Current Journal of Applied Science and Technology

40(24): 26-39, 2021; Article no.CJAST.73624
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Sustainable Farming Practices: Knowledge and Practices of Smallholder Farmers in Bamenda Highlands, Cameroon

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Authors' contributions

This work was carried out in collaboration among all authors. Author CTK literature review, field survey, data collection and analysis and manuscript preparation and submissions. Author AST overall management of the field survey and reviewing the manuscript. Authors MN and CT technical support and reviewing the manuscript. All authors read and approved the final manuscript

Article Information

DOI: 10.9734/CJAST/2021/v40i2431500
Editor(s):
(1) Dr. Alessandro Buccolieri, Università del Salento, Italy.
Reviewers:
(1) Shaik Mohammad Shameer, Potti Sreeramulu Telugu University, India.
(2) Makkies David Lengwati, South Africa.
Complete Peer review History: https://www.sdiarticle4.com/review-history/73624

Original Research Article

Received 20 June 2021
Accepted 02 September 2021
Published 20 September 2021

ABSTRACT

Background: Climate change inflicts negative consequences on food production especially on smallholder farms needed to achieve food security. Sustainable farming techniques seem to be the bridge between climate change and food security.
Aims: To evaluate knowledge and practices of sustainable agriculture within smallholder farmers in the Bamenda Highlands, by identifying methods of pest and disease control, soil preservation options, and their different tillage practices, i.e., conventional versus sustainable practices.
Study Design: Using a questionnaire survey.
Place of Study: Bamenda Highlands, Cameroon.
Methodology: A sample of 175 smallholder farmers (25 from each of the seven administrative divisions) were questioned about their tillage, soil preservation, crop protection, and knowledge of

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sustainable farming practices. Data collected were analysed and summarised to obtain frequencies and percentages. Pearson Product Moment Correlation (PPMC) was used to test for significant relationships between the pairs of variables (age, level of formal education, sex, some tillage and soil preservation practices).
Results: Out of the 161 farmers who returned the answered questionnaire, 111(68.9%) agreed to have knowledge of sustainable farming but yet 158(98.1%) were still involved with conventional unsustainable practices such as tillage with the formation ridges, and 150(93.2%) used mineral fertilizers and pesticides. Crop rotation 102(64.2%), intercropping 110(68.3%), and legume integration 124(78.0%) were the most used sustainable farming practices. Sex (r=0.419, *P*=0.000), age (r=0.450, *P*=0.000), level of education (r=0.430, *P*=0.000), no till (r=0.19, *P*=0.016), crop rotation (r=0.158, *P*=0.040), and intercropping (r=0.227, *P*=0.045) all showed significant positive relationships with knowledge of sustainable farming at α=0.05.
Conclusions: Sufficient knowledge and capacity development on sustainable farming may decrease usage of unsustainable farming practices, hence improving the adoption of sustainable farming practices.

Keywords: Smallholder farmers; Bamenda highlands; sustainable farming; tillage practices; soil preservation; crop protection.

1. INTRODUCTION

The two most pressing and interlinked challenges facing humanity in this 21st century are climate change and food security [1]. Agriculture and food security are threatened by climate change factors such as increase in mean temperature, variation in precipitation patterns, and more extreme weather events [2]. Various agricultural land use practices alter the soil organic carbon availability, pH, nutrient availability and other physico-chemical properties [3], which, in turn, alter soil microbial community structure and function, thus, altering productivity. Agricultural activities practiced in the Bamenda Highlands including slash and burn, complete tillage and formation of ridges, burning of crop residues within tilled ridges, and heavy applications of agrochemicals such as mineral fertilizers and pesticides jeopardise the role of agriculture in ensuring food security for the increasing world population of about 9.7 billion people and eradicating poverty and hunger by 2050 [4,5,6]. Most farmers worldwide are aware of the effects of climate change on humanity and food security [7] and the mitigation measures being investigated in the agricultural sector [8].

Increasing food productivity can overcome the challenge of ensuring food security. However, over the last five decades, most of the increase in productivity has been related to increased agricultural land, improved genetic resources, increased use of pesticides, increased input of agricultural mineral nutrients, increased agricultural mechanization and intensification of irrigation [9], which contribute significantly to environmental challenges such as climate change. Consent exists amongst agricultural scientists that resource use efficiency, climate change and food security challenges will exacerbate under these conventional agricultural practices. Therefore, to achieve food security, food production has to be intensified sustainably. Hence, concrete innovative activities to sustainably improve agricultural productivity are presently in dire need.

Growth in agricultural productivity in Africa is essential to reduce hunger and poverty and ensure food security within the continent. Agricultural growth can be achieved by reducing incidence of the major constraints to productivity such as climate change, pests, weeds and degraded soils. These constraints are responsible for the continent’s crop productivity being among the lowest in the world, thereby causing high levels of hunger, malnutrition and poverty. Governments, donors and stakeholders in the Agricultural value chains recognise that in order to address hunger and poverty, these constraints must be effectively addressed. Therefore, development and deployment of technologies that would improve sustainability and resilience of the farming systems are needed to contribute towards mitigating climate change, ending hunger and poverty in Africa and indeed the attainment of the Millennium Development Goals (MDGs).

Sustainable farming is defined as an integrated system of plant and animal production practices having a site-specific application that will over the long term, satisfy human food and fibre needs. It enhances environmental quality and the natural resource base upon which the agricultural economy depends. It makes the most efficient use of non-renewable and on-farm resources. It integrates, where appropriate, natural biological cycles and controls. It sustains the economic viability of farm operations and enhances the quality of life for farmers and society as a whole [9]. Conventional farming on the other hand, applies to all other farming practices not included under the definition of sustainable farming.

Sustainable farming practices must reduce the impact of climate change on food production and also mitigate the factors (deforestation, inappropriate agricultural practices etc) that cause climate change. Sustainable farming should further enhance soil biodiversity in order to improve ecosystem services for a better productivity and a healthier environment [10]. Conservation agricultural techniques which are a set of soil-crop-nutrient-water-landscape system management practices have the potential to improve soil organic carbon (SOC) sequestration, food quality and quantity, and reduce Greenhouse Gas (GHG) emission from soils. This is because the nutrient supply and pest control methods largely depend on biological processes [11-12]. These also reported that the soil enzyme activities and microbial population are higher in organically managed farming when compared to the conventional farming.

The goal of the Cameroon government is to sustainably use her biological resources to achieve emergence by 2035 [14]. For the agricultural sector, the objectives are to intensify research on modern farming methods linked with soil and water conservation, sensitize smallholder farmers in village communities and increase production using improved planting material [14]. However, industrial agriculture involving the use of heavy machineries and high application of agrochemicals both by individuals and corporations are still highly practiced in Cameroon. Detailed plans on how to achieve sustainability in agriculture are still lacking, however, new policies enacted focused on the sustainable use principle, participatory approach and access to benefit sharing. Some notable actions include: use of sustainable farming methods, avoid slash and burn practices, use organic manure, and regulate against obsolete fertilizers [14].

In this paper, we evaluated knowledge and practices of smallholder farmers towards sustainable agriculture in the Bamenda Highlands. We identified their methods to control pest and diseases, soil preservation options, and tillage practices, i.e., conventional versus sustainable practices. The results of this research are intended to provide valuable information to agricultural experts and policy-makers for the needed development and deployment of sustainable agricultural policies as well as create awareness to a broader audience.

2. MATERIALS AND METHODS

2.1 Study Area

This study was carried out in the Bamenda highlands (BH) (1,740,000 ha) that is located between latitudes 5°45’N and 9°9’N and longitudes 9°13’ E and 11°13’ E [15,16]. The BH has a great variation in topography from depressions of less than 400 m to mountains slightly more than 3000 m above sea level [15]. The region counts 1,968,600 people in 2015 with a density of 114 persons/km^2. The Bamenda highlands comprise seven Administrative Divisions (Mezam, Menchum, Ngoketunjia, Momo, Boyo, Donga-Mantung, and Bui), separated from each other by less than 200 km [17] (Fig. 1). These highlands experience an equatorial climate of the Cameroon type with two major seasons: A long, wet season of eight months (March to October), and a short, dry season of four months from November to March [18]. The average annual rainfall and temperature are 2675.2 mm and 22.3°C, respectively [19]. The soils of the Bamenda highlands are predominantly humic ferralsols [20]. The main economic activity of the population in the BH is agriculture. Erosion, resulting from the topographic nature and high rainfall, is a major obstacle to sustaining the soil fertility.

2.2 Methods

A short-term survey was conducted with smallholder farmers in the BH over a three-month period from 17 July 2020 to 17 October 2020. A sample of 175 (25 from each of the seven administrative divisions of the Bamenda Highlands) smallholder farmers determined using Cochran’s formula [21], were questioned to assess their knowledge and level of practice of sustainable agriculture. Participants were selected randomly through direct face to face contact aided by village associations and farmers’ common initiative groups. The survey required all participating farmers to own small scale farms in Bamemda Highlands and working full-time on the farms.

The instrument of the study was a questionnaire which was validated by a panel of experts. The questionnaire consisted of five sections. The first section highlighted the demographic data of the farmers. The second section consisted of questions with suggested responses from which respondents were asked to express the type of tillage they practiced in maize farming. The third section captured the type of soil preservation methods practiced by farmers and the type of fertilizer they frequently applied on their farms. The smallholder farmers were asked them to either agree or reject the use of five soil preservation techniques. The fourth section was designed to capture methods applied by farmers to control pests and diseases. Small holder farmers were requested to accept or refuse the usage of chemical and non-chemical methods, highlight the non-chemical methods used and the type of chemicals most often used. Lastly, the fifth section was to get farmers awareness/understanding of the concept of sustainable farming. Questions were answered by ticking on the response that best reflected what the farmer practiced.

Descriptive statistics was calculated for all variables to better understand sample composition and responses. The descriptive statistics for the entire samples have been reported and subgroups selected. Farmers were sub-grouped according to their devotion to sustainable or conventional farming practices in terms of tillage practice, pest and disease control methods, soil preservation methods, and awareness/understanding on sustainable farming. Cross tabulation was used to examine the effects of sex, age, and level of education on the variables of sustainable farming practices. Also, Pearson Product Moment Correlation (PPMC) was used to assess the relationships of these demographic factors as well as farming practices with awareness/knowledge of sustainable farming practices.

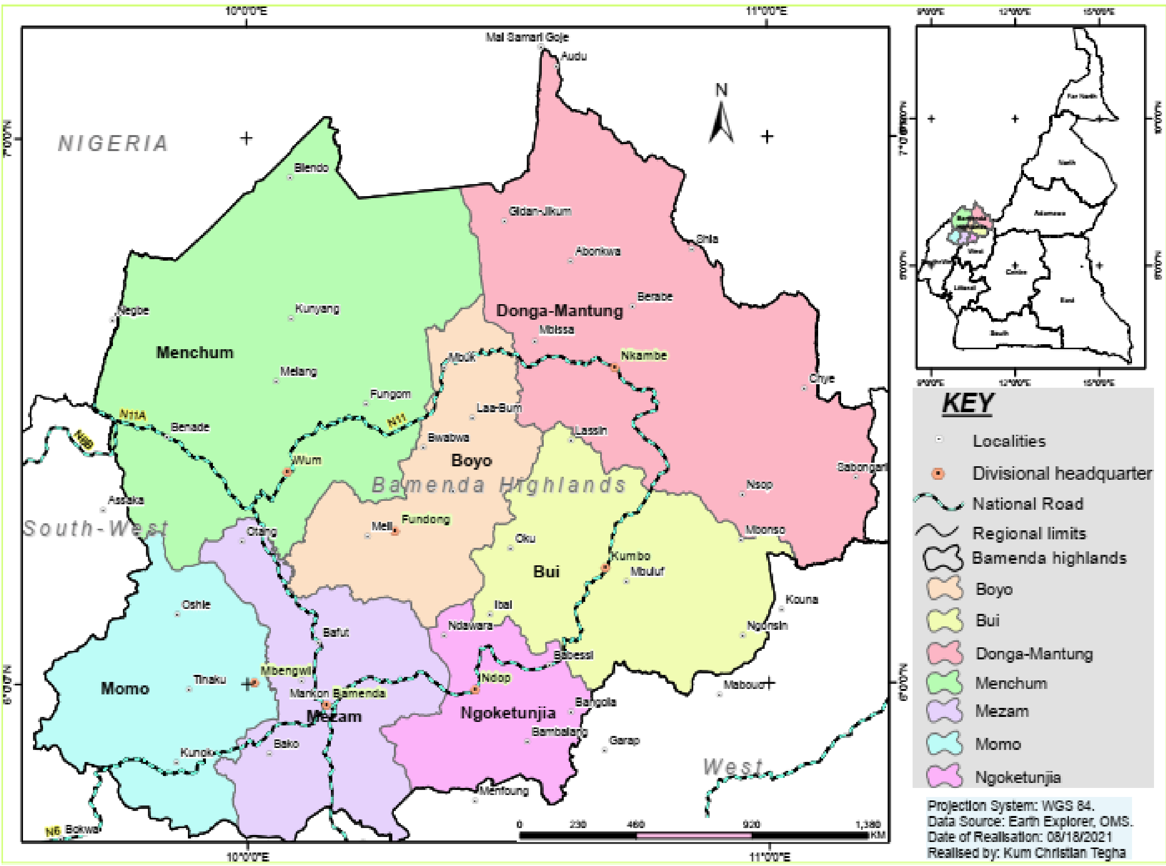

Fig. 1. Map showing the location of Cameroon within Africa, and the Bamenda Highlands, Cameroon

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Characteristics of the respondents

A total of 175 questionnaires were given out to smallholder farmers of the Bamenda Highlands (BH) and I61 were returned giving a response rate of 92.0%. The response number per division are shown on Fig. 2.

Of the 161 farmers who completed the survey, 64.0% were males and 36.0% were females. The participants were distributed among all age groups with the younger farmers of less than 30 years 81(50.3%) predominating, followed by 30-39 years 58(36.0%), ≥50 years 12(7.5%) and 40-49 years 10(6.2%). The average farm size was 1200 m^2. All of the participants (100%) worked full-time on their farm. A great proportion (42.9%) of participating farmers attained secondary education, 35.4% of the respondents were graduates from tertiary institutions, and 21.7% had finished primary education. None of the respondents had a master or PhD degree.

3.1.2 Smallholder farmers' tillage practices

The responses for all the tillage practices are summarised on Fig. 3 and the cross tabulation of tillage practices with sex, age, and level of education on Table 1.

3.1.2.1 Tillage with the formation ridges

The majority of the smallholder farmers 158(98.1%) agree that they do practice tillage with the formation of ridges. Almost two-third of them 98(62.03%) agree that this system of farming have long term negative consequences on the environment. This result showed significance at *P*=0.000 (Table 1). The 158 respondents were distributed approximately in the ratio of 1:3 for females and males, respectively. Approximately half of these respondents 80(50.6%) were less than 30 years of age, while about a third of them 56(35.4%) had graduated from the University (Table 1).

3.1.2.2 Tillage without the formation ridges

A small proportion, about one third of the respondents 51 (31.68%), practiced tillage without the formation of ridges which was significantly different (p=0.000) from the others. This is an indication that most of these smallholder farmers don't see the potential to reduce GHG emissions from the agricultural sector through a reduction in the rate of soil overturn (Table 1). Almost all of the respondents 48(94.1%) who practiced tillage without the formation of ridges were males. Thirty-six (70.6%) of the respondents were less than 39 years old while all of them had completed secondary education.

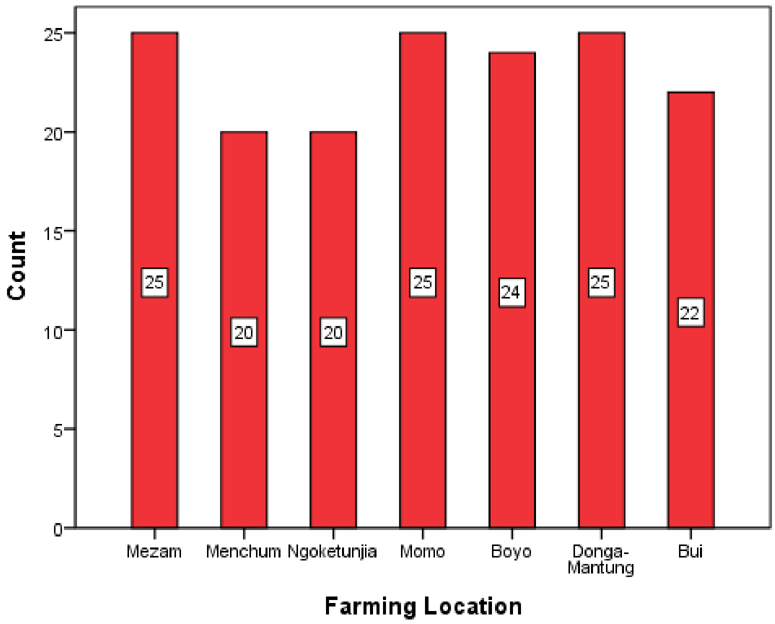

Fig. 2. Participant's response rate per Division of the Bamenda Highlands

3.1.2.3 Strip tillage

Only 22(13.7%) of smallholder farmers practiced strip tillage, while the majority of them are not involved in such a practice. Most of the farmers indicated that they have very little knowledge of strip tillage. All the 22 respondents using strip till cultivation were males within the ages of 30-49 years and non-had attained university education (Table 1).

3.1.2.4 No tillage

The majority of the smallholder farmers could not farm without tilling as only 12(7.5%) of them carried out maize cultivation with no tillage. All the 12 respondents practicing no tillage cultivation were males less than 30 years of age and holders of bachelor degrees (Table 1).

3.1.3 Soil Preservation techniques by Smallholder farmers

3.1.3.1Tillage technique

About half of the respondents 73(45.3%) agreed to their usage of tillage techniques to preserve the soil. A greater proportion 88(54.7%) denied ever using tillage as a method of soil preservation (Fig. 4). Out of the 73 respondents using tillage practices for soil preservation, a significant proportion 55(75.3%) had attained at least secondary education (p=0.000) and 36(49.3%) were within the age group of 30-39 years (p=0.000) (Table 2).

3.1.3.2 Intercropping

More than two-thirds 110(68.32%) of the respondents reported that they practice intercropping as method of soil preservation (Fig. 4). About two-thirds 73(66.4%) of these respondents practicing intercropping were males and the majority 91(82.7%) of them were young being less than 40 years (Table 2). Respondents practicing intercropping were split on their educational status with Forty-two (38.2%) of the respondents who practiced intercropping had completed secondary education and 34(30.9%) each being primary school leavers and University graduates.

3.1.3.3 Fertilizer application

The majority of the respondents 150(93.2%) regularly applied fertilizers as a means of preserving the soil. About a third 54(36.0%) of them were holders of bachelor degrees and nearly half 65(43.3%) were secondary education leavers. Also, the majority 96(64.0%) of them were males and about half 74(49.3%) very young being less than 30 years of age. The majority 80(53.3%) of the respondents applied chemical fertilizers while 70(46.7%) applied organic fertilizers to preserve soil. Sixty of the 70 respondents who used organic fertilizers indicated the type of organic fertilizers they used. About half 32(53.3%) of them applied poultry manure while 24(40.0%) applied cow dung, three (5.0%) applied household waste, and one (1.7%) applied green manure. Out of the 80 smallholder farmers who applied chemical fertilizers, the majority 70(87.5%) used NPK 20:10:10 fertilizer. The rest of the farmers 10(12.5%) could not identify the fertilizer used.

Table 1. Smallholder farmers' tillage practices by sex, age group, and level of education

		Tillage Practices				Chi- Square Test
		Tillage with formation of ridges	**No Tillage**	**Strip Tillage**	**Tillage without Ridges**	
Sex	Male	100(63.3)*	12(100)	22(100)	48(94.1)	x^2=52.903
	Female	58(36.7)	0(0.0)	0(0.0)	3(5.9)	df=04
	Total	**158(100)**	**12(100)**	**22(100)**	**51(100)**	p=0.000
Age Group	<30	80(50.6)	12(100)	0(0.0)	18(35.3)	
	30-39	58(36.7)	0(0.0)	18(81.8)	18(35.3)	x^2=107.361
	40-49	8(5.1)	0(0.0)	4(18.2)	3(5.9)	df=12
	≥50	12(7.6)	0(0.0)	0(0.0)	12(23.5)	p=0.000
	Total	**158(100)**	**12(100)**	**22(100)**	**51(100)**	
Level of education	FSCL	33(25.8)	0(0.0)	4(18.2)	0(0.0)	x^2=70.738
	Graduate	56(35.4)	12(100)	0(0.0)	21(41.2)	df=8
	Secondary	69(43.8)	0(0.0)	18(81.8)	30(58.8)	p=0.000
	Total	**158(100)**	**12(100)**	**22(100)**	**51(100)**	

**Values in parentheses are percentages*

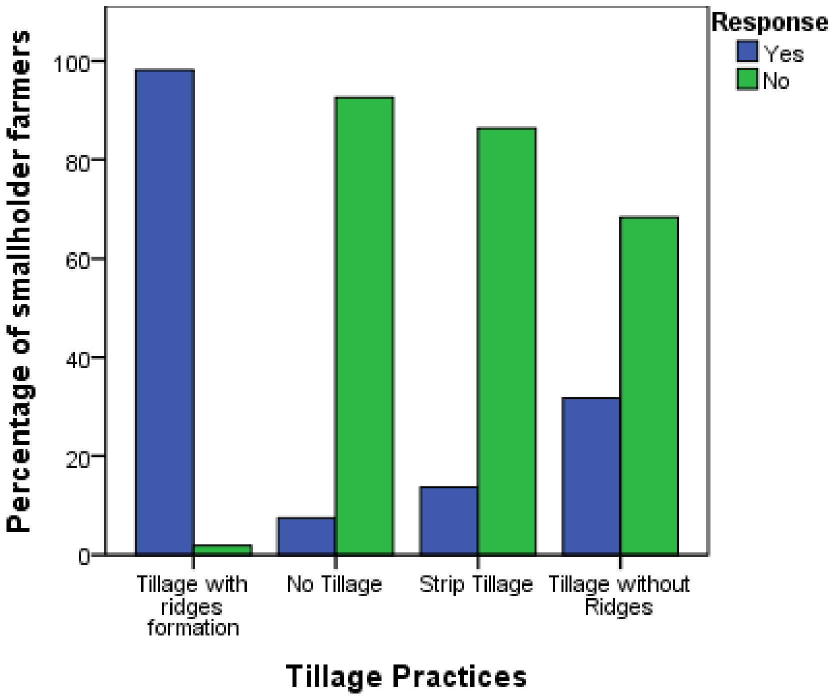

Fig. 3. Tillage practices of smallholder farmers in the Bamenda Highlands, Cameroon

3.1.3.4 Crop rotation

Almost two thirds 102(64.2%) of the respondents, agreed to the usage of crop rotation for soil preservation. Out of this proportion, 31(30.4%) and 30(29.4%) were primary and secondary school leavers, respectively while 41(40.2%) were first degree graduates. The majority of respondents 59(57.8%) were males. Out of the 102 respondents who practiced crop rotation, only one (1.0%) was more than 39 years of age (Table 2).

3.1.3.5 Legume integration

The majority of the respondents 124(77.0%) practiced legumes integration as a means to preserve the soil. Out of the 124 respondents, 73(58.9%) of them were males, 15(12.1%) were above 39 years, and nearly half 59(47.6%) were first degree holders.

3.1.4 Control of weeds, pests and diseases

3.1.4.1Control of pests and diseases

About a quarter 44(27.3%) of the respondents practiced non-chemical methods. Out of these 44 respondents, 24(54.5%) of them practiced biological methods of pest and disease control. They were all graduates and less than 40 years old (Table 3). While the remaining 20(45.5%) respondents practiced integrated pest management (IPM) techniques to control pest and diseases. All of these 20 respondents attained secondary level education and the majority 17(85.0%) were less than 30 years old (Table 3).

On the other hand, 117 (72.7%) respondents practiced chemical methods to control pests and diseases. Three quarters of these 117 respondents 88(75.1%) were undergraduates and 98(83.8%) were less than 40 years old (Table 3). Some of the chemicals used were:

Insecticides: ANFOUKA SUPPER 50, LAMIDACOT 90EC, OPTIMAL 20 SP, CYPERCOT, CAIMAN B, and KWIFU 5% WP,

Fungicides: FONGCHAM 720 WP, PENCOZEBB 80 WP, MONCOSTSR 80 WP, GLYCOT 5L, and BALADABA 480 SL,

Others: pesticides used are: MOCAP, BASTION SUPER.

3.1.4.2 Control of weeds

Fifty-two (32.2%) respondents used chemicals to control weeds. Out of these 52 respondents, more than three-quarters 41(78.8%) attained secondary level education. The majority of them 45(86.6%) were young farmers of less than 40 years of age (Table 4).

Furthermore, 109(67.7%) respondents practiced non-chemical methods to control weeds. Out of these 109 respondents, 57(52.3%), 32(29.4%) and 20(18.3%) practiced mechanical weeding, crop rotation/intercropping, and burning of refuse after harvest, respectively. About a third of the respondents 22(38.6%) who practiced mechanical weeding and 8(40.0%) of those who practiced burning of residue after harvest were graduates. While half 16(50.0%) of those who practiced crop rotation/intercropping were graduates (Table 4). In terms of age, 15(13.8%) of the respondents above the age of 40 years practiced non-chemical methods to control weeds. All of them practiced mechanical weeding (Table 4).

Table 2. Smallholder farmers' soil preservation methods by level of education, sex, and age group

		Soil Preservation Techniques					Chi-Square Test
		Fertilizer application for soil preservation	**Crop rotation for soil preservation**	**Intercropping for soil preservation**	**Tillage for soil preservation**	**Legume Integration**	
Level of education	FSCL	31(20.7)*	30(29.4)	34(30.9)	18(24.7)	30(24.2)	x^2=61.137
	Secondary	65(43.3)	31(30.4)	42(38.2)	39(53.4)	35(28.2)	df=10
	Graduate	54(36.0)	41(40.2)	34(30.9)	16(21.9)	59(47.6)	p=0.000
	Total	**150(100)**	**102(100)**	**110(100)**	**73(100)**	**124(100)**	
Sex	Male	96(64.0)	59(57.8)	73(66.4)	43(58.9)	73(58.9)	x^2=12.991
	Female	54(36.0)	43(42.2)	37(39.6)	30(41.1)	51(41.1)	df=05
	Total	**150(100)**	**102(100)**	**110(100)**	**73(100)**	**124(100)**	p=0.023
Age Group	<30	74(49.3)	45(44.1)	43(39.1)	21(28.8)	51(41.1)	
	30-39	58(38.7)	56(54.9)	48(43.6)	36(49.3)	58(46.8)	x^2=181.211
	40-49	6(4.0)	1(1.0)	7(6.4)	4(5.5)	3(2.4)	df=15
	≥50	12(8.0)	0(0.0)	12(10.9)	12(14.4)	12(9.7)	p=0.000
	Total	**150(100)**	**102(100)**	**110(100)**	**73(100)**	**124(100)**	

Values in parentheses are percentages

Table 3. Smallholder farmers' pest and disease control methods by level of education, sex, and age group

		Pest & Disease control methods				Chi- Square Test
		Biological	**IPM**	**Chemical**	**Total**	
Level of education	FSCL	0(0.0)*	0(0.0)	35(29.9)	35(21.7)	X^2=63.401
	Secondary	0(0.0)	16(80.0)	53(45.3)	69(42.9)	df=10
	Graduate	24(100)	4(20.0)	29(24.8)	57(35.4)	p=0.000
	Total	**24(100)**	**20(100)**	**117(100)**	**161(100)**	
Sex	Male	16(66.7)	16(80.0)	71(60.7)	103(64.0)	X^2=2.854
	Female	8(33.3)	4(20.0)	46(39.3)	58(36.0)	df=02
	Total	**24(100)**	**20(100)**	**117(100)**	**161(100)**	p=0.230
Age Group	<30	19(79.2)	17(85.0)	45(38.5)	81(50.3)	X^2=32.057
	30-39	5(20.8)	0(0.0)	53(45.3)	58(36.0)	df=6
	40-49	0(0.0)	3(15.0)	7(6.0)	10(6.2)	p=0.000
	≥50	0(0.0)	0(0.0)	12(10.3)	12(7.5)	
	Total	**24(100)**	**20(100)**	**117(100)**	**161(100)**	

Values in parentheses are percentages

Table 4. Smallholder farmers' weed control methods by level of education, sex, and age group

		Weeds control methods					Chi-Square Test
		Burning of residue after harvest	**Mechanical Weeding**	**Crop Rotation/ Intercropping**	**Use of Chemicals**	**Total**	
Level of education	FSCL	0(0.0)*	15(26.3)	10(31.2)	10(19.2)	35(21.7)	X^2=21.492
	Secondary	12(60.0)	20(35.1)	6(18.8)	31(59.6)	69(42.9)	df=6
	Graduate	8(40.0)	22(38.6)	16(50.0)	11(21.1)	57(35.4)	p=0.001
	Total	**20(100)**	**57(100)**	**32(100)**	**52(100)**	**161(100)**	
Sex	Male	19(95.0)	28(49.1)	21(65.6)	35(67.3)	103(64.0)	X^2=14.097
	Female	1(5.0)	29(50.9)	11(34.4)	17(32.7)	58(36.0)	df=03
	Total	**20(100)**	**57(100)**	**32(100)**	**52(100)**	**161(100)**	p=0.003
Age Group	<30	19(95.0)	25(43.9)	8(25.0)	29(55.8)	81(50.3)	X^2=51.588
	30-39	1(5.0)	17(29.8)	24(75.0)	16(30.8)	58(36.0)	df=9
	40-49	0(0.0)	9(15.8)	0(0.0)	1(1.9)	10(6.2)	p=0.000
	≥50	0(0.0)	6(10.5)	0(0.0)	6(11.5)	12(7.5)	
	Total	**20(100)**	**57(100)**	**32(100)**	**52(100)**	**161(100)**	

**Values in parentheses are percentages*

3.1.5 Understanding of Sustainable farming

The majority of the respondents 111(68.9%) agreed to be aware of the term sustainable farming. These 111 understood sustainable farming as: 41(36.9%)-productive over the long term, 21(18.9%)-farming for family consumption/subsistence, 28(25.2%)-farming that meets society's present needs without compromising future generation's needs, 14(12.6%)-farming that keeps soil unaltered, and 7(6.3%)-farming using natural inputs (Table 5).

Out of the 111 respondents who were aware of sustainable farming, only 13(11.7%) ended their education at the level of First School Living Certificate, 30(27.0%) of them were females, and 18(16.2%) were over 40 years of age (Table 5).

Table 5. Awareness level of sustainable farming within small holder farmers at different levels of education, sex and age group

		Meaning of sustainable farming					Chi-Square Test
		Makes farm more productive for a long time	**farming for family consumption**	**Meets society present needs without compromising future generations needs**	**Keeps soil unaltered**	**farming using natural inputs**	
Level of education	FSCL	1(2.4)*	0(0.0)	0(0.0)	5(35.7)	7(100.0)	X^2=76.929
	Secondary	21(51.2)	12(57.1)	19(67.9)	9(64.3)	0(0.0)	df=8
	Graduate	19(46.3)	9(42.9)	9(32.1)	0(0.0)	0(0.0)	p=0.000
	Total	**41(100)**	**21(100)**	**28(100)**	**14(100)**	**7(100)**	
Sex	Male	35(85.0)	20(95.2)	15(53.6)	9(64.3)	0(0.0)	X^2=31.786
	Female	6(14.6)	1(4.8)	13(46.4)	5(35.7)	7(100.0)	df=04
	Total	**41(100)**	**21(100)**	**28(100)**	**14(100)**	**7(100)**	p=0.000
Age Group	<30	18(43.9)	9(42.9)	25(89.3)	9(64.3)	0(0.0)	X^2=99.297
	30-39	20(48.8)	0(0.0)	0(0.0)	5(35.7)	7(100.0)	df=12
	40-49	3(7.3)	0(0.0)	3(10.7)	0(0.0)	0(0.0)	p=0.000
	≥50	0(0.0)	12(57.1)	0(0.0)	0(0.0)	0(0.0)	
	Total	**41(100)**	**21(100)**	**28(100)**	**14(100)**	**7(100)**	

**Values in parentheses are percentages*

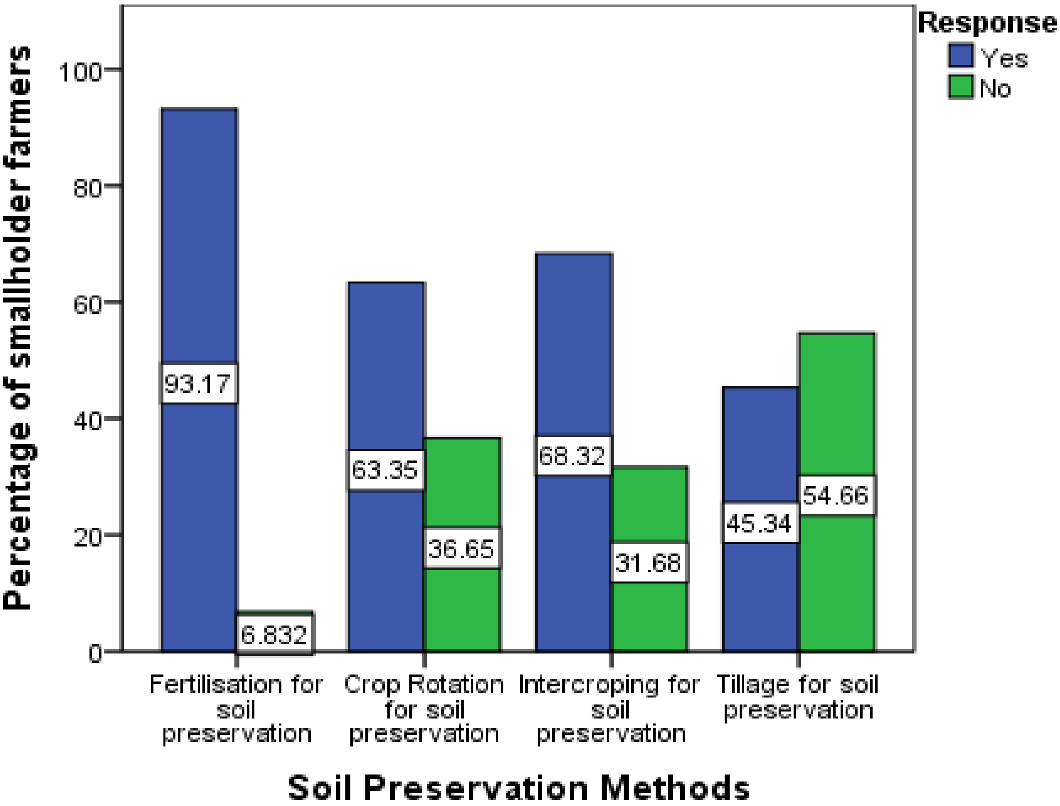

Fig. 4. Soil preservation methods of small holder farmers

Table 6. Relationships between Farmers' socioeconomic characteristics, some sustainable practices and the farmers' knowledge of Sustainable Agriculture

Characteristic	r-value	*P*-value	Remark
Age	0.450**	0.000	Significant
Sex	0.419**	0.000	Significant
Level of education	0.430**	0.000	Significant
No tillage farming	0.190*	0.016	Significant
Tillage with ridges formation	-0.205**	0.009	Significant
Intercropping	0.227*	0.040	Significant
Crop rotation practice	0.158*	0.045	Significant

***Correlation is significant at 0.01 level. * Correlation is significant at 0.05 level*

3.1.6 Relationships between Smallholder Farmers' socioeconomic characteristics, some sustainable farming practices and the farmers' knowledge of Sustainable farming

Sex, age and level of education of smallholder farmers had positive and significant (P = 0.000) relationship with their knowledge of sustainable farming. Also, no tillage, intercropping and crop rotation farming practices showed positive and significant correlations with farmers' knowledge at $p< 0.05$. Tillage with ridges formation which showed a negative significant relationship with farmers' knowledge (r=-0.205, P=0.009) (Table 6).

3.2 Discussion

The demographic characteristics of respondents showed that 86.3% of the farmers are younger than 40 years. According to [22], this is an active age when farmers are more responsive to the adoption of innovations. Also, the higher proportion of respondents at age group ≥50(7.5%) years than 40-49 years (6.5%), could be an indication that some of the respondents engaged in farming after going on retirement.

The high proportion of respondents (88.3%) who attained secondary level education is good for the implementation of sustainable farming. The level of attainment of functional literacy makes application of sustainable farming principles easy [23]. Furthermore, according to [24], the primarily knowledge gained from secondary, agricultural schools or universities, complemented with information from the Internet or other trainings can also boost the implementation of sustainable farming innovations. All of the smallholder farmers were working full time on their farms, which according to [25], is suitable for the application of sustainable farming innovations.

Sustainable farming practices could curb the challenges posed by climate change and food insufficiency. These results reveal that smallholder farmers in the Bamenda Highlands (BH) were aware of sustainable agriculture and a few were implementing some of the sustainable farming techniques.

The high level of awareness and low level of implementation of sustainable farming techniques exhibited through no-tillage, and tillage without formation of ridges indicates a lack of adequate capacity to effectively implement the sustainable farming techniques. Adequate capacity development on sustainable farming practices may enhance the willingness of farmers to effectively adopt them.

We investigated the method used to conserve the soil, a major component of agricultural production. Interestingly, about two-third of farmers used crop rotation, integration of legumes, and intercropping techniques to preserve the soil. This proves that farmers were willing to adopt sustainable farming techniques so long as the techniques can lead to an increase in their economic net revenues and improve their wellbeing. The adoption of fertilizer application methods to preserve the soil by over 90% of the farmers is an indication that farmers are ready to go an extra mile to improve yields. The fact that close to half of the fertilizer users used organic fertilizers adds impetus to the fact that farmers can easily adopt sustainable farming practices. The results also revealed that young and educated farmers were practicing legume integration more than old less educated farmers. These results indicate that smallholder farmers' knowledge on sustainable agriculture is less moderate. Some of them practice these sustainable practices unknowingly. Decisions on use of mineral fertilization and other unsustainable practices mostly made without considering the potential negative impacts. Information and knowledge flow from academia to the farmers are therefore blocked at a certain level [26].

Weed control is another important factor of agricultural production by smallholder farmers and thus is an effective tool for raising awareness and conveying information about the effects of chemicals and sustainable options to mitigate these effects. Overcoming knowledge and information gaps might spur farmers to adopt voluntary mitigation practices [27]. However, our results indicate that over three-quarters of the 52 farmers who used chemicals to control weeds never attended tertiary education. This is an indication of lack of sufficient knowledge on the effects of chemicals on the soil and human health. Moreover, just about one-third of farmers who practiced mechanical weeding and burning of refuse after harvest were graduate, probably also indicating the lack of sufficient knowledge about the harmful effects arising from burning of refuse. The higher rate of graduates amongst farmers who practiced crop rotation/intercropping methods to control weed confirms that more awareness will increase adoption of sustainable farming practices.

Adoption of precision agriculture which has been on the rise requires technology-intensive changes such as high investment cost, which could hamper their implementation [28]. Low level sustainable farming practices should be a competitive substitute. Over 80% of the farmers with knowledge of sustainable farming at least completed secondary education and were less than 40 years old. This is an indication of hope for the future of sustainable farming in the Bamenda Highlands as long as continues awareness raising and capacity building are put in place.

The results displayed in Table 6 revealed that farmers' age group had a significant positive ($r = 0.450$) relationship with their knowledge of sustainable agriculture. This results according to [21], indicates that the higher the age of the farmer, the more experienced and knowledgeable they are to develop a rightful perception of any issue that affects their wellbeing. Also, level of education ($r = 0.430$) revealed a positive and significant relation with smallholder farmers' knowledge of sustainable farming (Table 6). This indicates that the more farmers get formal education, the more the opportunities to learn about sustainable farming from diverse information sources [29]. Some of these information sources could be journal articles, conferences, and workshops. This is likely to place the farmer in a better position to perceive sustainable farming in a better way than other farmers with lesser level of education.

Farming practices such as no till ($r = 0.19$), intercropping ($r = 0.227$), and crop rotation ($r = 0.158$) all showed positive and significant ($p < 0.05$) relationships with farmers' knowledge on sustainable farming (Table 6). This is an indication that the more farmers become aware of sustainable farming, the more these farming systems are carried out. Tillage with ridges formation largely practiced by over 98% of the smallholder farmers in the BHs, showed a negative and significant ($p < 0.05$) relationship with knowledge on sustainable farming. This implies that the more farmers become aware of sustainable farming, they turn to partly withdraw from the practice of tillage with the formation of ridges or modify it with some of the sustainable techniques such as mulching to minimize soil loss due to erosion.

4. CONCLUSIONS

Our findings indicate that smallholder farmers in the BH were aware of and had favourable character towards sustainable farming techniques but inadequate knowledge and capacity prevented most of these farmers from fully adopting the sustainable practices. This is evident in the number of farmers who practiced tillage with the formation of ridges and those aware of sustainable farming. A solution to this challenge could be targeted information and training campaigns and adoption of appropriate policies such as provision of sustainable farming subsidies to farmers. Farmers' responses toward soil preservation methods, weed, pest and disease control with respect to sustainable farming practices indicated their willingness to embrace sustainable farming as an alternative to conventional agriculture. This positive attitude of farmers toward sustainable farming is expected to encourage their future participation in capacity building programmes on sustainable farming that will improve rural livelihood. With the awareness raising and capacity building programmes in place, sustainable farming engagements in future will yield adequate incomes and favourable environments.

We therefore recommend that governmental and non-governmental organisations should collaborate to disseminate appropriate information and capacity building on sustainable farming to smallholder farmers.

CONSENT

As per international standard or university standard, Participants' written consent has been collected and preserved by the author(s).

ACKNOWLEDGEMENTS

We thank all farmers who participated in the survey. We equally thank the lecturers and students of the Department of Agricultural and Environmental Engineering, College of Technology, University of Bamenda-Cameroon for validating and administering the questionnaires respectively.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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