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Insecticidal properties and persistence of *Berlinia grandifolia* (J. Vahl) and *Securidaca longepedunculata* Fres., two Aromatic Plants from the Far-North region of Cameroon alone or in Combination against *Sitophilus oryzae* L. (Coleoptera : Curculionidae).

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ABSTRACT: The aim of the present work was to evaluate the insecticidal effects of two plants used by farmers as natural pesticide to manage stored sorghum pests in the Far-North Region of Cameroon. Dried powders of Berlinia grandifolia (trunk bark) and Securidaca longepedunculata (root bark) were tested against Sitophilus oryzae. Powders were tested at 0.05, 0.5, 1, and 2 g/100 g of sorghum grain for screening LD50 and LT50 on adults' mortality of each plant. Combinations of plant powder toxicity and persistence were evaluated with screening results data's on adults' weevils toxicity. Results showed that the effects varied with plant species, quantity and exposure time. Securidaca longepedunculata plant powder is the most toxic (LD50 = 0.07g/100g grain) and have rapid effects (LT50 = 3.72 days at 1 g/100 grain) than Berlinia grandifolia (LD50 = 2.046g/100g of grain; LT50 = 7.82 days at 1 g/100g of grain). The toxicity of Berlinia grandifolia on adults decreased of 33.87 % from 7 to 19 days post treatment. There was not decrease observed in Securidaca longepedunculata mortality rate in the same conditions (69.975 ± 3.072 % of mortality mean). The mortality rates induced by combinations of the powders (Securidaca longepedunculata + Berlinia grandifolia) were increased by the proportion of Securidaca longepedunculata used, and, after 3 to 7 days exposure time, a synergic effect was observed. These results suggest that a suitable strategy for pest management of stored sorghum is possible by using natural product.

***Keywords*:** stored sorghum, Sitophilus oryzae, plant powder, toxicity persistence, synergic effects, Far-North Cameroon

INTRODUCTION

The rice weevil, *Sitophilus oryzae* L. (Coleoptera: Curculionidae), is the most important post-harvest insect pest of sorghum in Cameroon (Ngamo *et al.,* 2004). In a period of 100 days a single prolific female can produces 24 adults and more than 57% of grains are attacked (Ladang *et al.,* 2008). Futher more, these grains are the most common and constitute the bulk of food production in other parts of sahelian zone in Africa (Djanan, 2003 ; Hounhouigan, 2003 ; Nukenine, 2010 ; Guèye *et al*., 2011). To prevent losses, producers usually rely on the use of chemical insecticides (Guèye *et al***., 2011**). These chemical insecticide used frequently and abusively can lead to the environmental pollution and the intoxication of consumers. (Ngamo, 2001 ; Kouninki *et al*., 2007 ; Kaloma *et al.,* 2008, Kouninki *et al.,* 2010). There is an urgent need to develop user-friendly storage conditions with minimal adverse effects on the environment and on consumers. Since last decade, many researches on stored products protection are based on the alternative methods to synthetic chemical pest control (Ngamo et Hance, 2007 ; Kouninki *et al.,* 2010 ; Nukenine, 2010, Afful *et al.,* 2012, Kouninki *et al*., 2014; El Idrissi *et al.* ,2014). In Cameroon, many botanical insecticides have been found to control post-harvest pests: *Anonna senegalensis, Lippia rugosa, Hyptis spicigera* (essentials oils); *Azadirachta indica*, *Plectrantus glandulosus*, *Xylopia aethiopica, Ocimum canum, Vepris heterophylla* (powders) (Ngamo *et al.,* 2007 Ngassoum *et al.,* 2007; Kouninki *et al.,* 2007 ; Kouninki *et al*., 2010 ; Nukenine *et al*., 2010). In the Far-North Region of Cameroon, other investigations have revealed that *Berlinia grandifolia* (J. Vahl) and *Securidaca longepedunculata* Fres., two local's plants, are usually used by farmers as botanical insecticides to control insect pest during storage. These two local plants have not been tested in laboratories against the rice weevil. The objective of this study is to evaluate the insecticidal effect of these plants powders, alone or in combination on sorghum grain and its persistence effects against *S. oryzae.*

MATERIALS AND METHODS

Culturing of insects

The strain of *S. oryzae* was collected from infested stock of sorghum grains at the Mokolo market (Far-North region of Cameroon). Weevils were reared on sorghum in 1000 ml glass jar, in which 30 adults of mixed sex were introduced and kept under laboratory conditions to allow oviposition. The adults were removed after two weeks to enable the emergence by sieving the grain, after which the grains were reintroduced into the glass jars.

Collection and Preparation of plant powders

Trunk bark of *B. grandifolia* (J. Vahl) and roots bark of *Securidaca longepedunculata* Fres. were collected and air-dried in Mokolo at room conditions during three months (July to September 2011). Each part of the plant were pounded in a wood mortar until the powder passed through 0,4 mm mesh sieve. The powders were stored in plastic jar in laboratory conditions for bioessays.

LD50 and LT50 determination

Adults of Rice Weevil, *S. oryzae* were exposed with various increasing quantity of each plant separately. For each plant powder, four differents rates were used: 0.5, 5, 10 and 20g /kg of sorghum seed, and five replications were made. *Sorghum bicolor* (L) Moench (Poaceae) seeds were purchased in local market of Mokolo during the harvest period (October-November 2011). Seeds were disinfested by keeping in a freezer at 5°C for 24 hours and exposed to sun lightfor 4 hours. The sorghum was kept in laboratories conditions. The moisture content of the seed (8.3 +/- 0.31%) was determined by using the method of AFNOR (1982). The mixture was subsequently handshaken for 2 minutes to have uniform coating. 20 unsexed weevils were introduced in each jar. Control consisted of sorghum without insecticidal product and sorghum treated by Malagrain at the standar rate. Malagrain DP 5 which contained malathion 5 % was used as positive control. This chemical insecticide was autorized for 10 years by the Ministry of Agriculture and Rural Developpement on december 30th in 2004 in Cameroon (CAPANET, 2005)*.* The number of *adults* weevils'death was recorded after 1, 3, 7 and 14th days after weevil infestation. LD50 (rate of powder plant which induce 50% of weevil mortality) and LT50 (exposure period time which can cause 50% of weevil mortality) values were determined by Probit analysis (Finney, 1971).

The persistence insecticide effects of *Berlinia grandifolia* and *Securidaca longepedunculata* against *Sitophilus oryzae*

500 ml glass jar containing 50 g sorghum seeds were treated using the LD50 of *B. grandifolia* and *S. longepedunculata* obtained for the persistence insecticide effects. The control consisted of 50 g of untreated sorghum seeds. For each treatment, 5 pairs of *S. oryzae* were introduced in each jar after 7, 11, 15 and 19 days after application of treatment (Table 1). For Each treatment four replications were made. The mortality of *S. oryzae* was recorded 4 days after infestation.

Table1. Experimental protocol and days on which parameters were recorded

Experiment	Days			
Preparation of treatments	0			
Insect introduction (infestation)	7	11	15	19
Mortality observation	11	15	19	24

Insecticidal effect of *Berlinia grandifolia* and *Securidaca longepedunculata* combinations against *Sitophilus oryzae.*

500 ml of jar containing 50 g sorghum seed were treated by one of the three combinations of *B. grandifolia* and *S. longepedunculata.* Three combinations with different proportions of 7-days LD50 of plant powders have been prepared (Table 2). Five pairs of weevils were introduced. Each treatment was replicated five times. Mortality of *Sitophilus oryzae* was recorded after 4th, 8th and 14th days after treatments in presence of the various plants powder combinations.

Table 2. Different proportions of the plants combinations tests.

	7-days LD50 proportions	
Plant species	*Securidaca longepedunculata*+	*Berlinia grandifolia*
Combination1=	¼ +	¾
Combination2=	½ +	½
Combination3=	¾ +	¼

During bioassays period, the daily temperature and humidity of laboratory ranged from 26.26 to 28°C and 20 to 20.61% RH.

Data analysis

Data were subjected to the ANOVA procedure using STATGRAPHIC PLUS software. Chi square test was applied to evaluate insecticide combination effects. Probit analysis (Finney, 1971) was applied to determine lethal concentration causing 50% (LD50) mortality of *S. oryzae* at different exposure time. Abbot's formula (Abbott, 1925) was used to correct control mortality before probit analysis and ANOVA.

RESULTS

LD50 and LT50 determination

Results obtained showed that insecticidal effects varied with plant species, dose rate and exposure time. Within 1 day exposure time, and for all applied rates, no insect mortality was observed. *Securidaca longepedunculata* is the most toxic (7-days LD_{50} = 0.07g/100g grain) and have the most rapid effects (LT_{50} = 3.72 days at 1 g/100 grain) than *B. grandifolia* (7-days LD_{50} = 2.046g/100 g grain; LT_{50} = 7.82 days at 1 g/100 grain) Table 4 and 5. The *S. oryzae* mortality caused by malagrain (100% at standard rate) was similar for all exposures times.

Depending on the post exposure time, mortality tended to increase with the increasing of the quantity of powder rates for *S. longepedunculata* (and LT50 10,490 to 3,489 days respectively for 0.05 to 2 % of powder rate), *B. grandifolia* (46,918 to 6,728 days respectively for 0.05 to 2 % of powder rate) (Table 4).

High mortality rates of *B. grandifolia* (74 %) were gradually achieved within 14 days exposure time. Starting from 7 to 14 days exposure, higher mortality rates (94.6 +/-6.51 to 99 +/- 2.33%) were achieved for *S. longepedunculata*. These higher mean of toxicity do not differ significantly (Table 3).

Table 3. Corrected cumulative mortality (mean ± SE)[(a)] of *Sitophilus oryzae* exposed to four concentrations of *Berlinia grandifolia* and *Securidaca longepedunculata* powder

Product and concentration	Exposure period (days)			
	1	**3**	**7**	**14**
***B. grandifolia* (g/kg)**				
0	0.00 ± 0.00	0.00 ± 0.00 ^{d}	6 ± 4.1^{d}	7 ± 5.7^{f}
0.5	0.00 ± 0.00	0.00 ± 0.00 ^{d}	37 ± 14.83^{c}	12 ± 5.7^{e}
5	0.00 ± 0.00	17 ± 9.74^{cd}	52 ± 16.8^{bc}	61 ± 13.41^{c}
10	0.00 ± 0.00	28 ± 14.4^{bc}	52 ± 8.36^{bc}	56 ± 17.81^{b}
20	0.00 ± 0.00	34 ± 12.94^{b}	64 ± 21.9^{b}	75 ± 9.35^{b}
F value	-	66.07**	26.85**	60.51*
***S. longepedunculata* (g / kg)**				
0	0.00 ± 0.00	0.00 ± 0.00 ^{d}	6 ± 4.1^{d}	7 ± 5.7^{d}
0.5	0.00 ± 0.00	24 ± 7.41^{c}	45 ± 16.95^{c}	54 ± 8.21^{c}
5	0.00 ± 0.00	58 ± 6.7^{b}	95 ± 5^{b}	96 ± 2.23^{b}
10	0.00 ± 0.00	69 ± 7.41^{ab}	94 ± 6.51^{b}	99 ± 2.23^{ba}
20	0.00 ± 0.00	74 ± 19.17^{a}	97 ± 6.7^{a}	99 ± 2.23 ^{a}
F value	-	53.11**	107.87**	379.77**
Malagrain (0,5g / kg)	100 ± 0.00^{a}	100 ± 0.00^{a}	100 ± 0.00^{a}	100 ± 0.00^{a}

(a)=Means in the same column followed by the same lower case letter do not differ significantly at ANOVA test. ** P<0.00001 ;* P <0.0001
Each data represents the mean of four replicates.

Table 4. Speed action of *Securidaca longepedunculata* and *Berlinia grandifolia* powders on *Sitophilus oryzae*.

Concentration	n	R^2	Equation of regression	LT50 Days (Hours)
B. grandifolia				
0.05	4	0.976	y = 1.923x + 1.786	46.918 (1126.03)
0.5	4	0.955	y = 2.868x + 2.163	9.754 (234.09)
1	4	0.924	y = 2.974x + 2.258	8.355 (200.52)
2	4	0.913	y = 3.243x + 2.315	6.728 (161.47)
S. longepedunculata				
0.05	4	0.912	y = 2.694x + 2.250	10.490 (251.76)
0.5	4	0.919	y = 4.206x + 2.397	4.157 (99.76)
1	4	0.943	y = 4.621x + 2.359	3.725 (89.4)
2	4	0.892	y = 4.523x + 2.545	3.489 (83.52)

Table 5. *Securidaca longepedunculata* and *Berlinia grandifolia* toxicity on *Sitophilus oryzae* at 3, 7 and 14 exposure days.

Plant species	N	R^2	Equations of regression	LD_{50} (in % = g/100g of seeds)
3 days				
B. grandifolia	3	0.936	Y = 2.909x + 4.060	2.104
S.longepedunculata	3	0.944	y = 0.363x + 7,27	0.30
7 days				
B. grandifolia	3	0.785	y = 0.1268x + 5.219	2.046
S.longepedunculata	3	0.752	y = 0,.59x+ 4.795	0.07
14 days				
B. grandifolia	3	0.357	y = 0.405x + 4.874	0.671
S.longepedunculata	3	0.752	y = 0.659x + 4.495	0.04

The insecticidal effects of *Berlinia grandifolia* and *Securidaca longepedunculata* against *Sitophilus oryzae* in combination

The insecticidal effect of *B. grandifolia* and *S. longepedunculata* against *S. oryzae* in combination depends on the proportions of each plant powder and the exposure time of *S. oryzae.* Mortality obtained were higher than expected within 7 exposure days (5% more in $combination_2$ and 13% $combination_3$) but less than expected within 14 days exposure (χ^2 α=0.001) (Table 6). Toxic effects increase with proportion rate of *S. longepedunculata* in all combinations.

Table 6. Insecticidal activity of the three combinations of *Securidaca longepedunculata* and *Berlinia grandifolia* towards *Sitophilus oryzae*.

Combinations	Cumulative mortality (%)		CHI^2 (α = 0,001)
	expected	observed	
	3 days		
combination1	25	25	4
combination 2	25	27.5	52
combination 3	25	40	284
	7 days		
combination 1	50	41	44.625
combination 2	50	63	22.512
combination 3	50	55	108
	14 days		
combination 1	100	65	56.619
combination 2	100	76	29.191
combination 3	100	87.5	11

Persistence effects of *Berlinia grandifolia* and *Securidaca longepedunculata* toxicity against *Sitophilus oryzae*.

The percentages of mortality according to the delay of the introduction of *S. oryzae* after application of the treatment are given in figure1. Mortality induced by *S. longepedunculata* led to 69.75 ± 3.072 % between 7 to 19 exposure days. Slight decrease observed was not significant (χ^2 = 7.75 p>0.05). *Berlinia grandifolia* powder mortality decreased from 52 to 18.63 % during the same observation period (χ^2 = 25.27, p<0.05).

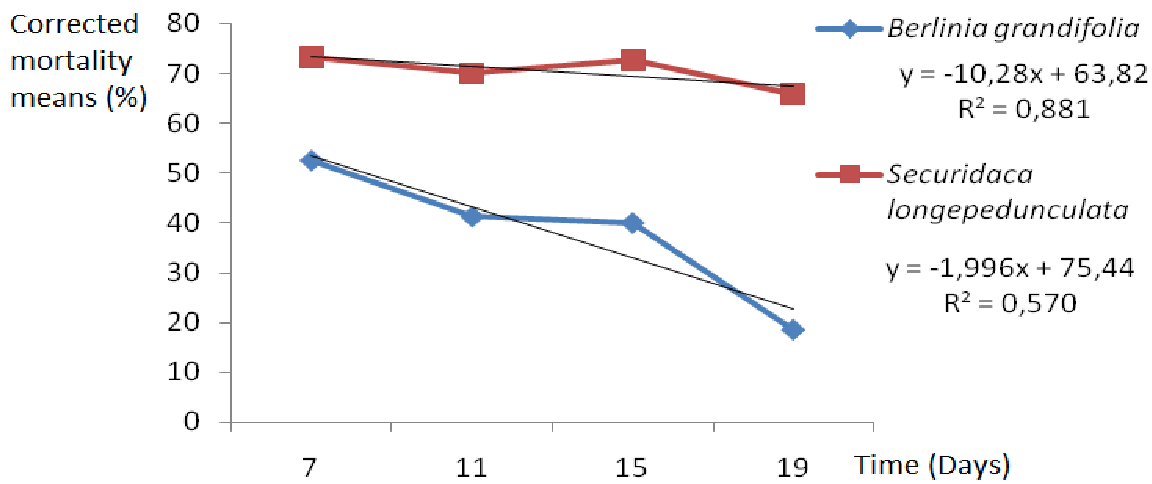

Figure 1. Mortality of *Sitophilus oryzae* in relation with the day of its introduction after treatment of grain with *Berlinia grandifolia* and *Securidaca longepedunculata*.

DISCUSSION

Higher toxic effects observed with *S. longepedunculata* against *S. oryzae* justify the use of this plant as natural pesticide to protect stored grain in Cameroon, Ghana and Senegal (Seck, 1994; Belmain and Stevenson, 2001; Boeke *et al.,* 2004, Stevenson *et al.,* 2009, Afful *et al.,* 2012). Previous authors are demonstrated efficiency of root bark extracts in controlling the progeny of *S. zeamais* and *C. maculatus.* Securidacasides A and B (Stevenson *et al*., 2009) and salicylate of methyl (Orwa et *al.,* 2009*)* are volatile compounds found in the roots of *S. longepedunculata.* These compounds are toxic against *C. maculatus*, *S. zeamais*, *R. dominica,* and *P. truncatus* (Seck, 1994; Jayasekara *et al.,* 2005; Afful *et al.,* 2012). After one day of exposure*,* neither *S. longepedunculata* nor *B. grandifolia* (0.5 to 2 %) has induced *S. oryzae* mortality. This result could be associated with the fact that applied rates were very low, comparatively to Ileke *et al* (2014), which has obtained 50 to100% of weevils' mortality, respectively for 2.5 to12.5% both with powders of *Sygygium aromaticum* and *Anacardium occidental* on *S oryzae* The sesthortest time of contact with the plant can also be explained the obtained result, because within 3 days, mortality is increase significantly*.* Similar results were obtained with powders of *Azadirachta indica* and *Zanthoxylum zanthoxyloides* on *S. oryzae, Oryzaephilus mercator* and *Ryzopertha dominica* (Kayode et Olaniyi*,* 2014), essential oils of *X. aethiopica* on *S. zeamais* (Kouninki, 2005), oil of *Arachis hypogea, Pinari macrophyla, Balanites aegyptiaca* on *Caryedon serratus* (Camara, 1997) and neem, eucalyptus, water hyacinth and guava powder on *P. truncatus* (Mukanga *et al.,* 2010).

Generally, the toxicity of both plants powders to stored product pest, *S. oryzae* is influenced by exposure time, applied dose and plant used (Oyeniyi *et al*., 2015; Thambi and Cherian, 2015).

The persistence toxicity test result showed that *S. longepedunculata* has preserved toxicity (69,97 ± 3,072 %) while for *B. grandifolia* plant powder, the toxicity decreases rapidly. These results can be explained through chemical active component of the species plant used. Investigations on the essential oil of several aromatics plants in Northern Cameroon (Ngassoum *et al.* 2002a; 2002b, Jirovetz *et al.* 2002 ; Ngamo *et al.*, 2007;Goudoum *et al.,* 2013) had proven that plant species has more persistence toxic effect when they contained higher proportion of oxygenated molecules such as oxygenated monoterpens and sesquiterpens. Regnault-Roger *et al.* (2002) showed the lower volatility of oxygenated molecules because of their higher molecular weight. Thus, persistence effect of *S. longepedunculata* toward *S. oryzae* could be justify by their higher oxygenated sesquiterpens contents (securidacasids A) which had been efficient against Curculionidae and Bruchidae (Seck, 1994 ; Stevenson *et al*., 2009). Obeng-Ofori *et al*. (1997). Ngamo *et al.* (2007) and Goudoum *et al.,* **(2013)** showed also that persistence of insecticidal activity was in relationship with the sensitivity of the major target pest to active compound. Decreasing toxicity of *B. grandifolia* is similar to those results obtained with *X. aethiopica* against *C. maculatus* (Kouninki *et al.,* 2010).

Combination test at different proportion of *S. longepedunculata* and *B. grandifolia* revealed synergic action both on toxicity effect and speed action of mixture (Ngassoum *et al.,* 2007; Khatun *et al.,* 2014).(Similar results were obtained by investigations made with essential oil combinations of *H. spicigera + V. heterophylla and O. canum + V. heterophylla* (Ngassoum *et al.,* 2007). Synergic effects were observed on both the toxicity on *S. oryzae* on reducing lethal time (LT50) and increased repellent properties of these combinations. The volatile nature of the compounds of the plants powder used could have induced chemical reactions and so the emergence of new toxic molecules or disappearance of antagonist compounds to toxic molecules (Ngassoum *et al.,* 2007); the combinations of low proportions of *B. grandifolia* induce higher mortality than expected and are faster than expected. *B. grandifolia* could amplify the toxic potency of *S. longepedunculata,* and therefore, the types of interaction between the combinations of different powders depends on the mixing ratios. Similar observations were made with combinations of chemical insecticides pirimiphos-methyl and other three essential oils in different proportions against *C. maculates* by Khalequzzaman Rumu (2010). These authors have observed synergistic effects between pirimiphos-methyl and *Elettaria cardamomum* (L.) only the ratio of 1:20. *Other* combinations (ratios of 1:1, 1:2, 1:5, 1:10) are rather antagonistic effects.

REFERENCES

Abbott WS. 1925, A method of computing the effectiveness of an insecticide. J. Econom. Entomol., 18: 265-267.

Afful E, Owusu EO and Obeng-Ofori D. 2012. Bioactivity of Securidaca longepedunculata Fres. against Callosobruchus maculatus Fab.(Coleoptera: Bruchidae) and Sitophilus zeamais Motsch (Coleoptera: Curculionidae). International Journal of Agricultural Science Research Vol. 1(3), pp. 046-054

Boeke SJ, Baumgart IR, Van Loon JJA, Van Huis Aand Kossou MDK. 2004, Toxicity and repellence of African plants traditionally used for the protection of stored cowpea against Callosobruchus maculates. J. Stored Prod. Res., 40: 423–438;

Camara A. 2009.Lutte Contre Sitophilus oryzae L. (Coleoptera: Curculionidae) et Tribolium castaneum Herbst (Coleoptera: Tenebrionidae) dans les stocks de riz par la technique d'étuvage traditionnelle pratiquée en basse-guinée et l'utilisation des huiles essentielles végétales. Thèse de doctorat en sciences de l'environnement université du Québec à Montréal ;

Camara M. 1997. Recherche sur les nouvelles substances biocides végétales : application au contrôle des bruches du niébé Callosobruchus maculatus et de l'arachide Caryedon serratus. Mémoire de fin de formation en ingénierie. Ecole Nationale Supérieure d'agriculture du Sénégal, Département Productions Végétales ;

Delobel A and Malonga P. 1987. Insecticidal properties of six plants materials against Caryedon serratus (OL) (Coleoptera: Bruchidae). J. Stored Prod. Res., 23 (3), 173-176;

Delobel A and Tran M. 1993. Les coléoptères des denrées alimentaires entreposées dans les régions chaudes. Faune Tropicale XXXII. ORSTOM/CTA Eds, Paris, 424 p ;

Delobel A. 1994. Les insectes ravageurs des tubercules et racines en Afrique tropicale: biologie, mesures de protection et méthodes de lutte. In: Post-récolte, principes et application en zone tropicale. ESTEM/AUPELF, Verstraeten et al. Eds., 63-78 ;.

Dharani N, Rukunga G, Yenesew A, Mbora A, Mwaura L, Dawson I and Jamnadass R. 2010. Common Antimalarial Trees and Shrubs of East Africa: a Description of Species and a Guide to Cultivation and Conservation Through Use. Dawson I ed. The World Agroforestry Centre (ICRAF), Nairobi, Kenya ;

Djanan D, Mbayhoudel K and Nandoum M. 2003. Organisation des unités de transformation artisanale en zone de savanes : Cas de la transformation du sorgho en bière locale bili-bili à Moundou au Tchad. In « Savanes africaines : des espaces en mutation, des acteurs face à de nouveaux défis ». Actes du colloque, mai 2002, Garoua, Cameroun. Prasac, N'Djamena, Tchad -CIRAD, Montpellier, France Jamin J.Y., Boukar S. L., Floret C. (éditeurs scientifiques) ;

El idrissi M, Elhourri M, Amechrouq A and Boughdad A. 2014. Étude de l'activité insecticide de l'huile essentielle de Dysphania ambrosioïdes L. (Chenopodiaceae) sur Sitophilus oryzae (Coleoptera: Curculionidae). J. Mater. Environ. Sci. 5 (Y) ISSN : 2028-2508 CODEN: JMESCN;

Finney DJ. 1971. Probit analysis. Cambridge University Press, London, United Kingdom ;

Goudoum A, Tinkeu LSN, Ngassoum MB and Mbofung CM. 2013. Persistence of active compounds of essential oils of Clausena anisata (rutaceae) and Plectranthus glandulosus (labiateae) used as insecticides on maize grains and flour.AJFAND vol 13;7324-7338

Guèye MT, Seck D, Wathelet JP and Lognay G. 2011. Lutte contre les ravageurs des stocks de céréales et de légumineuses au Sénégal et en Afrique occidentale : synthèse bibliographique Biotechnologie, Agronomie, Société et Environnement ISSN 1370-6233 (15) 3 ;

Hounhouigan JD. 2003. La valorisation des céréales locales pour les marchés urbains en Afrique de l'Ouest: atouts, contraintes et perspectives. 2ème Atelier international. Thème 3: Transformation des aliments au niveau des ménages et des communautés en vue d'améliorer la (bio) disponibilité ;

Isman MB. 2008.Perspective. Botanical insecticides: for richer, for poorer ;Pest Manag Sci 64:8–11 ;

Jayasekara T, Stevenson PC, Hall DR and Belmain SR. 2005. Effect of volatile constituents root of Securidaca longepedunculata on insect pests of stored grain. J. Chem. Ecol., 31: 303–313;

Jayasekara TK, Belmain, SR, Stevenson PC, Hall DR and Farman DI. 2002. Identification of methylsalicylate as the principal volatile component in the methanol extracts of the root of Securidaca longepedunculata Fres. J. Mass Spectrom., 37, 577–580;.

Jirovetz L, Buchbauer G, Puschman C and Ngassoum MB. 2000. Investigation of aromatic plants from Cameroon: Analysis of the essential oil of flowers of Hyptis spicigera (L.) Poit, By GC, GC/MS and olfactometry, Journal of essential oils-Bearing Plants 3(2): 71-77;

Kaloma, Kitambala K, Ndjango NL, Sinzahera U and Paluku T. 2008. Effet des poudres d'Eucalyptus citriodora, de Cupressus lucitanica et de Tagetas minitifora dans la conservation du maïs (Zea mays) et du haricot (Phaseolus vulgaris) dans les conditions de Rethy (République Démocratique du Congo). Tropicultura, 26, 1, 2427;

Kayode DI, and Olaniyi OC. 2014. Entomocidal Activity of Powders and Extracts of Four Medicinal Plants Against Sitophilus oryzae (L), Oryzaephilus mercator (Faur) and Ryzopertha dominica (Fabr.). Jordan Journal of Biological Sciences. Volume 7, pp 57-67.

Kenga R, Djorowe G and Gupta SC. 2005. Effect of sorghum varieties and herbicides application on subsequent season Striga hermonthica reproduction. In Rapport Général de la Revue Scientifique de l'IRAD du 25 au 28 juillet Yaoundé, Cameroun ;

Khalequzzaman M and Rumu SN. 2010.Toxicity of prirmiphos-methyl and three essential oils, alone and in combination against Callosobruchus maculatus (Fab.). Univ. j. zool. Rajshahi. Univ. (28), 01-05;
Khatun M, Nargis A, Talukder D, Seatara K and Ruhul A. 2014. Efficacy of Different Solvent Extracts of Chhoto Kamine (Murraya koenigii) Alone and Combined with Lignin and Sulphoneted Lignin Separately on the Adult Mortality of Sitophilus oryzae. Bangladesh Res. Pub. J. 9(4): 260-264.
Kouninki H, Ngamo LST, Hance T and Ngassoum MB. 2007. Potential use of essential oils from local Cameroonian plants for the control of red flour weevil Tribolium castaneum (herbst.) (Coleoptera : Tenebrionidae) African Journal of food Agricultur Nutrition and Developpement), 7 (5), 1684-5374;
Kouninki H. 2005. Etude de la toxicité des huiles essentielles de quelques plantes traditionnellement utilisées au Nord Cameroun contre les Bruchidae et les Curculionidae. Mémoire de DEA, Université Catholique de Louvain, Département de Biologie .84p ;
Kouninki H, Hance T, Djossou J, Noudjou F, Lognay G, Malaisse F, Ngassoum MB, Mapongmetsem PM, Ngamo TL and Haubruge E. 2010. Persistent effect of a preparation of essential oil from Xylopia aethiopica against Callosobruchus maculatus (Coleoptera, Bruchidae). African Journal of Agricultural Research 5(14), 1881-1888,18
Kouninki H, Sobda G and Nukenine NE. 2014. Screening of Bambara groundnut (Vigna subterranea) lines for Callosobruchus maculatus resistance in the Far North Region of CameroonJournal of Renewable Agriculture, 2(1):18-22
Ladang YD, Ngamo LTS, Ngassoum MB, Mapongmestsem PM and Hance T. 2008. Effect of sorghum cultivars on population growth and grain damages by the rice weevil, Sitophilus oryzae L. (Coleoptera: Curculionidae). African Journal of Agricultural Research 3 (2),. 255-258;
Mukanga MM, Yakub Deedat D and Mwangala FS. 2010. Toxic effects of five plant extracts against the larger grain borer, Prostephanus truncatus. African Journal of Agricultural Research 5(24), 3369-3378;
Ngamo LST and Hance T. 2007. Diversité des ravageurs des denrées et méthodes alternatives de lutte en milieu tropical. Tropicultura, 25, 4, 215-220 ;
Ngamo LST. 2001. Deuxième rapport annuel (2000-2001). Grand programme de recherche universitaire. Développement et valorisation des ressources animales et végétales. Protection intégrée des denrées stockées. Université de Ngaoundéré. 15 p ;
Ngamo LST, Ngassoum MB, Mapongmetsem PM, Noudjou WF, Malaisse F, Haubruge E, Lognay G, Kouninki H and Hance T. 2007. Use of essential oils of aromatic plants as protectant of grain durring the storage. Agricultural Journal 2 (2): 204-209;
Ngamo LST, Ngassoum MB, Jirovetz L, Ousman A, Nukenine E and Moukala OE. 2001. Protection of stored maize against Sitophilus zeamaïs (Motsch.) by use of essential oils of spices from Cameroon. Mededelingen van de Faculteit Landbouwwetenschappen, Universiteit Ghent, 66, 473-478;
Ngamo TLS, Goudoum A, Ngassoum MB, Mapongmetsem PM, Lognay G, Malaisse F and Hance T. 2007. Chronic toxicity of essential oils of 3 local aromatic plants towards Sitophilus zeamaïs Motsch. (Coleoptera: Curculionidae). African Journal of Agricultural Research 2 (4), 164-167;
Ngamo TSL, Ngatanko I, Ngassoum MB, Mapongmestsem PM and Hance T. 2007. Persistence of insecticidal activities of crude essential oils of three aromatics plants towards four major stored product insect pests. African Journal of Agricultural Research 2(4), 173-177;
Ngassoum BT, Tastsadjeu, Mapongmetsem PM, Jirovetz L , Buchbauer G and Shahabi M, 2002a. Comparative aroma compoud analysis of different essential oil of Lippia rugosa from Cameroon using GC-FID, GC-MS and olfactometry, J. Essent oil Res;
Ngassoum BT, Tastsadjeu, Mapongmetsem PM, Jirovetz L, Buchbauer G and Shahabi M. 2002b.Comparative aroma compoud analysis of different essential oil of Lippia rugosa from Cameroon using GC-FID, GC-MS and olfactometry ISEO conference , Lisbone Portugal;
Ngassoum MB, Ngamo TLS, Illiassa N, Tapondjou LA, Lognay G, Malaisse F and Hance T. 2007. Chemical Composition, Insecticidal Effect and Repellent Activity of Essential Oils of Three Aromatic Plants, Alone and in Combination, towards Sitophilus oryzae L. (Coleoptera: Curculionidae). Natural Product Communications 2 (12) 1229-1232 ;
Nukenine EN. 2010. Stored product protection in Africa: Past, present and future. 10th International Working Conference on Stored Product Protection 26 Julius-Kühn-Archiv;
Nukenine EN, Adler C and Reichmuth Ch. 2010. Bioactivity of fenchone and Plectranthus glandulosus oil against Prostephanus truncatus and two strains of Sitophilus zeamaïs. Journal of Applied Entomology 134 (2), 132-141;
Obeng-Ofori D, Reichmuth C, Bekele J and Hassanali A. 1997. Biological activity of 1,8-cineole, a major component of essential oil of Ocimum kenyense (Ayobangira) against stored products beetles. Journal of Applied Entomology, 121, 237-243;
Orwa C, Mutua A, Kindt R, Jamnadass R and Simons A. 2009. Agroforestree Database: a tree reference and selection guide version 4.0 (http://www.worldagroforestry.org/af/treedb/);
Regnault-Roger C and Hamraoui A. 1994. Reproductive inhibition of Acantocelides obtectus Say (Coleoptera) bruchid of kidney beans (P. vulgaris L.) by some aromatic essential oils, Crop Protection, 13, 624-628 ;
Stevenson PC, Dayarathna TK, Belmain SR and Veitch NC. 2009. Bisdesmosidic saponins from Securidaca longepedunculata Roots: Evaluation of deterrency and toxicity to Coleopteran storage pests. J. Agric. Food Chem., 57: 8860–8867;
Stoll G. 2000. Natural crop protection in the tropics, letting information comes on life Agrecol/CTA. Margraf Verlag.2, 23-89;
Jayasekara TK, Stevenson PC, Hall DR, and Belmain SR. 2005. Journal of Chemical Ecology, Vol. 31, No. 2, 303-313
Thambi M and Cherian T. 2015. Pesticidal Properties on the Leaf Extracts of Strychnos-Nux-Vomica Plant. JIPBS, Vol 2 (3), 266-272.
Oyeniyi EA, Gbaye OA and Holloway GJ. 2015. Interactive effect of cowpea variety, dose and exposure time on bruchid tolerance to botanical pesticide. African crop science Journal, Vol. 23,No.2,pp.165-175.
Ileke KD, Ogungbite OC and Olanyinka-olagunju JO. 2014.Powders and extracts of Sygygium aromaticum and Anacardium occidental as entomocides aigains theinfestation of S oryzae on stored sorghum grains. African crop science Journal, Vol. 22,No.4,pp.267-273
alley (Northeast Spain). Agron J. 94: 373-380.