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Effect of tobacco leaves (*Nicotiana tabacum*) on the weevil (*Acanthoscelides obtectus*) of common bean (*Phaseolus vulgaris*)

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ABSTRACT: A survey was conducted by administering a questionnaire to identify common bean (*Phaseolus vulgaris* L.) conservation methods used by farmers in the Hauts-Plateaux division, west region of Cameroon. To reduce post-harvest losses of common bean (P. vulgaris) in the study area, a six-month study was carried out on red and black beans. Vegetable powder of tobacco leaves (*Nicotiana tabacum*) was produced and tested against the bean weevil (*Acanthoscelides obtectus*). Tobacco leaves were dried to 13.5% moisture content, crushed and sieved to obtain a powder at pH 5.63. This powder and two other synthetic insecticidal powders (Antouka and Protect DP) based on permethrin were incorporated at a dose of 1 g kg-1 in batches of beans. The coated seeds were placed in 125 mL polyethylene boxes containing 100 seeds each, then stored for 6 months in a room at a temperature between 15 and 27 °C. The experimental set-up applied for each variety was a complete randomized design comprising four treatments and four replicates (Control without any treatment, Tobacco, Protect DP, Antouka). Data on perforated seeds, weevil emergence and mortality were observed throughout the experiment. Results showed that 41% of farmers use synthetic insecticides, 36% do not use any substance, 14% wood ash, 9% fir leaves. This study showed that tobacco powder significantly reduced the puncture of beans by weevils, indicating the importance of alternatives means for pest management. It also emerged from this study that the black bean is more resistant to weevils than the red one.

KEYWORDS: post-harvest, pest, insecticidal effect, food insecurity, legume seeds.

1 INTRODUCTION

According to the Food and Agriculture Organization of the United Nations (FAO), recent data confirms an increase in hunger in the world, while it had long been declining, and therefore a reversal of the trend. In 2018, the number of undernourished people was estimated at 820 million, or about one in ten people in the world [1]. Food insecurity contributes to overweight and obesity as well as undernutrition, and high rates of these forms of malnutrition coexist in many countries. The cost of nutritious foods, which are more expensive than others, the stress caused by food insecurity and the physiological adaptations to food restrictions also explain why families living in food insecurity may be at greater risk of overweight and obesity [2]. The cultivation of food legumes, a source of vegetable protein, is one of the best and least expensive solutions for feeding the populations of developing countries, like Cameroon. Indeed, vegetable proteins are cheaper than animal proteins. Legume seeds contain twice as much protein as cereals. Unfortunately, these crops are very often characterized by low and unstable yields. This is explained, in particular, by their sensitivity to abiotic constraints (cold, heat and soil degradation) and to biotic constraints (diseases and insect pests) and on the other hand by the absence of varieties resistant or tolerant to these constraints [3]. In fact, bean crops in particular are subject to numerous attacks, both in the field and in warehouses, by pests and diseases which can cause significant damage in the absence of appropriate control methods. Stored products are mainly attacked by insects and moulds. Losses due to insects are considerable in countries where modern storage techniques have not yet been introduced. In some African countries, damage due to Weevil (*Coleoptera Weevilae*) can destroy all stocks in 5 or 6 months [4]. Among these insects, the common bean weevil (*Acanthoscelides obtectus*) is a cosmopolitan insect, the larvae of which can infest their host plant both in the field and in storage. They can also attack other leguminous plants that were originally non-hosts, which are also food crops of economic importance for developing countries, such as cowpea [5].

In Central Africa, weight losses of stored seeds (beans, maize, sorghum) of the order of 10 to 60% are caused each year by the main stock pests (*Acanthoscelides obtectus*) in the region. Stored products are generally protected by the application of synthetic insecticides, most often by fumigation. But the presence of toxic residues in foodstuffs and the appearance of strains of insects resistant to these insecticides are becoming a problem. The methods used to limit losses in stocks are generally chemical insecticides such as pyrethroids and organophosphates, which can induce chronic intoxication of consumers, resistance in pests and have a negative impact on the environment [6]. In the case of small-scale storage, the use of chemicals is not always profitable, the costs are often much higher than the benefits.

The use of synthetic pesticides has often caused more problems than it has solved. In addition, the technologies proposed have not always had the expected results because of the fact that they are not always adapted, the health and environmental risks associated with their adoption, the habituation of insect pests and the selection of resistant strains, high cost and unavailability of the products in question [7], [8]. This is why, today, there is a need to develop alternative methods to synthetic pesticides in crop protection, effective control against insect pests and the limitation of losses due to *Weevilae Coleoptera*. In the search for alternative methods, the plant kingdom offers many ecological and health advantages with biopesticides. The use of insecticidal plants has the advantages of being eco-friendly and effective in controlling pests (Stevenson et al., 2014) and has no side effects on health [9]. Numerous studies are being developed to isolate or identify secondary substances extracted from plants which have an insecticidal activity, by repulsion, contact or inhalation on insects [10]. This is the case of nicotine which is one of the active substances present in tobacco. It is poisonous if inhaled and is a very rapid contact killer against various insects and molluscs. Tobacco cultivation is widespread in the world and particularly in Cameroon [11]. Although many studies have shown the insecticidal potential of tobacco leaves, very few studies have been conducted on its effect in the preservation of foodstuffs, specifically beans.

The aim of this work is to contribute to the reduction of post-harvest losses in Cameroon. More specifically to: Identify the various substances and techniques of common beans conservation used by farmers in the west highlands of Cameroon, Produce, test and evaluate the insecticidal effect of tobacco leaf powder.

2 MATERIAL AND METHODS

We used the most available powder insecticides from market traders in the district of Bamendjou (Hauts-Plateaux). These are ANTOUKA super and PROTECT DP. It should be noted that the availability of these insecticides intended for the protection of foodstuffs against storage pests is not permanent and changes in the trade names of these products are very frequent. However, the presence of synthetic pyrethroids as active ingredients and/or organophosphates is common amongst these phytosanitory procducts with different trade names.

(a) ANTOUKA SUPER (b) PROTECT DP

Fig. 1. Synthetic insecticides used

Fig. 1 shows the conventional insecticides commonly used by farmers.

ANTOUKA super contains permethrin (pyrethroids) (3 g kg-1) and Pyrimiphos-methyl (organophosphates) (16 g kg-1). PROTECT DP contains another pyrethroid which is Deltamethrin (1 g kg-1) and Pyrimiphos-methyl (15 g kg-1). These insecticides were applied as indicated on the labels at 1g for 2kg of grains.

2.1 INSECTICIDAL PLANT: NICOTIANA TABACUM

N. tabacum plant is covered with short slimy glandular hairs, which exudes a yellow secretion containing nicotine. The leaves and the stem are plant parts with insecticidal properties. The leaves were collected in Bameka in the district of Bamendjou.

Harvesting and drying of N. tabacum leaves

Plant leaves were harvested in January by cutting the leaves close to the stem to allow continuous growth or further harvesting and flowering. Mature leaves indicated by their colour (dark-green) that were longer, taller and curved downwards compared to young leaves that were higher up and closer to the tip of the plant were harvested and used in this study. After harvest, the leaves of *N. tabacum* were dried under a shade in a solar dryer for fifteen days. Drying was done at a temperature ranging from 18°C to 38.5°C between 6 a.m. and 6 p.m. until the leaves could crumble under pressure and allow to produce powder form-like particles. Dried leaves were stored in the dark until use.

Grinding and sieving

The dried leaves were pounded in a mortar for 10 minutes and passed through a 0.4 mm mesh sieve to obtain a fine powder of homogeneous particles. Drying, grinding and sieving were carried under safety measures by putiing on a mask.

Although some farmers often mix the whole leaves or other parts of the plant with the food to be stored, grinding the material and sifting to a fine powder proves to be more effective. Small particle size increases surface area and therefore increases activity. Small particles are more likely to stick with grains and insects. Note that you have to be careful not to inhale the fine powders during this transformation while wearing a mask. The moisture content of the *N. tabacum* leaves was determined by weigh fresh leaves and oven-dried leaves (105 0C for 24 hours) three times.

From the initial fresh leaves with a moisture content of 86.5%, a powder with a moisture content of 13.5% was obtained. This rate is adequate for storage because there will be almost no transfer of moisture from the powder to the grains. This corresponds to the recommendation of Hodges and Stathers [11], which is to reduce the moisture content of the grains to less than 15%, an essential characteristic to avoid infestations by insects and fungal species during storage. The moisture content (MC) was determined using the following equation:

$$MC = \frac{Initial\ mass - Final\ mass}{Initial\ mass} * 100 \quad (1)$$

After sieving, 86 g of fine powder was obtained, ie 40% of the initial mass. It should be noted that the other part of the powder (60%) is usable although being coarser, because it does not present any difficulty in being separated from the bean at the end of conservation.

pH of N. tabacum leaves

pH of the dried leaves was determined in the Laboratory of Renewable Energies of the Faculty of Agronomy and Agricultural Sciences, University of Dschang. 18g of dried *N. tabacum* powder was weighed and 144ml of water added to obtained 1: 8 solid-water ratio. The mixture was stirred for five minutes and the pH of the slurry measured using a pH meter on the liquid portion.

2.2 INSECTICIDAL TREATMENTS AND EXPERIMENTAL DESIGN

Two varieties of beans most consumed locally were selected. These are the red bean “little red bean”, locally called “*Méringué*” and the “black bean” in the western highlands of Cameroon. These varieties were selected based on yield and income satisfaction, taste and cultivation area according to the local farmers. Beans used in this experiment were obtained from the end-of-rainy season field harvests in December 2019 and January 2020 in Bameka, Bamendjou District, Hauts-Plateaux Division. The red and black beans were harvested from different plots, free of any insecticidal treatment throughout cultivation, in the same locality to ensure homogeneity of the experimental material. Freshly harvested dry pods were subjected to sorting to eliminate unhealthy pods and dried under the sun to a moisture content of 13% for the black bean and 15% for the red bean.

Each bean variety was divided into four batches. Three batches were mixed with one of the three treatment powders (*Nicotiana Tabacum*, ANTOUKA, PROTECT DP) at a dose of 1 g per 2 kg of grain, and the fourth batch left untreated (control).

One hundred bean seeds from each batch were placed in a 125 ml transparent well-aerated box that was considered an experimental unit. The boxes were designed to have enough space to accommodate the emergence of the Weevil. The *N. tabacum* leaf powders and seeds were placed in the boxes so as to occupy less than 25% of the volume. The remaining space in the box or experimental unit was large enough to accommodate the upward or downward movement of the insects. According to the table 1, boxes for each bean variety was arranged in a complete randomized design, with four repetitions and four treatments (Control, N. tabacum leaf powder, Protect DP and Antouka).

Table 1. Insecticidal treatments of the study

Bean type	Treatments			
	Control (without insecticidal treatment)	***N. tabacum* leaf powder**	**Protect DP (Permethrine)**	**Antouka (Permethrine)**
Black bean	N1, N2, N3, N4	NT1, NT2, NT3, NT4	NP1, NP2, NP3, NP4	NA1, NA2, NA3, NA4
Read bean	R1, R2, R3, R4	RT1, RT2, RT3, RT4	RP1, RP2, RP2, RP3	RA1, RA2, RA3, RA4

2.3 DATA COLLECTION

The study was carried for a period of five months (February to June) and the temperature ranged between 17 and 270C, giving an average of 20.70C. The different treatments were introduced into transparent plastic jars of 125 ml in volume. This period was selected for the experiment according to the emergence cycle of the bean weevil (30 days) at a temperature of about 27°C, in order to be able to observe the damages caused by the weevils and to appreciate the effects of the experimental treatments. Low lighting throughout the experiment was intended to avoid disturbing the emerging Weevil thereby modifying their behavior in the boxes. Data was collected on the damage on the seeds and the emergence and mortality of the insects throughout the study.

Perforated seeds

The Weevil perforation index (PI) was used to evaluated damages on the bean seeds. PI for each treatment was calculated according to the formula of Fatope [12]. A PI value greater than 50 means that the product tested has no protective effect on the grains. A PI value was obtained by the following equation:

$$PI = \frac{\%\ of\ perforated\ seeds\ treated}{\%\ control\ perforated\ seeds + \%\ treated\ perforated\ seeds} * 100 \quad (2)$$

Weevil emergence and mortality

The number of Weevil that emerge: the emergence or absence of emergence of adults is an indicator of the effect or absence of effect of the treatments on the Weevil or their eggs. Counting was manually done every 30 days throughout the trial.

The Weevil mortality rate (MR) was evaluated every 30 days during the experimental period. The contents of each box were dumped on the bench in order to count the dead Weevil and the living Weevil using metal tongs and a spoon. This also gave the number of Weevil that had emerged since the last count. Any individual without reaction of legs and wings after several touches was considered dead. At the end of each manipulation, the materials were cleaned with a white cloth to avoid contamination by other treatments. The MR was calculated by the following equation:

$$MR = \frac{Number\ of\ dead\ bruchids}{Number\ of\ bruchids\ emerged} * 100 \quad (3)$$

2.4 DATA ANALYSIS

Collected data were entered into Microsoft excel for cleaning and organization into a spreadsheet. Statistical analysis was performed using SPSS 23.0 software. Analysis of variance was carried and means compared using Fischer test at a threshold of 0.05.

3 RESULTS

3.1 BEAN PRESERVATION SUBSTANCES AND TECHNIQUES USED IN THE HAUTS-PLATEAUX DIVISION

This study showed that synthetic insecticides are mostly used and commonly called "powder" by users who do not master the trade names and application doses. These insecticides contain pyrethroids and/or organophosphates as active substances. The best known insecticide in the study zone according to the information given by farmers is called “RAMBO” which contains permethrin. It is effective, easy to apply, with a shelf life of up to 18months and available in the local markets. Also, it is expensive and farmers seldom respect the indicated doses.

Farmers often use pesticides without adequate protective measures due to the high rate of illiteracy amonst them. This corroborates findings of a survey conducted in Senegal by [13] that established a positive correlation between the level of education of producers and unsafe practices regarding the use of pesticides. In addition, it is revealed the use of rat poisons, fungicides or herbicides on corn intended for human consumption.

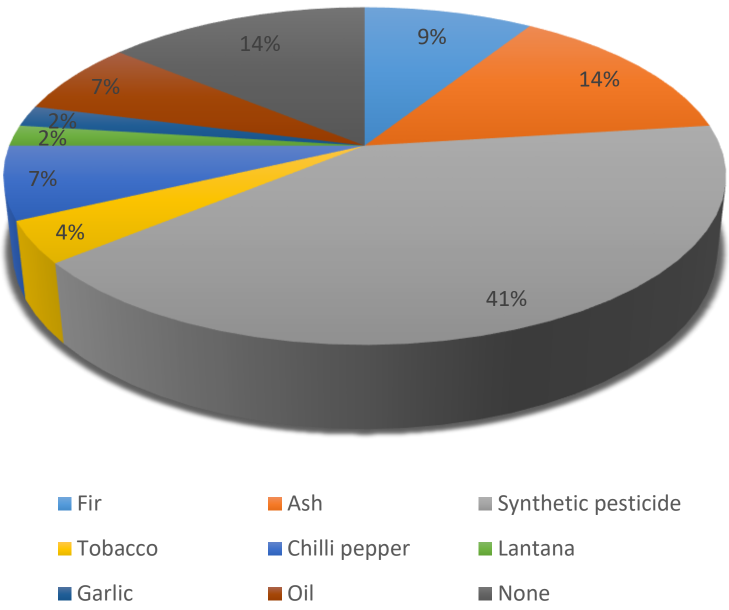

Fig. 2. Frequency of use of bean preservatives

Fig.2 shows different elements use for bean preservation.

Synthetic insecticides mostly used (41%) against bean weevil by farmers while only 14% of farmers do not use any treatment due to the high cost of synthetic insecticides, lack of knowledge on natural substances against weevil, or by the fact that some small producers do not find it useful given that they store the farm produce in a short while.

Cost of tobacco leaves

Tobacco leaves dried to make the powder gave a mass of 216 g. Mass close to that of the small packets of tobacco sold on the markets of Bameka and Bamendjou which varies between 170 g and 200 g and costs 500 FCFA. In comparison, the 50 g sachets of synthetic pesticides used in this study cost 500 FCFA. In the study area, some residents and farmers regularly grow tobacco plants on the edge of homes for other uses, which represents an alternative to buying in markets.

3.2 Effect Of Tobacco Powder On Bean Weevil

Perforation index on red bean

According to table 2, perforation index was calculated using the cumulative number of perforated grains for a given period of time. Results showed that thirty days after the start of the test, the untreated bean kernels showed the highest perforation index (50.00). *N. tabacum* leaf powder treatment gave an index of less than 50.00; which indicates a protective effect on the grains. Significant differences were observed between the control and the *N. tabacum* leaf powder treatment throughout the duration of the study. Bean seeds treated with synthetic insecticides showed lower perforation Indices than those of tobacco, therefore more protective, with significant differences between the effects observed at the 30th and 150th days between the Antouka and tobacco. It is observed that all the batches had their maximum perforation during the first 30 days.

Table 2. Weevil perforation indices recorded on red bean during seed storage

Treatment	30th day	60th day	90th day	120th day	150th day
Control	50.0±0.0 a	50.0±0.0 a	50.0±0.0 a	50.0 ± 0.0 a	50.0±0.0 a
Tobacco	43.1±4.7 b	43.8±2.9 b	36.0±4.9 b	36.4 ± 2.6 b	35.6±2.6 b
Antouka	36.7±3.1 b	33.4±4.0 c	27.0±3.6 b	26.3 ± 3.5 b	26.1±3.2 c
Protect DP	42.7±4.1 b	38.9±5.1 b	32.1±4.9 b	33.9 ± 9.4 b	30.4±4.5 b

Values (means±standard deviation) in a column followed by the same letter are not significantly different at the 5% level by the test of the least significant difference (PPDS).

Weevil emergence in stored red bean

According to the results in table 3, the number of Weevil that emerged in the batches of stored red beans was higher in the control with the highest (19) recorded during the first month of the experiment. Batches treated with *N. tabacum* leaf powder, Antouka powder and Protect DP recorded the lowest number of Weevil with the best performance for Protect DP as well as peaks in the first month of storage. Cumulatively, the control treatment totals a number of 56 Weevil against 20 for the *N. tabacum* leaf powder treatment. Emergence peaks during the first month of storage is due to the fact that the grains were already infested at the level of the field and the treatments had no effect on the larvae or insects already in the grains. [14] had obtained more significant effects on the number of Weevil emerged with three local plants (Agava, Maesa, Tagetes) from the Kivu province in the DRC in the conservation of three local bean varieties, using higher doses, large ranging from 1% to 3%.

Table 3. Weevil emergence in stored red bean for the tested experimental treatments

Treatment	30th day	60th day	90th day	120th day	150th day
Control	19±5 a	12±15 a	17±12 a	4±8 a	4±8 a
Tobacco	17±3 a	2±3 a	1±1 b	0±0 a	0±0 a
Antouka	13±3 a	2±4 a	1±2 b	0±0 a	0±0 a
Protect DP	16±3 a	1±1 a	0±0 b	0±0 a	0±0 a

Values (means±standard deviation) in a column followed by the same letter are not significantly different at the 5% level by the test of the least significant difference (PPDS).

Mortality of Weevil in stored red bean

According to the results in table 4, on the 30th day after setting up the trial, the lowest mortality rate was recorded in the control (48.04%). The treatment of grains with tobacco gave a higher Weevil mortality rate with 58.43% and the highest rate was obtained in grains treated with Protect DP (94.32%).

Table 4. Mortality of Weevil assessed during seed storage of red bean

Treatment	30th day	60th day	90th day	120th day	150th day
Control	48.0 ± 18.6 a	13.4±9.0	39.5±25.6	/	14.5±25.2
Tobacco	58.4 ± 11.3 a	57.1±50.8	66.6±28.8	/	/
Antouka	82.2 ± 9.41 b	88.8	100.0±0.0	/	100
Protect DP	94.3 ± 4.2 b	100.0±0.0	/	/	/

Values (means±standard deviation) in a column followed by the same letter are not significantly different at the 5% level by the test of the least significant difference (PPDS).

Perforation index on black bean

According to the results in table 5, observations showed that thirty days after storage, the control treatment recording the highest perforation index (50.00) similar to that of red bean. In the same manner, *N. tabacum* leaf powder treatment gave an index of less than 50.00 indicating a protective effect on the grains. However, no significant difference was observed between the control and the Tobacco treatment throughout the duration of the study probably due inssuficient dose of the applied *N. tabacum* leaf powder. This is similar to findings of [15] in the study of the insecticidal effect of the powders of some plants on the conservation of maize seeds against the weevil Sitophilus *Zea mais* observed significant differences between the control and the leaf powder treatments at one dose of 0.2 g per 100 kernels of maize.

Table 5. Weevil perforation indices recorded during storage of black bean seeds according to treatment

Treatment	30^{th} day	60^{th} day	90^{th} day	120^{th} day	150^{th} day
Control	50.0±0.0 a	50.0±0.0 a	50.0±0.0 a	50.0±0.0 a	50.0±0.0 a
Tobacco	20.0±40.0 a	20.0±40.0 a	20.0±20.0 a	20.0±40.0 a	20.0±20.0 a
Antouka	20.0±40.0 a	20.0±40.0 a	40.0±23.0 a	40.0±46.0 a	40.0±23.0 a
Protect DP	0.0±0.0 a	20.0±40.0 a	20.0±20.0 a	20.0±40.0 a	40.0±23.0 a

Values (means±standard deviation) in a column followed by the same letter are not significantly different at the 5% level by the test of the least significant difference (PPDS).

Weevil emergence in stored black bean

According to results in table 6, *N. tabacum* leaf powder treatments recorded the lowest number of Weevil that emerged during the storage period. The number of Weevil that appeared in the batches of stored black beans was higher in the control treatment with a peak of at the third month (7.0). During this same period, the batches treated with *N. tabacum* leaf powder had no of weevils. A total of 9 occurrences were observed in the control versus zero in the *N. tabacum* leaf powder treatment. This could be due to the long-lasting effect of the tobacco powder or the fact that the Weevil larvae were inhibited from the start, preventing the proliferation of this pest. This corroborates previous assertion reported by [11] that nicotine is a very rapid contact killer of insects and small soft-bodied organisms.

Table 6. Average numbers of Weevil recorded during grain storage

Treatment	30^{th} day	60^{th} day	90^{th} day	120^{th} day	150^{th} day
Control	0.2±0.5 a	0.0±0.0 a	00±0.0 a	1.7±1.5 a	7.0±8.7 a
Tobacco	0.2±0.5 a	0.0±0.0 a	0.0±0.0 a	0.0±0.0 b	0.0±0.0 a
Antouka	0.7±1.5 a	0.0±0.0 a	0.7±1.5 a	0.0±0.0 b	0.0±0.0 a
Protect DP	0,0±0.0 a	0.2±0.5 a	0.0±0.0 a	0.0±0.0 b	0.2±0.5 a

Values (means±standard deviation) in a column followed by the same letter are not significantly different at the 5% level by the test of the least significant difference (PPDS).

Mortality of Weevil in stored black bean

In the case of the stored black bean, the absence of mortality in several batches and the insufficient number of mortality observations in some blocks did not permit the analysis of variance. According to results in table 7, the absence of mortality is linked to the absence of weevil which could be explained by the effect of tobacco powder and other powders in the treated batches.

Table 7. Mortality rate (%) in black bean batches

Treatment	30th day	60th day	90th day	120th day	150th day
N1	0	/	/	0	/
N2	/	/	/	50	10
N3	/	/	/	100	/
N4	/	/	/	100	50
NT1	/	/	/	/	/
NT2	/	/	/	/	/
NT3	/	/	/	/	/
NT4	100	/	/	/	/
NA1	/	/	/	/	/
NA2	100	/	/	/	/
NA3	/	/	/	/	/
NA4	/	/	100	/	/
NP1	/	100	/	/	/
NP2	/	/	/	/	/
NP3	/	/	/	/	/
NP4	/	/	/	/	0

This is contrary to the results obtained with the red bean and suggests the red bean is more vulnerable to the pest than the black bean. This observation corroborates the work of [16] who show a lower sensitivity of black beans to Weevil compared to red beans.

4 DISCUSSION

The high use of synthetic insecticides by farmers is similar to the works of [17] and [18] as the best method to prevent pest damage in grains. According to these authors, the advantages of this practice is related to its cost, which can be relatively low, the ease of application and the duration of protection, which can extend over several months. However, poorly conducted applications of insecticides may cause serious drawbacks, including the appearance of resistant strains, chronic intoxication of consumers and a negative impact on the environment.

Results showed that the inert material used in the study zone against bean pest is wood ash. It is sieved to obtain the finest ash, that is mixed with beans and kept in containers or plastic bags. It is used at a dose almost equivalent to a quarter of the volume of the bean to be treated and stored for more than 12 months. Some particularities in the use of wood ash depends on the material that was burnt. Common materials that has proven to be more effective according to the results obtained are the ashes obtained from dried plantain peelings and bean pods. This is similar to findings of [19] in the Far North of Cameroon indicating ashes to be a good repellant of insects that deter posing a mechanical barrier to the penetration of pests. The absence of intergranular voids in the sieved ash, slows down the progress and limits the attacks of Weevil and neonate larvae.

Previous studies showed that plants or some plant parts have been used locally to control insect pests. The techniques used in their preparation and the plant parts used are different. These plants and substances with the exception of Lantana camara are different from those listed by [19] and [20] respectively in the North-West region and the Ménoua Division in Cameroon. The plants identified by these authors include: *Clausena anisata*, *Cupressus sempervirens*, *Capsicum frutescens*, *Chenopodium ambrosioides*, *Eucalyptus saligna* and *Lantana camara*. Traditionally, these plants are commonly used for this type of protection. In the traditional conservation of millets, this same author cites, an odoriferous insecticidal plant, *Hyptis spicigera*, which is a repellent showing chemical effects linked to the emission of volatile products. Without being lethal, the latter acts on the pest by inhibiting its behavior.

5 CONCLUSION

This study that was aimed at investigating the effet of an alternatively low-cost pesticide against an important pest of stored *Phaseolus vulgaris* seeds in the west region of Cameroon showed that the *N. tabacum* leaf powder has a protective effect on the grains with a perforation index of less than 50 and significantly reduces Weevil perforation. This protective effect is comparable to that of synthetic products commonly used by farmers in the study zone.

In addition, the black bean seems to be more resistant to the weevil *Acanthoscelides obtectus* than the red bean indicating a possible significant interaction between the bean varieties and the insecticidal treatments. Thus, the *N. tabacum* leaf powder that is eco-friendly could be recommended for use to small- and large-scale farmers in the study zone to curb the addition costs involved in the used of synthetic pesticides.

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