Assessing the Effectiveness of Indigenous Plants on Postharvest Pests Control in Rwanda: Case of Tetradenia Riparia and Tephrosia Vogelii on Bean Weevil (Acanthoscelides obtectus)

Kamugire Digne Brigitte[1*], Nshutiyayesu Samuel[2]

***Corresponding author**: dibaju94@gmail.com

[1]University of Rwanda, College of Science and Technology

[2]Rwanda Institute of Conservation Agriculture (RICA)

ABSTRACT

In Rwanda, beans (*Phaseolus vulgaris*) are important staple crops and constitute the main source of protein, zinc and iron. *Acanthoscelides obtectus* is a bean weevil, major store pest of beans, caused damages reduce the weight, quality and viability of the seeds. Synthetic pesticides used to control *A.obtectus* are unfriendly to the environment due to residues. This study was meant to contribute to food security promotion by proposing the use of *Tetradenia riparia* and *Tephrosia vogelii*, native species, as botanical alternatives to be used for *A.obtectus* control. Through this study, ethnobotanical uses of *T.riparia* and *T.vogelii* were assessed by the use of semi-structured interviews with local people, to understand their knowledge and perceptions on the pesticidal properties of these plants. A review was carried out to supplement collected information. Plants'dried-leaves powder was used to treat RWV(11-29) variety, reported vulnerable to *A.obtectus*, data about average damaged grains and weight loss were collected every 2 weeks. Chi-square, ANOVA and Ducan mean separation method were used for statistical analyses. 91% of respondents stated that *T.riparia* and *T.vogelii* are used as medicine to treat various ailments. 87% and 53% confirmed to possess some knowledge about the use of *T.riparia* and *T.vogelii* respectively in protecting beans against the pest with a treatment period of at least 2 years for *T.riparia*. Compared to Skana super which is a synthetic pesticide, *T.riparia* and *T.vogelii* are less effective; *T.riparia* is more effective in reducing weight loss where after 4 weeks of treatment *T.riparia* showed no significant difference from Skana super; 5.48% and 5.20% of weight loss respectively. Further researches and trainings of farmers about the adequate use and handling of botanicals would help in reducing residues in the environment.

Keywords: *Acanthoscelides obtectus*, Bean Weevil, Pesticides, *Tephrosia vogelii*, *Tetradenia riparia*

1. INTRODUCTION

Acanthoscelides obtectus is known as bean bruchid or dry bean weevil. It originates in Southern America but has been spread in many African countries (Chernoh, 2014). It is the major store pest of stored bean in Africa, with rate of 40% in harvested crop in Tanzania (Chernoh, 2014) and 30% in Rwanda and Burundi (Jones, 1999), reducing the weight, the quality and the viability of bean seeds (Reuben *et al*, 2006). Common bean is the major source of nutrients especially in developing countries (Civelek & Kaban, 2016) as it is the major source of protein for about 70 million people in the world (Umubyeyi & Rukazambuga, 2010) and provide other nutrients such as Zinc and Iron. In Rwanda, one person consumes about 29 kg per year which is the highest consumption in the world (Larochelle *et al*, 2014) and this confirms that bean is the key crop of food security in the country.

Synthetic pesticides have been used to control *Acanthoscelides obtectus* in stored beans but were found to form persistent residues which can be accumulated and cause harm in the food chain. They are unfriendly to the environment and they can cause the development of resistance in insects (Mulungu *et al*, 2007). In some other cases, *Acanthoscelides obtectus* is controlled using fungi like *Beauveria bassiana* which is known to be able to kill insect pests of different classes (Padin *et al*, 2001), but as fungi protect against insect pest by external contact, they were found to also be able to degrade seeds slowly (Thomas & Read, 2007). In Rwanda, farmers use also ash, lime, sand or edible oil to control the pest insects in stored beans (Umubyeyi & Rukazambuga, 2010).

Botanical pesticides which are essential oils or other products from plants can also be used as protectants against pests of stored grains. Unlike synthetic ones, they are friendly to the environment and mammals which will later consume the grains. Besides, they are biodegradable and do not form residues which would be bioaccumulated later, and at the other hand they were found to be effective protectants (Rajashekar *et al*, 2012). *Tetradenia riparia* (Lamiaceae) and *Tephrosia vogelii* (Fabaceae) are two indigenous native plant species in Rwanda localy known as Umuravumba and Umuruku respectively and which have been long tested by scientists in different parts of the world and were found to be effective in protecting grains against postharvest storage insect pests (Dunkel *et al*, 1990; Mukanga *et al*, 2010). The use of *Tetradenia riparia* as protectant against bean storage pests was found to reduce the fecundity and fertility of bean bruchids and weevils (Weaver *et al*, 1992). *Tephrosia vogelii* as a pesticidal plant, was mostly reported by farmers in Zambia and Malawi as protectant of stored bean and maize (Kamanula *et al*, 2010). In Rwanda, however, synthetic pesticides are mostly used while we already know that they are harmful to human and to the environment (Mulungu *et al*, 2007).

In this study, the pesticidal effect of indigenous plants like *Tetradenia riparia* (TR) and *Tephrosia vogelii* (TV) as well as the ethnobotanical uses of these plants and how one could grow them in ex-situ conditions were determined. This would help decision makers to know the effectiveness of the plants in food protection and preservation, and in the future improve their use in food postharvest handling and sustainable food security.

2. METHODOLOGY

Used plant materials were made of (1) leaves of TR and TV whose powder was used by mixing it with beans; and (2) bean grains from a variety called "RWV11-29", one chosen for its high destruction by *A. obtectus* as reported by Rwanda Agriculture Board (RAB) technicians. Ethnobotanical uses of TR and TV were assessed through semi-structured interviews with fifteen members of the Amizero-Gakondo Traditional Healers Association located in Huye District. To know the effect of *T. riparia* and *T. vogelii* in protecting stored beans against *Acanthoscelides obtectus*, beans were treated with TR and TV leaves powder on one hand, and chemical pesticide commonly used namely "Skana Super" on the other hand. A total of sixteen boxes were used for the whole experiment, each containing 200 grams of bean grains. Two weeks after the pesticides have been applied to bean grains, we counted the number of damaged grains as well as weight of 100 grains randomly selected from the 200 grams from each box. Weight loss was obtained by subtracting the weight of 100 grains from each box from the initial weight of 100 grains. The counting and weighing were done every 14 days which correspond to the number of days an adult *A. obtectus* lives (Jones, 1999), and this was done for a period of six weeks.

TR and TV plants were collected from Rubona, one of research stations of the Rwanda Agriculture Board (RAB). Only young leaves were collected from branches. Young leaves were dried in an oven set at 40˚C for 48 hours (Da Silva *et al*.,2016 and

Müller & Heindl, 2006) and then grounded to obtain a thin powder. Exactly 12 grams of *T. riparia* powder and 12 grams of *T. vogelii* powder were each mixed with 1ml of distilled water as suggested by Da Silva *et al.*, (2016). Four treatment namely *T. riparia* powder, *T. vogelii* powder, Skana super and the controlled sample (boxes with bean grains without any pesticide) were applied to the 200 gram of bean grains for a single replication, and this was making a total of four replications and therefore 16 boxes for the whole experiments (four treatments and 4 replications)..

Treatment effects on *A. obtectus* in beans' stores were compared using ANOVA. Whenever effects were different, Duncan method (Tallarida & Murray, 1987) was used for means' separation and grouping.

3. RESULTS

3.1. Ethnobotanical uses of *Tetradenia riparia* and *Tephrosia vogelii* in Rwanda

During the investigations on ethnobotanical use of TR and TV, the two plant species were mentioned to be used traditional medicine to treat various ailments both for humans and livestock (Table 1 and 2). Moreover, *T. vogelii* was said to be used in handcraft such as making baskets.

Table 1: Medicinal uses of *Tetradenia riparia*

	Disease	Used part	Preparation	Way of administration
Human disease	Adenoiditis (gapfura)	Leaves	Pounding and decoction of fresh leaves	Vigorously rub in the pharynx with pounded leaves then drink the juice.
	Oral candidiasis (ubugendakanwa)	Leaves	Pounding and decoction of fresh leaves	Rub on wound in the mouth then drink the juice
	Respiratory diseases	Leaves	Pounding and decoction of fresh leaves	Drink the juice, spray the juice in the nasal cavity for sinusitis
	Skin disease	Leaves	Pounding leaves	Rub the pounded leaves on the infected skin part
	Mastitis, dizziness, malaria, intestinal worms, cough and flu,	Leaves	Pounding and decoction of fresh leaves	Drink the juice
	Aromatherapy sauna	Leaves	Infusion of leaves	Inhalation of vapours containing the extracts
Livestock diseases	Mastitis (ifumbi)	Leaves	Pound fresh leaves	Cows eat pounded leaves
	Theileliosis (ikibagarira)	Leaves	Pounding and decoction fresh leaves	Cows drink the juice
	Anaplasmosis (umukira)	Leaves	Pounding and decoction leaves	Cows drink the juice

Table 2: Medicinal use of *Tephrosia vogelii*

	Disease	Used part	Preparation	Way of administration
Human disease	Skin disease	Leaves	Pound fresh leaves	Rub the pounded leaves on the infected skin part
	Aromatic sauna	Leaves	Infusion	Patient inhale vapors containing *T. vogelii* extracts
Livestock disease	Hairball/Lung worms	Leaves	Pounding flesh leaves	Cows eat the pounded leaves
	Theileliosis	Leaves	Pounding and decoction of fresh leaves	Make the cattle drink the juice

Even though local people don't usually use *T. riparia* and *T. vogelii* as pesticides, they possess some knowledge about the ideal period of treatment using either plant. Most recorded duration is of 58.4% for *T. riparia* which can be used for more than 2 years before another treatment is applied (Figure 1).

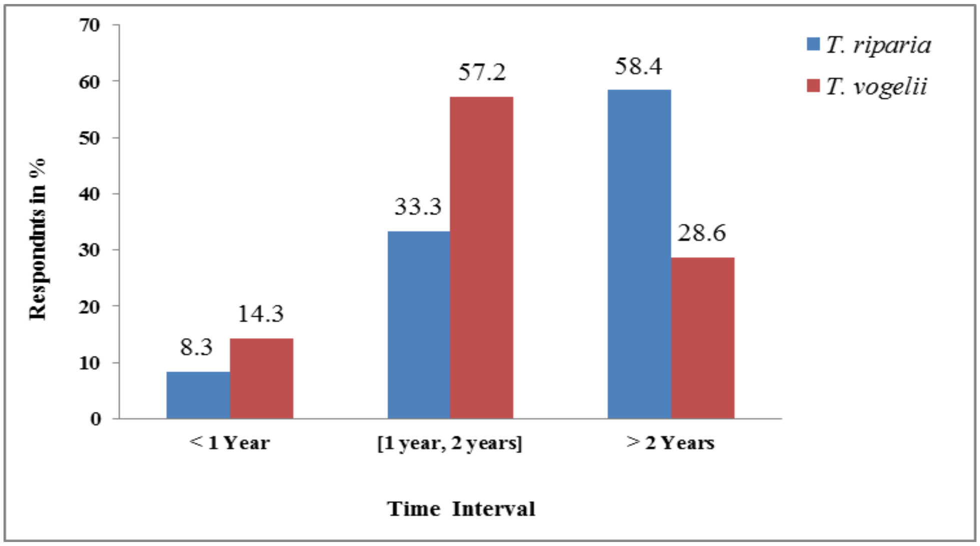

Figure 1: Farmers' perception on lifespan of pesticide from *T. riparia* and *T. vogelii* to protect common bean grains against store pests

3.2. Effect of *T. riparia* and *T. vogelii* on bee weevil

There was a significant difference (p-value <0.05) among treatments for weight of 100 grains after four weeks and a highly significant difference (p-value<0.01) among treatments for the average number of damaged grains at week 4, weight of 100 grains at week 6 as well as average number of damaged grains at week 6 (Table 3).

Table 3: Effect of insecticides on the number of bean's damaged grains over time (Mean ± standard error of the mean

Treatment	Week 2	Week 4	Week 6
	Av. Number of damaged grains	**Av. number of damaged grains**	**Av. number of damaged grains**
Control	10.5±0.65	26.75±1.03[a]	33.25±1.11[a]
Skana super	7.75±0.85	14.25±1.16[c]	21.00±1.41[c]
T. riparia	9±0.70	20±0.71[b]	25.50±1.19[b]
T. vogelii	9.5±0.65	20.75±0.43[b]	29±0.41[b]
R^2	56.57	92.27	87.04
CV	15.20	8.48	8.63
P-value	0.11	<0.0001	0.0003

Treatments whose means share at least one letter in their superscript within the same column (time point and dependent variable) are not significantly different and are in the same group mean.

Duncan means separation has shown that at week four, Skana Super and *T. riparia* are the best insecticides to prevent loss weight (Figure 2), followed by *T. Vogelii* which did not show any statistically significant difference from the control.

Table 4: Effect of insecticides on beans' weight change over time

	Week 2	**Week 4**	**Week 6**
Treatment	**% of weight loss**	**% of weight loss**	**% of weight loss**
Control	4.80±0.79	7.35±0.38[a]	16.95±0.43[a]
Skana super	3.93±0.42	5.20±0.33[b]	11.04±0.33[d]
T. riparia	4.18±0.37	5.48±0.46[b]	12.32±0.60[c]
T. vogelii	4.54±0.30	6.23±0.39[ab]	15.31±0.72[b]
R^2	39.14	74.13	94.67
CV	17.41	12.10	5.58
p-value	0.43	0.01	<0.0001

4. DISCUSSION

In this study, as far as the average number of damaged grains is concerned, means' separation has shown that TR and TV are equally efficient (same mean group) and are significantly inferior to Skana super and significantly superior to the control at both week 4 and week 6, and *T. riparia* was superior to *T. vogelii* for the variables of interest on week six.

Earlier studies proved that both *Tetradenia riparia* and *Tephrosia vogelii* are effective in repelling ticks which are the main spreading vector of both theileriosis and anaplasmosis (Gazim *et al*, 2014, Onyambu *et al*, 2014). But *T. riparia* has been long reported as antimicrobial, acaricidal and analgesic (Gazim *et al*, 2014).

Earlier studies showed that *Tephrosia vogelii* has been used as pesticide even before the invention of DDT (Dichlore Diphenyl Trichloroethane), where rotenone which is found in leaves is the active ingredient (Stevenson, *et al*, 2012). It was confirmed as a better pesticide rather than synthetic ones such as Skana Super because it leaves any residue on plants (Squarespace, 2017). Not many studies were done on testing *Tephrosia vogelii* against *A.obtectus* but some have shown that *T. vogelii* is able to kill other storage insects like *S. zeamais*, pest damaging stored maize, at 85.0 to 93.7% within 3 weeks (Ogendo *et al*, 2005). In other studies, *Tephrosia vogelii* was found to be able to protect stored grains by sun drying leaves, ground and then mixed by 100 grams of the powder with 100 kilogram of bean or maize for the protection against the bean weevils or the larger grain borer (Squarespace, 2017). Extracts of *T. vogelii* were found to be more effective in causing the mortality of bruchids (Belmain *et al.*, 2012).

A study done by Dunkel *et al.* (1990), showed that *Tetradenia riparia* highly reduce eggs laid by *A. obtectus* when the concentration was 2% w/w of *T. riparia* leaves (Dunkel *et al*, 1990). Grain loss is mainly caused by eggs laid by *A. obtectus* in bean grains causing holes on the grain, grains with many holes are then removed from others and taken as complete loss (Dunkel *et al*, 1988) in an earlier study. *Tetradenia riparia* was found not to kill *A. obtectus* even when high concentration was used, its effect was found to instead reduce the loss when removing holled grains, this means it reduces the egg laying which damage grains (Dunkel *et al*, 1990).

5. CONCLUSION AND RECOMMENDATION

In this study, Skana Super, an artificial marketed pesticide, was proved to be better pestide in beans storage, followed by *Tetradenia riparia*. However, Skana Super is known to be hazardous to human when consumed, because it leaves residues which are dangerous to human and to the environment in general. *Tetradenia riparia* is a good pesticide which helps in reducing the weight lost by beans infected by *A. obtectus. Tephrosia vogelii* was the least effectif in the experiment proveing to be a pesticide to protect stored beans, but had not showen a great perfomance, *T. riparia* was more effectif than *T. vogelii*. The improvement of the utilisation of *T. riparia* in the control of *A. obtectus* can reduce food losses in Rwanda as Skana super is not affordable by all farmers.

As shown by the results, T. *riparia* is more recognised by Rwandan as pest control as well as human and livestock medicine while *T. vogelii* is mostly recognised only as livestock medicine

Each research is limited in time, space and by the means, the following research themes may be recommended: (1) Extending research to a longer period (for at least six months), (2) to assess the environmental effects of the used pesticide

REFERENCE

Belmain S.R., Amoah B.A., Nyirenda S.P., Kamanula J.F. & Stevenson P.C. (2012). High Variable Insect Control Efficacy of Tephrosia vogelii Chemotypes. *J. Agric. Food Chem, 60(40)*, 10055-10063.

Chernoh E. (2014). *Bean Bruchid, Acanthoscides obtectus.* Africa Soil Health Consortium.

Civelek S.H. & Kaban O. (2016). The Effects of Some Natral Substances on Acanthoscelides obtectus Say (Coleoptera: Bruchidae). *Journal of International Scientific Publications, 4*, 537-543.

Da Silva K.F., Baldin E.L.L. & Pannuti L.E. (2016). Use of Botanical Insecticides as Alternative For the Management of the Mexican Bean Weevil. *Revista Caastinga, 29*, 348-357.

Dunkel F.V., Clarke *S.A.* & Kayinamura, P. (1988) Storage of beans and sorghum in Rwanda: Synthesis of research, recommendations and prospects for the future. *Misc.Publ. Minnesota Experiment Station. University of Minnesota. St. Paul. No.51*. 74 *p.*

Dunkel F., Weaver D., Puyvelde L.V., Cusker J.L. & Serugendo A. (1990). PopulationSuppression Effectsof Rwandan Medicinal Plant,Tetradenia riparia (Hochst.) Codd (Lamiaceae) on Stored Grain and Bean Insects. *Proceedings 5th International Working Conference Stored Products Protection*, 1609-1618

Gazim Z.C., Rodrigues F., Amorin A.C.L., Moraes de Rezende C., Soković M., Linde G.A., Colauto N.B. &Cortez L.E.R. (2014). New Natural Diterpene-Type Abietane from Tetradenia riparia Essential Oil with Cytotoxic and Antioxidant Activities. *Molecules, 19*, 514-524.

Jones A.L. (1999). *Phaseolus Beans: Posthaverst operations.* Cali, Colombia: CIAT.

Kamanula J., Sileshi G.W., Belmain S.R., Sola P., Mvumi B.M., Nyirenda G.KC., Nyirenda S.P. & Stevenson P.C. (2010). Farmers' insect pest management practices and pesticidal plant use in the protection of stored maize and beans in Southern Africa. *International Journal of Pest Management, 57*, 41-49.

Larochelle C., Alwang J., Norton G.W., Katungi E. & Labarta R.A. (2014). *Impact of*

Bean Research in Rwanda and Uganda. Rome: ISPC Secretariat.

Müller J. & Heindl A. (2006). Drying of medicinal plants. *Medicinal and Aromatic Plants*, 237-252.

Mukanga M., Deedat Y. & Mwangala F. S. (2010). Toxic effects of five plant extracts against the larger grain borer, Prostephanus truncatus. *African Journal of Agricultural Research, 5(24),* 3369-3378.

Mulungu L.S., Luwondo E.N., Reuben S.O.W.M. & Misangu R.N. (2007). Effectiveness of Local Botanicals as Protectants of Store Beans (Phaseolus vulgaris L.) Against Bean Bruchids. *Journal of Entomology, 4(3),* 210-217.

Ogendo J.O., Belmain S.R., Deng A.L. & Walker D.J. (2005). Efficacy of Lantana camara L. and Tephrosia vogelii Hook against Sitophilus zeamais (Coleoptera: Curculionidae) in Stored Maize Grains. *Proc. WOCMAP III, 5*, 137-141.

Onyambu G.K., Maranga R., Ndungu M., Mkoji G.,Kareru P. & Wanjoya A. (2014). Toxicity and repellent effects of leaf extracts of four Kenyan plants against nymphs and adults of Rhipicephalus appendiculatus (Neuman 1901). *Journal of Applied Chemistry, 7*, 33-39.

Padin S., Dal Bello G.M. and Fabrizio M. (2001). Grain loss caused by Tribolium castaneum, Sitophilus oryzae and Acanthoscelides obtectus in store durum wheat and bean treated with Beauveria bassiana. *Journal of Stored Product Research*.

Rajashekar Y., Bakthavatsalam N. & Shivanandappa T. (2012). Botanicals as Grain Protectants. *Psche* , 13.

Reuben S.O.W.M., Masunga M., Makundi R.H., Misangu R.N., Kilonzo B.S., Mwatawala M., Lyimo H.F., Ishengoma C.G., Msuya D.G. & Mulungu L.S. (2006). Control of Cowpea Weevil (Callosobruchus maculatus L.) in Stored Cowpea (Vigna unguculatus L.). *Asian Journal of Plant Science, 5*, 91-97.

Squarespace. (2017). *Squarespace*. Retrieved May 24, 2017, from Squarespace: https://static1.squarespace.com/static/52f220cbe4b0ee0635aa9aac/t/53d8f8d6e4b03775e0dd5a17/1406728406049/tephrosia+vogelii.pdf.

Stevenson P.C., Belmain S.R.,Kite G.C., Lewis G.P., Forest F., Nyirenda S.P., Sileshi G.W. & Veitch N.C. (2012). Distinct chemotypes of Tephrosia vogelii and implications for their use in pest control and soil enrichment. *Phytochemistry, 78,* 135-146.

Tallarida R.J. & Murray R.B. (1987) Duncan Multiple Range Test. In: *Manual of Pharmacologic Calculations. Springer, New York, NY*

Thomas M.B. & Read A.F. (2007). Fungal Bioinsecticide with a sting. *Natural Biotechnology, 25*, 1367-1368.

Umubyeyi S. & Rukazambuga D. (2010). *Farmers knowledge on grain losses from bean bruchid, pesticides use by small-scale farmers and implication on food security and safety in Huye District, Rwanda.* Huye, Rwanda.

Weaver D.K., Dunkel F.V., Cusker J.L. & Puyvelde L.V. (1992). Oviposition Patterns in Two Species of Bruchids (Coleoptera: Bruchidae) as Influenced by the Dried Leaves of Tetradenia riparia, a Perennial Mint (Lamiales: Lamiaceae) that Suppresses Population Size. *Environment Entomology*, 1121-1129.