Research Journal of Applied Sciences 2 (6): 653-658, 2007

Field Evaluation of Neem (*Azadirachta indica* A. Juss) Products for the Management of Lepidopterous Stem Borers of Maize (*Zea mays* L.) in Calabar, Nigeria

[1]D.A. Ukeh, [2]S.O. Emosairue, [1]I.A. Udo and [1]U.A. Ofem
[1]Department of Crop Science, University of Calabar, Nigeria
[2]Department of Agronomy, Delta State University, Asaba Campus, Asaba, Nigeria

Abstract: Stem borers are the most important field insect pests of maize in the Calabar humid environment of southern Nigeria. Field experiments were conducted in April-July 2004 and 2005 to evaluate the efficacy of neem products for the management of *Busseola fusca* and *Sesamia calamistis* in maize plots. Five treatments namely; 3% Crude Neem Oil (3% CNO), 5% CNO, 3% Neem Seed Kernel Extract (3% NSKE), 5% NSKE and the untreated (control) were laid out in the randomized complete block design and replicated 5 times. The experiments showed that there were significant differences ($p<0.05$) between neem-treated and the untreated plots in terms of grain yield and the mean number of stem borer larvae per plant. In 2004, the mean grain weight per plant (g) was 3% CNO (65.21), 5% CNO (72.16), 3% NSKE (67.44), 5% NSKE (74.41) and the untreated (45.15). During the 2005 trial, grain weights per plant were; 3% CNO (83.25), 5% CNO (77.82), 3% NSKE (77.57), 5% NSKE (82.6) and the untreated plots (46.15). In 2004, *B. fusca* had the least larval density per plant of 2.48 in 5% CNO and the highest density of 9.09 in the untreated, while *S. calamistis* had the least larval colonization of 2.33 in 5% CNO and 7.56 in the untreated plots. And in 2005, the least borer infestation of 2.32 and 2.15 per plant of *B. fusca* and *S.calamistis* were obtained from 5% CNO treated plots, respectively. Therefore, neem products offer desirable alternatives to using synthetic chemicals in agricultural systems where protection of the environment and preservation of beneficial organisms are important.

Key words: *Busseola fusca*, *Sesamia calamistis*, crude neem oil, neem seed kernel extract, azadirachtin, maize

INTRODUCTION

Maize (*Zea mays* L.) is one of the major cereal crops in Africa, which currently accounts for up to 20% of domestic food production and provides well over 50% of stable calories. Its importance has increased as it has replaced other food staples, such as millet and sorghum and has also become a major source of cash for smallholder farmers (Smith *et al*., 1994). The crop is grown primarily for human consumption, but surpluses are used in feeding livestock. In Nigeria, maize is grown across all agro-ecological zones ranging from the forest zone through the savannah and Sahel zones. Maize is grown mainly under rain fed conditions and farmers' yields are generally low, averaging about 1-1.5 t ha^{-1}. This low maize productivity is associated with several constraints, including unreliable rainfall, land degradation due to soil erosion, pre- and post-harvest pest infestation, pre- and post-harvest losses, poor infrastructure and marketing and policy bottlenecks (Law-Ogbomo and Enobakhare, 2006).

Lepidopterous stem borers are the most important biotic constraints to maize production throughout Africa. They seriously limit potentially attainable maize yields by infesting the crop throughout its growth, from seedling stage to maturity. Seventeen species in two families (Pyralidae and Noctuidae) have been found to attack maize in various parts of Africa. Yield losses of maize caused by stem borers, vary widely in different regions and comprise 20-405 of potential output, depending on agro ecological conditions, crop cultivar, agronomic practices and intensity of infestation. However, *Chilo partellus* (Swinhoe), *Chilo orichalcociliellus* (Strand), *Busseola fusca* (Fuller), *Sesamia calamistis* (Hampson) and *Eldana saccharina* (Walker) are of great importance (Ampofo *et al*., 1986; Khan *et al*., 2001).

In West Africa, the major stem borers of maize and sorghum include *B. fusca*, *S. calamistis* and *E. saccharina* (Polaszek, 1998). In Ghana, a positive relationship between the number of *Sesamia* sp. larvae and the extent of damage to maize stems and a negative relationship between damage to maize stems and maize yield were

Corresponding Author: D.A. Ukeh, Department of Zoology, Tillydrone Avenue, University of Aberdeen, AB24 2TZ, United Kingdom

shown. The calculated yield loss caused by *Sesamia* sp. to maize in the rain forest coastal, derived and Guinea ecological zones were 27, 15, 18 and 14%, respectively (Gounou *et al*., 1994). In Cameroon, Cardwell *et al.* (1997) found that stem borers, primarily *B. fusca*, were responsible for a 9 grammes loss in grain yield per plant per borer and caused an 11% loss of plants owing to dead heart.

Reducing losses caused by stem borers would significantly increase maize production and result in better nutrition and purchasing power of many maize farmers in Nigeria. However, the use of synthetic chemical insecticides as advocated by the Ministry of Agriculture for the control of stem borers is uneconomical and impractical to many resource-poor, small-scale farmers. Other problems include acute and chronic poisoning of applicators, farm workers and even consumers, destruction of aquatic organisms, birds and other wildlife, disruption of natural biological control and pollination, extensive groundwater contamination, potentially threatening human and environmental health issues and the evolution of resistance to pesticides in pest populations (Emosairue and Ukeh, 1996; Perry *et al*., 1998; National Research Council, 2000). Thus, field trials were set up to evaluate the effects of neem (*Azadirachta indica*) products for the management of stem borer infestations and the yield of maize. In our study, emphasis was given to *S. calamistis* and *B. fusca* that are the most prevalent pests in southeastern Nigeria.

MATERIALS AND METHODS

Experimental set up: Two field experiments were conducted between April and July 2004 and during the same period in 2005 at the University of Calabar Teaching and Research Farm of the Faculty of Agriculture (located within latitude 5°00′ and 5°40′ North and longitude 8°04′ and 8°62′ East). Calabar has a humid tropical climate with total annual rainfall of 1500-3000 mm, humidity of 65-90%, ambient temperatures of 22.2-23.8°C min and 27-38.2°C max. Two seasons predominates in this area, namely hot and wet from April to September and hot and dry from October to March (Obhiokhenan *et al*., 2002). The trials were laid out in pre-fallowed piece of land in a Randomized Complete Block Design (RCBD) consisting of five treatments with each treatment replicated five times. The treatments were: Untreated control, 3% Crude Neem Oil (3% CNO), 5% Crude Neem Oil (5% CNO), 3% Neem Seed Kernel Extract (3% NSKE) and 5% Neem Seed Kernel Extract (5% NSKE). The maize variety "Oba super 1" obtained from the National cereals sub-station, Umuahia, Abia State, Nigeria was used for planting. The crop was planted in a 28×23 m piece of land demarcated into 25 blocks each 4×3 m separated by 2 m paths from each other to reduce interactions. During the 2004 trials, the crop was planted on April 3 and in 2005, planting was done on April 4. On each experiment, two seeds of maize were planted at a depth of about 3 cm with a spacing of 60 cm between rows and 30 cm within rows. Seedlings were thinned down to one per stand 14 Days After Emergence (DAE) to give a plant population of 55,000 per hectare. A Day After Emergence (DAE) was fixed after 70% of the seeds have germinated. A nitrogen-phosphorus-potassium fertilizer (N-P-K: 15-15-15) was applied at the rate of 500 kg ha^{-1} in split dosage, at 14 DAE and at 42 DAE .The plots were kept weed free during the experimental period.

Preparation of crude neem oil and neem seed kernel extracts: Matured ripe fruits obtained from *A. indica* trees in Calabar metropolis were collected, washed and sun dried for 4-7 days. Dried fruits were cracked open to obtain the seeds. The seeds were ground into a fine paste using a laboratory mechanical grinder. Crude Neem Oil (CNO) was obtained by placing the fine neem paste into a clean muslin cloth and the oil pressed out into a container. Three and 5% crude neem oil (3% CNO and 5% CNO) and 3 and 5% Neem Seed Kernel Extract (3% NSKE and 5% NSKE) were prepared using the method adopted by Emosairue and Ukeh (1996). Using this method, 30 and 50 mL of CNO was mixed with 970 and 950 mL of distilled water containing an emulsifier (1% soap solution) to obtain 3 and 5% CNO, respectively. The 3 and 5% NSKE was prepared by soaking 30 and 50 g of neem seed paste in one litre of distilled water for 12 h then filtering through a clean muslin cloth. A knapsack sprayer was used for the application of the various treatments that commenced at 14 DAE. In all cases plants were sprayed to run-off point on a weekly basis during the morning hours between 7:00 and 9:00 a.m.

Pest numbers, plant damage and yield: Six plants were sampled from the centre of each block (4×3 m) destructively every two weeks beginning from 15 DAE, till harvest. Data recorded include the number of stem borers per plant, number of cobs per plants and plant height at the time of harvest. At harvest, grain yield was taken for each plot by weighing dried and shelled seeds using PC 440 electronic balance (Mettler Instrument AG, Zurich).

All data were subjected to the Analysis of Variance (ANOVA) and means separated using Duncan's Multiple Range Test (DMRT) at 5% significant level.

RESULTS

The results of the yield and yield related parameters of maize in response to treatment with neem products during the 2004 and 2005 early season cropping are presented in Table 1, while Table 2 shows the mean number of stem borer colonization per plant after treatment with neem products. Maize grain yields in neem-treated plots were significantly different ($p<0.05$) from the untreated plots during the 2004 and 2005 growing seasons. Although yield differences between neem-treated plots were not significantly different ($p<0.05$), 5% NSKE treated plots recorded the highest yields of 74.42 g of grains per plant in 2004. This was followed by 5% CNO with 72.16 g, 3% NSKE with 67.44 g and 3% CNO with 65.21 g plant^{-1}. However, during the 2005 experiment, the highest grain yield was recorded in the 3% CNO treated plots with 83.25 g plant^{-1}, followed by 5% NSKE (82.6 g), 5% CNO (77.82 g) and 3% NSKE (77.57 g), respectively. Plant height at harvest was generally significantly different ($p<0.05$) between the treated and untreated plots during both trials and appeared to be positively related to the yield. The mean number of maize cobs per plant did not vary significantly ($p<0.05$) among different treatments during the two study seasons (Table 1). There was significant differences ($p<0.05$) in stem borer larvae colonization per plant in the 2004 and 2005 field trials.

Table 1: Mean yield and yield related parameters of Maize after treatment with *A. indica* products during the 2004 and 2005 cropping seasons

2004	Grain weight/ plant (g)	No. of cobs/plant	Final plant height (cm)
3% CNO	65.21a	1.4a	131.47c
5% CNO	72.16a	1.4a	152.32a
3% NSKE	67.44a	1.3a	141.54b
5% NSKE	74.41a	1.4a	151.39a
Untreated	45.15b	1.3a	109.52d
2005			
3% CNO	83.25a	1.1a	147.83a
5% CNO	77.82a	1.4a	150.04a
3% NSKE	77.57a	1.1a	150.63a
5% NSKE	82.6a	1.3a	148.93a
Untreated	46.15b	1.1a	109.83b

Table 2: Mean number of stem borer larvae per plant after treatment with *A. indica* products during the 2004 and 2005 cropping seasons

2004	*B. fusca*	*S. calamistis*
3% CNO	4.8b	4.04b
5% CNO	2.48c	2.33c
3% NSKE	4.12b	3.68b
5% NSKE	3.59bc	3.18bc
Untreated	9.09a	7.56a
2005		
3% CNO	4.41b	4.06b
5% CNO	2.32d	2.15c
3% NSKE	3.79bc	2.92bc
5% NSKE	3.02cd	2.89bc
Untreated	8.58a	8.35a

Borer larval densities were significantly lower in neem-treated than in untreated plots (Table 2). The lowest mean number of *B. fusca* and *S. calamistis* larvae was recorded in the 5% CNO treated plots with 2.48 and 2.32 larvae per plant and 2.33 and 2.15 larvae per plant in 2004 and 2005 seasons, respectively. This showed that plants treated with 5% CNO had the least larval colonization and infestation. Figure 1 and 2 showed the mean population responses of *B. fusca* and *S. calamistis* per plant, respectively in response to treatments with neem products. Pest numbers did not significantly differ ($p<0.05$) between 2004 and 2005 for each treatment, but the number of larvae of *S. calamistis* were higher in 2004 than in 2005. The highest pest densities of *B. fusca*

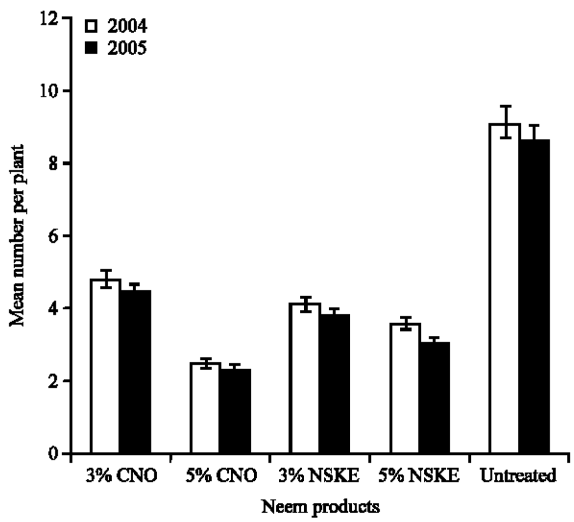

Fig. 1: Mean population responses of *B. fusca* larae per plant to treatment with neem products

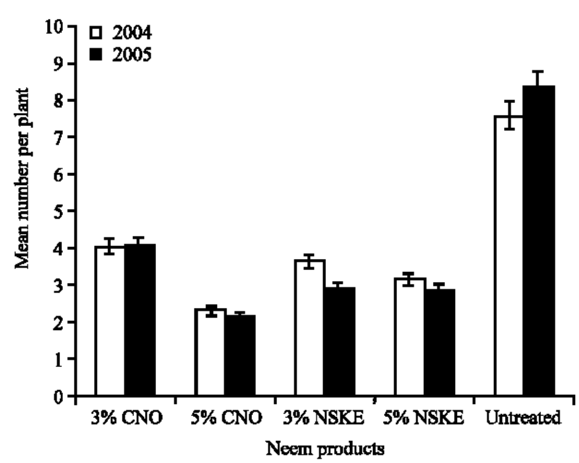

Fig. 2: Mean population responses of *S. calamistis* larae per plant to treatment with neem products

per plant in the untreated plots were 9.09 and 8.58 in the 2004 and 2005 experiments respectively. *S. calamistis* had the highest larval densities of 7.56 in 2004 and 8.35 in 2005 trials in the untreated plots, respectively (Table 2, Fig. 2).

DISCUSSION

Some plants produce chemical substances for their own chemical protection, which are poisonous or indigestible for pests (Herms and Matson, 1992). The finding that in some plants secondary metabolites prevent colonization and nutrition of most herbivorous insects, resulted in a considerable increase of empirical studies of insects/plant interactions, more investigation of plant extracts and their practical use in crop protection. The insects register toxic, repellent and antifeedance substances of plant origin and they react on them, while olfaction systems do not give any information regarding most synthetic chemicals (Zabel *et al*., 2002).

Field evaluations of the effects of crude neem products on the lepidopterous insect pests of maize indicated that the survival rates of *B.fusca* and *S. calamistis* in neem treated plots were reduced compared to the untreated plots in 2004 and 2005 trials. The results of this research showed that neem have high contact toxicity on *B. fusca* and *S. calamistis* larvae. The insects on neem products- treated plants probably die because of starvation, due to the antifeedant effect of neem. The effects of Azadirachtin, a liminoid that accumulates in the seeds of the neem tree, on insect pests are manifold and include antifeedant effects, delay in the development of immature stages, effects on metamorphosis, ecdysis inhibition, oviposition repellency effects and deteriorating effects on reproduction and longevity (Emosairue and Ukeh, 1996; Mordue (Luntz) *et al*., 1998; Riba *et al*., 2003; Seljasen and Meadow, 2006; Schulthess *et al*., 2006). Generally, Azadirachtin have been reported to exert a variety of toxic effects on nymphs and adult bugs (Heteroptera) as shown by Abudulai *et al.* (2003) and Schulte *et al.* (2006) on *Lymantria dispar* (Lepidoptera: Lymantriidae) larvae and *Leptinotarsa decemlineata* (Coleoptera: Chrysomelidae) larvae (Zabel *et al*., 2002) and on the root weevil *Diaprepes abbreviatus* (Coleoptera: Curculionidae) larvae (Weathersbee and Tang, 2002). Mordue (Luntz) *et al.* (1996) reported similar results for the locust *Locusta migratoria* which would ingest enough treated plant foliage to cause toxic physiological effects while another locust *Schistocerca gregaria* would starve before feeding on treated foliage. Studies have shown that plants are able to take up Azadirachtin and translocate the active component to various parts of the plant (Sundaran, 1996; Schulthess *et al*., 2006).

In these experiments, yield differences between neem-treated plots and the untreated plots were observed in both 2004 and 2005 trials. *B. fusca* lays its egg batches on the inner side of leaf sheaths of pre-tasseling maize plants and the emerging larvae migrate to the whorl (Kaufmann, 1983; Stoll, 2000). After feeding on the whorl leaves, causing the typical "window pane" symptoms, the larvae either disperse or bore into the stem from the funnel (Chabi-Olaye *et al*., 2005). This could mean that the higher leaf nitrogen contents of plants in the untreated plots resulted to higher survival of young larvae. Similar results have been reported by Setanau *et al.* (1993) from fertilizer trial, which yielded a positive relationship between survival of young stem borer larvae and nitrogen applied. For *S. calamistis*, Setanau *et al.* (1993) reported that nitrogen fertilizer levels did not affect egg-pupae development time on maize. Feeding and stem tunnelling by borer larvae on plants results in crop losses as a consequence of destruction of the growing point, early leaf senescence, interference with translocation of metabolites and nutrients that result in malformation of the grain, stem breakage, plant stunting, lodging and direct damage to ears (Bosque-Perez and Mareck, 1991; Polaszek, 1998).

Pest population was generally low during the trials with the highest mean number of 9.09 *B. fusca* larvae per plant in 2004 and 8.35 *S. calamistis* larvae per plant in 2005 in the untreated plots. This could also be attributed to the indigenous parasitoids associated with African cereal stem borers belonging to either the Hymenoptera or Diptera. Ndemah *et al.* (2001) reported fifteen hymenopterous, two dipterous and one fungal species on African stem borers. Among these were six pupal, six larval, four egg, one larval-pupal parasitoids and four hyperparasitoids including *Telenomus busseolae* and *T. isis* found on *B. fusca* eggs. However, the effectiveness of parasitoids in keeping stem borer populations below acceptable thresholds has been doubted by several researchers (Kfir, 1997).

CONCLUSION

Our objective was to assess the efficacy of neem products for the control of *B. fusca* and *S. calamistis* of maize in the Calabar humid environment of Southern Nigeria. Results show that neem products increases the yield of maize and reduces stem borer colonization of cultivated plants, but did not increase the number of cobs per plant. Neem-based insecticides have been found to have little impact on many beneficial organisms such as pollinators, predators and parasitoids (Isman, 2002; Walter, 1999; National Research Council, 2000). Neem products are therefore, compatible with integrated pest management in the maize and arable crops ecosystems.

REFERENCES

Abudulai, M., B.M. Shepard and P.L. Mitchell, 2003. Antifeedant and toxic effects of a neem (*Azadirachta indica* A.Juss)-based formulation Neemix® against *Nezara viridula* (L.) (Hemiptera:Pentatomidae). J. Entomol. Sci., 38: 398-408.

Ampofo, J.K.O., Z.T. Dabrowski and E.O. Omolo, 1986. Registration of germplasm lines of maize. Crop Sci., 26: 650.

Bosque-Perez, N.A. and J.H. Mareck, 1991. Effect of the stem borer *Eldana saccharina* (Lepidoptera: Pyralidae) on the yield of maize. Bull. Entomol. Res., 81: 243-247.

Cardwell, K., F. Schulthess, R. Ndemah and Z. Ngoko, 1997. A systems approach to assess crop health and maize yield losses due to pests and diseases in Cameroon. Agric. Ecosys. Environ., 65: 33-47.

Chabi-Olaye, A., C. Nolte, F. Schulthess and C. Borgemeister, 2005. Relationships of intercropped maize, stem borer damage to maize yield and land-use efficiency in the humid forest of Cameroon. Bull. Entomol. Res., 95: 417-427.

Emosairue, S.O. and D.A. Ukeh, 1996. Field trial of neem products for the control of Okra flea beetles (*Podagrica* sp.) in South Eastern Nigeria. Afr. J. Plant Prot., 37: 22-26.

Gounou, S., F. Schulthess, T. Shanower, W.N.O. Hammond, H. Braima, A.R. Cudjoe, R. Adjakloe, K.K. Antwi and I. Olaleye, 1994. Stem and ear borers of maize in Ghana. Plant Health Management Research Research Monograph No. 4. International Institute of Tropical Agriculture, Ibadan, Nigeria, pp: 23.

Herms, D. and W.J. Mattson, 1992. The dilemma of plants: To grow or defend. Quarterly Rev. Biol., 67: 283-335.

Isman, M.B., 2002. Insect antifeedants. Pestic. Outlook, 13: 152-157.

Kaufmann, T., 1983. The behavioural biology, feeding habits and ecology of three species of maize stem borers, *Eldana saccharina*, *Sesamia calamistis* and *Busseola fusca* in Ibadan, Nigeria, West Africa. J. Ga. Entomol., 18: 259-272.

Kfir, R., 1997. Competitive displacement of *Busseola fusca* (Lepidoptera: Nuctuidae) by *Chilo partellus* (Lepidoptera: Pyralidae). Ann. Entomol. Soc. Am., 90: 620-624.

Kfir, R., W.A. Overholt, Z.R. Khan and A. Polaszek, 2002. Biology and management of economically important lepidopteran cereal stem borers in Africa. Ann. Rev. Entomol., 47: 701-731.

Khan, Z.R., J.A. Pickett, L.J. Wadhams and F. Muyekho, 2001. Habitat management strategies for the control of cereal stemborers and striga in maize in Kenya. Insect. Sci. Applied, 21: 275-380.

Law-Ogbomo, K.E. and D.A. Enobakhare, 2006. Efficacy of rubber seed oil, Palm oil and Palm kernel oil as grain protectants against *Sitophilus zeamais* (Motschulsky) (Coleoptera: Curculionidae) in three maize varieties. J. Entomol., 3: 40-47.

Mordue (Luntz), A.J., A.J. Nisbet, M. Nasiruddin and E. Walker, 1996. Differential thresholds of Azadirachtin for feeding deterrence and toxicity in locusts and an aphid. Entomol. Exp. Applied, 80: 69-72.

Mordue (Luntz), A.J., M.S.J. Simmonds, S.V. Ley, W.M. Blaney, W. Mordue, M. Nasiruddin and A.J. Nisbet, 1998. Actions of Azadirachtin, a plant allelochemical against insects. Pesticide Sci., 54: 277-284.

National Research Council, 2000. The future role of pesticides in US Agriculture. Natl. Acad. Press. Washington, DC., pp: 301.

Ndemah, R., F. Schulthess, S. Korie, C. Borgemeister and K.F. Cardwell, 2001. Distribution, relative importance and effect of lepidopterous borers on maize yields in the forest zone and mid-altitude of Cameroon. J. Econ. Entomol., 94: 1434-1444.

Obhiokhenan, A.A., E.J. Usua and S.B.A. Umoetok, 2002. Distributions of Lepidopterous stem borers of maize (*Zea mays* L.) in ecological zones of Cross River State of Nigeria. Glo. J. Agric. Sci., 1: 89-92.

Perry, A.S., I. Yamamoto, I. Ishaaya and R.Y. Perry, 1998. Insecticides in Agriculture and Environment: Retrospect and Prospects. Springer-Verlag, Berlin, pp: 261.

Polaszek, A., 1998. African cereals stem borers: Economic importance, taxonomy, natural enemies and control. CABI, Wallingford, UK., pp: 530.

Riba, M., J. Merti and A. Sans, 2003. Influence of Azadirachtin on development and reproduction of *Nezara viridula* L. (Heteroptera: Pentatomidae). J. Applied Entomol., 127: 37-41.

Schulthess, M.J., K. Martin and J. Sauerborn, 2006. Effects of Azadirachtin injection in litchi trees (*Litchi chinensis* Sonn) on the litchi stink bug (*Tessaratoma papillosa* Drury) in northern Thailand. J. Pest. Sci., 79: 241-250.

Seljasen, R. and R. Meadow, 2006. Effects of neem on oviposition and egg and larval development of *Mamestra brassicae* L.: Dose response, residual activity, repellent effects and systemic activity in cabbage plants. Crop Prot., 25: 338-345.

Setanau, M., F. Schulthess, N.A. Bosque-Perez and A. Thomas-Odjo, 1993. Effects of plant nitrogen and Silica on the bionomics of *Sesamia calamistis* Hampson (Lepidoptera: Noctuidae). Bull. Entomol. Res., 83: 405-411.

Smith, J., A.D. Barau, A. Goldman and J.H. Mareck, 1994. The role of technology in agricultural intensification: the evolution of maize production in the northern Guinea savannah of Nigeria. Econ. Dev. Cult. Change, 42: 537-554.

Stoll, G., 2000. Natural crop protection in the tropics: letting information come to life. Margraf Verlag, Weikersheim, pp: 376.

Sundaran, K.M.S., 1996. Root uptake, translocation, accumulation and dissipation of the botanical insecticides, Azadirachtin in young spruce trees. J. Environ. Sci. Health B., 31: 1289-1306.

Walter, J.F., 1999. Commercial Experience with Neem Products. In F.R. Hall and J.J. Menn (Eds.), Biopesticides: Use and Delivery. Humana, Totowa, New Jersey.

Weathersbee, A.A. and Y.Q. Tang, 2002. Effect of neem seed extract on feeding, growth, survival and reproduction of *Diaprepes abbreviatus* (Coleoptera: Curculionidae). J. Econ. Entomol., 95: 661-667.

Zabel, A., B. Manojlovic, S. Rajkovic, S. Stankovic and M. Kostic, 2002. Effect of neem extract on *Lymantria dispar* L. (Lepidoptera: Chrysomelidae). J. Pest. Sci., 75: 19-25.