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Farmers' Knowledge and Perception on Common Beans Production Constraints and their Mitigation Methods in the Humid Rainforest and Highland Savanna of Cameroon

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Authors' contributions

This work was carried out in collaboration between both authors. Author HAA managed the literature searches, wrote the first draft of the manuscript. Author NNN designed the study, wrote the protocol and managed the analyses. Both authors read and approved the final manuscript.

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ABSTRACT

Background: Common beans, *Phaseolus vulgaris* is one of the most important plant protein sources in many African countries including Cameroon. It is a major source to smallholder farmers and some large-scale farmers. Common beans also fixes atmospheric nitrogen in symbiosis with rhizobia thus improving soil fertility. Despite the importance of this major food and cash crop, its production in Cameroon is constrained by several abiotic and biotic factors. Therefore it was hypothesized that bean farmers in the study regions have knowledge on; (1) the various factors that hamper bean production; (2) the planting periods/seasons that the various constraints are more important; (3) they have their own indigenous methods of mitigating these constraints but would prefer more appropriate methods if available.

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Aims: To document when farmers plant beans, how they handled the crop when matured, and if they faced problems with rot/mould, insects or any other constraints in their beans and how they manage these problems.
Study Design: Random interviewing of beans farmers.
Place and Duration of Study: Interviewed farmers in Buea and Dschang of the humid rainforest and highland agro-ecological zones of Cameroon respectively from January 2017 to December 2017.
Methodology: A semi-structural questionnaire was administered to 519 randomly selected bean farmers in two agro-ecological zones; the humid rainforest and highland savanna. A total of 163 from Buea in the south west (humid rainforest) and 356 from Dschang in the west (highland savanna) were randomly interviewed to document the farmers' perceptions on various constraints hampering beans production, when these are most limiting and the various methods they use to mitigate them.
Results: Farmers in both agro-ecological zones lacked adequate land surface area for bean production and suffered from low yields. In the highland savanna or west region, 166 (45.98%) and 119 (75.32%) in the humid rainforest or south west region grew beans in farms of sizes <1Ha. Only 2 (1.27%) of bean farmers in the South West and 35 (9.69%) in the West produced beans on farms >2Ha. Most farmers in the west 267 (73.96%) and 139 (87.97%) in the south west produced only 1-3 bags of 50kg each of beans/ha. The farmers faced problems with mold/rot and insect pests; the mold/rot was the most nagging for beans that matured during the rainy season while insect pests was the major constraint for the dry season beans. The mold/rot was controlled mainly by the adjustment of the planting dates of beans while different types of insecticides were used against the insect pests. Farmers also face problems in having adequate/appropriate staking materials for the climbing or indeterminate bean varieties.
Conclusion: Considering that farmers face the actual daily challenges of bean production. Their knowledge and perceptions of the production constraints of this crop are quintessential and should count in defining research priorities aimed at mitigating the problems in order to increase beans production. Therefore, there is need for research to test and/or validate these farmers knowledge and perceptions about bean production constraints as a prelude to vulgarizing the effective control/management options.

Keywords: Insect pests, mould/Rot; phaseolus vulgaris; seasonal differences; production constraints.

1. INTRODUCTION

Agriculture is a source of income for farmers, affiliated entrepreneurs, government and a major source of employment as well as foreign exchange earner in Cameroon. Therefore boosting agricultural productivity and food availability without extending the available arable cropland nor depleting water resources is a major priority for Cameroon. The common beans, *Phaseolus vulgaris* (L.), is an important low cost source of dietary proteins for millions of the rural poor in developing countries especially in Sub-Saharan Africa. It is the third most important food grain legume after soybean and peanut worldwide with nutritional and economic value to human and feed to livestock [1]. Common beans are an important source of proteins, minerals (iron and zinc) and vitamins [2]. Immature pods are eaten fresh and can be easily preserved by freezing, canning or dehydrating. Mature beans are eaten boiled, baked, fried, or ground into flour. Crop residues, such as dried pods and stems (straw) and processing by-products (discarded pods, pod extremities), can be used as fodder [3,4]. Common bean also improves soil fertility through fixation of atmospheric Nitrogen in symbiosis with rhizobia [5,6]. Its nitrogen fixing ability also means that it can encourage much-needed, longer term improvements in soil fertility [7,8]. Health wise, haricot bean consumption has reportedly reduced colon and breast cancer, and heart diseases [9]. Beans is produced in a wide range of intercropping systems and environments spanning across regions in Latin America, Africa, the Middle East, China, Europe, the USA , and Canada [10,11]. Intercropping is one of the most prominent cultivation systems of smallholder farmers due to shortage of land, with individually owned pieces of land rarely exceeding 1.5 ha. Intercropping ensures avoidance of risks associated with complete crop failure [12].

In Cameroon, the Western Highlands are the highest common bean producing zone with more than 90% of the national production [13]. Beans consumption per capita reached 13.5 kg in 2018 and it is the second most important grain crop

after maize in terms of production and consumption in Cameroon especially in the Western Highlands [14]. World dry bean production was 24.6 million tons in 2013, of which 200 000 tons was produced by Cameroon as the 17th world producer out of a total of 230 000 hectares representing a yield of 870 kg ha-1 [15]. During the first (March) and second (August/September) plantings in Cameroon, beans is often intercropped with maize in the Western Highlands but with yams and/or maize in the humid rainforest.

Despite the importance of common beans, its production in Cameroon and other beans producing countries is hampered by a number of biotic and abiotic factors [16,17]. The crop is extremely susceptible to diseases and insect pests and over 50% of the production in tropical Africa is estimated to be lost yearly [18]. Some main diseases of the crop such as, angular leaf spot, anthracnose, and bean rust together may cause yield losses of 600,000 t/year in sub-Saharan Africa [19]. In combination with sub-optimal growing conditions in developing countries, pests and diseases may act synergistically to cause significant or total yield losses [20,21].

Therefore, this study was conducted to document farmers' knowledge and perception on common beans production constraints their mitigation methods in the humid rainforest and highland savanna of Cameroon. It was hypothesized that the farmers: (1) know the various field constraints they face when growing beans (2) know the planting periods/seasons that the various constraints are more important; (3) they have their own indigenous methods of mitigating these constraints but would prefer more appropriate methods if available.

Consequently, we therefore sought to know if or not beans farmers in the study areas face field problems that hinder their increased bean production. If so, whether the problems are more important during particular bean planting periods/seasons and when precisely. We also sought to know whether the farmers have indigenous methods of mitigating these problems and if these methods are effective or not as well as whether they will prefer to use alternative more effective methods to mitigate/overcome their bean field production challenges. The study also sought to know if there were differences in knowledge and practices in mitigation beans filed production constraints in the different regions studied.

2. MATERIALS AND METHODS

2.1 Study Site

The survey was conducted in Buea and Dschang in the humid rainforest and western highland savanna agro ecological zones of Cameroon, respectively. Buea is located at $4^0$08'036" N, and 9^o25' 826"E, and573m above sea levels with a relative humidity of 90%.It is at the east slope of Mount Cameroon, with an annual rain fall of about 4,090mm, rich volcanic rocky soils and a temperature range of 18 -23^0C. It has an equatorial climate with a rainy season from March to Mid-November and a dry season from Mid-November to March. Dschang is located at $05^0$26' 666"N, and $01^0$03' 798"E on an altitude of 4523m above sea level; It has temperature range between of between 15.5^0C-17.0^0C. The annual rainfall is between 1100m-2000mwith a relative humidity of 71%. It also has two seasons; the dry season from November to March and rainy season from April to October.

2.2 Survey

A semi structured questionnaire was used in the survey. A total of 519 participants (356 from Dschang and 163 from Buea) comprising of male and female aged between 18 – 60 years bean farmers were interviewed separately within their farming areas, business locations or around their residence. Participants in the study were selected on the basis that they had been involved in beans cultivation for at least one year and were willing to participate in the survey. Interviews were done in English or local language (pidgin) in Buea and French in Dschang; all interviews were done with the assistance of local agricultural extension workers.

The questionnaires was developed in English and later translated into the French language which could be better understood by farmers in the francophone region of Dschang. The questions sought to know: (a) the bean farm sizes and the other legumes they planted aside beans (b) when and why farmers planted beans and the yields of the crop (c) whether they planted determinate or indeterminate beans and the heights of stakes they used for the indeterminate varieties (d) problems faced by farmers when beans was planted during the rainy or dry seasons and how they mitigated these problems (e) Reasons for immediate use of their beans after harvest

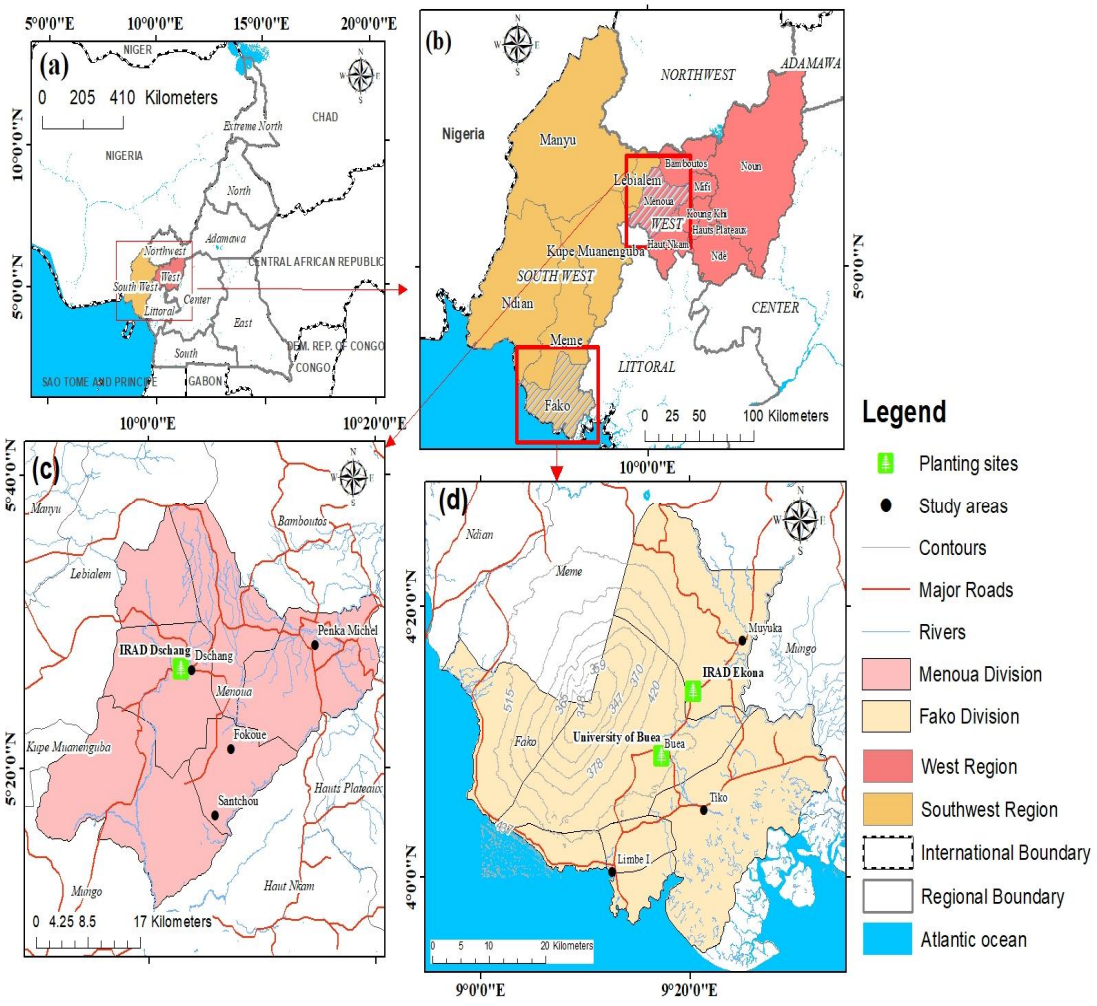

Fig. 1. Maps of Cameroon (a) South West and West regions (b) and the study sites (c) and (d).

2.3 Data Analysis

Data collected were keyed into Microsoft Excel spread sheet 2016 and analyzed using statistical packages for social sciences (SPSS) software, version 17.0. Analysis of variance (ANOVA) was performed at 95% confidence level to compare the findings. Significant data means were compared using Tukey's HSD $P< 0$.

Frequency distribution and percentages were used to describe the findings of the survey.

3. RESULTS

3.1 Socio-demographic and Gender Distribution of Farmers

Out of 356 farmers interviewed in the savanna highlands (Dschang), there were101 (27.98%) males and 260 (72.02%); females: in the humid rainforest (Buea) out of 163 interviewed, 37 (23.42%) were males and 121 (76.58%) females giving a total of 519 farmers interviewed in both ecozones (Fig. 2).

3.2 Level of Education

Very few of the beans farmers, 84 (43.1%) from both regions had no formal education. In Buea, 48 (30.4%) had no formal education followed by 58 (36.7%) and 39 (7.5%) who had attended primary and secondary education, respectively. For Dschang, most 161 (44.6%) had secondary education, followed by 98 (27.1%) and 66 (18.3%) who had primary and tertiary education, respectively while 36 (12.7%) hadno formal education (Fig. 3).

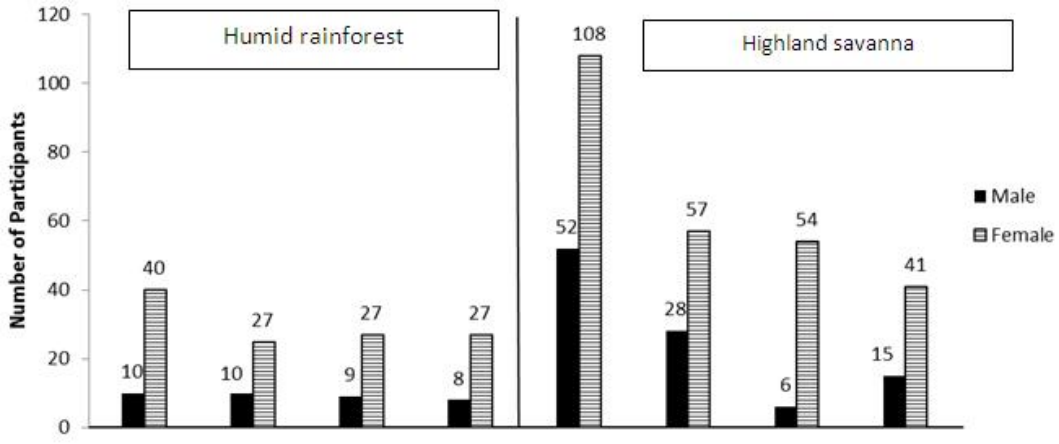

Fig. 2. Gender distribution of respondents in the various areas surveyed.

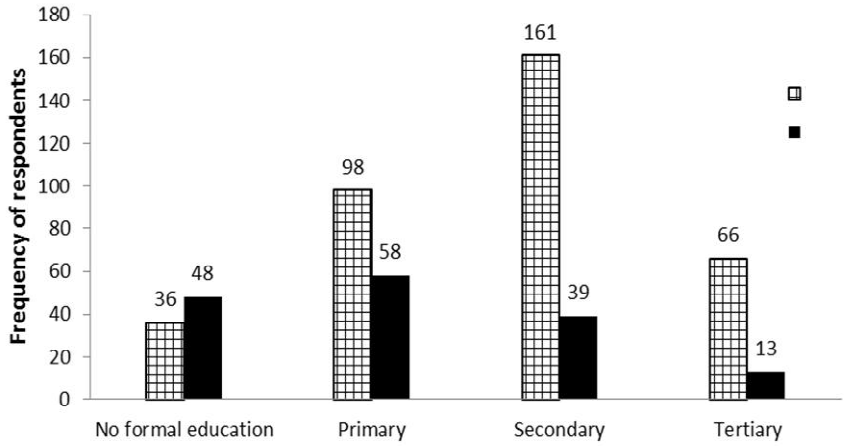

Fig. 3. Educational level of beans farmers (respondents) in the various areas of study

3.3 Bean Farm Sizes in The areas Studied

Most bean farmers in the highland savanna, 166 (45.98%) and 119 (75.32%) in the humid rainforest, grew beans in farms <1Ha (Fig. 4).The bean farms in the highland savanna were generally larger than those jn the humid rainforest where only 2 (1.27%) of bean farmers compared to 35 (9.69%) in the highland savanna grew beans in farms >2Ha (Fig. 4).

3.4 Different Legumes Cultivated Apart from Common Beans

The majority of respondents in the humid rainforest 147(93.04%) and 258 (71.47%) in the highland savanna planted other legumes alongside common beans. Groundnut was most frequently cultivated alongside with beans in the highland savanna 176 (68.22%) compared to 114 (77.55%) in the rainforest; this was followed by cowpea, then soybeans. Only 10 (3.88%) of the participants cultivated pigeon pea in the highland savanna and none in the rainforest (Fig. 5).

3.5 Bean Yieldsper Hectarein the Areas Surveyed

Most farmers in the highland savanna, 267 (73.96%) produced between 1-3 bags/ha of beans of 50 kg each, followed by 22 (6.09%) with 4-6bags (Table 5). In the rainforest, most farmers 139 (87.97%); also produced 1-3 bags of beans, but none in this region produced >6 bags. Generally, more beans is produced in the highland savanna than in the humid rainforest; these differences are statistically significant (P<0.05).

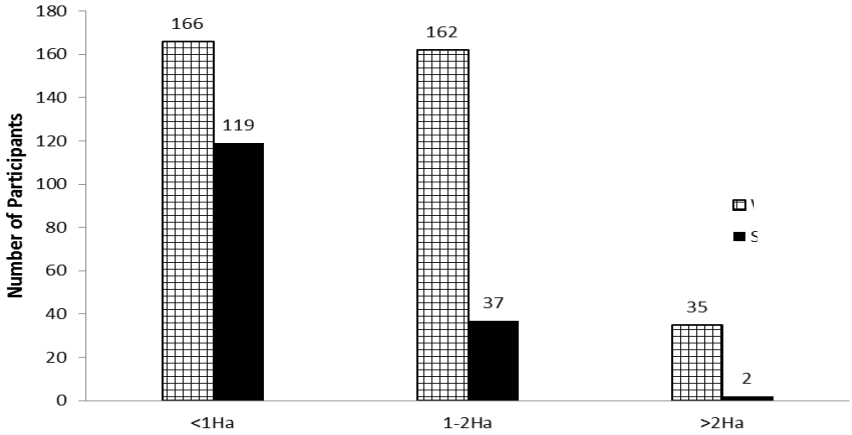

Fig. 4. Beanfarm sizes (Ha) in the various areas studied

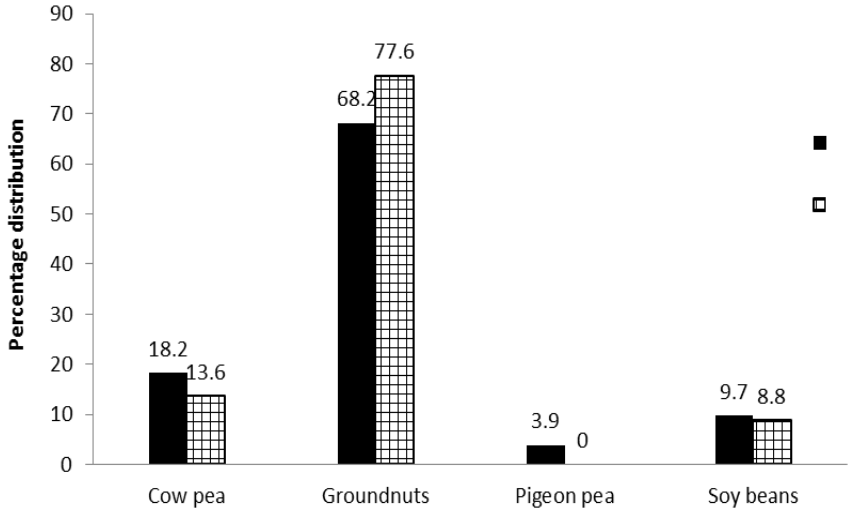

Fig. 5. Different legumes cultivated alongside common beans in the areas studied

Table 1. Quantities of beans (50 kg bags)/ha produced by farmers in the areas surveyed

Eco-zone	Bean yields in 50 kg bags (%)/ha					
	<1	1-3	4-6	7-9	10-12	>12
Highland Savanna	3 (0.83)	267(73.96)	22 (6.09)	5 (1.39)	4 (1.11)	3 (0.83)
Rainforest	10 (6.33)	139 (87.97)	9(5.69)	0(0.00)	0(0.00)	0(0.00)

X^2: 30.1412, P value: 0.012

3.6 Months When Farmers Planted Beans and their Reasons

The preferred months of planting beans in the humid rainforest were September as indicated by 114 (72.15%) of farmers, August89 (56.32%), and March 31 (19.62%), respectively. In the highland savanna, the preferred months of planting beans were March as reported by 256 (70.91%) of farmers and 147 (40.72%)for September. Generally, the period when beans are planted in the highland savanna ranged from February to October with a major peak in March and a minor peak in September (Table 2).

The most popular reasons given by farmers for planting beans during the different months were to control insects, followed by that the month

selected was the best planting period and then also to control diseases.

Most farmers who planted in March in the humid rainforest reported that their main reason was to control insects as indicated by 29 (32.58%) while in the highland savanna, most of those who planted in March stated that it was the best month of planting reported by 34 (13.28%). Most 58 (50.88) farmers in the humid rainforest and 82 (55.78) in the highland savanna who planted in September advanced no reason for planting during this month (Fig. 6). Overall, based on the farmers' responses, the best period to plan beans in the highland savanna was March and September in the humid rainforest (Fig. 6).

3.7 Reasons Why Farmers grew Beans

The main reasons for planting beans advanced by 169 (46.81%) and 90 (56.96%) of farmers in the highland savanna and humid rainforest, respectively was both for selling and domestic consumption. This was followed by those who planted beans only for domestic consumption as reported by 119(32.96%) and 50(31.64) in the humid rainforest and highland savanna respectively (Table 3).

3.8 Problems Faced by Farmers when Beans Was planted during the Rainy Season

Majority of farmers in both regions faced problems when beans was planted in the rainy season as reported by 318(88.09%) in the highland savanna and 130 (82.28%) in the humid rainforest (Fig. 7) while 43 (11.9%) in the highland savanna and 28 (17.7%) in the humid rainforest did not face problems producing beans during the rainy season (Fig 7).

Regarding those who reported that they faced problems with rainy season, 151 (47.5%) in the highland savanna and 68 (52.3%) in the humid rainforest reported that insects were the major production constraints. The second most reported production constraint was mold in both regions (Table 4).However, there was no statistically significant difference.

Table 2. The preferred months of planting beans by farmers in the West and South West Regions and their various reasons

Region	Months	Frequency of respondents (%)	Reasons (%)			
			Best planting period	Control diseases	Control insects	No reason
South West	January	1(0.63)		1(100.0)	-	-
	February	2(1.27)	-	1(50.0)	1(50.0)	-
	March	89(56.33)	8(8.99)	12(13.48)	29(32.58)	27(30.34)
	April	2(1.27)	2(100.0)	-	-	-
	May	1(0.63)	-	-	1(100.0)	-
	June	1(0.63)	-	-	1(100.0)	-
	July	-	-	-	-	-
	August	31(19.62)	2(6.45)	3(9.68)	11(35.48)	16(51.61)
	September	114(72.15)	14(12.28)	18(15.79)	38(33.33)	58(50.88)
	October	8(5.06)	5(62.5)	3(37.5)	4(50.0)	1(12.5)
	November	-	1	-	-	-
West	January	11(3.05)		-	1(9.09)	7(63.64)
	February	62(17.17)	2(3.23)	-	3(4.84)	51(82.26)
	March	256(70.91)	34(13.28)	4(1.56)	26(10.16)	19(7.42)
	April	12(3.32)	4(33.33)	2(16.67)	7(58.33)	2(16.67)
	May	34(9.42)	1(2.94)	-	-	1(2.94)
	June	7(1.94)	2(28.57)	2(28.57)	1(14.28)	2(28.57)
	July	54(14.96)	-	2(3.70)	2(3.70)	2(3.70)
	August	48(13.29)	10(20.83)	5(10.42)	25(52.08)	15(31.25)
	September	147(40.72)	22(14.96)	19(12.92)	30(20.41)	82(55.78)
	October	58(16.07)	8(13.79)	6(10.34)	16(27.59)	29(50.00)
	November	11(3.05)	1(9.09)	-	2(18.18)	3(27.27)

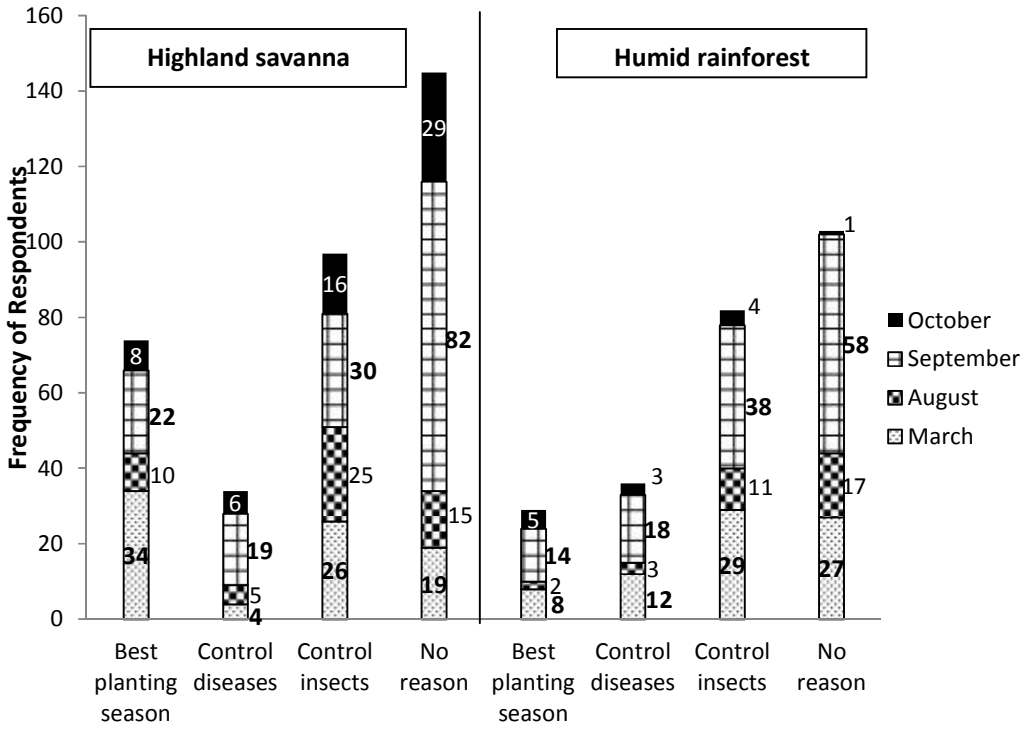

Fig. 6. Most frequent months that farmers plant beans and their reasons

Table 3. Numbers and percentages of farmers in parentheses who used beans for different purposes in the regions studied

Region	Both sales and consumption)	For domestic consumption	For sale	Feed animals	Total
Humid rainforest	90 (56.96)	50 (31.64)	18 (11.39)	0 (0.00)	158 (30.44)
Highland savanna	169 (46.81)	119 (32.96)	17 (4.71)	56 (15.51)	361 (69.55)
Total	259 (49.90)	169 (32.56)	35 (6.75)	56 (10.79)	519(100.00)

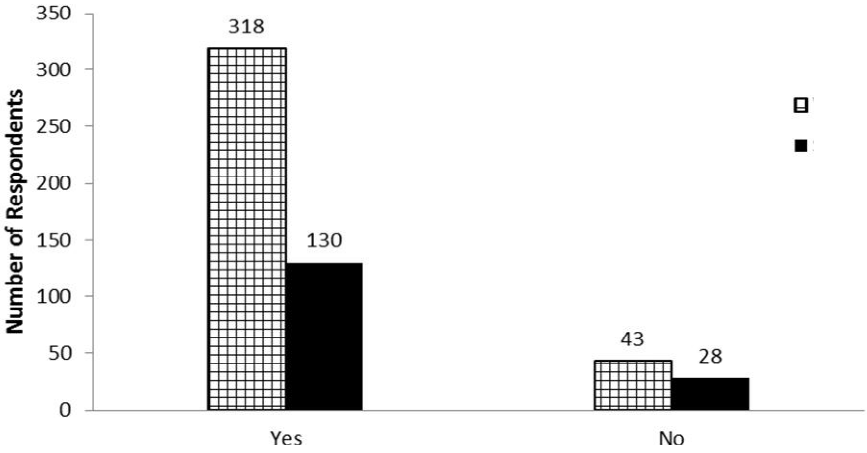

Fig. 7. Participants' responses to whether they face problems when beans was planted in the rainy season

Table 4. Problems faced by farmers in the humid rainforest and highland savannawhen beans was planted and matured in the rainy seasons

Problems	Highland savanna (%)	Humid rainforest(%)	Total 9%)
Birds	32(10.1)	4 (3.1)	36 (8.0)
Excess rainfall	7(2.2)	3 (2.3)	10 (2.2)
Insects	151(47.5)	68 (52.3)	219 (48.9)
Mold	128(40.3)	55 (42.3)	183 (40.8)

X^2:3.540, P-value:0.170

3.9 Farmers' Notion of Where Mold Attacks their Beans along the Value Chain

Most farmers in the highland savanna and humid rainforest 334 (92.52%) and 143 (90.51) respectively reported that they face serious problems with mold. In the highland savanna 142 (42.51%) and humid rainforest 124 (86.71%) of the farmers revealed that mold attacked their beans both in the field and storage. Very few farmers in the humid rainforest 13 (9.09%) stated that mold attacked their beans only in the field while 6 (4.19%) t reported that mold was a major problem only during storage (Fig. 8).

3.10 Problems Faced with Beans that Matured during the Dry Season

In both ecozones, 427 (82.27%) of the farmers reported that they faced problems when beans matured in the dry season. In the highland savanna 292 (80.89%) of the farmers reported that they faced such problems as against 135 (85.44%) in the humid rainforest.

The most important constraint when beans was planted during the dry season was inadequate rainfall/drought/ in the highland savanna as reported by 120 (41.09%) of the farmers while birds were the main problem in the humid rainforest as reported by 60 (44.44%) of the respondents. The second most important constraint were insect pests as reported by 105 (35.96%) and 43 (31.85%) of the respondents in the highland savanna and humid rainforest respectively (Table 5). Mold was considered the least important constraint of producing beans during the dry season in both ecological zones (Table 5).

3.11 Conventional Pesticides Farmers Used to Control Mold in the Field

Most farmers, 273 (75.62%)in the highland savanna and 147 (93.04%) in the humid rainforest reported that they do not use conventional pesticides to control mold or rot compared to 88 (24.38%) and 11 (6.96%) in these respective ecological zones who used conventional pesticides to control mold or rot.

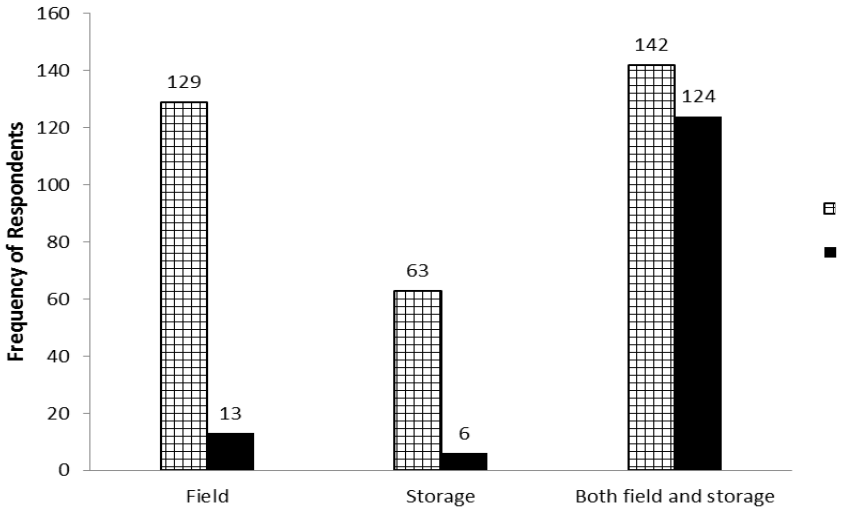

Fig. 8. Farmers' 'idea of where mold is most serious along the beans value chain

Table 5. Problems faced by farmers when beans is planted in the dry and rainy seasons

Problems	Humid rainforest (%)	Highland savanna (%)	Total (%)
Dry season			
Birds	64 (21.91)	60 (44.44)	124 (29.04)
Inadequate rainfall	120(41.09)	31 (22.96)	151 (35.36)
Insects	105(35.96)	43 (31.85)	148 (34.66)
Mold	3 (1.03)	1 (0.7)	4 (0.94)
Total	292(100.0)	135(100.0)	4249(100.0)
Rainy season			
Birds	4 (3.1)	32(10.1)	36 (8.0)
Excess rainfall	3 (2.3)	7(2.2)	10 (2.2)
Insects	68 (52.3)	151(47.5)	219 (48.9)
Mold	55 (42.3)	128(40.3)	183 (40.8)
Total	130(100.0)	304(100.0)	448(100.0)

For those who used conventional pesticides to control mold or rot, when asked to mention the chemicals they used, surprisingly some mentioned chemicals that turned out to be insecticides such as Dusband®, Cypercal®, Paraster® and Cigon® and many others in the highland savanna; some even mentioned herbicides such as glycot® as well as the fertilizer plantonus® (Table 6). Some of the farmers in the highland savanna correctly reported that they used fungicides such as callomil®, manizang® and ridomil® while all the farmers in the humid rainforest mentioned instead insecticides such as counter® and cyperca®l (Table 6).

3.12 How Farmers Handle Beans Immediately After Harvest

Most farmers in both ecological zones who allowed beans to dry reported that they wanted to extend the shelf live as indicated by 53 (53.0%) in the humid rainforest and 93 (47.69%) in the highland savanna for first season beans, and 67 (54.47%) and 67 (22.41%) respectively, for second season. For those who harvested first season beans fresh, 25 (39.06%) of farmers in the humid rainforest stated that fresh beans is more nutritious while 50 (54.35%) of those in the highland savanna stated that they harvested fresh beans for family consumption. For those who harvested second season beans fresh, lack of drying facility was the most popular reason in the humid rainforest as reported by 9 (52.94%) and 23 (37.70%) in the highland savanna. Selling for income was the main reason for those who sold first season beans in the humid rainforest and second season beans in both regions (Table 7).

3.13 Farmers' Responses Regarding Climbing Bean Varieties and Heights of Stakes Used

Majority of the farmers, 105 (66.46%) in the humid rainforest and 237 (65.65%) in the highland savanna reported that they do not plant climbing bean varieties while 53(33.54%) and 66(18.28%) in the respective ecological zones planted climbing varieties of beans. For those who planted the climbing varieties, most in the humid rainforest 40 (75.47%) and 49 (74.24%) in the highland savanna had no idea of the heights of stakes used, while 10 (18.87%) and 3 (4.54%) in the respective ecological zones used bamboos of 1 m high (Table 8).

4. DISCUSSION

The results revealed that most beans farmers in humid rainforest and highland savanna were females which corroborates earlier studies that in most parts of Africa and Cameroon in particular most subsistence and small scale farmers are women [22].

Most of the farmers in the study areas had no formal education which is in conformity with similar studies carried out in Nigeria on Grain storage and management of Insect pests [23].The lack of formal education amongst farmers is often a hindrance to new knowledge and technology adoption since these farmers will be unable to grasp and apply novel developments.

Table 6. Conventional pesticides reportedly used by farmers to control mold/rot in the study areas

Type	Class	Type/Family	Active Ingredient	Highland savanna (%)	Humid rainforest (%)
Poudrox®	Organophosphate	Contact insecticide	Melathion 50 g/kg	15(17.05)	-
Plantonus®	Organophosphate	Fertiliser	NPK 20.20.20 +Oligo Elements	1(1.14)	-
Callomil®	Copper -based	Wide spectrum systemic fungicide	12% metalaxyl+60% Cuprous oxide	6(6.82)	-
Cypercal 12EC®	Pyrethroids	Contact Insecticide	Cypermethrine12 g/L	8(9.09)	-
Cypercal 50EC®	Pyrethroids	Contact Insecticide	Cypermethrine 50/L	2(2.27)	6(54.54)
Dursband 40EC®	Organophosphate	Contact Insecticide	Ethylchloropyrifos480 g/L	19(21.59)	-
Glycot®		Systemic herbicide	Glyphosphate 41/% SL	1(1.14)	-
Pyriforce®	Organophosphorus	Insecticides	Chlopyriphos-ethyl60 g/L;EC	4(4.54)	-
Parastar 40EC®	Neonicotinoid + Pyrethroids	Contact and Systemic Insecticide	20gr/kg Imidaclopride+20 gr/kg Lambdacyhalothrine	1(1.14)	-
Manizang®		Fungicide	Metalaxyl-m(80 g/kg) +Mancozeb(640 g/kg)	9(10.23)	-
Mucap/Counter®15FC	Organophosphorus	Nematocide/Insecticide	Terbufos	11(12.5)	5(45.45)
Antouka Super®	Organophosphate	Grain Protectant Insecticide powder	Pirimiphos-methyl 16 g/kg +Permethrine 3 g/kg:DP	3(3.41)	-
Cigogne®	Pyrethroids	Contact Insecticide	Cypermethrine	7(7.95)	-
Ridomil Plus 72WP®	Copper-based	Wide spectrum systemic fungicide	12% Metalaxyl +60% Cuprous oxide	1(1.14)	-
Total				88(24.38)	11(6.96)

Table 7. Ways farmers handle beans at maturity during the first and second seasons

Practice	First season		Second season	
	Highland savanna (%)	Humid rainforest (%)	Highland savanna (%)	Humid rainforest(%)
Allow to dry	195(54.02)	100(63.29)	299(82.83)	123(77.85)
Harvest fresh for consumption	92(25.48)	64(40.51)	61(16.89)	17(10.76)
Sell fresh	27(7.48)	12(7.59)	17(4.71)	4(2.53)

Table 8. Heights of bamboo stakes used by farmers to support climbing beans varieties

Region	75cm N (%)	1m N (%)	1.5m N (%)	2m N (%)	No idea N (%)
Humid rainforest	0(0.00)	10(18.87)	3(5.66)	0(0.00)	40(75.47)
Highland savanna	0(0.00)	3(4.54)	4(6.06)	1(1.51)	49(74.24)

X^2:50.016, df: 8, p value: 0.000

Famers in the humid rainforest planted beans mostly in the month of August and September as opposed to the highland savanna where beans is planted in March, September and October. This is understandable since the humid rainforest ecological zone has a long rainy season stretching from March to November with a peak in August in contrast to the highland savanna ecological zone with less rainfall and higher temperatures during the dry season suitable for more drought tolerant crops like common beans. Beans planted in March in the humid rainforest matures in the heart of the rainy season (June-July) and hence most of the pods get moldy in the field due to the very humid environmental conditions conducive for mold growths. Consequently, planting beans in the humid rainforest ecozone in September appears to be a sensible way to ensure that the crop matures in the dry season for the pods to get dry in the field to acceptable moisture content to minimize mold-induced post-maturity losses. Beans in the highland savanna is planted in March since this zone has less rainfall and low humidity which render the bean pods less prone to rot. Also, in March, the farmers often inter crop indeterminate bean varieties which mature in piece meal and are harvested before rot sets in.

The main problems faced by beans farmers in both ecological zones were insects, followed by mould then birds for the rainy season beans. This corroborates similar findings in the Center and South Regions of Cameroon [24] and also those of Abate [25] that insects are the major constraint of bean production in many African countries. These insects attack all parts of beans during all the growth stages from seedling to storage. They feed on the different parts of the plants and also create avenues for diseases. Rot/mold was reported as one of the main constraints to bean production in the humid rainforest during the first planting season (March-July); this may be attributed to the heavy and frequent rains during this period which cause increases in relative humidity [26] conducive for the proliferation and development of fungi.

Most farmers in the humid rainforest despite planting beans mostly during the second seasons often lacked dry beans throughout the year compared to those in the highland savanna. This is presumably because beans cultivated during the second seasons are severely damaged by weevils due lack of appropriate safe storage facilities. This is consistent with other studies [27] that beans quantity and quality is reduced in storage by bruchids. In contrast, farmers in the highland savanna often have beans throughout the year because of adequate drying and storage facilities. These farmers use drying ovens, fuel wood kitchens that are frequently heated to protect the crop from mould/rot attack especially for the rainy season beans.

The rot/mould problem was reported in both ecological zonesas a major constraint both in the field and storage. This is obviously due to the heavy and frequent rains and high relative humidity that prevail during the harvest period conducive for mold growth prior to harvesting and even in storage. This supports earlier findings in the Western highlands of Cameroon that most grains harvested during the rainy seasons have favourable conditions for infections

by fungi and subsequently mycotoxin contamination [28,29]. To manage rot/mould problems, most of the farmers sensibly used various methods of drying the crop; some dried beans under the sun while others smoked it in fuel wood kitchens. Drying grains to safe moisture levels is an effective methods to prevent mould growth [30]; smoking is also an efficient method of reducing moisture content and protecting beans grains against fungal infection and also insect infestations [31].

Most farmers also faced problems with the insects that damage their grains in the fields and also those carried into storage. This is not surprising since insect are known to be very destructive to cereals and legumes in general and their infestations often begins in the field and continues in storage [32,33,34]. Insects are gotten from the field into storage possibly because beans in the humid rainforest is planted in August and September and usually allowed after maturity to dry in the field thereby predisposing the pods to insect infestations which subsequently are carried into storage. Farmers in both ecological zones were also of the view that insect damage on their beans was more important than the rot/mould problem and that these insect attacks also increase mold problems. This is sensible since storage fungi normally accompany or follow insect infestations [35] partly because of the metabolic heat and water generated by insects in stored foods which eventually increases the water activity and temperature of the commodity to levels suitable for fungal growth and multiplication [36,37]. Most of the farmers dried beans on the bare grounds which further predisposes the grain to mould contamination and hence mycotoxin production [38]. A good proportion of farmers in the study areas used tarpaulins to dry their beans. The major reason advanced for using tarpaulins was to avoid accumulation of sand particles in the produce which often makes sorting of the grains for consumption or sale difficult. Most of the farmers relied more on the use of synthetic chemicals to control insects than the reduced-risk plant-based products. This is contrary to the current interest in reducing environmental contamination and global warming which have prompted the re-evaluation and intensification of environmentally friendly and cost effective pest management technologies such as the use of traditional botanicals. Such plant-based indigenous pest control practices have remained largely underexploited due to limited resources allocated for such research [39,40]. The use of botanicals could be an important component for the development of practical integrated pest management programs. As regards storage, the majority of farmers in the study areas stored the produce in their living houses mainly in polyvinylchloride (PVC) bags, though a few farmers stored their grains in traditional granaries. These indigenous storage methods are often not quite appropriate to prevent insect infestations which usually also facilitate the proliferation of various molds in storage. The major stored bean insects observed in the study areas were, *Acanthoscelides obtectus* and *Zabrotes subfasciatus* which emerged from the dry beans purchased from farmers and incubated in the laboratory. This agree with earlier reports that these two weevil species are cosmopolitan and also the major insect pests of stored beans in Africa [41]. It would therefore be sensible and vital to seek for low-cost and sustainable methods of mitigating the effects of these insects in storage as a means of contributing to improved nutrition and food security in Africa.

5. CONCLUSION

The studies revealed that most beans farmers in the areas studied faced problems with bean rot/mold and insects which are brought from the fields into the stores. The insect problems were more important in storage. This constraint is usually partly controlled by appropriate drying of the beans. The farmers also relied more on synthetic chemicals to control these insects than the use of environmentally friendly methods like local plants and their derivatives. These insects exacerbate the prevalence of rot/moldy beans and also cause increases in bean prices despite the use of synthetic chemicals.

CONSENT

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

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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