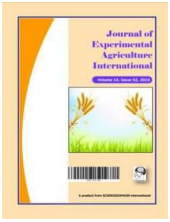

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Farmer's Knowledge and Perception on Factors Limiting Maize Storage and Their Management in the Humid Rainforest and Highland Ecozones of Cameroon

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Authors' contributions

This work was carried out in collaboration between all authors. Author DN managed the literature searches, performed the statistical analysis, wrote the protocol, and the first draft of the manuscript. Authors NNN and EBF managed the analyses of the study. Author NNN designed the study. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The study sought to determine planting dates, handling of the crop when mature and if farmers faced problems with maize ear rot/mould, insects and any other constraints and how they control these problems.
Study Design: Random interviewing of maize farmers.
Place and Duration of Study: Interviewed farmers in Ndop and Buea of the humid rainforest and highland ecological zones which are two agro-ecological zones of Cameroon respectively from September 2014 to January 2016.
Methodology: Structured questionnaires administered randomly to 300 farmers with 150 each from Ndop and Buea to document the constraints of handling and storing maize after maturity.

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Results: The results showed that most farmers, 139 (92.7%) in Ndop and 123 (82.0%) in Buea planted maize in March. Most farmers in Ndop 137 (92.7%) stored maize in barns while most in Buea 106 (70. 7%) stored in bags**.** Most famers in Ndop 119 (79.3%) and Buea127 (84.7%) faced problems with maize ear rot/mould and this ear rot/mould is as a result of lack of storage infrastructure/drying facilities as most of them controlled this by drying; 96 (80.7%) out of those who had problems with ear rot/mould in Ndop dried maize in firewood kitchens and 96 (80.7%) of those in Buea sunned their maize as a control measure. They indicated that ear rot/mould prevented them from storing maize that was planted during first season (March, April and May). Also most farmers indicated they had problems with insects, 143 (95.3%) in Ndop and 117 (85.4%) in Buea. These insects create favourable conditions for ear rot/mould in Ndop ($\chi2 = 17.66$, $P = 0.001$) and Buea ($\chi2 = 13.71$, $P = 0.00$). Furthermore, Farmers in Buea reported that insects were gotten from the field in to stores ($\chi2 = 4.34$, $P = 0.04$) as well as those from Ndop ($\chi2 = 10.67$, $P = 0.001$). Famers had limited knowledge on the use of plant based products to control insects as only 4 (2.7%) used plant derivatives in Buea and relied more on the use of synthetic chemicals.
Conclusion: to sustainably control maize ear rot/mould and stored insect pests, the following integrated approaches can be used; timely harvesting of maize, using appropriate drying technologies supplemented with judicious use of synthetic pesticides and environmentally friendly methods like plant-based products which are underexploited in Ndop and Buea.

Keywords: Maize; rot/mould; insects; control; Ndop; Buea.

1. INTRODUCTION

Agriculture plays a prominent role in the economy of every country in sub Saharan Africa though it is widely seen as underperforming [1]. Agriculture is one of the principal sub-sectors in the economy of Cameroon in the absence of a strong industrial sector. It is the primary sub sector that contributes to the Gross Domestic Product (GDP) of Cameroon [2]. Agriculture is a source of income for farmers, affiliated entrepreneurs, government and a major source of employment as well as a 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. Most of the new generation agriculturists grow a wide range of short duration crops such as fruit and leafy vegetables, selected legumes and various cereals depending on soil the conditions and water availability.

Maize (*Zea mays* L.) is the third most important cereal in the world after wheat and rice [3]. Maize has historically played an important role in the quest for food and the struggle for human survival and is suitable in addressing the problems of food scarcity in most parts of the World [4]. It is an important cereal crop in developing and underdeveloped nations of Sub-Saharan Africa and South-east Asia where it serves as a source of food, feed and industrial raw material [5]. In Cameroon, it is one of the most important cereals cultivated and consumed in all regions.

Maize is grown by small-scale farmers with post-harvest losses recognized as being one of the critical constraints to food security among these resource poor farmers across Africa [6,7]. These post-harvest losses are caused by various exogenous and endogenous biotic and abiotic factors some of which start in the field and continue during storage. The abiotic factors that can cause losses are moisture content of maize, temperature of the storage environment and the sanitation of the storage environment while the biotic factors include fungi, insects, rodents and birds [8]. Of these biotic factors, insects constitute a major problem as grain weight loss of 20–30% on average has been recorded [9] and up to 80% loss may occur for untreated maize grain stored in traditional structures depending on the period of storage [10,11]. Postharvest insect pests cause serious quantitative and qualitative losses to cereals and in most cases they also create favourable conditions that pre-dispose the stored grains to secondary attack by micro-organisms (*Aspergillus* spp., *Penicillium*, spp. and *Fusarium* spp*.)* and their proliferation in the grains [12,13]. These cause most farmers to sell their maize at lower prices soon after harvesting to avoid anticipated storage losses and later buy food at higher prices. For those that store maize, they use synthetic chemicals that have adverse effects on human health and the environment in

general and may also induce resistance in insects.

Therefore, in order to meet the food demand for the ever increasing world population, it is necessary to address the issue of maize grain quality and quantity losses in storage. A major step in achieving this is by first identifying the problems that cause these qualitative and quantitative losses and also have farmers' views on how they deal with these problems. This study therefore investigated the knowledge and perception of farmers on factors that constrain maize storage and their control measures in two agro-ecological zones of Cameroon.

2. MATERIALS AND METHODS

2.1 Study Site

The survey was conducted in Ndop in the highland and Buea in the humid rainforest agro-ecological zones of Cameroon to identify maize storage constraints in Ndop and Buea districts. Ndop, is located 6.0603℃N, 10.4458℃E and at an altitude of 1195 m above sea level. It has an annual rainfall of 2300mm with two seasons; the dry season from November to March and the rainy season from April to October. Buea is located at 4.1537℃N and 9.2920℃E and 530 m above sea level. It is on the east slope of Mount Cameroon, with an annual rain fall of about 4,090 mm. It has an equatorial climate with a rainy season from March to Mid-November and a dry season from Mid-November to March.

2.2 Survey

Semi-structured open and close ended questionnaires were used in the survey. A total of 300 farmers (150 from Ndop and 150 from Buea) were interviewed. Farmers were selected randomly on the bases that each had been involved in maize cultivation for at least 10 years and was willing to participate in the study. Prior to administering the questionnaires, they were pre-tested on 10 farmers then improved upon to ensure that the respondents understood the questions. The questionnaire was develped in English and later translated to a local language spoken and understood by even illiterate farmers in the study areas.

The questionnaire sought to know: (1) When and why farmers planted maize; (2) how they dry and store their maize; (3) The maize cob or ear rot/mould problems encountered in the field and storage and their control measures; And (4) the maize ear insect pest problems in the field and storage and their control measures.

2.3 Data Analysis

Data collected was analysed using statistical package for social sciences (SPSS) software, version 17.0 (SPSS Inc. 2008). Frequencies and percentages were used to describe the findings. Data collected was analysed using statistical package for social sciences (SPSS) software, version 17.0 (SPSS Inc. 2008). Frequencies and percentages were used to describe the findings. Chi-Square analysis was also used to compare variables.

3. RESULTS

3.1 Demographic Data

Out of 150 farmers interviewed in Ndop, 21 (14.0%) were males and 129 (86.0%) females. For Buea, 29 (19.3%) were males and 121 (80.7%) females. This gave a total of 50 (16.7%) males and 250 (83.3%) females of the 300 farmers interviewed in both areas.

Most of the maize farmers 175 (58.3%) had no formal education. In Ndop, 81 (54.0%) had no formal education followed by 49 (32.7%) who had attended primary education, 19 (12.7%) had secondary education and 1 (0.9%) had a tertiary certificate. For Buea, most 94 (62.67%) had no formal education, followed by 32 (21.33%) with primary education, 20 (13.33%) had attended secondary school and 4 (2.67%) had a tertiary certificate.

3.2 Period (month) When Farmers Planted Maize and Their Reasons

Maize farmers in Buea reported that they planted the crop all year round while those in Ndop did not; most of the farmers in Ndop and Buea planted in March as indicated by 139 (92.7%) and 123 (82.0%) farmers respectively. Most of these farmers reported that they planted in March in order to benefit from adequate rainfall. The next popular month of planting maize in Buea was September as indicated by 87 (58.0%) farmers, followed by April with 54 (36.0%) and the least was June with 1 (0.9%) of farmers. They advanced varied reasons for planting maize during the different months (Table 1). Some of the reasons were to control rot, control insects, benefit from adequate rainfall, and to have maize when it is scarce in the market.

Table 1. Months farmers' planted maize in Buea and Ndop and their reasons

Month	Buea		Ndop	
	Frequency (%)	Reasons (frequency)	Frequency (%)	Reasons (frequency)
January	4(3.6)	get maize when it is scarce (4)	4(3.6)	get maize when it is scarce (4)
February	9(8.2)	get maize when it is scarce (9)	--	--
March	123(82.0)	benefit from adequate rainfall (63); None (31); Control rot (22); Control insects (5); reduce labour (2)	139 (92.7)	benefit from adequate rainfall (119); None (11); control insects (9)
April	54 (36.0)	none (23); Benefit from adequate rainfall (15); Get maize when it is scarce (8); Control insects (6); Control rot (2)	13 (7.3)	benefit from adequate rainfall (9); have maize when it is scarce (4)
May	11(7.3)	get maize when it is scarce(6); none (4); Reduce labour (1);	--	--
June	1(0.9)	get maize when it is scarce (1)	--	--
July	3(2.7)	benefit from adequate rainfall (2); Get maize when it is scarce (1)	--	--
August	29(26.4)	benefit from adequate rainfall(17); None (6); control insects (2); Get maize when it is scarce(2); Dry maize in the field (2)	--	--
September	87 (58.0)	benefit from adequate rainfall (39); none (25); Control rot (18); control insects (4); reduce labour (1)	--	--
October	7(4.7)	get maize when it is scarce (6); dry maize in the field (1)	--	--
November	2 (1.8)	have a swarm (1); Get fresh maize in dry season (1)	1 (0.9)	get maize when it is scarce (1)
December	4 (3.6)	get maize when it is scarce (3); Get fresh maize in dry season (1)	3 (2.7)	get maize when it is scarce (3)

Most farmers 125 (83.3%) and 117 (78.0%) in Ndop and Buea respectively planted maize both for sale and for food; 21 (14.0%) and 27 (18.0%) in Ndop and Buea respectively planted it solely for food and 4 (2.7%) and 6 (4.0%) respectively planted for sale only (Fig. 1).

Most farmers In Ndop 112 (74.7%) and Buea 126 (84.0%) indicated that they faced problems growing maize during the rainy season months, but the difference between these two localities was not significant ($\chi 2 = 0.67$, $P = 0.41$) as shown in Table 2. The most serious problems faced by farmers during the rainy months included damage by birds as reported by 66 (58.93%) of the farmers in Ndop and insect damage reported by 59 (46.8%) of respondents in Buea (Table 3).

Farmers in the two localities had different postharvest ways of handling first and second seasons' maize planted at the onset (March, April and May) and end (August, and September) of the rainy season respectively. For the first season in Ndop, 143 (95.3%) farmers allowed maize for the husk to turn brown in the field before harvest, 11 (7.3%) sold the corn fresh, and 3 (2.0%) harvested fresh. In Buea, 119 (79.3%) sold their maize fresh, 33 (22.0%) allowed it to turn brown before harvesting and 12 (8.0%) harvested fresh for home consumption. In Ndop, 133 (88.7%) farmers did not farm second season maize, 16 (10.7%) of those who farmed second season maize sold the crop fresh and 4 (2.7%) allowed it to get dry in the field before harvest. For Buea more farmers planted second

season maize than Ndop and most 129 (86.0%) farmers allowed their maize to dry in the field prior to harvest during second season. Some farmers 41(27.3%) sold the maize fresh, 11 (7.3%) harvested fresh and 2 (1.3%) did not plant second season maize (Table 4).

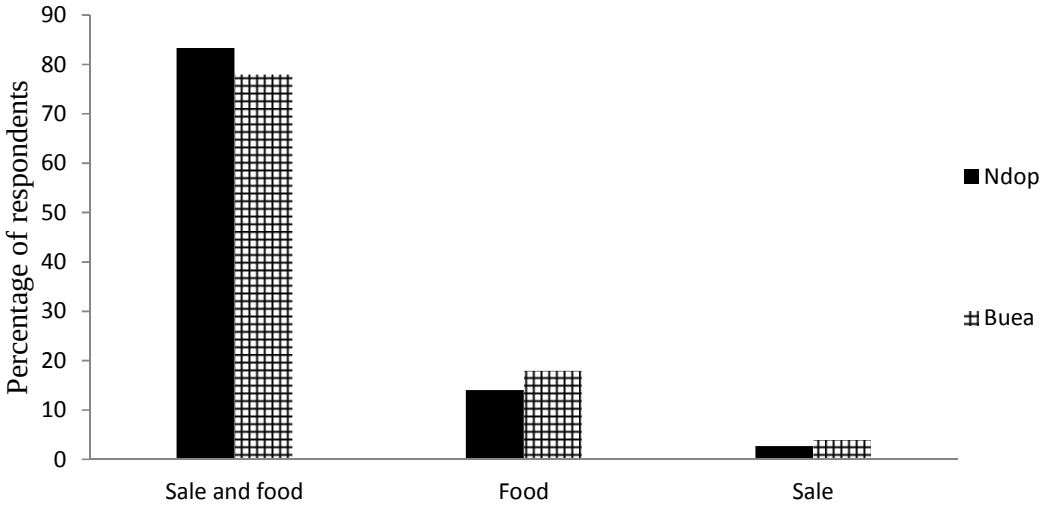

Fig. 1. Percentage of farmers who used maize for different purposes

Table 2. Chi-square cross-tabulations for various variables studied

Description		locality	
		Ndop	**Buea**
Problem growing maize during rainy season months	Yes	112	126
	No	38	24
Level of significance		χ^2 = 0.67, P = 0.41	
Opinion if farmers had maize throughout the year	Yes	103	23
	No	47	127
Level of significance		χ^2 = 59.13, P = 0.001	
Problem with maize ear rot	Yes	119	127
	No	31	23
Level of significance		χ^2 = 0.73, P = 0.39	
Problem with insects	Yes	143	137
	No	7	13
Level of significance		χ^2 = 2.31, P = 0.10	
Insects from field-to-stores	Yes	111	108
	No	39	42
Level of significance		χ^2 = 0.0, P = 0.56	
		Problem with insects	
		Yes	**No**
Increase in price of maize	Yes	251	29
	No	14	6
Level of significance		χ^2 = 22.81, P = 0.001	
Problem with maize ear rot	Yes	239	41
	No	4	13
Level of significance		χ^2 = 15.01, P = 0.00	
Insects from field-to-stores	Yes	212	68
	No	7	13
Level of significance		χ^2 = 6.09, P = 0.01	

Table 3. Percentage of farmers that faced different problems growing maize during the rainy season months

Ndop		Buea	
Problem faced	**Frequency (%)**	**Problem faced**	**Frequency (%)**
Damage by birds	66 (58.9)	Damage by birds	33 (26.2)
Damage by insects	47 (42.0)	Damage by insects	59 (46.8)
Inadequate rainfall	29 (25.9)	Inadequate rainfall	2 (1.6)
Ear rot/mould	16 (14.3)	Ear rot/mould	47 (37.3)
Lack of drying facilities	5 (4.5)	Lack of drying facilities	9 (7.1)
--	--	Too much rainfall at harvest	9 (7.1)
--	--	Lack of storing space	11 (8.7)

Table 4. Different ways the farmers handled maize at maturity

Ways of handling maize at maturity	Ndop	Buea
	Frequency (%)	**Frequency (%)**
First season		
Allowed husk to turn brown before harvest	143 (95.3)	33 (22.0)
Sold fresh maize	11 (7.3)	119 (79.5)
Harvested fresh maize	3 (2.0)	12 (8.0)
Second season		
Did not farm second season maize	133 (88.7)	2 (1.3)
Sold fresh maize	16 (10.7)	41 (27.3)
Allowed husk to turn brown before harvest	4(2.7)	129 (86.0)
Harvested fresh maize	--	11 (7.3)

3.3 Main Constraints of Drying and Storing Maize

The constraints of drying and storing maize varied with the season and study site. For first season maize usually planted at the onset of the rainy season in Buea, 64 (42.7%) of farmers reported that ear rot/mould was the main problem in storage, followed by 49 (32.7%) of farmers who complained of high and frequent rainfall at harvest. In contrast, the main problem against storing second season maize often planted towards the end of the rainy season was insect pests as reported by 97 (64.7%) of farmers, followed by lack of storing space (Table 5).

In Ndop, most farmers, 77 (51.3%) reported that insect pests were the main problem of storing first season maize while most 142 (94.7%) of farmers in this area did not farm second season maize while the few who grew second maize 6 (4.0%) sold their maize fresh and did not have a problem storing it (Table 5).

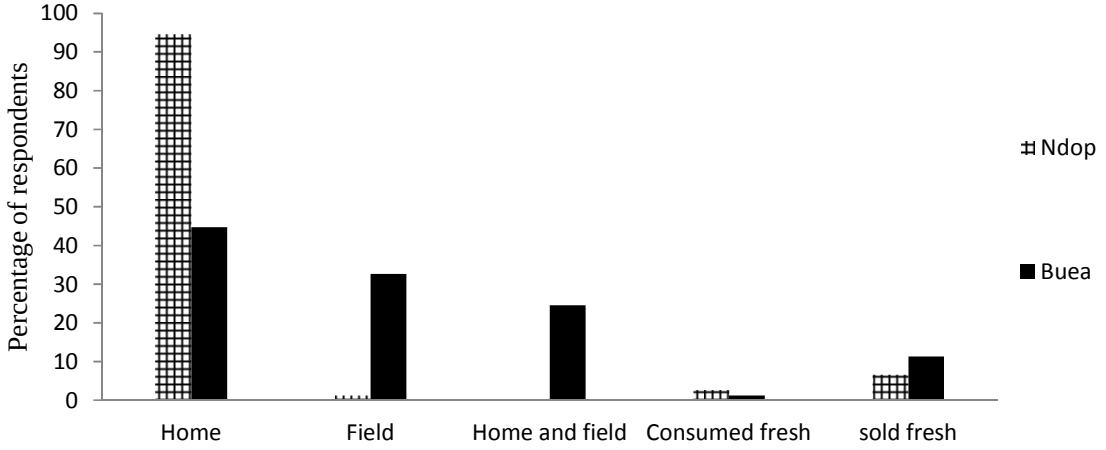

Fig. 2. Proportion of farmers indicating different areas where they dry their maize

Most, 142 (94.7%) of the farmers in Ndop dried their maize at home, 2 (1.3%) dried in the field, 10 (6.7%) sold maize fresh and 4 (2.67%) consumed the crop fresh. In Buea, 67 (44.7%) of the farmers dried maize at home, 49 (32.7%) dried it in the field, 27 (24.6%) dried both in the field and home and 17 (11.3%) sold maize fresh and 2 (1.3%) consumed the crop fresh (Fig. 2).

Farmers in Buea and Ndop stored maize in a variety of ways. In Buea, out of the 139 farmers who stored maize, 106 (70.7%) stored it in bags, followed by 71 (47.3%) who stored in barns, then 59 (39.3%) stored it in sealed containers, 10 (6.7%) hung the maize under verandas and 2 (1.3%) hung it in firewood kitchens. In Ndop, out of the 143 farmers who stored maize, 137 (92.7%) stored in barns followed by 61 (40.7%) who stored in bags, 10 (6.7%) in sealed containers, then 8 (5.3%) each who hung under verandas and firewood kitchens and 3 (2.0%) stored in a cribs (Fig. 3).

Table 5. Problems faced by farmers with storing first and second season maize

Problem	Ndop	Buea
	Frequency (%)	Frequency (%)
First season		
Ear rot/mould	45 (30.0)	64 (42.7
Insect pests	77 (51.3)	5 (3.3)
Too much rainfall at harvest	20 (13.3)	49 (32.7)
Lack of drying facilities	37 (24.7)	28 (18.7)
Lack of labour at harvest	12 (8.0)	--
Lack of storing space	3 (2.0)	11 (7.3)
Does not store maize	--	5 (3.3)
None	--	2 (1.3)
Second season		
Insect pests	--	97 (64.7)
Lack of storing space	--	29 (19.3)
Lack of drying facilities	--	19 (12.7)
Does not store maize	6 (4.0)	9 (6.0)
Lack of labour at harvest	--	4 (2.7)
None	2 (1.3)	4 (2.7)
Ear rot/mould	--	3 (2.0)
Does not plant second season maize	142 (94.7)	18 (12.0)

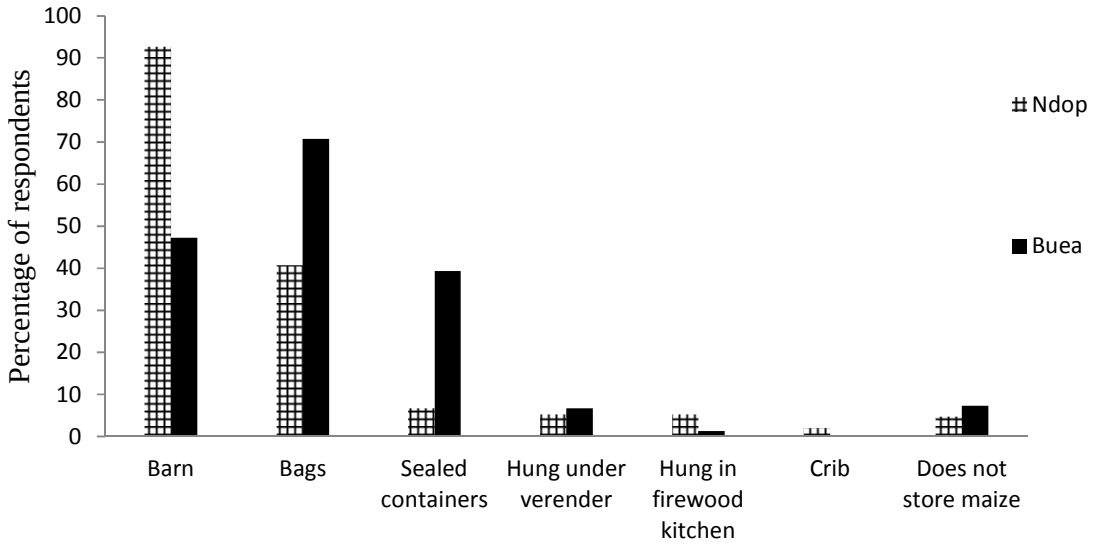

Fig. 3. Proportion of farmers indicating where they store maize

Out of the 139 farmers who stored maize in Buea, 94 (67.6%) stored it as threshed grains, 78 (56.2%) stored in the husk and 4 (2.9%) de-husked it before storing. For Ndop, 132 (92.3%) stored theirs in the husk, 56 (39.2%) as threshed grains and 8 (5.6%) de-husked the cobs before storing. Farmers advanced different reasons for storing maize in the various forms as shown in Table 6.

More farmers in Ndop 103 (68.7%) had dry maize throughout the year compared to Buea 23 (15.3%) and comparison between these two localities showed that there was a significant difference ($\chi 2 = 59.13$, $P = 0.001$). The farmers in the different towns advanced varied reasons for not having maize throughout the year as shown in Fig. 4.

Table 6. Different forms in which farmers' stored maize and reasons

Locality	Form of storage	Frequency (%)	Reasons	Frequency
Ndop	De-husked	8 (5.6)	From maize opened by birds	8
			To put in cribs	3
			To put in bags	2
	Threshed grains	56 (39.2)	From maize opened by birds	42
			To put in containers	13
			To put in bags	10
			Immediate use	9
			Lack of storing space	7
	In husk	132 (92.3)	prevent smoke	73
			prevent insects	64
			prevent dirt	10
			None	7
Buea	De-husked	4 (2.9)	To put in bags	4
	Threshed grains	94 (67.6)	To put in bags	69
			To put in containers	21
			Immediate use	13
			Lack of storing space	7
			To prevent insects	1
			To prevent dirt	1
			To put in hot water and store	3
	In husk	78 (56.1)	Prevent smoke	50
			Prevent insects	31`
			To hang on veranda	6
			Prevent dirt	6
			To spray with insecticide	4
			Later consumption	1
			None	1

Fig. 4. Reasons why farmers do not have maize throughout the year

Farmers in Ndop 126 (84.0%) and Buea 139 (92.7%) reported that the price of maize increased with the duration of storage because of scarcity of the commodity in the market. Also in Ndop, 44 (34.9%) reported that the increase in price of maize was due to an increase in demand for grain maize and while 3 (2.3%) of the farmers said the increase was because maize could not get dry in the field. For Buea, the next was 31 (22.3%) famers who indicated that the increase in prices was due to the fact that maize could not get dry in the field during first season and 17 (12.2%) said it was due to increase in demand (Fig. 5). Chi-square analysis between those who associated problems with storage insects and an increase in the price of maize from harvest to the next planting season was significant for Ndop ($\chi2 = 0.12.62$, $P = 0.006$), Buea ($\chi2 = 13.72$, $P = 0.005$) and when both localities were combined ($\chi2 = 22.81$, $P = 0.001$) (Table 2).

3.4 Ear Rot/Mould Problem and their Control

Most farmers in Ndop 119 (79.3%) and Buea 127 (84.7%) encountered problems with ear rot/mould though there was no significant difference between the two localities ($\chi2 = 0.73$, $P = 0.39$) (Table 2). As regard whether the ear rot/mould constraint was higher in the field or in storage, most 83 (65.4%) out of those who had problems with ear rot/mould in Buea and 67 (56.3%) out of those who had problems with ear rot/mould in Ndop indicated that it was more severe in both field and storage; 13 (10.2%) and 44 (37.0%) in Buea and Ndop respectively reported that the ear rot/mould problem was more severe in storage, while 31 (24.4%) and 8 (6.7%) in Buea and Ndop respectively indicated the problem but in storage (Fig. 6).

Farmers controlled maize ear rot/mould in varied ways, in Ndop 96 (80.7%) of them managed the problem through drying the harvested maize in firewood kitchens while most of the farmers in Buea 93 (73.2%) sunned their maize and 71 (40.2%) dried the maize in a fire wood kitchen but a few famers applied insecticides in both Ndop 8 (6.7%) and Buea 2 (1.6%) (Table 7). In Ndop, out of the 8 (6.7%) farmers who faced problems with maize ear rot/mould and used synthetic chemicals to deal with this problem; 7 (87.5%) of them used Gamalin® and 1 (12.5%) used Camphor®. In Buea, out of the 2 (21.6%) farmers who used synthetic chemicals to control ear rot/mould 1 (50%) used Cypercal® (cypermethrine) and the used a mixture of Mocap® (Ethopropos) and wood ash.

Table 7. Percentage of farmers who used different methods to control ear rot/mould in stored maize

Method of control	Ndop	Buea
	Frequency (%)	Frequency (%)
Drying in a firewood kitchen	96 (80.7)	71(40.2)
Sunning	14 (11.8)	93 (73.2)
Spacing maize in barn	17 (14.3)	11 (3.9)
Insecticides	8 (6.7)	2 (1.6)
None	9 (7.6)	30 (23.6)

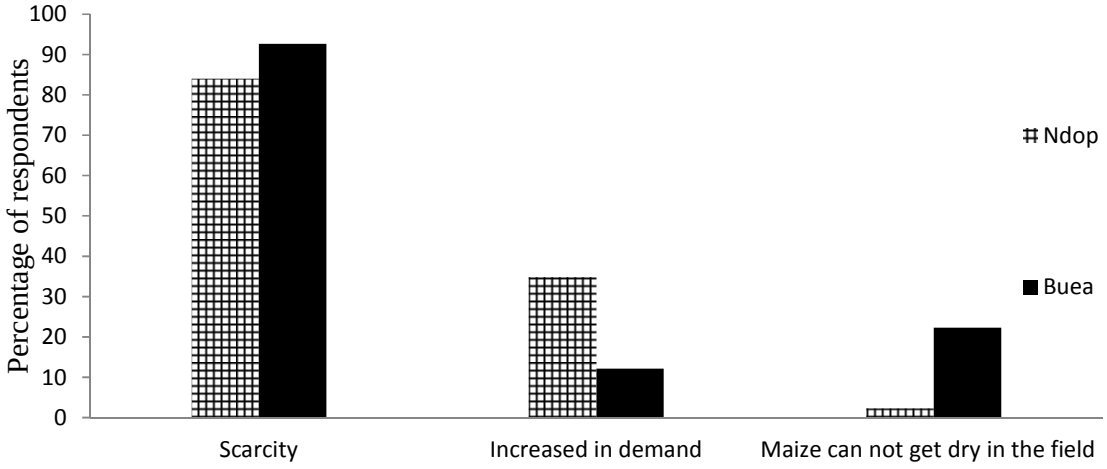

Fig. 5. Reasons for increases in maize prices

3.5 Stored Insect Problems and their Control Measures

Maize farmers in Buea and Ndop revealed that insects are a major problem that limits long-term storage of maize. In Buea and Ndop, 137 (91.3%) and 143 (95.3%) of the participants respectively reported that insects were the major post-harvest constraints of the crop. Out of those who had problems with insects, 117 (85.4%) in Buea and 100 (69.9%) in Ndop indicated that they encountered this in the field and in storage, while 8 (5.8%) and 33 (23.1%) for Buea and Ndop respectively in storage only and 10 (7.0%) and 12 (8.8%) indicated they had problems with insects only in the field for Buea and Ndop respectively (Fig. 7). There was no difference in both localities for those who accepted they had problems with insects ($\chi 2 = 2.31$, $P = 0.10$) (Table 2). There was a significant relationship between those who indicated they had problems with ear rot/mould and insects in Ndop ($\chi 2 = 17.66$, $P = 0.001$), Buea ($\chi 2 = 13.71$, $P = 0.00$) and when both localities were combined ($\chi 2 = 15.01$, $P = 0.00$) (Table 2).

Most farmers, 92 (61.3%) in Buea and 80 (53.3%) in Ndop did not use synthetic chemicals against the stored maize insect pests while 58 (38.7%) and 70 (46.7%) respectively used them. The most widely used insecticides in Buea was Mocap®, used by 29 (50.0%) of those who used insecticides followed by Actellic® powder 21 (36.2%). In contrast, in Ndop, the most widely used insecticide was Gamalin® 47 (67.1%), followed by camphor 28 (40.0%) and the least was 1 (1.4%) of the farmers who used a mixture of kerosene and corn powder (Table 8).

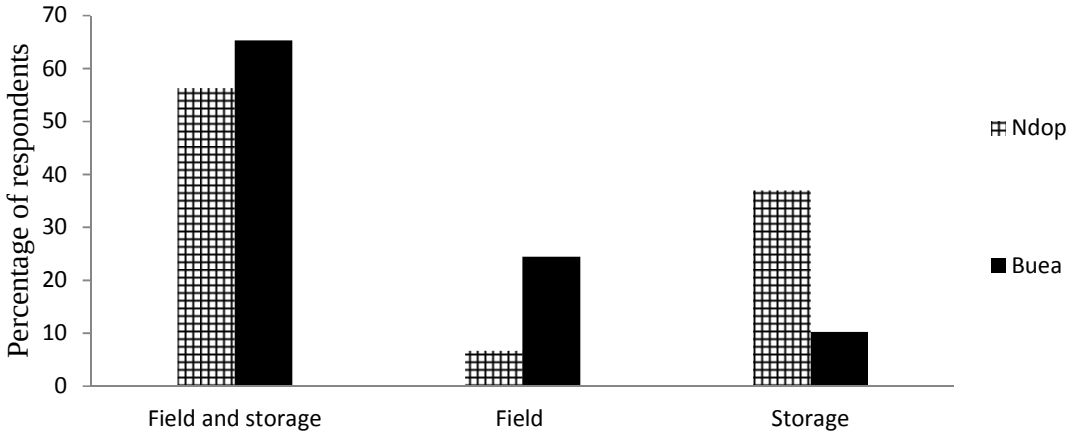

Fig. 6. Percentage of farmers who faced problems with maize ear rot/mould in the field and or storage

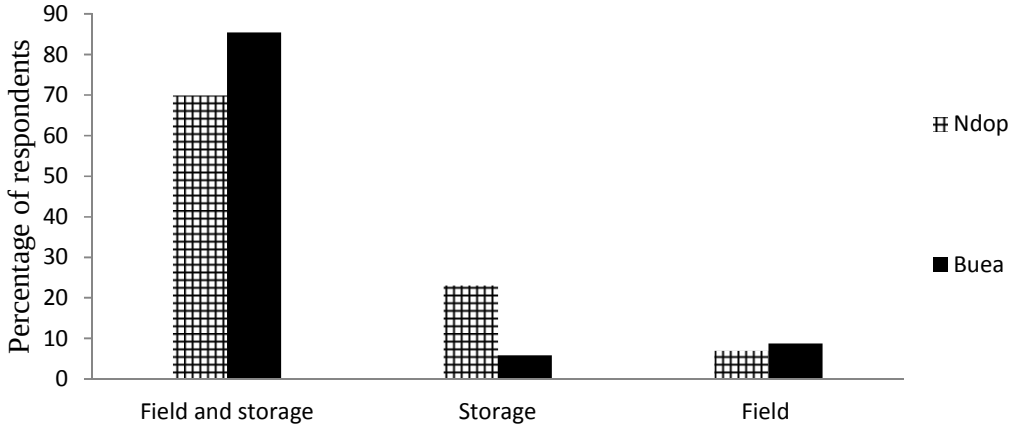

Fig. 7. Proportion of farmers facing problems with insects in the field and/or storage

Regarding whether farmers knew if insects could be brought from the field to stores, most respondents in Buea 108 (72.0%) and Ndop 111 (74.0%) knew while 42 (28.0%) and 39 (26.0%) respectively, did not know. There was no difference between the two localities regarding knowledge of whether insects were carried from the field in to stores ($\chi 2 = 0.0$, $P = 0.56$) (Table 2). Chi-square analysis between those who had problems with insects and the opinion if insects could be brought from the field in to stores was significant for Buea ($\chi 2 = 4.34$, $P = 0.04$), Ndop ($\chi 2 = 10.67$, $P = 0.001$) and when both localities were combined ($\chi 2 = 6.09$, $P = 0.01$) (Table 2).

There was limited knowledge in the use of local plants and their derivatives in Buea. Only 4 (2.7%) used local plants (cypress) to control stored product insects while 146 (96.3%) did not. Three of the farmers who used cypress reported that it was because it was free and one said it was effective. In contrast, Most farmers in Ndop 87 (58.0%) used local plants to control storage insects; 64 (73.6%) of these used cypress, followed by tobacco leaves 19(21.8%). Most of the farmers reported that they used these products because they were effective (Table 9).

Table 8. Insecticides used by farmers to control stored maize insects in Ndop and Buea

Locality	Insecticide (Active ingredient)	Frequency	Method of application
Ndop	Gamalin®	47	Spray on maize
	Camphor®	28	Place balls with maize
	Actellic® powder (Pirimiphos-methyl)	19	Sprinkle on maize
	Kerosene mixed with corn powder	1	Sprinkle on maize
Buea	Mocap® (Ethopropos)	29	Sprinkle on maize
	Actellic® powder (Pirimiphos-methyl)	21	Sprinkle on maize
	Cypercal® (cypermethrine)	4	Spray on maize
	Does not know	2	Spray on maize
	Parastar® (imidachlopride+ lambdacyhalothrine)	1	Spray on maize
	Cicogne® (cypermethrine)	1	Spray on maize
	Pacha® (acetamyprid+ lambdacyhalothrine)	1	Spray on maize
	Marshal® (Carbosulfan)	1	Spray on maize

Table 9. Farmers' methods of using various local plants to control insects in stored maize

Botanicals	Ndop	Buea	Method of application
	Frequency (%)	Frequency (%)	
Cypress (*Cupressus* ssp.) leaves	64 (73.6)	4(100.0)	dry leaves in barn
Tobacco (*Nicotiana tabacum*) leaves	19 (21.8)	0 (0)	dry leaves in barn
Sunflower (*Helianthus annuus)* leaves	6 (6.9)	0 (0)	dry leaves in barn
Dry garlic (*Allium sativum)*	1 (1.5)	0 (0)	mix maize with powder

Table 10. Different method used apart from synthetic insecticides or botanicals to control stored maize insects

Method	Ndop	Buea
	Frequency (%)	Frequency (%)
None	119 (79.3)	103 (68.7)
Cleaning of barn before storage	20 (13.3)	--
Sunning	6 (4.0)	19 (12.7)
Wood ash	7 (4.7)	5 (3.3)
Heating of maize in barn	3 (2.0)	--
Storing maize in sealed containers	--	11 (7.3)
Hot water treatment for few minutes	--	4 (2.7)

Apart from using synthetic insecticides or botanicals, in Ndop, 20 (13.3%) farmers practiced proper cleaning of barns before storage among other methods and 119 (79.3%) did not use any different method from synthetic chemical to control stored maize insects. In Buea, 19 (12.7%) of the farmers sunned their maize, 11 (7.3%) put the maize in sealed containers, 5 (3.3%) used wood ash, 4 (2.7%) used hot water treatment i.e. put their maize in boiled water for a few minutes prior to drying and 103 (68.7) did not use any different method apart from synthetic insecticides or botanicals (Table 10).

4. DISCUSSION

The results showed that most maize farmers in Ndop and Buea were females which corroborate earlier studies [14,15] that in most parts of Africa and Cameroon in particular most farmers are women. The results also revealed that most farmers in the study areas had no formal education which is in conformity with similar studies about a survey carried out on grain storage and management of insect pests in stored grain in Kebbi state in Nigeria [16]. This poses a serious problem to ecologically friendly pest management strategies as these farmers might be unable to understand the importance of such management practices as well as the demerits of synthetic pesticides on human health and the environment.

The famers in Buea planted maize during most months of the year as opposed to Ndop where they planted only during the months of January, March, November and December. This is understandable because Buea is the in the humid forest ecological zone that has a long rainy season stretching from March to November with abundant rainfall and optimal temperatures conducive for the planting of maize during most of these months. This is in contrast with Ndop situated in the highland ecological zone less rainfall and lower temperatures during the dry season optimal for more drought tolerant crops like beans (*Phaseolus vulgaris*).

The results showed that famers faced different problems growing maize during rainy season months in Ndop and Buea; the main problems in Ndop being damage by birds followed by insect damage while those in Buea being insect damage followed by ear rot/mould problem. These findings also can be attributed to the climatological differences between the two areas especially in case of maize rot or mould growth which is more prevalent under humid conditions as what prevails in the humid rain forest ecological zone. The findings in Ndop tie with earlier reports [17,18] that Maize damage by birds was on the increase as agriculture becomes more intensified. Besides the maize grains damaged/consumed by birds when they tear open the cobs, such damage is further detrimental because it leads to increase infestation by insects as revealed in this study. These findings are consistent with earlier studies that a tight and long maize husk can reduce weevil entry and thus grain damage [19]. Birds' damage on maize in the fields has an effect on increasing the numbers of insect pests that are carried from the field to the store. The generation of metabolic heat and water by insects in stored foods also increases moisture and temperature of the maize to levels suitable for fungal proliferation [20-22]. The fact that ear rot/mould appeared as one of the main constrains to maize production in Buea during the first planting season (March to May) may be attributed to the heavy and frequent rains during this period which continues till June/July when the crop is harvested. This is usually accompanied by an increase in relative humidity of the environments [23] which is conducive for the proliferation and development of fungi.

Most farmers in Buea despite planting maize during most of the months of the year did not have dry maize throughout the year compared to those in Ndop. This is mainly because most of the maize grown during the first season (major growing season) is usually sold and consumed fresh given the very humid environmental conditions during this season which are not favourable for the field drying of maize as commonly practiced in Buea. This agricultural practice by maize farmers in Buea to allow their crop to get dry in the field though more cost-effective and practical it predisposes the maize to infestation as reported from previous studies by [24] that the longer maize remains in the field, the greater the opportunity for stored grain insects to infest the grains. In contrast, farmers in Ndop stored their maize in the husk in fire wood kitchens that are frequently heated to protect the crop from ear rot/mould attack. It has been proven that a tight and long husk also reduces weevil entry and thus grain damage [19].

Maize ear rot/mould in Ndop and Buea was reported to be a major constraint both in the field and storage conditions. This could be mainly

attributed to heavy rains and high relative humidity that prevails during the harvest period of the crop and hence most of the maize gets mouldy in the field prior to harvesting so that when it is taken into storage, the mould spreads unto other healthy maize cobs. This is in line with earlier findings that in the western highlands of Cameroon, most grains are harvested during the rainy season, which creates favourable conditions for infections by fungi and subsequent mycotoxin contamination [25,26]. To manage the ear rot/mould problem, most of the farmers applied various methods of drying of the crop which is sound and expected. In Ndop, smoking in firewood kitchens was the most widely used method of drying while in Buea, most of the farmers practiced sunning as a control measure against the ear rot/mould problem. Earlier findings [27] reported that most famers in Pakistan controlled mould in wheat by drying to safe moisture levels. Smoking is an efficient method of reducing moisture content and protecting maize against infestation by fungi and this has an additional advantage as it also protects against insect infestation [28].

Most farmers also faced problems with insects destroying their maize both in the field and storage. This is not surprising since insects have been reported to be destructive to cereals in general and their infestation begins in the field and continues in storage in Cameroon and other African countries [29,30]. A significantly higher number of farmers were of the opinion that some insects are gotten from the field to stores. This might be due to the fact that maize planted Buea during the months of August and September are allowed in the field for long to get dry and that predisposes the cobs to infestations that are carried in to storage. The results also revealed that farmers in both Ndop and Buea were of the view that insect damage on their maize was more important than that of ear rot/mould and would increase attack of maize by the latter. Results have shown that storage fungi normally accompany or follow insect infestation [31]. This is partly because generation of metabolic heat and water by insects in stored foods also increases the water activity and temperature of the commodity to levels suitable for fungal growth and multiplication [21,22].

Most farmers in Buea did not have maize throughout the year and they attributed this to stored product insects attack which was also responsible for increases in maize grain prices as the duration of storage increases. There was a significant relationship between farmers who faced problems with stored product insects and used synthetic insecticides. This shows that the farmers in both Ndop and Buea relied more on the use of synthetic chemicals to control insects than plant based products. Despite current interest in reducing environmental contamination and global warming which are serving as added impetus for the re-evaluation and intensification of environmentally friendly and cost-effective pest management technologies such as the use of traditional botanical pest control agents, these plant based indigenous pest control practices have remained largely unexploited due to limited research intervention and resources committed [32]. The use of indigenous pest control measures and plant-based insecticides have been greatly neglected in Buea area presumably due to its urban setting and this may partly explain why farmers rely solely on synthetic pesticides [15]. However, there is a general consensus that the use of botanicals is likely important component for the development of practical integrated pest management programs.

5. CONCLUSION

The studies showed that most maize farmers in Ndop and Buea are illiterate women who faced problems with maize ear rot/mould and insects which are brought from the field in to stores. The ear rot/mould problem was more important during the harvesting period which coincides with the peak of the rains. This constraint is usually controlled by appropriate drying of the maize. Stored product insects were also a nagging problem throughout the storage duration. Farmers relied more on synthetic chemicals to control insects than the use of environmentally friendly methods like local plants and their derivatives. These insects exacerbate the prevalence of maize ear rot/mould as well caused increases in maize prices with increase in duration of storage despite the use of synthetic chemicals.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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