

Full Length Research Paper

Sustainable use of plant protection products in Nigeria and challenges

E. D. Oruonye¹ * and E. Okrikata²

¹ Department of Geography, Taraba State University, P. M. B. 1167, Jalingo, Taraba State, Nigeria.

² Department of Biology Education, School of Science Education, Federal College of Education, Technical, P. M. B. 1013, Potiskum, Yobe State, Nigeria.

Accepted 26 April, 2013

Nigeria's drive to boost food security and to fight off insect pests and yield-limiting crop pathogens has led to an unintended consequence: the mass importation and build-up of obsolete and toxic pesticides. Nigerian farmers have been relying heavily on these agrochemicals for the control of various weeds, insect pests and pathogens, leading to the high importation of these products. Although synthetic-chemical pesticides can be used to control some pests economically, rapidly and effectively; most of them cause serious negative impacts to the ecosystem. This paper highlights the need to improve the sustainability of the use of plant protection products. This can be achieved by integrating existing plant protection measures (chemical, mechanical, physical, biological, host-plant resistance, use of pheromones, cultural, etc.) under the framework of what is termed Integrated Pest Management (IPM) while identifying, advocating for and promoting the use of botanical pesticides in the pest management process.

Key words: Plant protection, plant protection products, sustainable use, integrated pest management (IPM), botanical pesticides/botanicals.

INTRODUCTION

Nigeria's drive to boost food security 1995; insect pests and yield-limiting crop pathogens has led to the build-up of obsolete and toxic pesticides and chemicals (Schwab et al., 1995). Several thousand tons of pesticides and other heavily contaminated materials have accumulated over the years, while inadequate legislation and lax regulations have exacerbated the problem (Lale, 2002). In general, plant insect pests, diseases and weeds impose a serious threat to crop production in Nigeria. Population of weeds, insect pests and diseases have increased over the years especially by the introduction of monoculture farming in the country (Emosairue and Ubana, 1998). Traditionally, Nigerian farmers have been relying heavily on pesticides for the control of various weeds, insect pests and diseases, leading to the high importation of these products and their price have become so high that it is becoming impossible for local farmers to afford (Nwanze, 1991; Schwab et al.,

Vanden toBerg fightandNur, 1998;off Okrikata and Anaso, 2008b). These have created the need for alternatives to synthetic pesticides. But inadequate infrastructure for research and extension remains a constraint to the advancement and continuity of such important activity in the country (Bugaje et al., 2007).

Although synthetic-chemical pesticides can be used to control some pests economically, rapidly and effectively; most of them cause serious negative impacts, such as: toxicity and residual effects to humans, target plants, foods and other living things; induction of insect/pathogen resistance resulting to ineffectiveness of pesticides; harmful effects to non-target beneficial organisms and unbalanced ecosystem due to pollution of soil, water and environment (Deedat, 1994; Gupta and Shyam, 1996).

The challenge to sustainable use of plant protection products is a long-term one. It involves helping farmers to properly control/manage pests in such a way that they do not only minimise immediate risks from dangerous pesticides but also reduce the possibility of accumulating future stocks. Synthetic pesticides pose a threat to sustainable development. The adverse impact of persistent organic pollutants, or POPs as many of the pesticides are

*Corresponding author. **E-mail:** eoruonye@gmail.com. **Tel:** 07039271480, 08025250182.

known, on the environment and health are serious. POPs do not degrade easily, but remain intact in the environment for a long period of time. The pollutants disperse easily across wide geographic areas, retain their toxicity and have a tendency to accumulate in the fatty tissues of organisms (FAO, 2007).

Human health and environmental safety are the two most important issues in the long-term application of pesticides. Therefore, the reduction in the amount of pesticides used in agricultural production has been a major issue to environmentalist. In order to maintain the balance of the ecosystem based on the conservation of natural resources and minimization of harmful effects to the environment; measures other than chemical control for pest management are seriously considered. These measures could partially replace and minimize the risk of using synthetic chemical pesticides to meet the requirement of organic farming in Nigeria. While empirical data on conventional and organic agriculture in Nigeria are scarce, it is worth noting that organic agriculture is at present poorly developed in Nigeria. Though, there are recent moves for the production of organic crops in Nigeria (Olabiya et al., 2008). Much agricultural production in Nigeria may be described as "organic neglect" as there is a lack of policy or regulation covering

organic agriculture in Nigeria. In a bid to advocate for organic farming, Olabiya (2009) reported that DDT, lindane, endosulfan, toxaphane, chlorpyrifos and many other persistent synthetic chemicals have been found in underground water and deep wells in Nigeria. This, no doubt buttress the need for reliable alternatives to synthetic pesticides.

Laboratory and field research in Nigeria have proved that botanicals could be economically feasible, technically effective and environmentally friendly alternatives to synthetic pesticides. Yusuf et al. (1998) observed that powders of leaves of *Azadiracta indica*, *Melia azaderach*, *Zingiber officinale*, *Eucalyptus camaldulensis*, *Ocimum basilicum*, *Capsicum frutescens* and wood ash of *Khaya senegalensis* are effective in the control of maize weevil (*Sitophilus zeamais*) in stored maize. Abdul-azeze (2009) applied cashew nut shell extract on cowpea pods infested with aphids and reported that the treatment has insecticidal effects on aphids. Insecticidal activity of some Nigerian plants such as *Eugenia aromatica*, *Piper umbellatum*, *Erythrophleum guineense*, *Aframomum melegueta*, *Hyptis suaveolens*, *Allium cepa*, *Carica papaya*, *Uvaria afzelli* and *Vernonia amygdalina* against maize weevil was reported by Lajide et al. (1998). Okrikata and Anaso (2008a) observed that different formulations of neem seed kernel powder was effective in controlling *Sesamia calamistis* in sorghum. Lale and Yusuf (2001) reported the efficacy of *Piper guineense* seed oil in controlling *Tribolium castaneum* in stored millet seed. Anaso (1999) reported the efficacy of neem kernel oil in controlling the pest complex of okro.

In 1988, local farmers in Borno state of Nigeria were

advised by extension workers to use aqueous extract of neem kernel, sprayed with twigs to ward off grasshoppers (Baba Yamta, personal communication). Emosairue and Ukeh (1996) reported the effectiveness of 3% neem oil and 5% neem seed kernel extract in the control of *Podagrica* spp. in south eastern Nigeria. Emosairue and Ubana (1998) also reported the effectiveness of neem seed kernel extract on *Maruca* pod borer. The potential of botanical pesticides cannot be overemphasised as they have also been found to be safe for humans and friendly to the environment. They are also characterized by low mammalian toxicity, lack of mutagenic activity and high rate of biodegradability (Kloss and McCullough, 1987). Therefore, the aim of this paper is to highlight the need to improve the sustainability of the use of plant protection products in Nigeria with special emphasis on the use and integration of botanicals in the pest management system.

PLANT PROTECTION AND PLANT PROTECTION PRODUCT

Plant protection means activities involving employment of biological, chemical, quarantine and other measures that

protect plants from disease agents, insect pests and

weeds, or decrease their harmful effects and also preserve their ecological equilibrium in nature (Anaso, 1999). Plant protection product on the other hand, means an active substance or a preparation containing one or more active substances, put up in the form in which it is supplied to the user, intended to: protect plants or plant products against all harmful organisms or prevent the action of such organisms; influence the life processes of plants, other than as a nutrient (for example, as a growth regulator); destroy undesired plants; or check or prevent the undesired growth of plants (Dorn, 1998).

In exercise of the powers conferred on the Governing Council of the National Agency for Food and Drug Administration and Control (NAFDAC) of Nigeria by section 8 of the Drugs and Related Products (Registration, etc.) Act of 1996 (As Amended); NAFDAC came up with the Pesticide Registration Regulations of 2005. The regulations lays down that no pesticide is to be manufactured, formulated, imported, exported, advertised, sold, or distributed in Nigeria unless it has been registered in accordance with the provisions of these regulations. Samples of pesticides for registration may, however, be manufactured, formulated, or imported with the approval of the Agency. Other sections deal with, inter alia, the submission of registration applications, the issuance of registration certificates and the withdrawal and cancellation of such certificates (The Pesticide Registration Regulations, 2005). The purpose of developing this national strategy was to act as a driver to enhance environmental protection within the context of sustainable use of plant protection products. The regulatory system is thus designed to ensure that plant protection products do

not endanger the health of people (operators, consumers or bystanders) and the environment. However, the Pesticide Registration Regulations of Nigeria has not been able to deliver well because of the following gaps or defects:

(1) It is silent on the need for re-registration of older pesticides under which the pesticides are to be re-examined to make sure that the supporting data for a registered pesticide satisfy current requirements for registration.

(2) The Pesticide Registration Regulations and Related Laws of Nigeria do not capture the need for retailers of pesticides to be trained. Most of them are illiterates and as such sell banned, expired and/or poorly stored pesticides to the end users (farmers) who in most cases know less and yet apply the pesticides themselves as trained applicators/sprayers of pesticides are rare to find and the farmers cannot afford to pay for their services.

(3) The Registration Regulations does not also consider the need for manufacturers or agents to write instructions and warnings on pesticide labels in commonly understood languages of end users (eg. English, Hausa, Igbo, Yoruba and Pidgin English) as most of them are not learned.

(4) Weak regulations as to banning the importation and use of dangerous pesticides and the inactivity or absence of government and non-government agencies of control is also another challenge.

(5) Monitoring and implementation of the Pesticide Regulations as it is, is also weak. For example, some pesticides such as, aldrin, binapacryl, captafol, chlordane, chlordimeform, DDT, dieldrin, dinoseb, ethylene dichloride, heptachlor, lindane, parathion, phosphamidon, monocrotophos, methamidophos, chlorobenzilate, toxaphane, merix endosulphan, delta HCH and ethylene oxide have been banned in Nigeria after having caused deaths in Nigeria (Inalegwu, 2008), yet; some of them are still found in the Nigerian market.

(6) Efforts to review the Pesticide Regulations as well as to work on how to effectively enforce and implement the regulations is yet to be seen.

All these have been combined to allow for the sale, misuse and abuse of dangerous pesticides with its attendant human and environmental (biotic and abiotic) hazards. Given the odds against the continued use of synthetic pesticides, the urgency in the need to find acceptable alternatives is obvious. The Nigerian Government should therefore re-strategise and make laws or policies to govern the processing and use of botanicals which have been found to be safer alternatives

Strategies/policies for sustainable use of plant protection products

Sustainable use, in the context of this paper means, minimising the hazards and risks to both man and his

environment from the use of plant protection products without compromising the necessary crop protection (Lale, 2002). Governments in developed countries and some developing countries have, for many years, operated a policy of 'pesticide mini 1997).

Given the rate of increase in human health related problems such as cancer, genetic disturbances and damage to the immune system, which are caused in part by some of the toxic substances contained in pesticides (Deedat, 1994; Ermel et al., 2002), there is need for the Nigerian government to strategise and consider the effective regulation of these plant protection products. Research findings in Nigeria and other parts of the world prove that integrating botanical pesticides in our pest management system will promote safer agricultural practice. In Nigeria for example, Botanical insecticides have been extracted from various plants including neem (*Azadiracta indica*), Pyrethrum (*Chrysanthemum cinerariaefolium*), Tobacco (*Nicotiana tabacum*), Derris (*Derris elliptica*), Pawpaw (*Carica papaya*), Tomato (*Lycopersicon esculentum*), Cashew nut (*Anacardium occidentale*), Garlic (*Allium sativum*), Alligator pepper (*Aframomum melegueta*), Curry leaves (*Hyptis suaveolens*), Onions (*Allium cepa*), Basil (*Ocimum basilicum*), Bitter gourd (*Momordica charatia*), Ginger (*Zingiber officinale*), Bitter leaf (*Vernonia amygdalina*), Siam weed (*Chromolaena odorata*), and pepper fruit (*Uvaria afzelli*). Their biological properties have been tested and found to include insecticidal and repellent effects against insect pests. Some have also been found to have antifeedant, growth regulatory, oviposition inhibitory, sterility inducing, antifungal and nematicidal properties (Lajide et al., 1998; Anaso, 1999; Abdul-azeez, 2009). Therefore, the following strategies/policies which centers on identifying/discovering, advocating for and promoting the use of botanical pesticides under the framework of integrated pest management will no doubt enhance sustainable use of plant protection products in Nigeria:

(1) The Nigerian government should consider making favorable laws and policies to govern the processing and use of selected botanical pesticides.

(2) There should be a purposeful encouragement of indigenous private sector participation in the formulation, testing and marketing of botanicals.

(3) As a matter of policy, the government should ensure that the period required to register botanicals is far less than that required to register conventional/synthetic pesticides.

(4) Another important policy issue is the possibility of indiscriminate harvesting of botanical materials to meet surge in demand. This could lead to environmental degradation and loss of biodiversity as is already happening in the case of neem in parts of South Asia (Ahmed and Stoll, 1996). To safeguard against this, a species of plant should not be promoted as a source of

biopesticide until adequate arrangements have been made for its increased production (Lale, 2002).

(5) The government should also design a policy to encourage and protect local companies that may be involved in the processing and marketing of botanical pesticides so that the citizens could derive maximum benefit from these locally available resources.

(6) Presently, many dangerous pesticides are being used in Nigeria for crop protection (Lale and Okunade, 1996). These classes of pesticides are either highly restricted or banned by law, but the laws not enforced. The strict enforcement of such law followed by a planned policy to adopt and promote the use of botanicals; which are comparably safer both to the applicator, food consumer as well as to the environment (Schwab et al., 1995; Lale and Mustapha, 2000), will stem the tide of deaths associated with pesticide poisoning (Lale, 2002).

(7) The Nigerian government should also promote aggressive enlightenment campaigns through the efforts of both public and private sectors to create a high level awareness amongst the citizenry about the available alternatives to synthetic pesticides.

Challenges to sustainable use of plant protection products

Intensive synthetic pesticide use, or overuse, in an effort to control pests and disease vectors can reduce the efficacy of pesticides (pesticide resistance). Often when pests are resistant to a certain pesticides, farmers will simply apply more or different pesticides, thereby increasing the residues on food crops and strengthening the pest's resistance even further. In the end, when a pesticide is no longer effective, farmers often face the need to purchase newer, often more expensive products, which can be especially problematic in developing countries. Negative effects on human health can be caused by direct or indirect exposure to pesticides and pesticide exposure can have either acute or chronic effects.

Developing countries and Nigeria in particular face the most challenges in achieving the sound management of pesticides. A large proportion of the population in Nigeria is directly engaged in agricultural work, often on a very small scale. Farmers will purchase pesticide products for individual use, but may not be sufficiently literate to read the instructions or be comfortable in the language the instructions are written in. Particularly in remote areas, the only source of advice may be the pesticide seller, who may also be poorly informed and whose advice may be guided by commercial self-interest. These populations are often not able to afford the newest minimum-risk pesticides, instead using older and often more dangerous products which are usually cheaper because they can be produced as generic products off-patent. Even appropriate products may be adulterated or have deteriorated

because their shelf life expired while they were in storage or because they were stored improperly. Farmers using such pesticides are at risk of developing pesticide related problems. Most farmers today rely on the use of pesticides to control pests. This sole reliance on pesticides is unsustainable. The lack of awareness and resources can also lead to improper disposal of pesticides and reuse of pesticide containers, thereby posing a threat to humans and the environment.

While evidences abound that botanical pesticides are generally safe and effective (Mallya, 1986; Ahmed and Grainge, 1986; Marandu et al., 1987; Ascher, 1993; Mordue and Blackwell, 1993; Emosairue and Ubana, 1998; Okrikata et al., 2008), their use in Nigeria as in other parts of Africa is still hampered by some challenges which include:

- (1) Most data on botanical pesticides are obtained from laboratory trials; field data are rare.
- (2) There is still hardly developed any appropriate technology for the application of botanicals, especially the oil and dust formulations (Lale, 2002).
- (3) Compared with synthetic insecticides, the effects of botanical insecticides are short-lived. So frequent applications are required to obtain a reasonable degree of crop protection.
- (4) Botanical pesticides formulations are yet to be available in usable forms to farmers in commercial quantities so as to serve as alternatives to synthetic pesticides.
- (5) There is the problem of farmers' acc seemingly new dimension/technology in pest control (Okrikata and Anaso, 2008a).

From the foregoing, the need to advocate for and implement integrated pest management strategies both on field pests, stored product pests, structural pests and domestic pests is indispensable. Therefore, the discovery, advocating for, adoption and promotion of the use of botanical pesticides in an integrated pest management framework is quite relevant.

CONCLUSION AND RECOMMENDATIONS

The key to attaining food sufficiency in Nigeria is ensuring that crops stay healthy and protected from damages by pests and diseases. In order to permanently maintain the productivity, ability to function, regenerative power and the buffering capacity of the open system within which plants are cultivated, plant protection measures must be generally acceptable, economically feasible, technically effective, environmentally friendly and easy to use or apply. National pesticide programmes have various goals, most of which can be met by an effective legal framework. The need to ensure the efficacy of pesticide products for their proposed use, while at the same time

protecting pesticide users, consumers, crops, livestock and the environment cannot be overemphasized. In this regard, the importance of recruiting botanicals in plant protection or pest control is imperative.

This study recommends the need to launch a nation-wide effort to clean up these harmful chemicals, prevent future accumulations, promote safe-handling techniques by working directly with farmers and strengthen the country's institutional capacities

Farmers should be enlightened on how to identify the actual pests and diseases, determine the level of infestation and the symptoms to describe the pathological conditions of crops, to be able to establish the economic injury level values for pests and diseases in order to derive a farm-level relevant methods in the context of effective plant protection. Farmers should also be advised to include the critical use of right pesticides and other protective measures in order to satisfy the criteria of effective plant protection. Plant protectionists should also include in their research, the development of crop resistant varieties to pests and diseases. Finally, the importance of food sufficiency, agricultural policy makers in Nigeria should advocate for a revision of the laws to facilitate the effective supervision of pesticide quality and monitoring of residues due to the use of agricultural chemicals. Adequate funding of researches in crop protection which amidst others is geared toward discovering botanical pesticides is also indispensable.

REFERENCES

- Abdul-azeez A (2009). The Effect of Cashew Nut Shell Extracts on Pest (Aphid) of Cowpea. *Biol. Environ. Sci. J.* 6(3), 25-28.
- Ahmed S, Grainge M (1986). Potential of the neem tree (*Azadirachta indica*) for pest control and rural development. *Econ. Bot.* 40: 201-209.
- Ahmed S, Stoll G (1996). Biopesticides. In: *Building on Farmers' Knowledge* (Bunders J, Haverkort B, Hiemstra W, eds.), Macmillan Education Ltd., London and Basingstoke. pp. 52-79.
- Anaso CE (1999). Evaluation of neem extracts for control of major insect pests of Okro (*Abelmoschus esculentus*). Ph.D Thesis. University of Maiduguri p. 131.
- Ascher KRS (1993). Non conventional insecticidal effects of pesticides available from neem tree. *Arch. Insect Biochem. Physiol.* 22: 433-449.
- Bugaje SM, Kuta DD, Magashi AI, Ubale AS (2007). Food security in Nigeria. Paper presented at the conference of young agricultural specialists, organized by SELHOZ (A Nigerian Non Governmental Organization Based in Russia). Held on 22nd July – 5th August at The People's Friendship University, Russia, Moscow.
- Deedat YD (1994). Problems associated with the use of pesticides: An overview. *Insect Sci. Applic.* 15: 247-251.
- Dorn S (1998). Integrated stored product protection as a puzzle of mutually compatible elements. *IOBC Bulletin* 21: 9-12.
- Emosairue SO, Ukeh DA (1996). Field trial of neem product for control of Okra flea beetles (*Podagrica spp.*) in south eastern Nigeria. *Afri. J. Plant Protect* 6: 22-26.
- Emosairue SO, Ubana UB (1998). Field evaluation of neem for the control of some cowpea pests in South Eastern Nigeria. *Global J. Pure Appl. Sci.* 4(3): 237-241.
- Ermel K, Schmutterer H, Kleeberg H (2002). Commercial product standardisation and problems of quality control. In: Schmutterer H(ed.). "The Neem *Azadirachta indica* (A. Juss) and Other Meliaceous Plants. Sources of Unique Natural Products for Integrated Pest Management, Medicine, Industry and Other". Neem Foundation, Mumbai p. 893.
- FAO (2007). Designing National Pesticide Legislation. Food and Agriculture Organization of the United Nations, Rome.
- Registration Regulations. The Federal Military Government of Nigeria. (Supplement to Official.
- Gazette Extraordinary, No.27, Vol 83, 18th June, 1996, Part B, pp. B303-B307).
- Gupta SK, Shyam KR (1996). Antisporulant activity of some fungicides against *Pseudoperonospora cubensis* on cucumber. *Indian J. Mycol.* to tackle the issue. *Plant Pathol.* 26(3): 293-295.
- http://www.businessonline.com/index.php?option=com_content&view=article&id=4501:agribusiness-is-organic.
- Inalegwu S (2008). 30 Agrochemical Products Banned in Nigeria After Deaths. *Vanguard*. Retrieved July 10, 2010, from http://www.organicconsumers.org/articles/article_12416.cfm.
- Kloss H, McCullough FS (1987). Plants with recognized molluscicidal activity. In: *Plant Molluscicides* (Mott, K.E., ed.), UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases. pp. 45-108.
- Lajide L, Adedire CO, Muse WA, Agele SO (1998). Insecticidal activity of powders of some Nigerian plants against the maize weevil (*Sitophilus zeamais* Motsch). *ESN Publications*. 31: 227-235.
- Lale NES, Okunade SO (1996). A survey of some aspects of fish processing in the Lake Chad district of Nigeria. *Ann. Borno*. 13: 362-368.
- Lale NES, Mustapha A (2000). Potential of combing neem (*Azadirachta indica* A.Juss) seed oil with varietal resistance for the management of cowpea bruchid, *Callosobruchus maculatus* (F.) (Coleoptera:Bruchidae). *J. Plant Dis. Protec.* 107: 399-405.
- Lale NES, Yusuf BA (2001). Potential of varietal resistance and *Piper guineense* seed oil to control infestation of stored millet seeds and processed products by *Tribolium castaneum* (Herbst). *J. Stored Prod. Res.* 37: 63-75.
- Lale NES (2002). Stored Product Entomology and Acarology in Tropical Africa. Mole Publications, Maiduguri, Nigeria p. 204.
- Mailu AM (1997). Review of Kenyan Agricultural Research. *Pest Plants*. 29: 3-11.
- Marandu WYF, Temu AEM, Kabango D (1987). Plant Protection. In: *Maize Improvement Programme Annual Progress Report 1987*. UAC, Mbeya, Tanzania, p. 3.
- Mallya GA (1986). Maize entomology. In: *Maize Improvement Progress Report 1985-1986*. UAC, Mbeya, Tanzania, pp. 27-31.
- Mordue AJ, Blackwell A (1993). Azadirachtin: an update. *J. Insect Phys.* 39: 903-924.
- Nwanze KF (1991). Components for the management of two insect pests of pearl millet in Sahelian West Africa. *Insect Sci. Applic.* 12: 673-678.
- Okrikata E, Bukar SM, Anaso CE (2008). Evaluation of Used Engine Oil and Other Nature Based Materials on the Emergence of Harvester Ants (*Messor galla* F.) in Maiduguri, Borno State. Academic Publications and Research Association of Nigeria (APRAN). A J. Manage. Sci. Technol. Edu. 4(1): 88-94.
- Okrikata E, Anaso CE (2008a). Influence of some inert diluents of neem kernel powder on protection of sorghum against pink stalk borer (*Sesamia calamistis*, Hmps) in Nigerian Sudan savanna. *J. Plant. Protect. Res.* 48(2): 161-168.
- Okrikata E, Anaso CE (2008b). Bioefficacy of Various Neem Dust Formulation for the Control of Sorghum Stem-borers II: Effect on Stalk and Peduncle in the Semi-arid zone of Nigeria. *Yobe J. Environ. Dev.* 1(1): 29-38.
- Olabiya TI, Okusanya AO, Harris PJ (2008). Accessing the World Market for Organic Food and Beverages from Nigeria. In: 16th IFOAM Organic World Congress, Modena, Italy. June 16-20, 2008. Retrieved July 11, 2010 from http://orgprints.org/11713/1/olabiya_11713_ed.doc.
- Olabiya TI (2009). Agribusiness: Is organic farming the best option? Retrieved July 11, 2010, http://www.businessdayonline.com/index.php?option=com_content&view=article&id=4501:agribusiness-is-organic.
- Schwab AI, Jager I, Stoll G, Gorgen R, Prexterschwab S, Attenburger R (1995). Pesticide in tropical agriculture: hazards and alternatives.

PAN ACTA Trop. Agroecol. No. 131.

The Pesticide Registration Regulations (2005). Retrieved July 10, 2010 from
http://www.nafdac.gov.ng/index.php?option=com_docman&task...12...

Van den BJ, Nur AF (1998). Chemical control. In: Andrew P (ed.) African Cereal Stem-borers: Economic Importance, Taxonomy, Natural Enemies and Control. CAB International in association with the ACP-EU Technical Centre for Agricultural and Rural Co-operation (CTA). pp. 319-332.

Yusuf SR, Ahmed BI, Chaudhary JP, Yusuf AU (1998). Laboratory evaluation of some plant products for the control of maize weevil (*Sitophilus zeamais* Mots.) in stored maize. ESN Occasional publications. 31: 203-213.