Egyptian Journal of Biological Pest Control, 25(2), 2015, 507-512

Use of Neem and Garlic Dried Plant Powders for Controlling some Stored Grains Pests

Onu, F. M.; E. Ogu and M. E. Ikehi
Agric. Unit, Dept. of Vocational Teacher Education, Univ. of Nigeria, Nsukka, Enugu State, Nigeria.
maduekefrancis@gmail.com
(*Received: October 4, 2015 and Accepted: December 2, 2015*)

ABSTRACT

The study experimented on the repellency, toxicity effectiveness, progeny emergence and consumption safety of grains treated with neem (*Azadirachta indica L.*) and garlic (*Allum sativum*) dried plant powders on some pests of stored cereal grains; rice (*Oryza sativa*), maize (*Zea mays*) and beans (*Vigna unguiculata*). Studies on the effects of bioactive plants on behavioral and biological makeup of pests were taken in consideration. Data showed that neem and garlic powders were effective in the control of the pests of the stored cereal gains. The study further revealed differences in the mean and percentage repellency, mortality and progeny emergence rates of the insect pests in the treated grains. A mixture of both the tested plant powders was found to be the most effective toxicants for the storage pests of maize, rice and beans with mortality percentage of 100% for both *Sitophilus zeamaiz* and *S. oryzae* and 95% for *Callosobruchus maculates* within 5 treatment days. Prolonged exposure to the treatments increased toxicity and mortality.

Key words: Biological activity, Cereal grains, Dried plant powder, Garlic, Neem, Storage pests.

INTRODUCTION

Insect pests are always present in field crops during cultivation and in storage of the produce, and can have a huge economic loss in production. Post-harvest losses are recognized as a major constraint in Africa, with storage damage sometimes as high as 40%. Control of storage pests of agricultural products largely depends on synthetic pesticides, which has been widely used since 1950s. In spite of their efficacy, the repeated use for several decades have disrupted biological control systems, which have led to outbreaks of resistant insect pests, undesired effects on non-target organisms and environmental and human concerns. There have been notable concerns on the persistent use of synthetic chemicals for pest control as studies revealed their adverse effects on humans,' wildlife, aquatic life and the environment (Köhler and Triebskorn, 2013; Perry *et al.*, 2014; Yuan *et al.*, 2014 and Meyer-Baron *et al.*, 2015). Apart from the negative effects of synthetic insecticides, in most remote rural areas their availability is unreliable, and are frequently adulterated (diluted to ineffective concentrations by unscrupulous traders) (Stevenson, 2014) and sometimes expired before reaching the farmers.

Alternatives to these synthetic chemicals are extracts or powders form of some plants. Studies indicate that some plants have pesticidal properties which show antifeedant, repellent and toxic effects on a wide range of insect pests, and are easy and cheap to prepare (Owusu, 2001; Khan and Gumbs, 2003; Mondal and Khalequzzaman, 2010; Shadia, 2011; Mousa, 2013; Anyanga *et al.*, 2013; Amoabeng *et al.*, 2014; Grzywacz *et al.*, 2014 and Stevenson, 2014). Examples of these plants with bioactive metabolites are neem (*Azadirachta indica L.*) and garlic (*Allum* sativum), and a host of others. Pest control or repelling organic extracts of plant origin offer protection with minimal impacts on the ecosystem and repel the insect pests from the treated grains by stimulating the receptors (such as the olfactory receptors) of the insect. Repellent when effective causes the target pest to make an oriented movement away from the source of stimulus, and in cases where escape is not possible, over stimulation of the receptors leads to death of the pest. Increasing public concern over chemical pesticide safety and possible damage to the environment has resulted in increasing attention being given to natural products of mostly plant origin for the control of storage pests, globally.

This study focused on determining the effectiveness of neem and garlic dried powders in the control of storage pests of some cereal grains such as rice (*Oryza sativa*), maize (*Zea mays*) and beans (*Vigna unguiculata*).

MATERIALS AND METHODS

The study adopted experimental design and was conducted at Agricultural laboratory of the Agric. Unit of the Department of Vocational Teacher Education, University of Nigeria, Nsukka. The study spanned from September, 2014 to July, 2015. It extended to progeny emergence of pests from the treated cereal grains and health safety concerns of consuming cereal grains treated with the different powders.

Preparations of the Plant Powders Used

Ripe neem kernel and garlic bulb were obtained fresh from the surrounding environment. To avoid poisoning of any kind, mature/ripe kernel of neem, which has a greenish yellow color was used, and was plucked directly from the tree as suggested by Salako (2008). The plant parts were air-dried under shade at ambient tropical conditions to avoid photo degradation of active ingredients by ultra-violet ray in line with the recommendation of Salako (2008). The air-dried materials were then grinded into fine powders using grinding machine and sieved with a 10mm sieve. The fine plants powders were then kept in air-tight containers until required.

Insect cultures

The parent stocks of *Sitophilus zeamais* (*motschulsky*), *Callosobruchus maculates* and *Sitophilus oryzea* were obtained from infested grains in the school farm storage. The insects were cultured under ambient temperature of 28±2°C and 75±5% RH. The food media for the insect cultures were maize for *S. zeamaiz*, beans for *C. maculates* and rice for *S.* oryzae. One kilogram (1kg) of each food medium was weighed into three different glass jars. Forty adult insect pests of each grain were introduced into each culturing medium. The culturing spanned for 45 days and at the end, over 200 adults of each insect pests emerged. Eighty adults of each insect pest were randomly selected for the experiment.

Insect Bioassay

Twenty-five gram (25g) of each plant powder corresponding to 25% volume per weight (v/w) concentration were weighed and each added to 100g of clean undamaged and uninfested maize, rice and beans (previously were kept in a deep freezer at freezing point for 72 hours in order to kill any stages of the insects and obtained sterile grains) in transparent glass jars. The grains and the treatments were then shaken gently to ensure through mixture of the grains and the treatment powders. Twenty adult insect pests of each grain (collected from the cultures) were introduced to each experimental glass jar and covered with muslin cloth. Three replicates of each treatment and control test (untreated grains) were used, and the average observations from the triplicates were reported.

Data collection

Data was collected through observation. The experimental jars were closely observed for migratory and mortality rate of insect pests in treated and untreated grains. The adult migration or mortality within 24 hours was noted for 5 days and on the 5th day; the entire insects (both dead and alive) were removed from the treated grains. The grains from the triplicate of experimental jars were mixed together, placed in containers, covered with muslin cloth, and kept for six weeks (45 days) for progeny test. At the end of the progeny test (when the total number of emergent insect pest from each treated grain was counted and recorded against each treatment), the treated grains were grinded and mixed with poultry feed and fed to stocked chicks for two (2) months to test their safety when consumed.

Repellency tests

To test for repellence effects of each powder, a double glass jar with a connecting duct was used in two methods:

1. The treated cereal grains were placed in one side of the glass jar while the insect pests for each grain were introduced in the other side of the double glass jar (with a connecting passage – glass tube) to observe migration to food and oviposting source.
2. The treated cereal grains and the pest were placed together in one side of the double glass jar while the other glass was clean, untreated and completely empty.

Toxicity test of the plant powders

The treated grains and each of the tested pests were placed together in a single transparent glass jar and mortality rate per day was observed and recorded for five (5) days.

Progeny emergence test

The treated grains and the control were kept in containers in conducive culture conditions for 45 days. At the end of the culture period, number of emergent insect pest for each treated grain and the control were recorded.

Safety of the treated grains

The treated cereal grains, after progeny tests, were grinded and mixed with regular feeds for stocked poultry (broiler chickens). All grains (beans, maize and rice), treated with neem powder, were combined and grinded together. Same was done for garlic and neem-garlic treated grains and the non-treated grains (control). Thus, were referred to as neem-feed (NF), garlic-feed (GF), neem-garlic feed (NGF) and non-treated feed (NTF), respectively. The stocked birds were not vaccinated but were kept away from possible contamination/infection as best possible. The birds (*Gallus gallus domesticus* at one-day old in February, 2015) were kept for 2 months in four different compartments for the three treatments and a control group, ten birds each. Each mixed feed was fed to different group twice in a week. Growth rate, activeness and dump coloration were recorded for each group. Activeness was weekly measured using an observation rating scale.

Data analysis

Frequency counts, means and percentages were used for data analysis. Percentages and mean mortality/migration rates of adult insect pests occurred was calculated and number of emerged progeny from the treated grains after six weeks were counted and reported.

RESULTS AND DISCUSSION

Repellence effect

In method A, despite the treatment of the grains with the powder, migration towards the food or ovipositing source was observed to be highest within 24 hours. The insect pests moved through the connecting duct to the treated grains which could be explained by the natural drive for feeding or depositing of the eggs on the grains. However, movements away from the treated grains became obvious after 72 hours. Most insect pests of the grains from the untreated glass jar that moved to the other glass jar (with the treated grains) made oriented movements back to the empty jar. Some were however found in the connecting glass tube (passage/duct) which could indicate movement away from the treatments. With the trend of movements away from the treated grains, it seemed that the action of the treatment on the pests became severe after 48 hours. On the 5th day, the pests in the glass jar with the treated grains were all dead. Some of the pests in the empty glass jar or in the duct were dead as well, meaning that contact with the powders (treatments) even after migration (away from the stimulus) could result to mortality of the insect pests.

A similar observation was made in method B; movements away from the food and ovipositing source to the empty glass jar through the duct became obvious after 48 hours. However, powder made from the combination of neem and garlic powders appeared to be more effective than that of neem and garlic separately. Higher migration (repellency) rate was observed (as the duration of exposure to treatment increased) across the triplicate treatments for each insect pest, with least repellency in garlic treatment. Effectiveness of the powders increased with prolonged exposure to the treatments as death rate in each glass jar rose with increasing number of days. For the control groups, all the insect pests migrated to the food and ovipositing source, no mortality was recorded and the insect pests remained active for the duration of the experiment (Tables 1 and 2).

Toxicity of the plant powders

The garlic powder seemed less effective among the three treatments. Percentage death rate was lower for the garlic powder and all insects were alive at the end of the 5th day. A mixture of both powders neem and garlic appeared to be most effective among the three. Death observed and recorded for neem-garlic powders treatment was as high as 100% with a mean of 4.00 for *S. zeamaiz* and *S. oryzae* within the five days of exposure. For the control groups, with no form of treatment, no mortality was recorded for any of the insect pests of the cereal grains within the 5-days experimental period (Table 3).

Table (1): Repellent effect of neem, garlic and a mixture (1:1) of neem-garlic plant powders on *S. oryzae, S zeamaiz* and *C. maculates*

Insect species	Method	24 h		48 h		72 h		96 h		120 h	
		TG	E	TG	E	TG	E	TG	E	TG	E
*S. zeamaiz**	A	18	2	20	0	13	7	4	16	3	17
	B	20	0	18	2	9	11	5	15	4	16
*S. oryzae**	A	20	0	19	1	15	5	14	6	9	11
	B	18	2	17	3	8	12	8	12	7	13
*C. maculates**	A	20	0	16	4	10	10	7	13	5	15
	B	19	1	18	2	16	4	12	8	10	10
Garlic plant powder											
*S. zeamaiz**	A	19	1	20	0	17	3	10	10	8	12
	B	20	0	19	1	18	2	11	9	9	11
*S. oryzae**	A	20	0	18	2	16	4	15	5	7	13
	B	18	2	16	4	10	10	8	12	8	12
*C. maculates**	A	20	0	19	1	12	8	7	13	4	16
	B	17	3	15	5	14	6	9	11	9	11
Neem-Garlic plant powder											
*S. zeamaiz**	A	18	2	16	4	6	14	6	14	6	14
	B	17	3	15	5	14	6	7	13	6	14
*S. oryzae**	A	16	4	18	2	7	13	5	15	5	15
	B	18	2	17	3	11	9	6	14	5	15
*C. maculates**	A	20	0	15	5	8	12	7	13	7	13
	B	19	1	16	4	11	9	10	10	10	10

**60 adult insects pest per grain for the triplicates *20 per replicate. TG- glass jar with treated grains.
E- empty glass jar (no treatment, no grain).

Table (2): Insect pest repellence of non-treated grains (control)

Insect species	Method	24 h		48 h		72 h		96 h		120 h	
		GG	E	GG	E	GG	E	GG	E	GG	E
*S. zeamaiz**	A	20	0	20	0	20	0	20	0	20	0
	B	20	0	19	1	20	0	20	0	19	1
*S. oryzae**	A	20	0	20	0	20	0	20	0	20	0
	B	20	0	20	0	20	0	20	0	20	0
*C. maculates**	A	20	0	18	2	20	0	17	3	18	2
	B	20	0	20	0	19	1	19	1	19	1

GG- glass with non-treated grains

Table (3): Mean mortality rate of adult insects in grains treated with neem, garlic and neem-garlic powders

Insect species	Mortality in days					Total mortality	Percentage mortality	Mean mortality	Std. error
	1	*2*	*3*	*4*	*5*				
*S. zeamaiz**	0	3	3	10	3	19	95	3.80	0.55
*S. oryzae**	0	2	3	9	4	18	90	3.60	0.58
*C. maculates**	1	2	3	6	7	19	95	3.80	0.53
Garlic powder treatment									
*S. zeamaiz**	0	2	1	3	5	11	55	2.20	0.39
*S. oryzae**	0	2	2	4	4	12	60	2.40	0.37
*C. maculates**	1	2	4	5	3	15	75	2.65	0.34
Neem-Garlic powder treatment									
*S. zeamaiz**	1	3	4	6	6	20	100	4.00	0.56
*S. oryzae**	1	5	3	7	4	20	100	4.00	0.59
*C. maculates**	1	4	3	6	5	19	95	3.80	0.53

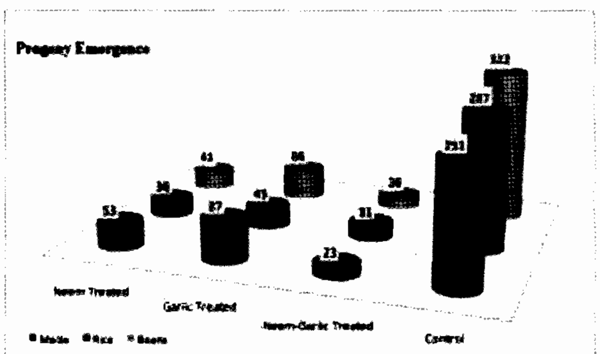

Fig. (1): Progeny emergence among the grains.

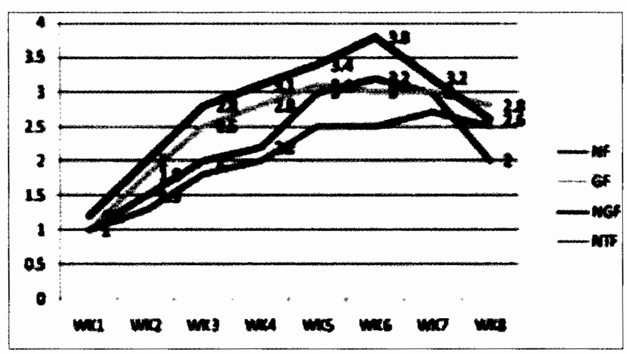

Fig. (2): Average weekly activeness chart of the birds fed on the grains.

Progeny emergence

At the end of the 45 incubation days, emergent off-springs were counted for each treated grain and the result presented in Fig. (1). Among the treated grains, highest progeny emergence was recorded for cereal grains treated with garlic powder, while the lowest was for grains treated with neem-garlic powder. However, emergence was low for *C. maculates* for beans treated with garlic powder when compared to *S. zeamaiz* for maize. Even with repellence effectiveness of the powders, oviposition likely took place in the first 24 h of the experiment, as the insect pests made successive migration and tolerance to the treated grains until prolonged exposure resulted to effective control. Adult emergence was very high for the untreated gains (control) (Fig. 1).

Consumption safety of the treated grains

In poultry keeping, the most prominent and cheapest means of detecting pending or prevalent illness among the stock is dump discoloration, when there is a deviation from normal gray-ash with whitish topping of the dumps to a different color blend depending on the impending disease infestation. Activeness and weight gain or growth rate of the birds was also an indication of good performance of the stuck. For the birds that fed on NF, GF and NGF, normal dumping coloration was observed with slightly varying weekly differences (Fig. 2). This was an indication that the birds remained healthy. Further, no death was recorded in the three compartments fed with the treated grains. The birds attained commendable weight gain across the three pens with an average weight of 2.7kg, 2.9kg and 3.3 kg for NF, GF and NGF fed birds within 2 months which was an indication of efficient feed conversion and absorption. Activeness rose steadily with age but declined faster with increased weight gain at 5th week (WK5). For the control group fed with a mixture of NTF and poultry feed, dump coloration was slightly normal. However, 4 birds died within the 2 months rearing period and the group had an average weight of 2.4kg which was lower than the average weight of any of the three experimental groups. This could be an indication that the powders on the treated grains fed to the birds helped the birds in the experimental groups to keep healthy and improve on weight gain.

The current findings of the study revealed that there were differences in repellence/ mortality rates of insects as well as differences in numbers of progeny emergence after 45 days from the treated grains. The difference is based on the different constituents and level of the bioactive agents present in each powder and the level of impact of each powder on the insect pest of the treated grains. The insect pests in the treated grains had their feeding, comfort, growth and prolific oviposition affected as a result of the presence of the active metabolites capable of repelling and inhibiting feeding and growth thus resulting to mortality of the insect pests. Reduction in progeny emergence after six weeks was a result of the active components in the powders disrupting the life cycle of the insects.

The present findings revealed also that powders of neem and garlic were effective in controlling insects of stored grains. As reported by Isman (2006), the powders contain *limnoids* such as *azadirachtin*, *salaninmeliantriol* and *nimbin* which are useful bioactive components for insect control. The presence of *Azadirachtin* has a profound effect on insects: at the physiological level, it inhibits the synthesis and release of molting hormones (ecdysteroids) from the prothoracic gland and leads to incomplete ecdysis in the insects. In adult female insects, a similar mechanism leads to sterility, thus preventing reproduction and multiplication. In addition, *Azadirachtin* is a potent antifeedant to many insects while *salannun* and *sodium nimbinate* are repellent and spermicide, respectively (Isman, 2006 and Shanmugapriyan and Dhanalakshmi, 2015). The findings of this study are in line with (Upadhyay, 2007; Rajendran and Sriranjini, 2008; Upadhyay and Ahmed, 2011; Anyanga *et al.*, 2013; Amoabeng *et al.*, 2014; Stevenson, 2014; Aziza and Asma, 2015 and Kamran *et al.*, 2015) who reported the effectiveness of some plant powders in pest control. Use of plants in this way as insecticides not only ensures safety of the environment and consumption of the treated produces, it is reliable, readily available for production by the farmer and economical, especially for the small scaled indigent farmers. Plants of insecticidal potentials are compelling alternative to synthetic pesticides (Anyanga *et al.*, 2013; Amoabeng *et al.*, 2014 and Stevenson, 2014).

Other bioactive agents in the neem and garlic powders include *gedunin* (anti-malarial), *nimbin* (anti-inflammatory, anti-pyretic), *quercentin* (anti-malaria) as reported by Kausik *et al.* (2002), Tomar *et al.* (2011) and Ruchi *et al.* (2014). The presence of these bioactive agents (as introduced in the feeds of the birds) possibly explained the healthiness of the birds as the birds remained active and no death was recorded. From the foregoing, data above favorably points to the administration of the treated grains as the major factor that ensured healthiness of the birds.

The study confirms the effectiveness of neem and garlic powders in the control of insect pests, especially storage pests of cereals such as maize, rice and beans. It reveals that prolong exposure of the insect pests to the powders increases efficiency in the control of the pests. The treated cereal grains were not only found to be safe for consumption but also improved healthiness and growth performance. The powders of neem and garlic are easy to prepare, cheap, safe and eco-friendly possible replacement of chemical insecticides for storage pests of cereal grains. The study thus recommends the following:

1. Information on the utilization of plant powders such as those of neem and garlic should be made available for the farmers and other grain keepers for safe and economic preservation.
2. The manufacture, packaging and mass distribution of storage pest repellents and controls of natural origin such as that of neem and garlic of plant origin should be encouraged to reduce the production and use of synthetic chemicals which has resulted to high ecological damage and has raised human/environmental health concerns over time.

ACKNOWLEDGMENTS

The researchers wish to thank the laboratory assistants at the Agricultural laboratory of the Agric Unit of the Department of Vocational Teacher Education, at the University of Nigeria, Nsukka, for their numerous help during the experimental stage of this research.

REFERENCES

Amoabeng B. W., G. M. Gurr, C. W., Gitau, and P. C. Stevenson 2014. Cost: benefit analysis of botanical insecticide use in cabbage: implications for smallholder farmers in developing countries. Crop Protection 57: 71-76.

Anyanga O. M., H. Muyinza, D. R. Hall, E. Porter, D. I. Farman, H. Talwana, R. O. Mwanga, and P. C. Stevenson 2013. Resistance to the weevils *Cylas puncticollis* and *Cylas brunneus* conferred by sweet potato root surface compounds. Journal of Agricultural and Food Chemistry 61: 8141-8147.

Aziza, S. and E. Asma 2015. Evaluation of some plant essential oils against the black cutworm *Agrotis ipsilon*. Global Journal of Advance Research 2(4): 701-711.

Grzywacz D., P. C. Stevenson, S. R. Belmain, and K. Wilson 2014. The use of indigenous ecological resources for pest control in Africa. Food Security 6: 71–86.

Isman, M. B. 2006. The role of botanical insecticides, deterrents and repellents in modern agriculture and an increasingly regulated world. Annual Review of Entomology 51: 45-66.

Kamran S., J. Salim, U. Amjad, F. S. Syed, U. Muhammad, S. Maqsood, A. M. Manzoor, and M. Amjid 2015. Evaluation of some botanical and chemical insecticides against the insect pests of okra. Journal of Entomology and Zoology Studies 3 (2): 20-24.

Kausik B., C. Ishita, K. B. Ranajit, and B. Uday 2002. Biological activities and medicinal properties of neem (*Azadirachta indica*). Current Science 82(11): 1336-1345.

Khan, M. A, and F. A. Gumbs 2003. Repellent effect of Ackee (*Blighia sapida* Koenig) component fruit parts against stored product insect pests. Journal of Tropical Agriculture 80: 19-27.

Köhler, H. R., and R. Triebskorn 2013. Wildlife ecotoxicology of pesticides: can we track effects to the population level and beyond? Science 341: 759-765.

Meyer-Baron M., G. Knapp, M. Schäper, and C. van Thriel 2015. Meta-analysis on occupational exposure to pesticides–Neurobehavioral impact and dose–response relationships. Environmental Research 136: 234-245.

Mondal, M., and M., Khalequzzaman 2010. Toxicity of naturally occurring compounds of plant essential oil against *Tribolium castaneum* (Herbst). J. of Biological Sciences 10: 10-17.

Mousa K. M., I. A. Khodeir, T. N. El-Dakhakhni and A. E. Youssef 2013. Effect of Garlic and Eucalyptus oils in comparison to Organophosphate insecticides against some Piercing-Sucking Faba bean insect Pests and natural enemies' populations. Egyptian Academic Journal of Biological Sciences 5 (2): 21 -27.

Owusu, E. O. 2001. Effects of some Ghanaian plant components on control of two stored product insect pests of cereals. Journal of Stored Product Research 37: 85-91.

Perry, L., R. D. Adams, A. R. Bennett, D. J. Lupton, G. Jackson, A. M. Good, S. H. Thomas, J. A. Vale, J. P. Thompson, D. N. Bateman, and M. Eddleston 2014. National toxicovigilance for pesticide exposures resulting in health care contact – An example from the UK's National Poisons Information Service. Clinical Toxicology 52: 549-555.

Rajendran, S. and V., Sriranjini 2008. Plant products as fumigants for stored product insect control. Journal of Stored Product Research 44: 126-135.

Ruchi T., K. V. Amit, C. Sandip, D. Kuldeep, and V. S. Shoor 2014. Neem (*Azadirachta indica*) and its potential for safeguarding health of animals and human: a review. Journal of Biological Sciences 14 (2): 110-123.

Salako, E. A. 2008. A review of neem biopesticide utilization and challenges in central Nigeria. African Journal of Biotechnology 7: 4758-4764.

Shadia, E. A. 2011. Control strategies of stored product pests. Journal of Entomology 8: 101-122.

Shanmugapriyan, R., and V. Dhanalakshmi. 2015. Biological effects of neem on the pupation of *Henosepilachna vigintioctopunctata* Fab. on Bitter gourd. Journal of Entomology and Zoology Studies 3 (1): 78-81.

Stevenson, P. C. 2014. Using pesticidal plants for crop protection. Royal Botanic Gardens. http://www.kew.org/discover /blogs/using-pesticidal-plants-crop-protection (accessed 22 March, 2015).

Tomar L., P. Sharma, M. Bachwani, V. Bansal 2011. Review on neem (*Azadirachta indica*): thousand problems one solution. International Research Journal of Pharmacy 2(12): 97-102.

Upadhyay, R. K, and S. Ahmed 2011. Management strategies for the control of stored grain insect pests in farmer stores and public warehouses. World J. Agric. Sciences 7(5): 527-549.

Upadhyay, R. K. 2007. Evaluation of biological activities of piper nigrum oil against *Tribolium castaneum*. Bulletin of Insect 60(1): 57-61.

Yuan Y., C. Chen, C. Zheng, X. Wang, G. Yang, Q. Wang, and Z. Zhang 2014. Residue of chlorpyrifos and cypermethrin in vegetables and probabilistic exposure assessment for consumers in Zhejiang Province, China. Food Control 36: 63-68.