory investigation done by the researchers flanked by agricultural extension agents and local authorities. A semi-structured questionnaire was used during household surveys. Questions were framed in both open and close-ended fashion in order to provide answers to all the specific objectives of the study. Data were collected on the various types of toxic agricultural chemicals, the rate and frequency of use of these toxic chemicals, and the socio-economic and environmental

attributes of agroforestry and non-agroforestry practitioners using these toxic agricultural chemicals.

Data collection

In the field, observations were carried out to catalogue the various soil fertility determinants as well as different agroforestry systems influencing soil fertility. A focus group discussion was organised in each village (Ndza Lekot, Apacpouh, Ntemzem, Ndzungkiet, Nkongafem, and Meleta), with the help of key informants (village head/chief).

This was to identify farmers, other key informants (agricultural engineers and other stakeholders). Thus, in total, six focus group discussions were organized. Resource persons (key informants) were also interviewed. In total, twenty key informants were interviewed. These key informants were chosen based on their knowledge of the environment and their degree of interaction with farmers in the community. From the information obtained from the focus group discussants and key informants, it was easier for the researchers to understand the general situation of agrochemical

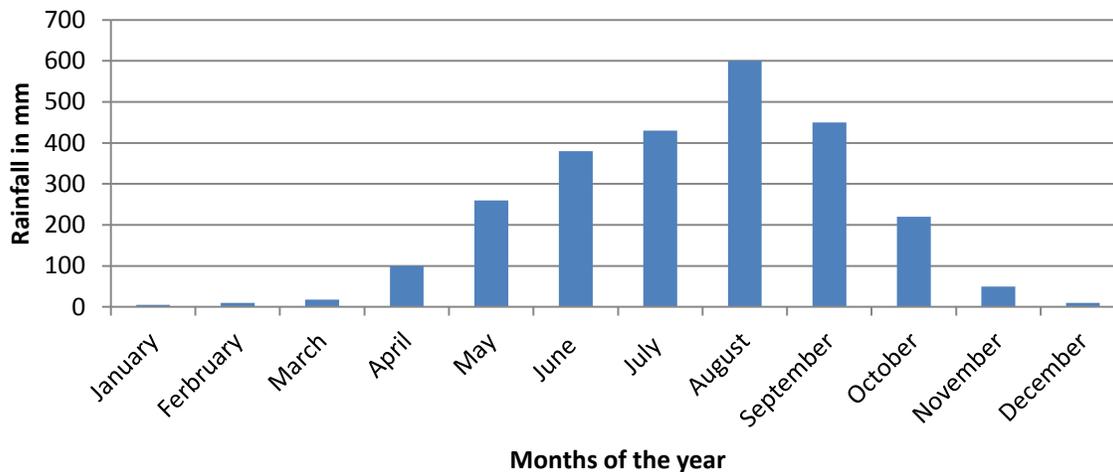


Figure 2. Precipitation distribution of rainfall in Mbelenka 2013.
Source: Wabane Council Report (2013).

use in the study area and other socio-economic attributes of the agroforestry and non-agroforestry practitioners.

One hundred and twenty questionnaires were administered to 120 farmers (72 women and 48 men) chosen. Women were more here because it was the sex largely involved in farming activities. Sixty questionnaires were administered in each of the clans (M'Muock-Fossimondi and M'Muock-Leteh). Interviews were conducted with key informants who were chosen based on their ages and longevity in farming activities and mastery of the different agroforestry systems and practices in the study area. This permitted the acquisition of information on the various types of agroforestry systems, agroforestry practices, toxic agricultural chemicals used, quantity and frequency of use of these toxic agricultural chemicals; and the relationship between the use of toxic agricultural chemicals and the practice/non-practice of agroforestry.

Data analysis

Collected data were subjected to descriptive and inferential statistical analyses. This was done using the statistical software Microsoft Excel 2007 and SPSS 17.0. Descriptive statistics were mainly frequency tables and percentage indices, while inferential statistics were the Spearman rank correlation, and logistic regression. The Spearman rank correlation and logistic regression were used respectively, to measure the non-cause-effect and cause-effect relationships existing between different independent variables and farmers' use of toxic agricultural chemicals.

RESULTS AND DISCUSSION

Main types of crops grown by agroforestry and non-agroforestry practicing farmers

It was found that most non-agroforestry practicing farmers cultivated mainly market gardening crops like potato (70%), tomato (60%), huckleberry (40%), carrots (50%), spices (40%), aubergine (20%), and cabbage (40%) (Figure 3). Meanwhile, most agroforestry practicing farmers cultivated mainly food and cash crops like sweet

potato (50%), maize (50%), beans (40%), yams (30%), cocoa (15%), coffee (15%), and banana/plantains (30%). Thus, non-agroforestry practicing farmers mainly cultivated market gardening crops while agroforestry practicing farmers mainly cultivated food and cash crops.

Toxic agricultural chemicals used by agroforestry and non-agroforestry practicing farmers

The main toxic agricultural chemicals used by both agroforestry and non-agroforestry practicing farmers were insecticides, fungicides, and herbicides (Figures 4 to 6).

Insecticides

For insecticides, over 50% of the non-agroforestry practicing farmers used four types of insecticides namely Cigogne 50 EC, CYPERCAL 100 EC, Iron 30 EC and Cypercot (Figure 4). Meanwhile, less than 20% of non-agroforestry practicing farmers made use of these four types of insecticides commonly used by farmers in South western Cameroon.

Fungicides

With respect to fungicides, over 40% of the non-agroforestry practicing farmers made use of seven types of fungicides which included Cleanzeb 80 WP, Mancozan super 80 WP, Mancozeb 80 WP, Ridomil plus, Penncozeb 80 WP, Callomil plus 72 WP, and Banko plus (Figure 5). Agroforestry practicing farmers on their part made use of less than 40% of these same fungicides commonly used by farmers in South western Cameroon.

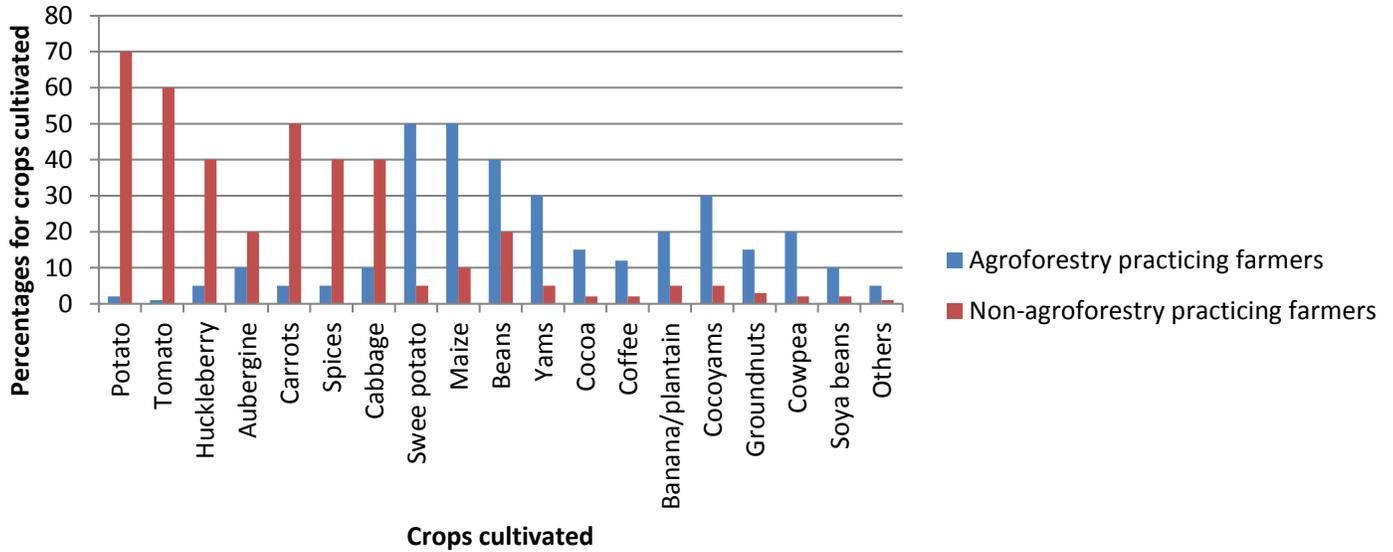


Figure 3. Crops grown by agroforestry and non-agroforestry practicing farmers.

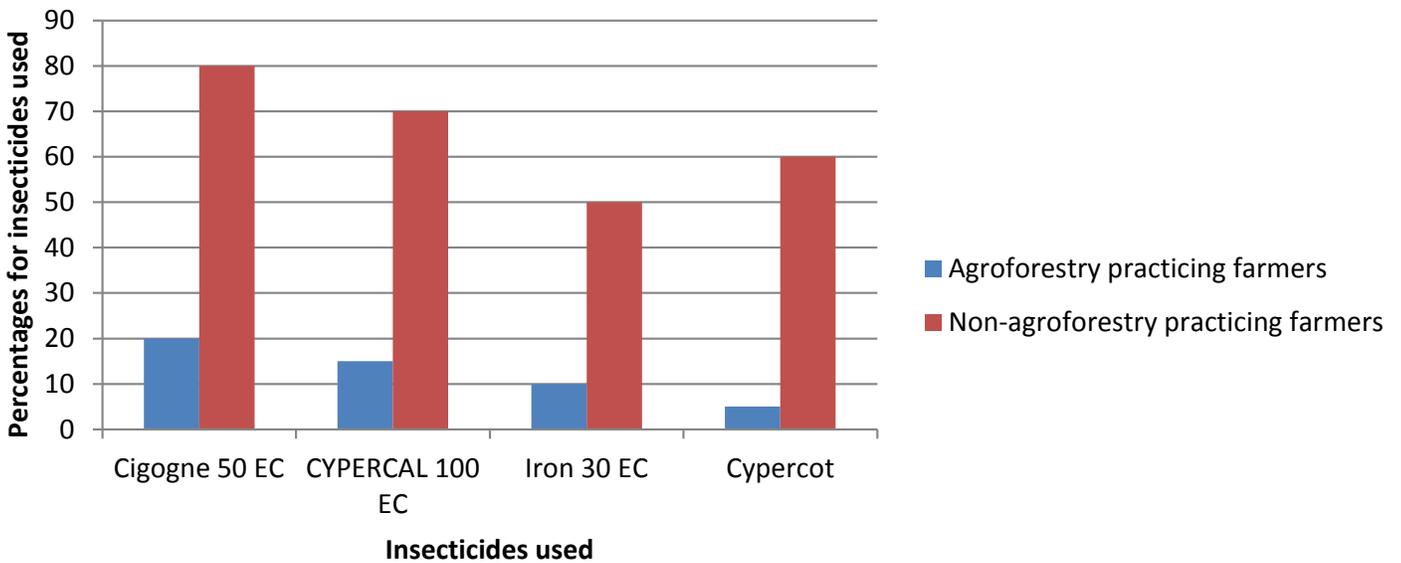


Figure 4. Insecticides used by agroforestry and non-agroforestry farmers.

Herbicides

Concerning herbicides, over 40% of non-agroforestry practicing farmers used all eight types of fungicides commonly used by farmers in south western Cameroon, that is, Gramazone, Quiclear 360, Glyphader 360, Roundup 360, Action (Digrow), Cantozone, Geant super, and Tromissil (Figure 6). Meanwhile, less than 40% of agroforestry practicing farmers made use of the same eight types of herbicides commonly used by farmers. Thus more non-agroforestry practicing farmers use toxic

agricultural chemicals than their agroforestry practicing counterparts.

Rate and frequency of use of toxic agricultural chemicals among agroforestry and non-agroforestry practicing farmers

The rate and frequency of use of toxic agricultural chemicals equally varied significantly among agroforestry practicing and non-agroforestry practicing farmers

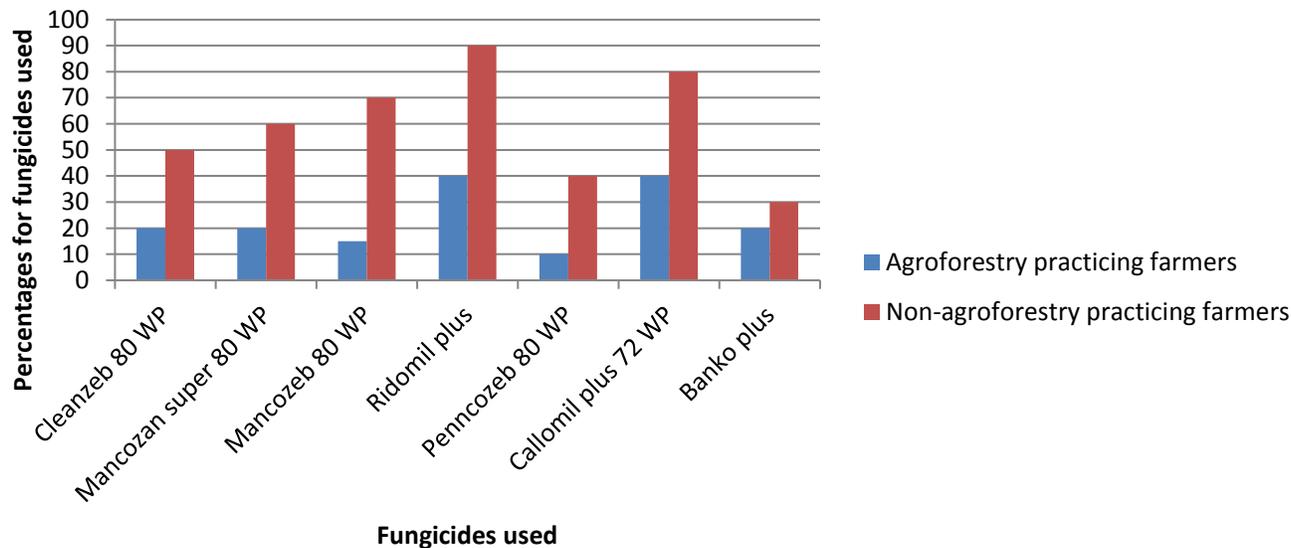


Figure 5. Fungicides used by agroforestry and non-agroforestry practicing farmers.

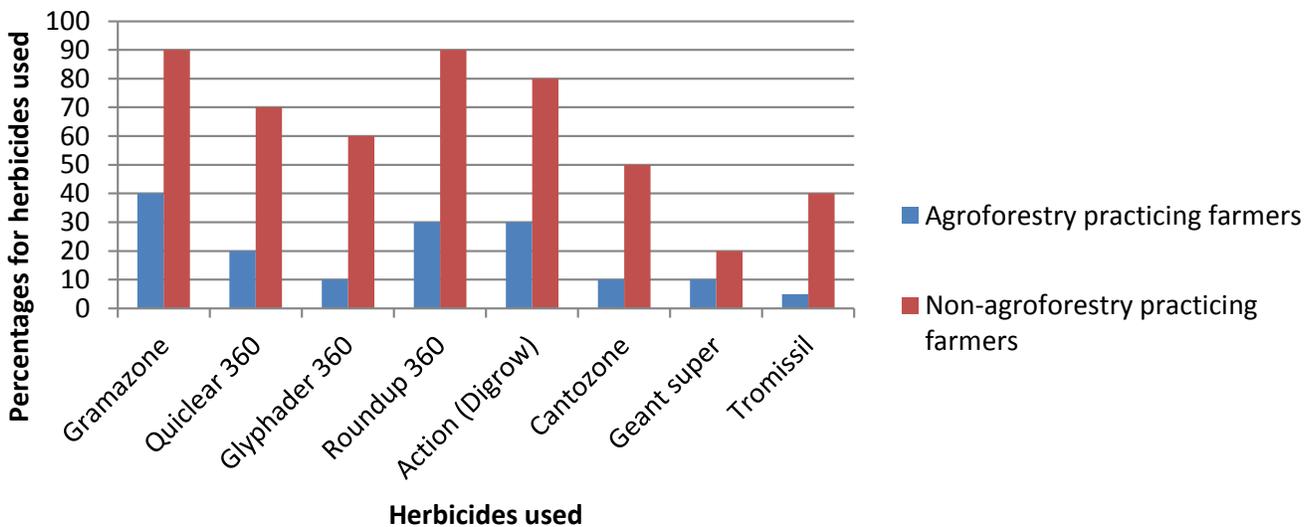


Figure 6. Herbicides used by agroforestry and non-agroforestry practicing farmers.

(Figures 7 to 12).

Rate of use of toxic agricultural chemicals

Insecticides

Concerning the rate of use of insecticides by farmers, it was found that most non-agroforestry practicing farmers (80%) used large quantities of insecticides while most agroforestry practicing farmers used either very small amounts (50%), or nothing (30%) (Figure 7). was noticed that most non-agroforestry practicing farmers (80%) used

Fungicides

With respect to the rate of use of fungicides by farmers, it was found that most non-agroforestry practicing farmers (70%) used large amounts of insecticides while most agroforestry practicing farmers used either small amounts (45%) or nothing (25%) (Figure 8).

Herbicides

Pertaining to the rate of use of insecticides, by farmers, it large amounts of herbicides, while most agroforestry

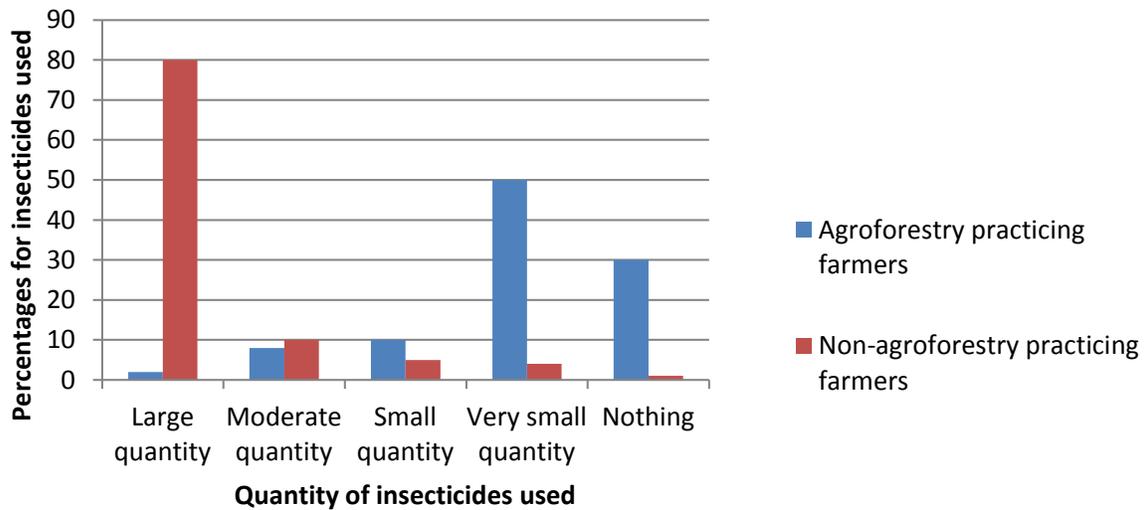


Figure 7. Quantity of insecticides used by agroforestry and non-agroforestry practicing farmers.

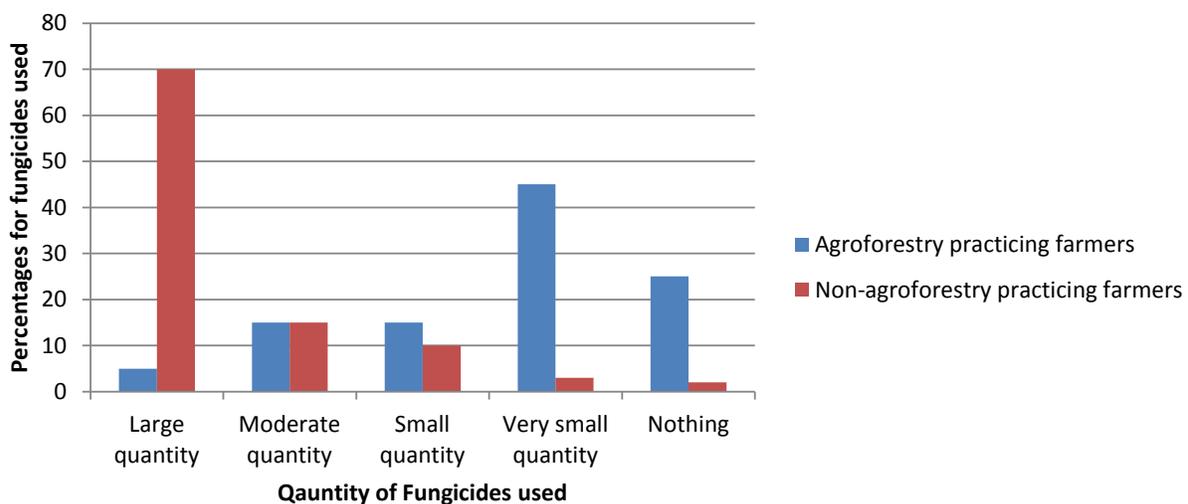


Figure 8. Quantity of fungicides used by agroforestry and non-agroforestry practicing farmers.

practicing farmers either used very small amounts (60%) or nothing (20%) (Figure 9). From the forgoing, it can be said that most non-agroforestry practicing farmers use large amounts of toxic agricultural chemicals for cultivation while most agroforestry practicing farmers use toxic agricultural chemicals either in small amounts or not at all.

Frequency of use of toxic agricultural chemicals

Insecticides

From analysis of primary data, it was found that most non-agroforestry practicing farmers (80%) use insecticides

very frequently while most agroforestry practicing farmers (70%) used insecticides less frequently (Figure 10).

Fungicides

For fungicides, it was found that most non-agroforestry practicing farmers (70%) use fungicides very frequently while most agroforestry practicing farmers use fungicides less frequently (60%) or never (30%) (Figure 11).

Herbicides

Pertaining to herbicides, analysis of primary data revealed

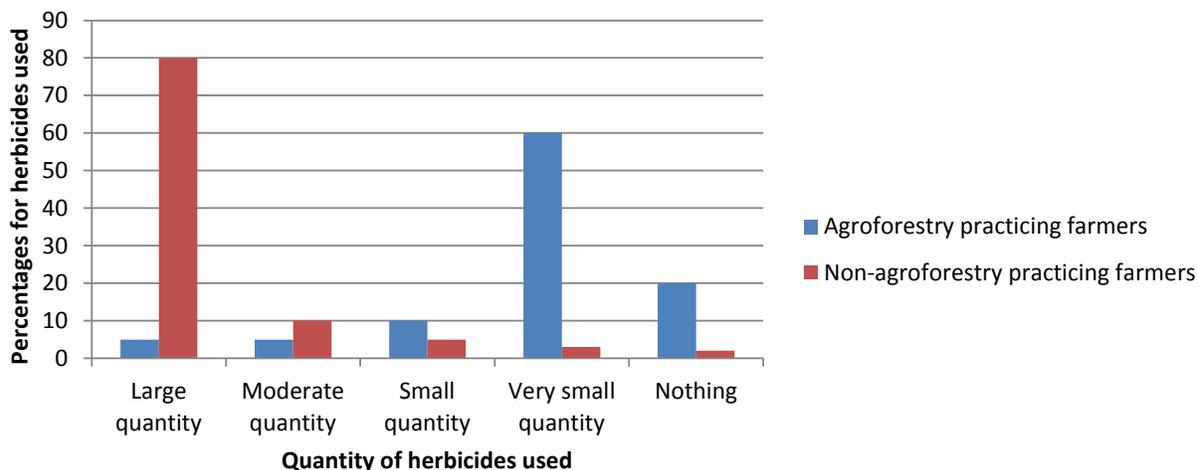


Figure 9. Quantity of herbicides used by agroforestry and non-agroforestry practicing farmers.

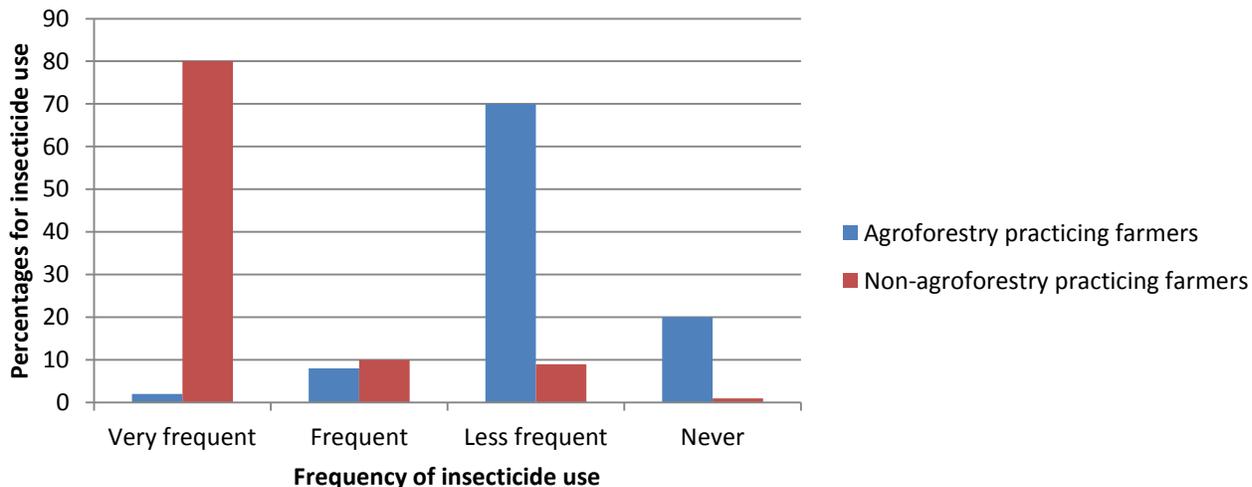


Figure 10. Frequency of insecticides used by agroforestry and non-agroforestry practicing farmers.

that most non-agroforestry practicing farmers (80%) use herbicides very frequently, whereas most agroforestry practicing farmers use herbicides less frequently (50%) or never (40%) (Figure 12). From the foregoing, it is noticed that most non-agroforestry practicing farmers use toxic agricultural chemicals very frequently, while agroforestry practicing farmers use toxic agricultural chemicals sparingly.

Non-causal and causal relationship between the practice/non-practice of agroforestry and the use of toxic agricultural chemicals

A non-causal and causal relationship was found to exist between the use of toxic agricultural chemicals and farmers’ practice/non-practice of agroforestry (Tables 1 to 3).

Insecticides

A significant direct non-causal and causal relationship was found to exist between the non-practice of agroforestry and farmers’ use of insecticides. Meanwhile, a significant inverse non-causal and causal relationship was found to exist between the practice of different agroforestry systems (agrosilvopastoral, silvopastoral and agrisilvicultural systems) and farmers’ use of insecticides) (Table 1).

Fungicides

For fungicides, a significant direct non-causal and causal relationship was found to exist between the non-practice of agroforestry and farmers’ use of fungicides. Meanwhile a statistically significant inverse non-causal and causal

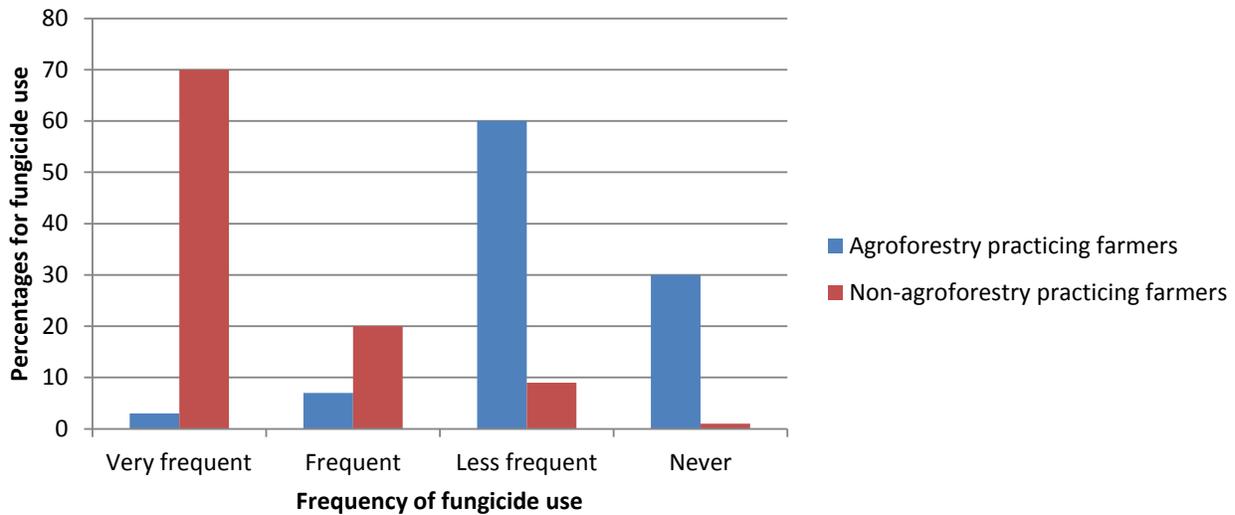


Figure 11. Frequency of fungicides used by agroforestry and non-agroforestry practicing farmers.

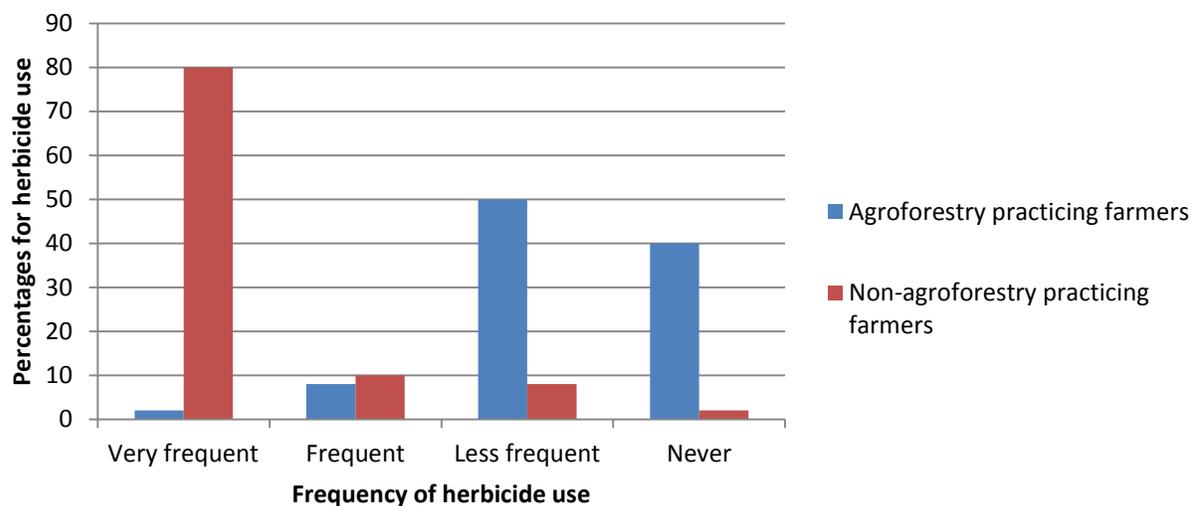


Figure 12. Frequency of herbicides used by agroforestry and non-agroforestry practicing farmers.

relationship was found to exist between the practice of agroforestry (agrosilvopastoral and agrisilvicultural systems) and farmers' use of pesticides (Table 2).

Herbicides

Pertaining to herbicides it was found that a statistically significant positive non-causal and causal relationship exist between the non-practice of agroforestry and farmers' use of herbicides. Meanwhile the practice of agroforestry (agrosilvopastoral and agrisilvicultural systems) had a statistically significant inverse non-causal relationship with farmers' use of herbicides (Table 3). Thus the non-practice of agroforestry (sole cropping) had

a direct non-causal and causal relationship with farmers' use of toxic agricultural chemicals while the practice of agroforestry had an inverse non-causal and causal relationship with farmers' use of toxic agricultural chemicals.

DISCUSSION

Crops cultivated by agroforestry and non-agroforestry practicing farmers

Findings revealed that agroforestry practicing farmers mostly cultivated food and cash crops, while non-agroforestry practicing farmers mostly cultivated market

Table 1. Relationship between insecticide use and the practice/non-practice of agroforestry.

Type of practice	r	p-level	B	p-level
No agroforestry	0.841*	0.000	1.624*	0.000
Agrosilvopastoral	- 0.895*	0.000	- 1.996*	0.000
Silvopastoral	- 0.501*	0.015	- 0.309*	0.048
Agrisilvicultural	- 0.798*	0.000	- 1.543*	0.000
Constant			- 5.751*	0.000
Pseudo R ²			0.602	

*Significant at 5% probability level.

Table 2. Relationship between fungicide use and the practice/non-practice of agroforestry.

Type of practice	r	p-level	B	p-level
No agroforestry	0.816*	0.000	1.839*	0.000
Agrosilvopastoral	- 0.943*	0.000	- 2.107*	0.000
Silvopastoral	- 0.106 ^{ns}	0.421	- 0.062 ^{ns}	0.658
Agrisilvicultural	- 0.831*	0.000	- 1.748*	0.000
Intercept			-8.113*	0.000
Pseudo R ²			0.503	

* Significant at 5% probability level.

Table 3. Relationship between herbicide use and the practice/non-practice of agroforestry.

Type of practice	r	p-level	B	p-level
No agroforestry	0.794*	0.000	1.625*	0.000
Agrosilvopastoral	- 0.895*	0.025	- 1.996*	0.037
Silvopastoral	- 0.521*	0.031	- 0.409*	0.048
Agrisilvicultural	- 0.798*	0.000	- 1.543*	0.000
Intercept			- 4.962*	0.000
Pseudo R ²			0.517	

*Significant at 5% probability level.

gardening crops, and to a lesser degree, food crops. The predominance of food and cash crops in the different agroforestry systems could be attributed to the suitability of these crops within an agroforestry system. This is because, crops cultivated within an agroforestry system should be able to tolerate shade and some competition from other components of the system like trees/shrubs. Most food crops like maize, soya beans, beans, yams, cocoyam, cassava, sweet potato, plantain, as well as cash crops like coffee, cocoa and banana do very well in agroforestry systems which could account for the integration of these crops by agroforestry practicing farmers in their agroforestry-based farming plots. On the other hand, the predominance of market gardening crops in the farming plots of non-agroforestry practicing farmers could be attributed to the fact that these crops do not tolerate shade from trees/shrubs as well as competition

from trees/shrubs which has pushed farmers to grow them in sole cropping systems. Equally, market gardening crops are very demanding in terms of nutrient needs which explain why farmers prefer to grow them in sole cropping systems in order to limit competition.

Some studies undertaken across Cameroon and other parts of sub-Saharan Africa (Kimengsi and Botanga, 2017; Awazi and Tchamba, 2019; Awazi and Avana, 2020; Awazi et al., 2020; Tsufac et al., 2019) have shown that farmers cultivate different crops in sole cropping and agroforestry systems. However, few studies have examined the crops grown by agroforestry and non-agroforestry practicing farmers within the context of the use of toxic agricultural chemicals. This study by laying emphasis of the crops cultivated by agroforestry and non-agroforestry farmers within the context of the use of toxic agricultural chemicals has therefore filled a knowledge

void.

Toxic agricultural chemicals used by agroforestry and non-agroforestry practicing farmers.

For the three main toxic agricultural chemicals (fungicides, herbicides and insecticides) under consideration, it was found that more non-agroforestry practicing farmers were using the different varieties of these toxic agricultural chemicals than the agroforestry practicing farmers. This could be explained by the fact that non-agroforestry practicing farmers are mainly involved in the cultivation of market gardening crops, and their single most important goal is to sell their farm produce and make as much profit as possible. With this mind-set, they apply all these toxic agricultural chemicals in order to improve crop yields which they can sell and make more money. Studies carried out by some researchers (Manfo et al., 2019; Mfopou et al., 2017; Asanga-Fai et al., 2019; Tarla et al., 2013; Tarla et al., 2014; Yengoh and Ardo, 2014; Tarla et al., 2015; Nkemleke, 2019; Tarla et al., 2020; Yengoh and Ardo, 2014; Tarla et al., 2015; Nkemleke, 2019; Tarla et al., 2020) have generally shown that most of the farmers involved in market gardening, apply a lot of toxic agricultural chemicals in order to improve crop productivity and increase farm income.

The limited number of agroforestry practicing farmers using different varieties of toxic agricultural chemicals could be attributed to the potential role played by agroforestry systems in regulating and controlling pests and diseases, which makes it unnecessary for agroforestry practicing farmers to use chemicals to control pests and diseases. Some studies have shown that agroforestry has potentials to control pests and disease outbreaks within the system (Jose, 2009; Awazi and Tchamba, 2019).

Rate and frequency of use of toxic agricultural chemicals by agroforestry and non-agroforestry practicing farmers

The findings of this study revealed that non-agroforestry practicing farmers used large quantities of toxic agricultural chemicals very frequently, while agroforestry practicing farmers used limited quantities of toxic agricultural chemicals less frequently. This could be attributed to several factors. First, for non-agroforestry practicing farmers, they cultivate mainly market gardening crops which demand a lot of nutrients and are prone to pest and disease attacks which explain the high and frequent use of toxic agricultural chemicals. Secondly, market gardeners seek to make quick profit which explains why they use toxic agricultural chemicals to speed up the growth process of crops, in order to commercialize them and make more profits. Studies

carried out by different researchers (Matthews et al., 2003; Yengoh and Ardo, 2014; Nkemleke, 2019) have indicated this trend of high toxic agricultural chemical use among farmers involved in market gardening in particular. For agroforestry practicing farmers, they cultivated mostly food and cash crops which have less nutrient demands and are less frequently attacked by pests and diseases. Equally, agroforestry systems have a natural way of self-controlling pests and diseases owing to the diversity of components (that is, crops, trees/shrubs, livestock) in the system (Jose, 2009; Awazi and Tchamba, 2019). With all its ecological advantages, agroforestry systems therefore need limited use of chemical fertilizer.

Relationship between the use of toxic agricultural chemicals and the practice/non-practice of agroforestry

From the results of this study, it was found that the non-practice of agroforestry has a significant direct relationship with farmers' use of toxic agricultural chemicals, while the practice of agroforestry has a significant inverse relationship with farmers' use of toxic agricultural chemicals. This implies that the non-practice of agroforestry increases the propensity of the farmers to use toxic agricultural chemicals, while the practice of agroforestry reduces the propensity of the farmer to use toxic agricultural chemicals. This could be attributed to several factors. First, agroforestry systems provide a plethora ecosystem services (food, fuelwood, fibre, soil fertility improvement, building materials, traditional medicines, climate regulation, finance, protection from the wind, as well as pest and disease control), which mainly sole cropping systems like market gardening practiced by market gardeners, will not provide. It is the diversity of the ecosystem services provided by agroforestry systems that make them robust and resilient when faced with pest and disease attacks, compared to sole cropping systems (like market gardening), where the presence of a single crop makes it prone to pest and disease attacks.

Equally, sole cropping systems (market gardening in this case) are very demanding in terms of nutrient inputs and other chemicals which push farmers to go the extra mile in order to purchase and apply these toxic agricultural chemicals for increased crop productivity (Nkemleke, 2019; Matthews et al., 2003; Tarla et al., 2015).

The "make profit at all cost" mentality of market gardening farmers equally accounts for the high use of toxic agricultural chemicals among non-agroforestry practicing farmers. The main goal of these farmers is to make profit irrespective of the environmental and health costs. This naïve mind-set has pushed these farmers to indulge in poor and unsustainable practices such as the abusive application of toxic agricultural chemicals.

Moreover, crops cultivated in agroforestry systems are less demanding in terms of nutrient inputs and other chemicals, coupled with the diversity of components in the system which makes pest and disease attacks rare, as some components act as traps for pest and diseases, sparing the other components (Awazi and Tchamba, 2019). Studies carried out by other researchers and research institutions (ERUDEF, 2013; AMFN, 2017; The Farmer's Voice, 2018; Trees for the Future, 2019; Bell, 2020; Urgess, 1999; Tsonkova et al., 2012; Pumarino et al, 2015; Staton et al., 2019; Peng et al., 1993; Long et al, 2016; Wolton, 2018; Bell, 2019; Staton, 2019; FAO, 2020) have shown that agroforestry has huge potentials to limit the use of toxic agricultural chemicals by farmers. Although most of these studies were not empirical, the findings of this study have come to show that agroforestry has huge potentials to limit the use of toxic agricultural chemicals by farmers.

Agroforestry is therefore a sustainable and viable option, with huge potentials to limit the use of toxic agricultural chemicals by farmers if promoted and properly managed.

Conclusion

The excessive use of toxic agricultural chemicals especially insecticides, fungicides and herbicides is a reality in South western Cameroon in particular and Cameroon in general. There are however disparities in the use of these toxic agricultural chemicals between agroforestry practicing farmers on the one hand and non-agroforestry practicing farmers on the other hand. Non-agroforestry practicing farmers use more toxic agricultural chemicals than their agroforestry practicing counterparts. Non-agroforestry practicing farmers equally used toxic agricultural chemicals more frequently than agroforestry practicing farmers. A significant direct cause-effect relationship was found to exist between the non-practice of agroforestry and the use of toxic agricultural chemicals; meanwhile a significant inverse cause-effect relationship was found to exist between the practice of agroforestry and the use of toxic agricultural chemicals. This indicates that the non-practice of agroforestry increases the propensity of the farmer to use toxic agricultural chemicals, while the practice of agroforestry reduces the propensity of the farmer to use toxic agricultural chemicals. Hence, agroforestry is recommended as a sustainable and viable option, which can be employed to phase out the use of toxic agricultural chemicals by farmers in South western Cameroon in particular and Cameroon in general.

Policy implications

On the basis of the findings of this study, the following policy implications arise:

First, most agroforestry practicing farmers cultivate mainly food and cash crops while most non-agroforestry practicing farmers cultivate mainly market gardening crops and to a lesser extent food crops. Policy makers should pay attention to this when formulating policies geared towards addressing the plight of either group.

Secondly, non-agroforestry practicing farmers use toxic agricultural chemicals more frequently and in large amounts than agroforestry practicing farmers. Measures geared towards limiting the use of toxic agricultural chemicals should therefore target non-agroforestry practicing farmers most.

Last but not the least, a significant direct cause-effect relationship was found to exist between the non-practice of agroforestry and the use of toxic agricultural chemicals; while a significant inverse cause-effect relationship was found to exist between the practice of agroforestry and the use of toxic agricultural chemicals. Policy makers should therefore use this as a benchmark to formulate policies that will encourage the practice of agroforestry as a sustainable and viable option capable of contributing towards the complete eradication of toxic agricultural chemicals.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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