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Farmers' Knowledge of Potato Viruses and Management Strategies in the Western Highlands of Cameroon

Temfack Deloko Dély Carlos[1], Achiangia Patrick Njukeng[1], Anoumaa Mariette[1], Chofong Gilbert Nchongboh[1,2], Djomo Simé Hervé[1], Lontsi-Demano Michel[3], Fonkou Théophile[1]

[1]Research Unit of Applied Botany, University of Dschang, Dschang, Cameroon
[2]Julius Kuehn Institute, Institute of Epidemiology and Pathogen Diagnostics, Braunschweig, Germany
[3]Research Unit of Applied Biology and Ecology, University of Dschang, Dschang, Cameroon
Email: carlos_deloko@yahoo.com

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Abstract

Potato (*Solanum tuberosum* L.), important staple food and a source of income to small-scale farmers, is mostly cultivated in Cameroon in the Western Highlands. Production constraints are exerted on this crop by many pathogens including viruses responsible for considerable yield losses. This study aimed at assessing the perception of farmers on the virus diseases that can affect potatoes, and to identify the control methods adopted against them. A semi-structured survey was carried out among 230 farmers in 24 villages of the Western Highlands zone of Cameroon. Out of these farmers, 80.87% had never heard of potato viruses. Those having pre-knowledge about potato viruses were 19.13%. Among the latter, 16.52% had heard of potato viruses and transmission mode during capacity building workshops while 2.61% didn't know about the means of transmission. Insect control is essentially chemical (100%). However, few farmers use biological methods such as intercropping (7.39%) and application of plant extracts (4.78%) to control insects. Twelve plant species, belonging to nine families, were mentioned for insect control. In addition to plants, farmers also use wood ash and rabbit urine for insect control. These results show the knowledge gap possessed by farmers with respect to potato viruses and their transmission mode. It is thus speculated that this spans to other crops in Cameroon settings. This finding can serve as a base and a working document for policymaking to ameliorate teaching, research and devilment related to plant viruses for better sustainable food production.

Keywords

Farmers Knowledge, Virus Control, Potato, Cameroon

1. Introduction

In Cameroon, potato is grown in six of the ten regions of the country: West, North-West, South-West, Littoral, Adamaoua and Far North. The West and the North-West regions account for more than 80% of this production annually. Potato (*Solanum tuberosum* L.) refers both to the plant and the edible tuber. It is one of the most important industrial crops [1]; the starch-rich tubers are mainly used for food and feed [1]. The expected yield of potatoes is estimated at 25 t/ha in Cameroon [2]. However, that yield remains below average recording approximately 8 - 9 t/ha. Myriad of biotic and abiotic factors can be raised to explain the low yield of potatoes in Cameroon. The climatic and ecological diversity that Cameroon possesses is not only favorable to the growth and development of a varied number of plant species but also conducive to the proliferation of many pathogens [3], which are responsible for causing many diseases that attack plants including potatoes and reduce productivity. Among these causal agents, local and resource-poor potato farmers in Cameroon are constantly faced with late blight and wild diseases. They have developed a trend of going for chemicals against such diseases. On the other hand, this attack is not only limited to fungal and bacterial diseases but extended to viruses [4]. On a global perspective, RNA, DNA viruses (more than 50) and viroid (one) are known to infect potato some of which can persist in the host plant, some integrate in the host genome and transmitted via cell lines and by several vectors including beetles, thrips, whiteflies, leaf hopper, aphids, psyllids, *spongospora*, nematodes and fungi [5]. These infectious entities use potato cellular machinery, while contributing to the disruption of its physiological processes, and causing significant yield losses [6]. Relatively, very few plant virologists are in Cameroon with less attention paid to plant viral diseases. Here, we hypothesized that a high proportion of potato farmers have scanty knowledge about plant viruses. The present study was conducted to assess the farmer's knowledge about potato viruses, their mode of transmission and management. This finding may raise awareness to plant and help as a base of virus framework for research and development in Cameroon.

2. Materials and Methods

2.1. Study Site

This research work was focused on potato as it is one of the major economically important crops grown by many households in the Western Highlands of Cameroon. It is located between latitudes 4˚54' and 6˚36'N, and between longitudes 9˚1' and 11˚24'E measuring a land surface area of 3.1 million hectares, including the West and the North-West regions of Cameroon.

At the initial stage, our research team interviewed local crop expert of several Agric Post Stations to collect informations that allowed us to identify the main localities of potato production. Through local extension officers we then choose the administrative units (Divisions, Sub-Divisions and Villages), where potatoes are most produce. This study was conducted between January 2019 and May

2020, in 7 divisions of the agro-ecological zone of the Western Highlands of Cameroon covering 24 villages (Table 1).

2.2. Sampling Method and Data Collection

The farmers surveyed were the ones largely in charge for plantations with an area of at least 1000 m^2, and directly involved in day to day management of the farm activities.

A survey was carried out using a semi-structured questionnaire in 12 sub-divisions of the Western Highland zones of Cameroon.

Table 1. List of villages, Sub-divisions and divisions where respondents were targeted.

Division	Sub-division	Villages	Geographical coordinates	
Bamboutos	Babadjou	Kombou	10˚9'52.94"E	5˚43'45.57"N
	Batcham	Messan	10˚9'58.25"E	5˚35'42.79"N
		Nzindong	10˚11'36.57"E	5˚34'39.05"N
	Galim	Bamedjing	10˚29'21.22"E	5˚42'20.02"N
		Bagam	10˚17'9.95"E	5˚41'5.18"N
Haut-Nkam	Bana	Batcha	10˚19'52.19"E	5˚6'56.00"N
		Bakassa	10˚15'34.52"E	5˚7'36.85"N
Hauts-Plateaux	Bangou	Bandenkop	10˚22'3.71"E	5˚14'54.26"N
		Baloumgou	10˚25'28.17"E	5˚13'7.89"N
		Mendjieu	10˚23'57.00"E	5˚14'57.01"N
Koung-Khi	Bayangam	Kassap	10˚26'46.51"E	5˚18'0.49"N
		Nkako	10˚26'31.90"E	5˚18'3.99"N
Menoua	Dschang	Batseng'la	10˚5'15.31"E	5˚26'33.34"N
		Djuttitsa	10˚5'11.15"E	5˚35'11.45"N
		Meguia	10˚1'1.15"E	5˚33'1.07"N
	Fokoué	Fomepéa	10˚9'58.91"E	5˚16'39.17"N
		Fontsa-Toula	10˚7'28.09"E	5˚20'1.40"N
		Fotomena	10˚6'1.58"E	5˚22'41.37"N
	Fongo-Tongo	Loung	10˚5'0.70"E	5˚32'46.30"N
	Penka-Michel	Bansoa	10˚19'21.26"E	5˚27'31.22"N
		Bamendou	10˚11'58.10"E	5˚27'19.41"N
Mifi	Bafoussam 3e	Bamougoum	10˚20'1.00"E	5˚30'10.06"N
Noun	Foumbot	Fossang	10˚39'14.14"E	5˚23'12.23"N
		Kwetvu	10˚34'17.00"E	5˚27'58.00"N

A total of 230 potato farmers were randomly selected. So, twenty (20) farmers per sub-division were surveyed, with the exception of Foumbot where only ten (10) farmers were surveyed due to the low number of potato farmers found there. The number of respondents varied from one village to another per sub-division, due to the unavailability of farmers to great time to answer the questionnaire. Data were collected on socio-demographic characteristics (gender, age, level of education, matrimonial status), seed management, nematodes control, cultivated varieties, knowledge of potato viruses and methods of insect control. The survey was carried out using a smartphone with ODKCollect v-1.11.3 software in which the questionnaire was previously integrated.

2.3. Data Processing

Collected responses to the questionnaires were loaded on the ODK Tools kits platform and data exported to Excel2007 worksheet. Here, the calculation of the percentage of adoption of the practices by the farmers was done. The chi-square test (χ^2) was used to evaluate the significance at the 5% probability threshold, using the MedCalc v15.8 software.

3. Results and Discussion

3.1. Characteristics of Farmers

As per collected data, the farmers were stratified based on the general socio-demographic characteristics (gender, age, study level and marital status). Out of the 230 interviewed, 56.96% were men, whereas 43.03% were women ($\chi^2 = 2.970$; DF = 1; $p = 0.0848$). Most of the farmers aged between 30 - 50 (46.52%) followed by those with age greater than 50 representing 32.61%. The youth are less engaged in potato production with the age range between 15-30 years of age accounting for 20.87%. According to the chi-square test ($\chi^2 = 33.652$; DF = 2; $p < 0.0001$), there was a significant difference between the different age groups (**Table 2**). Kateka *et al.* [7] found higher percentage for the same age group, among potato farmers in Malawi.

Majority of the farmers acquired formal secondary education (50.43%), 84.78% married and 15.22% were single ($\chi^2 = 43.999$; DF = 1; $p = 0.0001$).

3.2. Seed Management

3.2.1. Origin and Category of Seeds

The source of planting material is a paramount concern and essential for potato virus studies. Our finding shows that 60.87% of farmers acquired their seeds from individual conservation from previous seasons to be used for the upcoming season. In a decreasing percentage, 54.35%, 28.26% 16.96%, 8.26% 2.17% and 2.17% obtain seeds from the markets, seed multipliers, farmer-to-farmer exchange, Institute of Agricultural Research and Development (IRAD), Ministry of Agriculture and Rural Development (MINADER) and imported respectively ($\chi^2 = 250.058$; DF = 6; $p < 0.0001$). The high frequency of use of individually saved

Table 2. Summarized date based on surveyed farmers per administrative division (n = 230) with relation to sex, age, educational level and marital status.

	Administrative Divisions of the surveyed area							
	Bamboutos	Hauts-Kam	Hauts-Plateaux	Koung-Khi	Menoua	Mifi	Noun	
Variables	Number of respondents surveyed per divisions (percentage)							Total (%)
Sex								
Male	44 (19.13)	4 (1.74)	6 (2.61)	18 (7.82)	49 (21.31)	8 (3.48)	2 (0.87)	131 (56.96)
Female	16 (6.95)	16 (6.95)	14 (6.09)	2 (0.87)	31 (13.48)	12 (5.22)	8 (3.48)	99 (43.04)
Age group								
[15 - 30[	29 (12.61)	00 (00)	2 (0.87)	2 (0.87)	14 (6.09)	00 (00)	1 (0.43)	48 (20.87)
[30 - 50[	14 (6.08)	10 (4.35)	10 (4.35)	16 (6.95)	40 (17.4)	10 (4.35)	7 (3.04)	107 (46.52)
[50 and more[	17 (7.4)	10 (4.35)	8 (3.47)	2 (0.87)	26 (11.30)	10 (4.35)	2 (0.87)	75 (32.61)
Educational level								
Unschooled	4 (1.74)	00 (00)	00 (00)	00 (00)	4 (1.74)	2 (0.87)	00 (00)	10 (4.35)
Primary education	27 (11.74)	10 (4.35)	6 (2.60)	2 (0.87)	17 (7.4)	8 (3.48)	5 (2.17)	75 (32.61)
Seconary education	27 (11.74)	7 (3.04)	9 (3.91)	15 (6.52)	45 (19.57)	8 (3.48)	5 (2.17)	116 (50.43)
Higher education	2 (0.87)	3 (1.30)	5 (2.17)	3 (1.30)	14 (6.10)	2 (0.87)	00 (00)	29 (12.61)
Marital status								
Single	17 (7.4)	00 (00)	2 (0.87)	2 (0.87)	13 (5.65)	00 (00)	1 (0.43)	35 (15.22)
Married	43 (18.7)	20 (8.7)	18 (7.82)	18 (7.82)	67 (29.13)	20 (8.7)	9 (3.91)	195 (84.78)

seeds would be an asset for the spread of viruses, these because, farmers generally save their seeds in inappropriate conditions. In addition, respondents stated that they do not make any diagnosis to check the health status of saved seed for the present of viruses which equally holds for market sold seeds.

Potato farmers surveyed presented three categories of seed used including basic, certified and non-classified seeds. As summarized, 90.44% of these farmers use unclassified seed, 28.26% (certified seed) and 3.92% use basic seed ($\chi^2 = 153.543$; DF = 2; $p < 0.0001$). The low frequency of use of basic seed could be justified by its high price. Indeed, these seeds are obtained by meristem cultivation and require a long production period. According to Ali *et al.* [8], virus eradication has been successful in many potato varieties through in vitro meristem culture.

3.2.2. Seed Stock Duration (in Years) Handling and Treatment during Conservation

Based on the respondent's feedback, 60.87% of potato farmers used seed stock saved from their produce from 3 - 6 years. A proportion of farmers (32.17%) and 6.69% used stock from 0 - 3 and 6 years more, respectively ($\chi^2 = 77.476$; DF = 2; $p < 0.0001$). The farmers interviewed explained this by the lack of good quality seeds, which is however related to a shortage of seeds production stations. In addition, good quality seeds are sold at very high prices. Unfortunately, the long-term multiplication of infected seeds favors the development of viruses because with each new generation, new viruses of the same or different species may be added to the existing ones, hence increasing the viral load in the plants [9]. According to Thomas-Sharma *et al.* [10], long seeds storage leads to an accumulation of pathogens that reduce seed vigor and yield.

Handling and treatment of planting material during its conservation was analyzed and data showed that 99 farmers recording 43.04% performed seed treatment with men constituting 32.61% (75) and women 10.43% (24) (χ^2 = 17.987; DF = 1; p < 0.0001). On the other hand, 131 (56.96%) do not practice seed treatment (χ^2 = 2.970; DF = 1; p = 0.0848). Although there is no significant difference, the high percentage of farmers who do not treat seeds could be explained by the lack of knowledge of seed saving methods. This high rate of the male gender could be linked to the fact that potato is produced by men for it is considered a business; the majority of men are heads of households and are responsible for providing needs for their families. Thus, they take time to treat their seeds in order to guarantee production in the next seasons and/or to keep the seeds in good condition for marketing. However, the low percentage of women is said to be related to the fact that most women generally grow potatoes for consumption only.

Horizontal transmission allows viruses to pass from one plant or seed to another with the help of vectors. To limit or reduce this type of transmission, vector control is encouraged. Among the 99 farmers who treat seeds, 98.98% (98) use synthetic insecticides, 18.18% (18) use fungicides and 2.02% (2) use alternative methods (χ^2 = 88.497; DF = 2; p < 0.0001). Insecticide is however the product most used by the farmers surveyed. This high frequency of insecticide use would only be effective against viruses that are transmitted in a persistent manner, as these require a recognition relationship between the host and the vector [11]. Thus, the use of insect repellants and/or anti-insect nets could be crucial for the control of non-persistent transmissible viruses [12]. Similarly, the use of fungicides for seed treatment should not be neglected. Indeed, according to Andika *et al.* [13], many fungi, in addition to being plant pathogenic for potatoes, are also vectors of viruses.

The frequency of seed treatment of potatoes during storage shows that 61.62% (61) of farmers treat seed once during the entire shelf life, while 31.31% (31) and 7.07% (7) treat their own once a month and twice a month respectively (χ^2 = 33.934; DF = 2; p < 0.0001). The low frequency of treatment recorded among the majority of farmers during this study is also one of the causes that may favor the spread of vector-transmissible viruses. Indeed, the insecticide treatment should be renewed regularly in order to maintain the toxicity of the environment [14] where the seeds are stored.

With the exception of vector transmission, which can be controlled by pesticides, mechanically transmitted viruses can be transmitted from an infected tuber to a healthy tuber by simple contact [1] during storage. To overcome this problem, the temperature of the seed storage medium should be lowered to the recommended level (4˚C - 6˚C), followed by a relative humidity of 80% [15]. Low storage temperatures and high relative humidity would thus slow down virus activity and further limit the possibilities for mechanical transmission.

3.2.3. Plant Species Used in Seed Treatment

Among the different farmers surveyed, only 0.87% (2) resort to seed treatment using plants derivatives. The plant used for this purpose is *Lantana camara*, which is used in various forms. These farmers use it in the form of aqueous extracts or cut it and place on the potato seeds. They admitted that they find this way of treating the seeds satisfactory because they combine it with a small quantity of synthetic insecticide and it is done at a lower cost. The plant has fungicidal, nematicidal and insecticidal properties [16].

3.3. Nematodes Control

Nematodes such as the potato golden nematode (*Heteredera rostochiensis*) attack potato roots and cause yield losses. In addition to devastating potatoes, some nematodes are vectors for viruses in potato crops. This is the case of the nematodes such as *Trichoorus* sp. and *Paratrichodoru*s sp. that transmit *Tobacco rattle virus* to potatoes [17]. However, it emerges from this study that no farmer surveyed practices phytosanitary treatment against nematodes; attitude that could be justified by the lack of information.

3.4. Cultivated Varieties

Figure 1 shows the different potato varieties grown by the farmers surveyed. Fifteen (15) potato varieties were identified during this study. However, the Dosa (87.83%) and Désiré (80.43%) varieties are the most widely grown, while the Juwel (10.87%) and Spinta (7.4%) varieties are the least grown. Several reasons have been put forward to explain this difference in the production rate of the different varieties. These include seed availability (54.35%), yield (48.26%), disease resistance (42.17%), short cycle (38.7%), early germination (32.62%), consumer demand (19.57%) and taste (12.61%). Independently of the varieties, potatoes are subject to numerous attacks by pathogens, including viruses. Viruses account for almost half of the pathogens involved in emerging infectious crop diseases [18]; and their spread is linked to several factors including the susceptibility of the crop variety [19]. Lack of resistance to pests and diseases is known to be one of the major problems for potato cultivation in Cameroon [20]. Faced with the non-existence of virucides, the genetic heritage of certain potato varieties confers resistance to certain viruses [21]. Varietal resistance can also be acquired artificially. This process requires the search for resistance genes and their incorporation into potato genotypes. This is the case of the *Rysto* gene taken from *Solanum stoloniferum* which is grafted onto chromosome number 12 of the potato and which confers resistance to the different strains of *Potato virus Y* (PVY) [22].

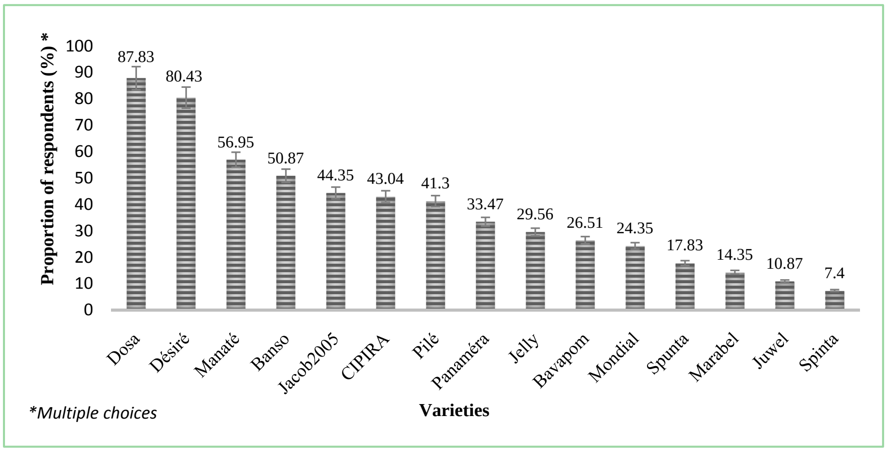

Figure 1. Bar chart representing the proportion farmers with varieties grown in the agro-ecological zone of the western highlands of Cameroon.

3.5. Potato Viruses

3.5.1. Knowledge of Potato Viruses

According to the knowledge of viruses, 80.87% (186) of the respondents have never heard of potato viruses, compared to 19.13% (44) who have heard of them ($\chi^2 = 60.943$; DF = 1; $p < 0.0001$). This shows that very few farmers are aware of the existence of the viruses, as reported by Biao *et al.* [23]. However, farmers' lack of knowledge of viruses and vectors is believed to lead to their rapid spread in plantations [24]. Although some virus symptoms are almost identical to those of other pathogens, there are also symptoms that are easily differentiated, such as Potato leaf roll caused by *Potato leaf roll virus*. However, farmers tend to confuse all the symptoms of the different viruses with those caused by other pathogens, especially fungi (late blight) and bacteria (bacterial wilt). This lack of knowledge about viruses, combined with lack of symptom control, could thus be justified by a lack of training. According to Schreinemachers *et al.* [25], strategies to control viruses include training, which could increase farmers' awareness and knowledge of viruses, including disease identification, epidemiology and management.

Figure 2 shows the percentage of farmers' citations on virus knowledge according to level of education. The figure shows that 10.43% of respondents with knowledge of viruses have a secondary school education, while 6.53% have a higher school education and 2.17% a primary school education ($\chi^2 = 9.570$; DF = 2; $p = 0.0084$). However, 40%, 30.43% and 6.09% of respondents without knowledge of viruses have respectively secondary, primary and higher levels of education; 4.35% are unschooled ($\chi^2 = 86.730$; DF = 3; $p < 0.0001$).

The percentage of respondents' citation of where they heard about the potato viruses shows that, 86.36% of respondents heard about the viruses during training, 47.72% from researchers, 20.45% from reading, 9.09% from other farmers, 4.54% from teachers and 2.27% from heads of agricultural posts ($\chi^2 = 57.719$; DF = 5; $p < 0.0001$). Thus, the level of study could not influence the knowledge of

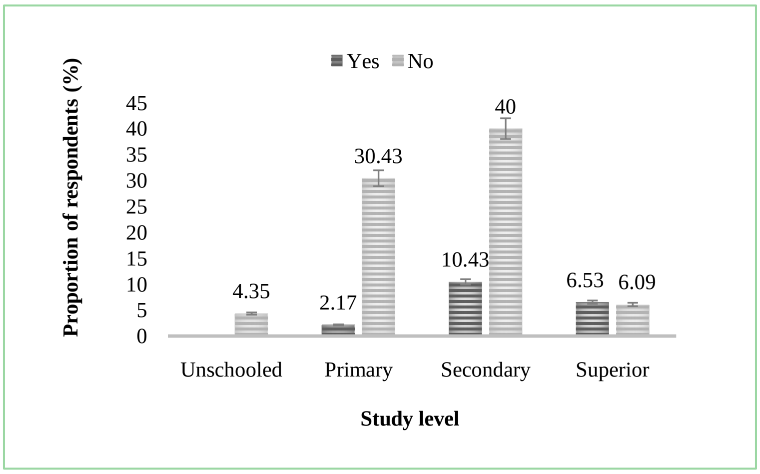

Figure 2. Bar chart representing the proportion farmers as function of educational level.

viruses. There is an urgent need for training programs to fill the lack of knowledge of farmers in various topics, in order to contribute to improvement of yield, as reported by Rahman *et al.* [26].

3.5.2. Mode of Transmission of Viruses

Knowledge of the mode of transmission of viruses and their life cycles is very important for disease prevention [29]. Among the 44 farmers who know about the existence of viruses, 38 (16.52%) have ideas on the different modes of transmission. However, only 5 (2.17%) of the farmers know about all modes of virus transmission (**Figure 3**). It therefore appears that very few farmers know the modes of transmission of potato viruses.

3.6. Methods of Insect Control in Potato Farms

Surveys have revealed that several control techniques are being adopted against insects in potato cultivation. 100% of farmers opt for chemical control, 77.83% for scrubbing, 70.44% for crop rotation, 63.91% for weeding, 15.22% for fallow, 7.39% for intercropping and finally 4.78% for the use of plant extracts (χ^2 = 312.779; DF = 6; $p < 0.0001$). The use of chemicals is generally the main strategy of insects control on crops [27]. According to Mondedji *et al.* [28], African market gardeners mainly use synthetic products to reduce pest damage. However, their inappropriate use causes various drawbacks, including increased insect (pest and vector) resistance [29] which contributes to crop devastation and virus transmission.

Several reasons were given for the choice of different insect control techniques adopted by the surveyed farmers. Indeed, 84.35% do not know that plants have insecticidal and/or insect repellant properties; 12.61% do not know which plants are associated with potatoes for intercropping; and finally, 3.04% talked of the unavailability of plant extracts. These results could thus justify the low proportions of intercropping and the use of plant extracts in insect control in the agro-ecological zone of the western highlands of Cameroon.

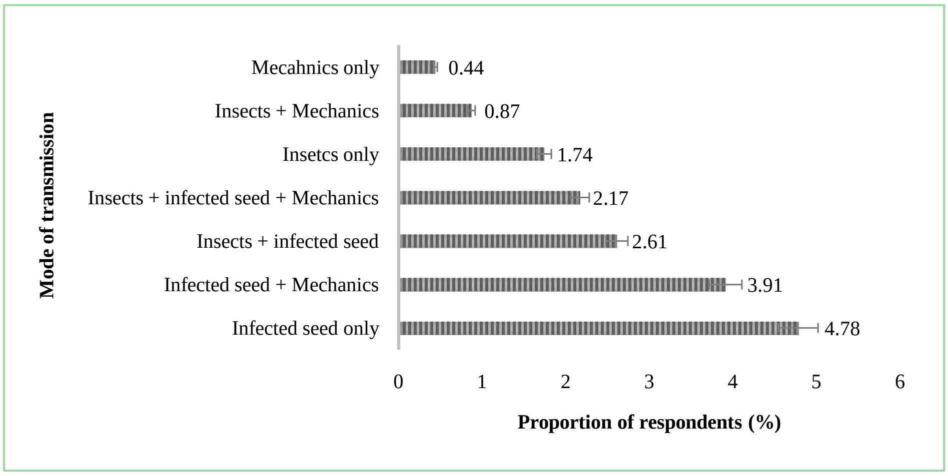

Figure 3. Bar chart representing the proportion farmer's perception of the modes of transmission of viruses.

3.6.1. Synthetic Insecticides Used by the Respondents

All the farmers surveyed use various combinations of synthetic insecticides. Among these insecticides, that with the trade name Cofresh 100 EC (69.13%) was the most cited. It was followed by the Cicogne 360 EC (64.35%), Parastar 40 EC (61.73%) (Table 3).

3.6.2. Plants Used for Insect Control

Plant species used by farmers as plant extract for insect control. It emerges that eight (8) plant species were cited, and are among others: *Chenopodium ambrosioides* (3.91%), *Lantana camara* (3.04%), *Azadirachta indica* (2.61%), *Nicotina tobacum* (1.74%), *Tephrosia vogelii* (1.30%), *Tithonia diversifolia* (1.30%), *Capsicum* spp (0.87%) and *Carica papaya* (0.43%). According to the respondents' statements, the leaves of these plant species are finely ground and the extracts are sprayed onto potatoes. It should be noted, however, that some farmers use neem oil (*Azadirachta indica*) bought in markets. As for intercropping, four (4) plant species were cited by the farmers surveyed. These were *Zea mays* (5.65%), *Allium cepa* (3.91%), *Allium porrum* (3.04%) and *Allium sativum* (0.87%).

A total of twelve (12) plant species, belonging to nine (9) botanical families, were cited in the field of potato protection against insects. Many studies have already demonstrated the insecticidal and/or insect repellant effect of some of these plants. These include the species *Allium cepa*, *Azadirachta indica*, *Carica papaya* and *Lantana camara* [30] [31].

3.7. Other Control Methods

In order to destroy insects and all potato pests, 10 (4.38%) farmers stated that they use different products and combinations of products for this purpose. These include: wood ash and rabbit urine. Many authors have already demonstrated the pesticidal effects of wood ash of some tree species [32].

Table 3. Summary of synthetic insecticides used by farmers surveyed.

Trades names	Active ingredients	Percentage of respondents (%)*
Abamet 18 EC	Abamectin 18 g/l	33.47
Acarius	Abamectin 18 g/l	40.43
Aceplant 40 EC	Acetamiprid 40 g/l	48.26
Ampligo 150 ZC	Lambda-cyhalothrin 50 g/l + chlorantranilole 100 g/l	46.08
Area 50 EC	Emamectine benzoate 10 g/l + Lambda-cythalothrin 40 g/l	47.78
Ballecot 4.9 EC	Lambda-cyhalothrin 50 g/l	47.87
BOMEC	Abamectin 18 g/l	35.21
Cicogne 50 EC	Cypermethrin 50 g/l	43.91
Cicogne 360 EC	Cypermethrin 360 g/l	64.35
Cofresh 100 EC	Cypermethrin 80 g/l + Imidacloroprid 20 g/l	69.13
Cyper-Sam 50 EC	Cypermethrin 100 g/l	57.83
Cyperfresh 100 EC	Cypermethrin 100 g/l	52.06
Cythrine 25 EC	Cypermethrin 25 g/l	55.65
Parastar 40 EC	Imidacloroprid 20 g/l + Lambda-cyhalothrin 20 g/l	61.73
Proclaim 019 EC	Emamectin-benzoate 19.2 g/l	42.17
Super 50 EC	Cypermethrin 50 g/l	50.87
Tamega 25 EC	Deltaméthrin 25 g/l	22.17
Tourbillon super 35 EC	Lambda-cyhalothrin 15 g/l + Acetamiprid 20 g/l	54.35
Viper 46 EC	Acetamiprid 16 g/l + Indoxacarde 30 g/l	35.56

*Multiple choice.

4. Conclusion

The concept of viral disease and its transmission are little known by potato farmers in the Western Highlands of Cameroon; only 19.13% of farmers know of its existence. Insect control is essentially chemical and very few farmers use alternative methods (7.39% for intercropping and 4.78% for plant extracts). However, *Chenopodium ambrosioides* has been the most cited plant species in the fight against insects as a plant extract; while *Zea mays* has been the most for intercropping. Therefore, it emerges from this study that knowledge of potato viruses is not linked to the level of education, age or marital status, but rather to the training undergone by farmers. Faced with these results, it is imperative to train farmers with regard to potato virus diseases and their management, in order to help to improve yields.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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