

Full Length Research Paper

Inorganic fertilizer use among agroforestry and non-agroforestry practicing farmers in South West Cameroon: A comparative assessment and policy ramifications

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Received 13 October, 2020; Accepted 15 December, 2020

Continuous and excessive use of inorganic fertilizers by farmers across the world is causing more harm than good to croplands. This is because most of these inorganic fertilizers are toxic, which in essence defeats the very purpose for which they are produced. This paper sought to comparatively assess the use of inorganic fertilizer among agroforestry and non-agroforestry practicing farmers in south west Cameroon. Data was collected from both primary and secondary sources, and analyzed using appropriate descriptive and inferential statistics. Findings revealed that, more non-agroforestry practicing farmers were using inorganic fertilizer, in large quantities, and frequently, when compared to their agroforestry practicing counterparts. From logistic regression predictions, it was found that, variables such as level of education, cultivation of cash crops, number of farms, farm size, age, and farm experience had an inverse causal relationship ($p < 0.05$) with agroforestry practicing farmers' use of inorganic fertilizer, and a direct causal relationship ($p < 0.05$) with non-agroforestry practicing farmers' use of inorganic fertilizer. Meanwhile, variables such as income level, household size, cultivation of food crops, cultivation of market gardening crops, membership in farming group, access to extension services, and access to markets had a direct causal relationship ($p < 0.05$) with the use of inorganic fertilizer for both agroforestry and non-agroforestry practicing farmers. It was equally found that, a direct causal relationship ($p < 0.05$) exist between the non-practice of agroforestry and the use of inorganic fertilizer, while an inverse causal relationship ($p < 0.05$) exist between the practice of agroforestry and the use of inorganic fertilizer. This indicates that the practice of agroforestry has huge potentials to contribute towards limiting the use of inorganic fertilizers by farmers. On the basis of these findings, it is recommended that policy makers pay more attention to agro-ecological practices like agroforestry in order to limit the use of inorganic fertilizer by farmers.

Key words: Agroforestry, sole cropping, farmers, inorganic fertilizer, Cameroon.

INTRODUCTION

Soil infertility is a major constraint to agricultural production in sub-Saharan Africa (Chianu et al., 2012;

Kelly and Naseem, 2020). Many drivers account for the poor state of soils in sub-Saharan Africa. Some are natural but most are anthropogenic (FAO and ITPS, 2015). Natural drivers include soil erosion and leaching while anthropogenic drivers include deforestation, poor agricultural practices and man-made climate change (Juo et al., 1995; FAO and ITPS, 2015).

Poor soils have triggered a loss in crop production and declining crop yields (Kelly and Naseem, 2020). Identifying the major constraints to crop yield decline is a prerequisite to finding appropriate soil and water conservation, and fertility management approaches or solutions (Yerima and Van Ranst, 2005a; Yerima and Van Ranst, 2005b). To promote competitiveness and sustainability, tropical agricultural systems have to strive to maintain soil fertility (FAO and ITPS, 2015).

As soil fertility continues to decline at an alarming rate across several parts of Cameroon – south western Cameroon inclusive, farmers are forced to take to practices such as the use of improved seeds or inorganic fertilizers in order to improve crop yields (Yerima and Van Ranst, 2005b; Tsufac et al., 2019). Unfortunately, the unavailability of these improved seeds in most cases pushes farmers to make use of poor seeds they have been using in the past without any positive outcome. Poverty equally makes it difficult for farmers to buy inorganic fertilizers, for those who are willing to (Tsufac et al., 2019).

A good knowledge of what the nutrient requirements of the soil are is a prerequisite for tackling plant nutritional problems in the field. Without this, it is difficult to develop or transfer technology that would improve plant nutrient utilization (Sanchez and Salinas, 1981). In this light, plant related constraints and soil fertility evaluation at the farmer's field are necessary to increase crop yield. The type and amount of fertilizers, source of fertilizers and cost implications are key elements especially to farmers in developing countries with a low purchasing power (Foy and Brown, 1964). Farm productivity is handicapped by physical constraints such as poor water management resulting from runoff losses, leaching losses in rain fed farming systems, unprotected and uncontrolled erosion which reduce the crops conditions for good yields (Tsufac et al., 2019; Awazi and Tchamba, 2019). Farmers find it difficult to adapt to such conditions and so cannot improve their output enough in such situations.

Agroforestry which is an environmentally friendly, climate-smart and sustainable practice has been found to improve soil fertility, thereby contributing to the improvement of farm productivity (Nair, 1985; Young, 1991; Young, 1997; Young, 2002; Bishaw et al., 2013; Munjeb et al., 2018; Tsufac et al., 2019; Awazi and Tchamba, 2019). Agroforestry contributes towards the

provision of different ecosystem services including provisioning, regulating, supporting, and spiritual and recreational services (Jose, 2009; Montagnini, 2017). This implies that, everything being equal, farmers practicing agroforestry have to use less inorganic fertilizer than their non-agroforestry practicing counterparts. However, few studies have done a comparative analysis of the inorganic fertilizer used by agroforestry and non-agroforestry practicing farmers. Thus, this study sought to fill this void by working on the following objectives: (1) To identify the different types of inorganic fertilizer used by agroforestry practicing and non-agroforestry practicing farmers; (2) To identify the rate and frequency of use of inorganic fertilizers among agroforestry practicing and non-agroforestry practicing farmers; (3) To examine the factors influencing the use of inorganic fertilizers for agroforestry practicing farmers on the one hand and non-agroforestry practicing farmers on the other hand; and (4) To assess the non-causal and causal relationship between the practice/non-practice of agroforestry and farmers' use of inorganic fertilizer.

MATERIALS AND METHODS

Description of the study site

Location of Mbelenka

This study was carried out in the southwest region of Cameroon, specifically in the district of Mbelenka, found in Lebialem division. It is located between longitude 10° 2'E to 10° 4 E and latitude 5° 37' to 5° 39 N. Its vegetation is made up of mostly savannah with xerophytic tree species. Mbelenka extends from M'muock-Fossimondi right up to the western flanks of the Bamboutous Mountain located in the west region of Cameroon. Mbelenka covers parts of Alou and Wabane sub-Divisions, that is, parts of Mmuock-Fossimondi, Mmuock-Leteh and Bamumbu Fondoms, respectively. It extends from the old market in M'muock-Fossimondi passing through the whole of M'muock-Leteh to Magha in Bamumbu chiefdom.

Mbelenka is characterized by an undulating landscape with broad hilltops and gentle slopes with an altitude of 2200 m and suitable for intensive vegetable farming. Most slopes of this area are very steep and this explains the frequency of landslides at the lower parts of the slopes. The area equally has broad hill tops with gentle slopes (Wabane Council Report, 2013).

From Mbelenka right up to Magha (Western flank of Mt Bamboutos), the soils are Mollisols and andosols that have resulted from the weathering of tuffs and ignimbritic flows. The results of a soil analysis carried out in the study area by the Institute of Agricultural Research for Development (IRAD) in 2010 showed that the soils are dark in colour, with a deeper upper layer, slightly acidic (pH 4.87-6.64), higher in nitrogen and a CEC of less than 10 cmol. These soils support the cultivation of vegetable crops including potato, cabbage, carrots and leeks. However, due to the topography of the land and the silty to sandy texture of the soil, these soils are susceptible to leaching and soil erosion which have

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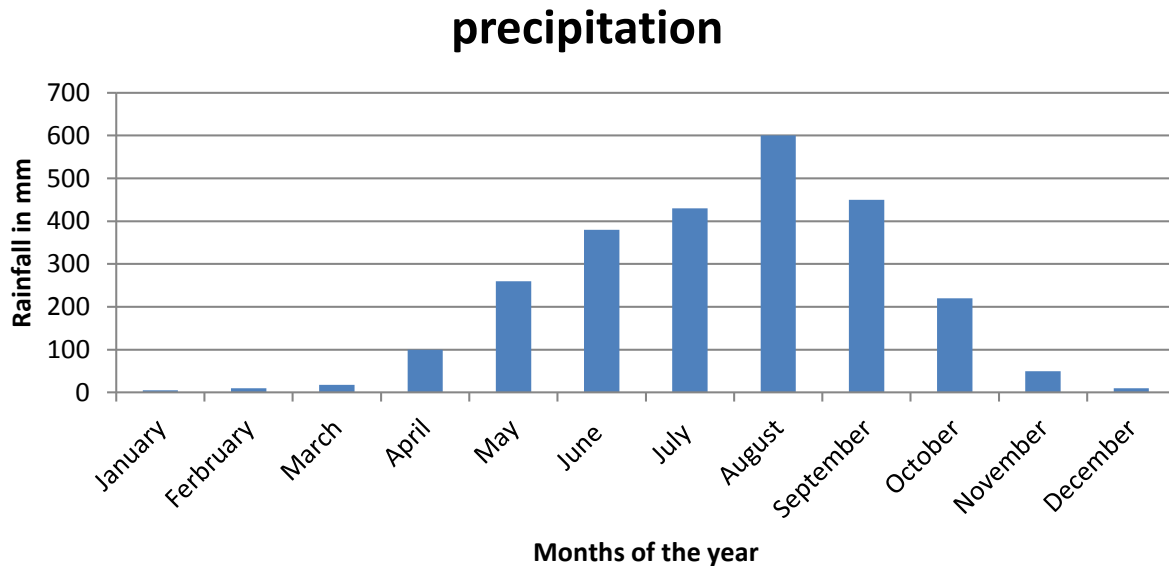


Figure 1. Distribution of rainfall in Mbelenka (Wabane Council Report, 2013)

led to its infertility over time.

With respect to climate, the area experiences two seasons; the dry season that begins in November and ends in April and the rainy season that commences in May and stretches up to October and early November with a mean annual rainfall of about 300 mm (Figure 1). Here the 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).

This area is located in the transition zone between the forest and the grassland and thus has characteristics of both zones but with the grassland savanna vegetation characteristics dominating. Due to the degradation of water catchments owing to the felling of trees for farming and animal rearing activities, the hydrographical network here has sharply decreased resulting in the scarcity of water resources.

The population of this environment is made up of the indigenous Bangwa of the M'mock clan, the Bamileke, Mundani and the Mbororos who are mostly nomads. The indigenes (Bangwa) of this environment belong to the M'mock clan that migrated up from the forest area to this environment. People from other tribes then migrated to this environment being drawn by the agricultural potential of the environment. The population lives in harmony with each other irrespective of their origin.

Sampling and questionnaire design

M'Muock-Fossimondi and M'Muock-Leteh (two clans), all found in Mbelenka, south west region of Cameroon were purposively selected after an exploratory investigation which showed that crop productivity was declining and soils were rapidly eroding. A semi-structured questionnaire (closed and open-ended questions) was formulated for this study. Questions were tailored to provide answers to all the specific objectives of the study. Information was collected on the various types of agroforestry and non-agroforestry systems practiced in the study area; acquisition of first-hand information about the real nature of the soil fertility problems on the field; farmers' perceptions on their different farming practices, levels of soil fertility decline and impacts of soil fertility decline on crops yields, types of agroforestry systems, types of inorganic fertilizers used, rate and frequency of use of inorganic fertilizers.

Data collection

On the field, direct observations were done to identify some of the determinants of soil fertility decline, different agroforestry and non-agroforestry systems, and the types of inorganic fertilizer used by agroforestry and non-agroforestry practicing farmers. A focus group discussion was organised in each village (Ndza Lekot, Apacpouh, Ntemzem, Ndongkiet, Nkongafem, and Meleta), with the help of key informants (village head/chief and agricultural extension officials). This was to identify farmers, other key informants (agricultural engineers and other stakeholders). The villages were selected from the two main clans in the study area, that is, M'Muock-Fossimondi and M'Muock-Leteh. The villages selected were characterized by declining crop productivity, soil infertility and high use of inorganic fertilizers. Six focus group discussions were organized and 26 key informants were interviewed. These key informants were chosen based on their longevity in farming. This also permitted the vivid understanding of the farmers' perceptions vis-à-vis the fertility of the soil in the area, types of inorganic fertilizers used, rate and frequency of use of different inorganic fertilizers.

One hundred and twenty questionnaires were administered to 120 farmers (72 women and 48 men). Women were the most dominant because they were largely involved in farming activities. Sixty questionnaires were administered in each of the clans (that is, M'Muock-Fossimondi and M'Muock-Leteh), thus a total of 120. 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 types of inorganic fertilizers used by farmers (agroforestry and non-agroforestry practitioners), the rate and frequency of use of inorganic fertilizers; the various types of agroforestry systems and practices; factors affecting farmers' use of inorganic fertilizers; and the relationship between different agroforestry systems and farmers' use of inorganic fertilizers.

Data analysis

Data collected from the field was analysed with the Statistical Package for Social Sciences (SPSS) version 17.0 as well as

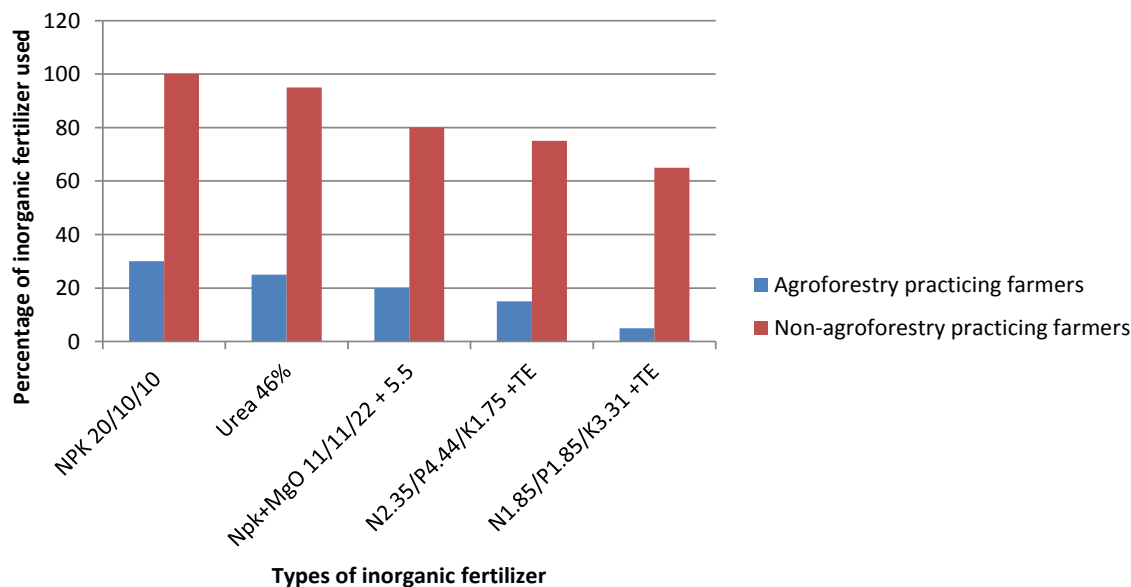


Figure 2. Types of in organic fertilizer used by agroforestry and non-agroforestry practicing farmers.

Microsoft Excel 2007. Both descriptive and inferential statistics were used. Descriptive statistics were mainly frequency tables and percentage indices, while inferential statistics included 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 relationship existing between different independent variables and farmers' use of inorganic fertilizer.

RESULTS AND DISCUSSION

Types of inorganic fertilizer used by agroforestry and non-agroforestry practicing farmers

From data analysis, it was found that, farmers mostly use nitrogenous, potash, and phosphate fertilizers. However, the type of inorganic fertilizer used differed significantly between agroforestry and non-agroforestry practicing farmers (Figure 2).

Overall, it was found that, over 60% of non-agroforestry practicing farmers used all five types of inorganic fertilizer used by farmers in the study area in significantly large amounts, while less than 35% of agroforestry practicing farmers used the five types of inorganic fertilizer in large amounts.

Rate and frequency of use of inorganic fertilizers among agroforestry and non-agroforestry practicing farmers

Rate of use of inorganic fertilizer

Concerning the rate of use of inorganic fertilizers between

agroforestry and non-agroforestry practicing farmers, it was found that, roughly 80% of non-agroforestry practicing farmers used inorganic fertilizer in large amounts while most of the agroforestry practicing farmers (40 and 30% respectively), used inorganic fertilizers in very small amounts or no inorganic fertilizer at all (Figure 3).

Frequency of use of inorganic fertilizer

With respect to the frequency of use of inorganic fertilizers among agroforestry and non-agroforestry practicing farmers, it was found that, most non-agroforestry practicing farmers (60%) used inorganic fertilizer very frequently, while most agroforestry practicing farmers (65 and 25% respectively), used inorganic fertilizers less frequently or never (Figure 4).

Factors influencing the use of inorganic fertilizers for agroforestry practicing farmers on the one hand and non-agroforestry practicing farmers on the other hand

Coefficients of the logistic regression model revealed that, the main factors influencing the use of inorganic fertilizers by agroforestry and non-agroforestry practicing farmers were gender, level of education, income level, cultivation of cash crops, cultivation of food crops, cultivation of market gardening crops, household size, number of farms, farm size, access to credit, membership in farming group, access to extension services, access to information, access to market, age, and farm experience (Table 1).

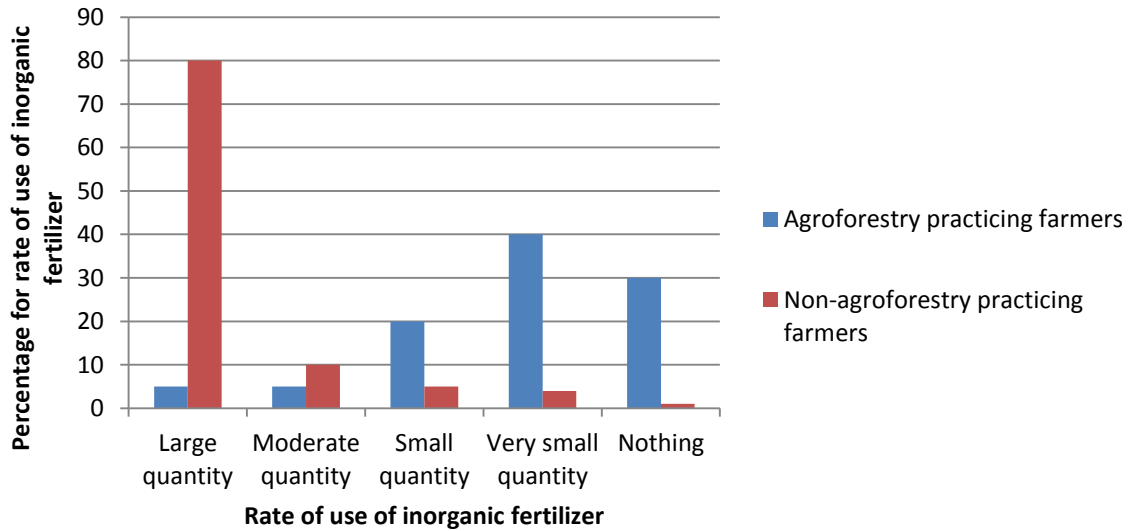


Figure 3. Rate of inorganic fertilizer use by agroforestry and non-agroforestry practicing farmers.

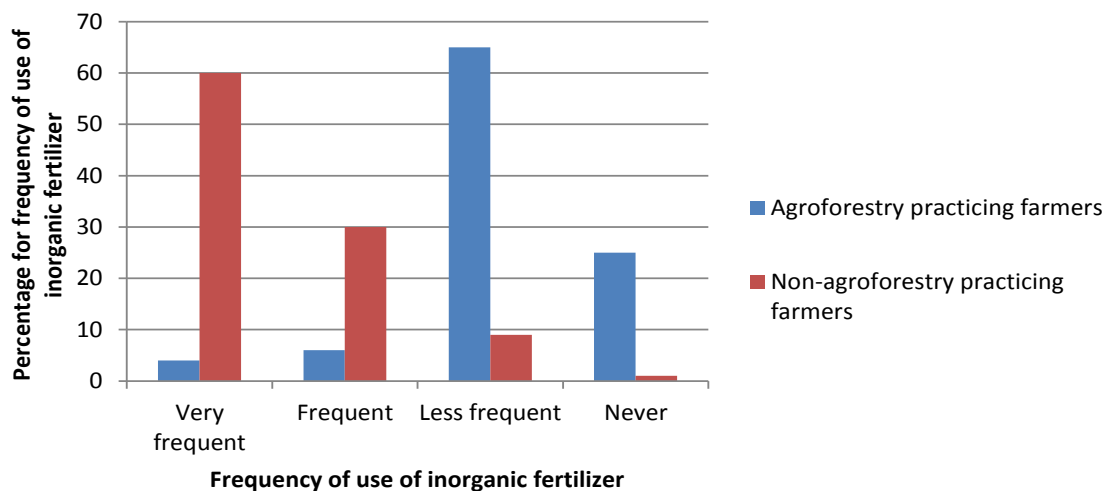


Figure 4. Frequency of use of inorganic fertilizer by agroforestry and non-agroforestry practicing farmers.

Although these factors influenced the use of inorganic fertilizers by both agroforestry and non-agroforestry practicing farmers, the degree and type of influence varied between the two. While factors such as level of education, cultivation of cash crops, household size, number of farms, farm size, age, and farm experience had a statistically significant inverse causal relationship ($p < 0.05$) with agroforestry practicing farmers' use of inorganic fertilizer, these same variable had a statistically significant direct causal relationship ($p < 0.05$) with non-agroforestry practicing farmers' use of inorganic fertilizer.

It was however found that, variables such as income level, cultivation of food crops, cultivation of market gardening crops, membership in farming group, access to extension services, and access to market had a statistically significant direct causal relationship ($p < 0.05$)

with the use of inorganic fertilizer for both agroforestry and non-agroforestry practicing farmers.

Relationship between the practice/non-practice of agroforestry and farmers' use of inorganic fertilizer

A non-causal and causal relationship existed between the use of inorganic fertilizer and the practice/non-practice of agroforestry by farmers (Table 2). Spearman rank correlation coefficients showed the existence of a statistically significant direct non-causal relationship ($p < 0.05$) between the non-practice of agroforestry and the use of inorganic fertilizer. Meanwhile, a statistically significant inverse non-causal relationship ($p < 0.05$) was found to exist between the practice of agroforestry

Table 1. Determinants of inorganic fertilizer use among agroforestry and non-agroforestry practicing farmers.

Independent variable	Agroforestry practicing farmer		Non-agroforestry practicing farmer	
	Coeff. B	p-level	Coeff. B	p-level
Gender	0.024 ^{ns}	0.571	0.032 ^{ns}	0.603
Level of education	- 0.821*	0.039	1.641*	0.000
Income level	0.732*	0.041	1.578*	0.000
Cash crops	- 0.697*	0.045	0.617*	0.047
Food crops	1.568*	0.000	1.689*	0.000
Market gardening crops	1.425*	0.000	2.789*	0.000
Household size	0.936*	0.021	1.411*	0.000
Number of farms	- 0.841*	0.011	1.762*	0.000
Farm size	- 0.823*	0.014	1.238*	0.000
Access to credit	0.041 ^{ns}	0.471	0.058 ^{ns}	0.575
Membership in farm group	1.824*	0.000	0.641*	0.044
Access to extension services	0.671*	0.029	1.042*	0.002
Access to information	1.048*	0.000	1.119*	0.000
Access to market	1.521*	0.000	0.824*	0.023
Age of farmer	- 1.622*	0.000	1.137*	0.000
Farm experience	- 0.942*	0.012	1.258*	0.000
Constant	- 6.947*	0.000	- 8.358*	0.000
Nagelkerke R ²	0.571		0.624	

*Significant at 5% probability level.

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

Type of practice	r	p-level	B	p-level
No agroforestry	0.863*	0.000	2.137*	0.025
Agrosilvopastoral	- 0.737*	0.000	- 1.024*	0.031
Silvopastoral	- 0.146 ^{ns}	0.448	- 0.007 ^{ns}	0.739
Agrisilvicultural	- 0.824*	0.000	- 1.253*	0.000
Constant			- 5.312*	0.000
Nagelkerke R ²			0.742	

*Significant at 5% probability level.

(agrosilvopastoral and agrisilvicultural systems) and the use of inorganic fertilizer.

Coefficients of the logistic regression model equally showed the existence of a statistically significant direct causal relationship ($p < 0.05$) between the non-practice of agroforestry and farmers' use of inorganic fertilizer. While, a statistically significant inverse causal relationship ($p < 0.05$) was found to exist between the practice of agroforestry (agrosilvopastoral and agrisilvicultural systems) and farmers' use of inorganic fertilizer.

Types of inorganic fertilizer used by agroforestry and non-agroforestry practicing farmers

Farmers have generally used different types of inorganic fertilizer to improve soil fertility with the most common types being nitrogenous, potash and phosphate fertilizers.

However, a comparative analysis of the types of fertilizer used by agroforestry and non-agroforestry farmers has scarcely been done which was the *raison d'être* for this study. Farmers' use of different types of fertilizers has generally been to improve soil fertility and increase crop yields. Soils in south western Cameroon in particular (Tsufac et al., 2019) and across Cameroon in general have generally been found to lack phosphorous, a vital nutrient needed by crops for effective growth. Most soils in Cameroon have average to high amounts of nitrogen and potassium. Hence, farmers generally use these different types of fertilizer to improve the fertility of the soil when the soil is lacking some of these essential elements.

Studies have shown that farmers use different types of inorganic fertilizer in order to improve soil fertility and increase crop yield (Jaza-Folefack, 2009; Chianu et al.,

2012; Kamga et al., 2013; Asongwe et al., 2014; Tsozue et al., 2015; Tayoh et al., 2017; Mishra et al., 2018; Engwali et al., 2019; Ngosong et al., 2019; Depigny et al., 2019; Thuries et al., 2019; Tambi et al., 2019; Temegne et al., 2020; Buvaneshwari et al., 2020; Kelly and Naseem, 2020; Djoufack et al., 2020). However, few studies have tried to examine the types of inorganic fertilizer used by agroforestry and non-agroforestry practicing farmers which has been done in this study.

Rate and frequency of use of inorganic fertilizers by agroforestry and non-agroforestry practicing farmers

Non-agroforestry practicing farmers are generally known to use large amounts of inorganic fertilizer to improve soil fertility and increase crop yields. This large quantity of inorganic fertilizer is used very frequently in order to sustain high crop yields. Large quantities and frequent use of inorganic fertilizer by non-agroforestry practicing farmers could be attributed to the fact that, most of the crops cultivated are either food crops or market gardening crops, grown using the sole cropping system. And since most of these crops are cultivated for the market, farmers do everything they can to minimize costs and maximize profits. Hence, they are prepared to go the extra mile in order to have greater yields which will give them more income. Meanwhile in agroforestry systems, most of the crops grown are fruits, food crops or cash crops. Few studies have compared the quantity of inorganic fertilizer used between agroforestry and non-agroforestry practicing farmers. However, the limited use of inorganic fertilizers in agroforestry systems could be attributed to the presence of nitrogen fixing tree/shrub species which help to improve soil fertility; the presence of the livestock component which provides manure; the cultivation of cash crops like cocoa, coffee and banana, fruits like pears, mangoes, guava, oranges, as well as food crops like cocoyam (Taro), cassava, and yams which need limited inorganic fertilizer.

Although few studies have examined the rate and frequency of use of inorganic fertilizers by agroforestry and non-agroforestry practicing farmers, some studies have shown that agroforestry contributes towards soil fertility enhancement (Nair, 1985; Nair, 1989; Nair, 2004; Nair and Garrity, 2012; Jose, 2009; Atangana et al., 2013; Bishaw et al., 2013; Leakey, 2017; Munjeb et al., 2018; Quandt et al., 2018; Amare et al., 2018; Leakey, 2019; Tsufac et al., 2019; Awazi and Tchamba, 2019). This implies that, the rate and frequency of use of inorganic fertilizers could be reduced if farmers take to more sustainable agroforestry systems.

Factors influencing inorganic fertilizer use by agroforestry and non-agroforestry practicing farmers

A comparative analysis showed the existence of both

differences and similarities in the factors affecting the use of inorganic fertilizer by agroforestry practicing and non-agroforestry practicing farmers.

The main differences were at the level of variables such as level of education, cultivation of cash crops, household size, number of farms, farm size, age, and farming experience which had a significant inverse causal relationship with agroforestry practicing farmers' use of inorganic fertilizer and significant direct causal relationship with non-agroforestry practicing farmers' use of inorganic fertilizer. The inverse causal relationship between variables such as level of education, cultivation of cash crops, number of farms, farm size, age, farming experience, and the use of chemical fertilizers in the case of agroforestry practicing farmers could be attributed to several reasons. For level of education, it could be because farmers with more education are aware of the environmental impacts resulting from the use of inorganic fertilizer; for the cultivation of cash crops, it could be because cash crops are generally cultivated within an agroforestry-based system; for household size, it could be because more persons provide the necessary labour force for intensive agroforestry practices which makes it unnecessary to use inorganic fertilizer; for farm size and number of farms, it could be because large farms and many farms are difficult to manage especially in terms of fertilizer application; while for age and farm experience, it could be due to the fact that, the older and more experienced the farmer is, the more they are prone to take to best practices like agroforestry which helps to limit the amount of inorganic fertilizer used. The direct causal relationship between variables such as level of education, cultivation of cash crops, number of farms, farm size, age, farming experience, and the use of chemical fertilizers in the case of non-agroforestry practicing farmers could be attributed to several reasons. Firstly, the prime objective of non-agroforestry practicing farmers is to cultivate and commercialize their farm products and in the process make as much profit as possible. Equally, most non-agroforestry practicing farmers are engaged in sole cropping systems which require intensive management for maximum yields. All these, make non-agroforestry farmers to focus mainly on the use of inorganic fertilizer irrespective of their level education, cultivation of cash crops, number of farms, farm size, age, and farm experience.

The major similarities were at the level of variables like household size, income level, cultivation of food crops, cultivation of market gardening crops, membership in farming group, access to information, access to extension services, and access to markets which had a significant direct causal relationship with the use of inorganic fertilizer for both agroforestry and non-agroforestry practicing farmers. The reasons for this are multifarious. For household size, more persons imply the need for more food which can in most cases be gotten by using inorganic fertilizer on the farm. For income level, more

income implies a greater capacity to buy better farm inputs like inorganic fertilizers. For cultivation of food crops, it is noticed that food crops generally yield better when inorganic fertilizer is used which explains why both agroforestry and non-agroforestry practicing farmers use relatively large quantities of fertilizer on food crops. For market gardening crops, the prime goal is to cultivate, sell and make maximum profits, explaining the high use of inorganic fertilizer. For membership in farming group, access to information, and access to extension services, all these generally contribute towards increase use of inorganic fertilizer because most media advertisements are usually on how to use inorganic fertilizers, and farming groups and extension services usually share ideas on the use of inorganic fertilizer as well as distribute inorganic fertilizer to their farmers. Access to markets on its part equally promotes the use of inorganic fertilizers because the closer the market, the more the quantity of inorganic fertilizers bought and used by farmers.

Most studies have generally focused on the role played by agroforestry in soil fertility enhancement (Jose, 2009; Bishaw et al., 2013; Leakey, 2017; Munjeb et al., 2018; Amare et al., 2018; Leakey, 2019; Tsufac et al., 2019; Awazi and Tchamba, 2019). Few studies have examined how farmers' practice/non-practice of agroforestry influences their use of inorganic fertilizer. This study by focusing on how the practice/non-practice of agroforestry influences farmers' use of inorganic fertilizer has therefore opened up a new path for further research.

Relationship between the use of inorganic fertilizer and farmers' practice/non-practice of agroforestry

Agroforestry has been identified as a climate-smart, agro-ecological practice capable of improving soil fertility (Nair, 1985; Nair, 1993; Munjeb et al., 2018, Awazi and Tchamba, 2019; Tsufac et al., 2019), while practices like sole cropping deplete soil fertility. This explains why, non-agroforestry practicing farmers use a lot of inorganic fertilizer while agroforestry practicing farmers use less inorganic fertilizer. The good nutrient cycling that occurs in agroforestry systems, permits the soils to maintain their fertility (Nair, 1993). This is not the case with sole cropping systems where little or no nutrient cycling occurs. Few studies have examined the relationship existing between the use of inorganic fertilizer and farmers' practice/non-practice of agroforestry which is what this study sought to unearth.

Conclusion

The findings of this study have revealed that, agroforestry practices and non-agroforestry practicing farmers use different types of inorganic fertilizer to improve soil fertility

and increase crop yields. The main inorganic fertilizers used were potash, nitrogenous and phosphate fertilizers. However, the rate and frequency of use of these inorganic fertilizers varied significantly between agroforestry practicing and non-agroforestry practicing farmers. While agroforestry practicing farmers used small amounts of inorganic fertilizer and less frequently, non-agroforestry practicing farmers used large quantities and more frequently. There were similarities and dissimilarities in the determinants of inorganic fertilizer use among agroforestry and non-agroforestry practicing farmers. For the dissimilarities, it was found that, variables such as level of education, cultivation of cash crops, number of farms, farm size, age, and farm experience had a significant inverse causal relationship with agroforestry practicing farmers' use of inorganic fertilizer, and a significant direct causal relationship with non-agroforestry practicing farmers' use of inorganic fertilizer. For the similarities, it was found that, variables such as income level, household size, cultivation of food crops, cultivation of market gardening crops, membership in farming group, access to extension services, and access to markets had a significant direct causal relationship with the use of inorganic fertilizer for both agroforestry and non-agroforestry practicing farmers. It was equally found that, a statistically significant direct causal relationship exist between the non-practice of agroforestry and the use of inorganic fertilizer, while a statistically significant inverse causal relationship exist between the practice of agroforestry and the use of inorganic fertilizer implying that, the practice of agroforestry has huge potentials to contribute towards limiting the use of inorganic fertilizers by farmers.

Policy implications

Based on the findings of this study, the following policy ramifications need to be looked into: Firstly, non-agroforestry practicing farmers use more inorganic fertilizers than agroforestry practicing farmers which could be attributed to the sole cropping nature of most non-agroforestry practicing farmers' plots and the diverse nature of most agroforestry practicing farmers' plots. Measures therefore need to be taken to regulate the use of inorganic fertilizers especially among non-agroforestry practicing farmers. Determinants of agroforestry practicing and non-agroforestry practicing farmers' use of chemical fertilizers diverge in some cases and converge in others. Policy makers therefore need to look at the similarities and differences in order to better tackle the problem of inorganic fertilizer use in farming systems. Agroforestry contributes towards reducing the use of inorganic fertilizers on farms which could be attributed to the diverse components that make up an agroforestry system, that is, tree/shrub, crop as well as animal components which contribute to enhance nutrient cycling

thereby maintaining the fertility of the soil. Thus, adequate measures should be put in place to promote the practice of agroforestry among farmers.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

The authors are immensely thankful to the Faculty of Agronomy and Agricultural Sciences of the University of Dschang for providing much needed material, morale, and logistics support during the study. Much thanks equally goes to the farmers and key informants who provided vital information during the reconnaissance and field surveys.

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