WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 5.045
Volume 4, Issue 3, 1610-1620. Research Article ISSN 2277– 7105

GROWTH INHIBITORY EFFECTS OF NEEM ON THE PHYTOPHAGOUS PEST *HENOSEPILACHNA VIGINTIOCTOPUNCTATA* (Fab.) ON BITTERGOURD

R. Shanmugapriyan[1]* and Jaiby Cyriac[2]

[1]Lucine Agro Tech India Pvt. Ltd., Coimbatore, Tamilnadu, India.

[2]Department of Biology, Nirmala college, Muvattupuzha, Ernakulam District, Kerala.

Article Received on
30 Dec 2014,

Revised on 24 Jan 2015,
Accepted on 18 Feb 2015

***Correspondence for Author**
Dr. R. Shanmugapriyan
Lucine Agro Tech India Pvt. Ltd., Coimbatore, Tamilnadu, India.

1. ABSTRACT

Azadirachta indica (A.Juss) plant extracts were tested for their growth inhibitory effects on the phytophagous pest *Henosepilachna vigintioctopunctata* (Fab.) on bittergourd. In this research neem oil and extracts of neem cake, seed kernel, seed coat and bark powder were evaluated. Fed with leaves of bittergourd treated with neem oil 0.25 to 2.5% resulted 90.0% inhibition on adult emergence, 70.0% of pupal mortality and 20.0% of adults with deformities. 2.5% concentration of neem seed kernel extract inhibited the adult emergence upto 56.6%. The growth inhibitory effect of neem cake extract at 0.25 to 2.5% concentration was 10.0 to 46.6%. Bio-efficacy of neem oil on adult emergence is followed by extracts of neem seed kernel, neem cake, neem bark powder and neem seed coat. Extracts of neem bark powder and seed coat were moderately effective on the growth of epilachna beetle. Neem seed coat and bark powder extracts at 2.5% concentration inhibited the adult emergence upto 30.0 and 36.6%. The growth inhibitory effect of neem extracts on adult emergence is directly proportional to the increase of concentration. All the tested neem extracts affected the normal adult emergence by showing morphological deformities in the wings and the shape of the insect. Because of these versatile biological impacts, cost effectiveness and the bio-degradable nature, neem derivatives are suitable component for the bitter gourd IPM schedule.

KEYWORDS: Adult emergence, Adult malformation, *Henosepilachna vigintioctopunctata*, Integrated Pest management (IPM), Neem derivatives, Total inhibition.

2. INTRODUCTION

The bitter gourd, *Momordica charantia* is a popular vegetable in South Indian food. Its pods are rich source of phytonutrients like dietary fibre, minerals vitamins and antioxidents. The well known health benefit of bitter gourd is the ability to lower blood glucose in diabetics. *Henosepilachna vigintioctopunctata* (Fab.) is one of the economically important pest on bittergourd. It is a polyphagous pest which shows its presence on cucurbitaceous and solanaceous crops. It is highly destructive at both, adult and larval stages which feed on the leaves, flowers and fruits by scraping the chlorophyll content and cause a big yield loss (Imura and Ninomiya, 1978; Srivastava and Butani, 1998; Ghosh and Senapati, 2001). The larvae confine their attack to the lower surface while adult beetles usually feed on the upper surface of the leaves (Prodhan *et. al*., 1990; Khan *et. al*., 2000). Management of this pest using synthetic chemicals has failed because of resistance to insecticides, pest resurgence, environmental contamination and persistent toxicity on produce. Plant derived pesticides are desirable alternatives to the synthetic chemicals using in an agricultural ecosystem to combat the negative impact on environment and non - target organisms. They are biodegradable and safe to the beneficial organisms. It has been used for at least two millennia, when plant derived insecticides were considered important products for pest management in Ancient China (Long *et. al.*, 2006), Egypt, Greece and India (Isman, 2006). Botanical insecticides were predominantly used, before the discovery of organochlorated and organophosphorated insecticides in European countries (Isman, 1997). Plant products exhibit insectistatic effect on insects through inhibition on development and behaviour (Celis *et. al*., 2008). The insectistatic effect of plant extracts was repellent (Viglianco *et. al.*, 2006), anti-feeding activity (Eriksson *et. al.*, 2008), growth regulation (Wheeler, 2001), feeding deterrents (Koul, 2004), and oviposition deterrents (Banchio *et. al.*, 2003). About 2000 plant species posses pest control properties (Ahmed, 1984). Among them, use of neem *Azadirachta indica* A. Juss (Meliacea) as an insecticide is the most widespread and widely researched. Its insecticidal effect is known to work in various ways, like antifeedant, repellent, growth inhibitor, ovipositional deterrent, impaired reproductive ability, etc. (Schmutterer, 1995). Azadirachtin inhibits the growth, affects survival and causes anatomical abnormalities in several species of insects (Martinez and Emden, 1999; Mordue *et. al.*, 2000). According to Isman (1999), azadirachtin from neem is the effective naturally available biodegradable insect growth regulator which rapidly metabolizes in the environment. A research was conducted to elucidate the growth inhibitory effects of neem derivatives on the phytophagous pest *H. vigintioctopunctata* (Fab.).

3. MATERIALS AND METHODS

The egg masses of *H. vigintioctopunctata* (Fab.) collected from the field and incubated at room temperature 28±2ºC. After the young ones hatched, they were transferred into plastic basins (40.0 cm X 8.8 cm) at the rate of twenty five larvae per basin. Mouth of the basin is covered with mosquito net and tied with elastic bands. Every day, the containers were cleaned and provided with fresh bittergourd leaves. Studies were undertaken using the larvae reared from such stock culture. To evaluate the growth inhibitory effect, ten prestarved fourth instar larvae were fed with leaves treated with neem oil, extracts of neem cake, seed kernel, seed coat and bark powder at 0.025, 0.5, 1.5 and 2.5 percent and thiamethoxam at 0.025 percent, quinalphos, chlorpyriphos and dimethoate at 0.05 percent concentration. Each treatment replicated thrice. The observations were made on pupal mortality, adult malformation and normal adults. The data were statistically analyzed with the help of SPSS computerized software (version 20) for Duncan's multiple range test (DMRT) at the 5% level.

4. RESULTS AND DISCUSSIONS

Fed with leaves, treated with neem oil 0.25, 0.5, 1.5 and 2.5 percent, the pupation of fourth larval instars of *H. vigintioctopunctata* results in the pupal mortality from 3.3 to 70.0 percent, malformed adults from 16.6 to 26.6 percent and total inhibition of 20.0 to 90.0 percent (Table - 1). This corroborates with the findings of Patnaik *et. al.*, (1987 a). When the larvae of *Arthalia lugens* were fed with leaves treated with neem oil in the concentration range of 0.1 to 3.0 percent, the percentage of adult emergence ranged from 66.7 to 0.0 percent. Wilps *et al* (1993) observed 15.0 and 39.0 percent of malformation when the larvae of *Schistocerca gregaria* were treated with pure neem oil 0.04 and enriched neem oil 0.2 percent. Moreover Ramamurthy and Venugopal (1997) also noted the percentage of adult emergence varied from 8.65 to 1.91 percent, when *Sitotroga ceralella* was treated with neem oil 1.0, 2.0 and 3.0 percent. The adult emergence effect of neem oil is also studied by Ahmed *et. al*., (1999) on *Callosobruchus chinensis*, Chakraborti and Chatterjee (1999) on *Dactynotus carthami* and Gajmer *et al* (2001) on *Earias vittella*. Soosaimanickam Maria Packiam *et. al.*, (2014) found the growth inhibitory effects of neem oil, nimbicidine and commercial neem product (Ponneem) against *Helicoverpa armigera*.

The percentage of pupal mortality ranges from 3.0 to 33.3 percent, inhibition on adult emergence from 10.0 to 46.6 percent, and normal adult emergence from 90.0 to 53.3 percent

in the pupation of *H. vigintioctopunctata*, when fourth larval instars were fed with leaves treated with neem cake extract in 0.25, 0.5, 1.5 and 2.5 percent concentrations. The same effect is also observed by Nelson *et. al.*, (1993), when the larvae of white backed plant hopper were fed with leaves treated with neem cake extract 5.0 percent concentration, recorded 53.3 percent adult emergence.

Fed with leaves, treated with neem seed kernel extract 0.25, 0.5, 1.5 and 2.5 percent, the pupation of fourth larval instars of epilahna beetle results in the pupal mortality, adult malformation and total inhibition ranges from 0.0 to 36.6, 13.3 to 23.3 and 13.3 to 56.6 percent, respectively. The inhibitory effect of the adult emergence of neem seed kernel extract was also studied by Savitri and Subbarao (1976). They observed the adult emergence of 4.68 to 0.71 %, 3.03 to 0.71 % and 12.4 to 0.0 %, when they treated against *Rhizopertha dominica, Sitophilus oryzae and Sitotroga cerealella*. In the present research, emergence of adults with malformed wings and shape was observed (Figure - 1). This is in accordance with the earlier findings of Schmutterer (1990). He found adults of *Epilachna varivestis* with malformed wings when treated the larvae with neem seed kernel extract. The effect of neem seed kernel extract on adult emergence is also noted on *Spodoptera litura* (Gujar and Mehrotra, 1983), *Spodoptera litura* (Badge *et. al*, 1999), *Heliothis armigera* (Mahapatro and Padmaja, 2000) and *Helicoverpa armigera* (Morale *et. al.*, 2000). Doses of more than 500 ppm of the neem seed kernel extract in the diet caused 100 % larval mortality in *Anticarsia gemmatalis*, whereas lower doses reduced food intake and reproductive capacity and increased production of pupae with morphological deformities (Almedia *et. al*., 2014). Radha (2013) recorded reduction in adult emergence of *Aphis craviccora* while treating with neem seed kernel extract at 6.0% concentration. In the present study the toxicity of neem seed kernel extract increases significantly with the increase in its concentration. This corroborate with the earlier findings of Syeda Azra Tariq *et. al.*, (2013). They found that insect growth inhibition effect of neem seed powder was increased by increasing the dose against *Tribolium castaneum*.

The percentage pupal mortality, adult malformation and total inhibition of adult emergence ranged from 0.0 to 16.6 percent, 3.3 to 13.3 percent and 3.3 to 30.0 percent, when fourth larval instars were fed with leaves treated with neem seed coat extract 0.25, 0.5, 1.5 and 2.5 percent. Prabhu and Singh (1993) also observed the effect of neem seed coat extract 0.25, 0.5 and 1.0 percent on the adult emergence of *Spodoptera litura*. Pathak and Tiwari (2010) found

complete arrest of the adult emergence of *Corcyra cephalonica*, when treated with 3.0 % neem leaf extract along with 5.0% yeast.

The percentage effect of neem bark powder extract was very low when compared to neem oil, neem seed kernel and cake extract. In the present investigation, it was observed that as the concentration of neem derivatives increases the percentage inhibition on adult emergence also increases. This is in accordance with the findings of Patnaik *et. al.,* (1987 b) on *Arthalia lugens*. They found an increased inhibitory effect on adult emergence with an increase in the concentration of neem oil from 0.1 to 3.0 percent. Similar findings were done by Prabhu and Singh (1993) on *Spodoptera litura* and Gupta *et. al*., (1998) *Helicoverpa armigera*. Misbah Rashid and Aftab Ahmad (2013) reported that larvae of *Culex pipiens fatigans* did not enter into pupation and resulted in complete cessation of adult emergence when treated with 20 % neem leaf extract.

Thiamethoxam at 0.025% concentration showed significant reduction in adult emergence. It caused 86.6% of inhibition on adult emergence. In the present study synthetic chemicals offered strong pupicidal effect. The inhibitory effect on adult emergence of thiamethoxam is followed by quinalphos, dimethoate and chloripyriphos at 0.05 % concentration. Development of malformed insects was almost nil when treated with synthetic chemical insecticides.

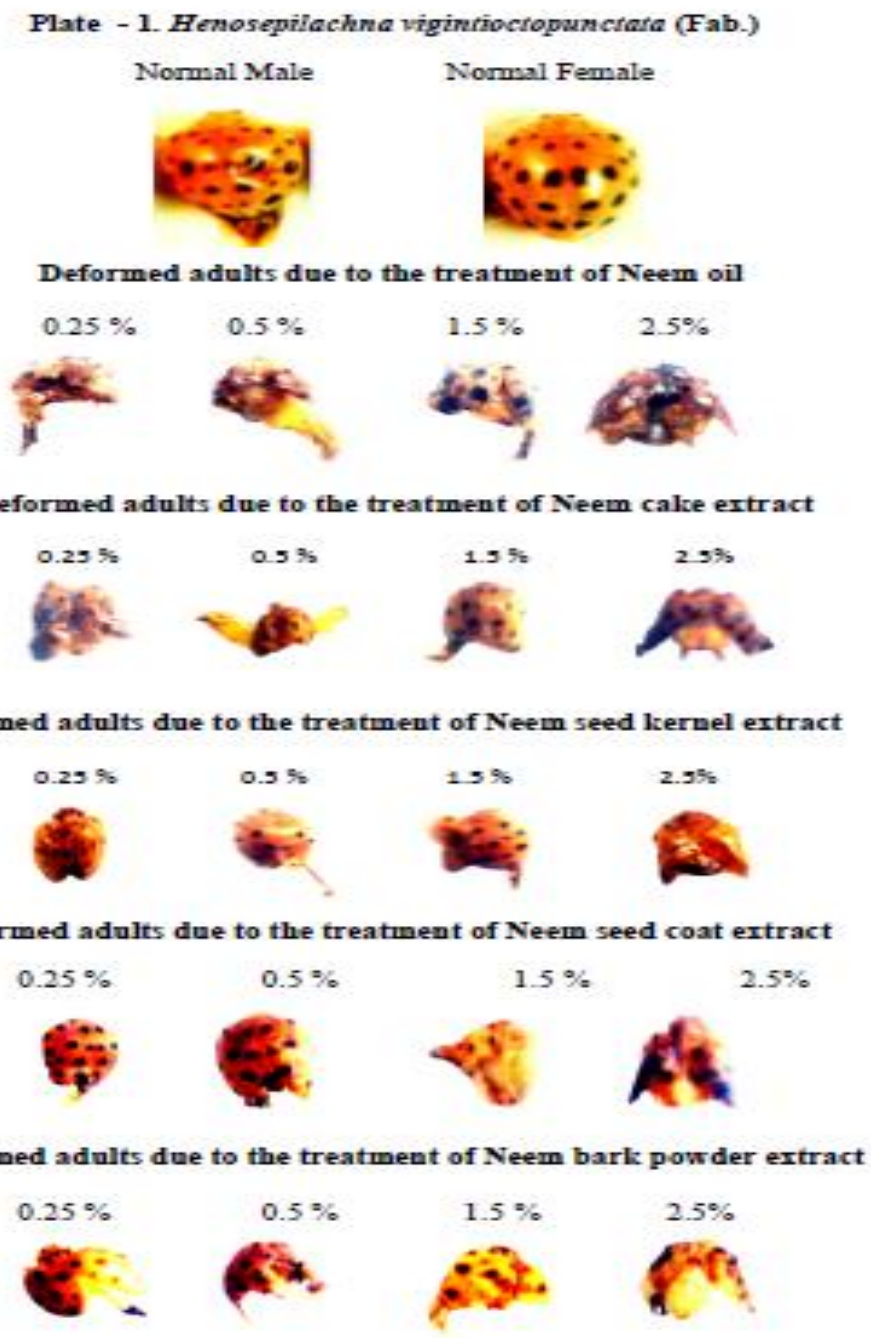
Table - 1. Effect of neem derivatives on the growth of *Henosepilachna vigintioctopunctata* (Fab.)

Treatments (%)	Pupal Mortality (%)	Malformed Adults (%)	Normal Adults (%)	Total Inhibition (%)
Neem oil 0.25	3.3333 (6.1450)hi	16.6666 (23.8550)ab	80.0000 (63.9296)d-g	20.0000 (26.0702)d-g
Neem oil 0.5	10.0000 (18.4381)gh	26.6666 (30.9955)a	63.3333 (52.7753)e-h	36.6666 (37.2245)c-f
Neem oil 1.5	30.0000 (33.0024)c-f	23.3333 (28.7803)a	46.6666 (42.7846)hij	53.3333 (47.0068)bc
Neem oil 2.5	70.0000 (56.9974)b	20.0000 (26.0702)a	10.0000 (18.4381)k	90.0000 (71.5681)a
Neem Cake Extract 0.25	3.3333 (6.1450)hi	6.6666 (12.2899)b-e	90.0000 (74.9999)a-d	10.0000 (15.0000)g-j
Neem Cake Extract 0.5	13.3333 (21.1449)efg	10.0000 (18.4381)a-d	76.6666 (61.2195)d-g	23.3333 (28.7803)d-g
Neem Cake Extract 1.5	16.6666 (23.8550)d-g	16.6666 (23.8550)ab	66.6666 (54.9905)e-h	33.3333 (34.9252)c-f

Neem Cake Extract 2.5	33.3333 (35.2177)cde	13.3333 (21.1449)abc	53.3333 (47.0068)ghi	46.6666 (42.7846)cd
Neem Seed Kernel Extract 0.25	0.0000 (0.1910)i	13.3333 (21.1449)abc	86.6666 (68.8549)b-e	13.3333 (21.1449)f-i
Neem Seed Kernel Extract 0.5	13.3333 (21.1449)efg	16.6666 (19.9253)abc	70.0000 (57.7006)e-h	30.0000 (32.2992)c-f
Neem Seed Kernel Extract 1.5	16.6666 (19.9253)fgh	23.3333 (28.2855)a	60.0000 (50.8524)fgh	40.0000 (39.0633)cde
Neem Seed Kernel Extract 2.5	36.6666 (37.2245)cd	20.0000 (26.0702)a	43.3333 (40.8618)hij	56.6666 (48.8456)bc
Neem Seed Coat Extract 0.25	0.0000 (0.1910)i	3.3333 (6.1450)de	96.6666 (83.8550)ab	3.3333 (6.1450)ij
Neem Seed Coat Extract 0.5	0.0000 (0.1910)i	6.6666 (8.8550)cde	93.3333 (81.1449)abc	6.6666 (8.8550)hij
Neem Seed Coat Extract 1.5	10.0000 (15.0000)gh	10.0000 918.4381)a-d	80.0000 (63.9296)d-g	20.0000 (26.0702)d-g
Neem Seed Coat Extract 2.5	16.6666 (23.8550)d-g	13.3333 (21.1449)abc	70.0000 (56.9974)e-h	30.0000 (33.0024)c-f
Neem Bark Powder Extract 0.25	3.3333 (6.1450)hi	3.3333 (6.1450)de	93.3333 (77.7099)a-d	6.6666 (12.2899)g-j
Neem Bark Powder Extract 0.5	13.3333 (12.2899)ghi	10.0000 (18.4381)a-d	83.3333 (66.1448)c-f	16.6666 (23.8550)e-h
Neem Bark Powder Extract 1.5	10.0000 (18.4381)gh	13.3333 (21.1449)abc	76.6666 (61.2195)d-g	23.3333 (28.7803)d-g
Neem Bark Powder Extract 2.5	20.0000 (26.5674)c-g	16.6666 (23.8550)ab	63.3333 (52.7753)e-h	36.6666 (37.2245)c-f
Thiamethoxam @ 0.025	86.6666 (72.2899)a	0.0000 (0.1910)e	13.3333 (17.7100)k	86.6666 (72.2899)a
Quinalphos @ 0.05	73.3333 (59.2127)b	3.3333 (6.1450)de	23.3333 (28.0771)jk	76.6666 (61.9227)ab
Chlorpyriphos @ 0.05	40.0000 (39.1474)c	0.0000 (0.1910)e	60.0000 (50.8524)fgh	40.0000 (39.1474)cde
Dimethoate @ 0.05	73.0000 (59.2127)b	0.0000 (0.1910)e	26.6666 (30.7871)ijk	73.3333 (59.2127)ab
Control	0.0000 (0.1910)i	0.0000 (0.1910)e	100.0000 (89.8089)a	0.0000 (0.1910)j

Values mean of three replications.

Means followed by a common letter are not significantly different at the 5% level by DMRT.



5. CONCLUSION

Increasing environmental issues, reduction of cropping area and natural resources were seriously affected the agricultural production, availability of residue free food and human health in the world. Incorporation of botanical pesticides in the IPM package is mandatory to combat the issues which are caused by the synthetics. In the present research it was clear that neem derivatives have diverse biological action on insect pests. Higher concentration of neem oil, extracts of neem cake and seed kernel offered satisfactory control on adult emergence of *H. vigintioctopunctata* (Fab.). The natural growth inhibitory effect of neem extracts offered

the development of malformed adults, which unable to fly, search food and their mates to continue the generations. The order of efficacy of neem derivatives on the growth of epilachna beetle was, neem oil > neem seed kernel > neem cake > neem bark and neem seed coat extract. Hence, neem derivatives are biologically active, economically viable, bio-degradable botanical insecticide and suitable alternatives in place of synthetics in the bittergourd IPM schedule.

REFERENCES

1. Ahmed K S, Itino T and Ichikawa T. Effects of plant oils on oviposition preference and larval survivorship of *Callosobruchus chinensis* (Coleoptera; Bruchidae) on azuki bean. Appl. Ent. and Zool., 1999; 34(4) : 547 - 550.
2. Ahmed S. Studies on neem oil: A potential antifeedant and growth inhibitor of epilachna beetle, *Epilachna dodecastigma* (Wied.) (Coleoptera: Coccinellidae). M.S. Thesis, Dept. of Entomology, Bangladesh Agricultural University, Mymensingh., 1984; 68.
3. Almeida G D, Zanuncio J C, Senthil-Nathan S, Pratissoli D, Polanczyk R A, Azevedo D O, Serrão J E. Cytotoxicity in the midgut and fat body of *Anticarsia gemmatalis* (Lepidoptera: Geometridae) larvae exerted by neem seeds extract. ISJ, 2014; 11: 79-86, 2014.
4. Badge M A, Sarnaik D N, Bhalkare S K and Satpute U S. Influence of neem seed extract in combination with some fertilizers on *Spodoptera litura* (F.) Pestology., 1999; XXIII(9): 57 - 59.
5. Banchio E, Valladares G, Defago M, Palacios S and Carpinella C. Effects of *Melia azedarach* (Meliaceae) fruit extracts on the leafminer *Liriomiza huidobrensis* (Diptera, Agromyzidae): Assessment in laboratory and field experiments. Annals of Applied Biology., 2003; 143: 187-193.
6. Celis A, Mendoza C, Pachón M, Cardona J, Delgado W and Cuca L. 2008. Extractos vegetales utilizados como biocontroladores con énfasis en la familia Piperácea. Una Revisión. Agronomía Colombiana., 2008; 26: 97-106.
7. Chakrborti S and Chatterjee M L. Bioefficacy of neem based pesticides against safflower aphid, *Dactynotus carthami* HRL and their impact on coccinellid predators. J. Interacademicia., 1999; 3(2): 186 - 191.
8. Eriksson C, Mansson P, Sjodin K and Schlyter F. Antifeedants and feeding stimulants in bark extracts of ten woody non-host species of the pine weevil, *Hylobius abietis*. Journal of Chemical Ecology., 2008; 34: 1290-1297.

9. Gajmer T, Ram Singh and Saini R K. Effect of methanol extracts of neem and bakain seeds on the biology and food consumption – utilization indices of *Earias vittella* (Fabricius). Abstracts of conference on biopesticides : Emerging trends, 2001; February 7-9, Chandigarh, India.22.
10. Ghosh S K and Senapati S K. Biology and seasonal fluctuation of *Henosepilachna vigintioctoctopunctata* Fabr. on brinjal under terai region of West Bengal. Indian Journal of Agricultural Research, 2001; 35: 149-154.
11. Gujar G P and Mehrotra K N. Inhibition of growth and development of the tobacco caterpillar *Spodoptera litura* Fabr. Due to azadirachtin and other neem products. Ind. J. Ent., 1983; 45: 431 - 435.
12. Gupta G P, Mahapatro G K and Ajanta Chandra. Neem seed powder: Targetting the quiescent stages of *Helicoverpa armigera* Hubner. Ann. Pl. Protec. Sci., 1998; 6(2): 170 - 173.
13. Imura O and Ninomiya S. Quantitative measurement of leaf area consumption by *Epilachna vigintioctopunctata* (Fabricius) (Coleoptera: Coccinellidae) using image processing. Appllied Entomological Zoological, 1978; 33(4): 491-495.
14. Isman M B. Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. Annual Review of Entomology., 2006; 51: 45-66.
15. Isman M B. Neem and other botanical insecticides: barriers to commercialization. Phytoparasitica., 1997; 25: 339-344.
16. Isman, M. B. Neem and related natural products, In. Biopesticides use and delivery. F. R. Hall and J. J. Menn (eds.), Humana, Totowa, NJ, 1999; 139-153
17. Khan M H, Islam B N, Rahman A K M M and Rahman M L. Life table and the rate of food consumption of epilaclina beetle, *Epilachna dodecastigma* (Wied) on different host plant species in laboratory condition. Bangladesh Journal of Entomology, 2000; 10(1-2): 63-70.
18. Koul O. Biological activity of volatile D-n-Propyl Difulside from seeds of neem, *Azadirachta indica* (Meliaceae), to two species of stored grain pests, *Sitophilus oryzae* (L.) and *Tribolium oryzae* (Herbst). Journal of Economic Entomology., 2004; 97: 1142-1147.
19. Long Z, Hock S and Hung S. Screening of Chinese medicinal herbs for bioactivity against *Sitophilus zeamais* Motschulsky and *Tribolium castaneum* (Herbst). Journal of Stored Products Research., 2006; 43: 290-296.

20. Mahapatro G K and Padmaja P G. Neem - derivatives in controlling hardy stages of gram pod borer, *Helicoverpa armigera* Hubner. Pestology., 2000; XXIV(10): 40 - 42.
21. Martinez SS, van Emden HF. Sublethal concentrations of azadirachtin affect food intake, conversion efficiency and feeding behaviour of *Spodoptera littoralis* (Boisduval) (Lepidoptera: Noctuidae). B. Entomol. Res. 1999; 89: 65-71.
22. Misbah rashidi and Aftab Ahmad. The Effect of Neem (*Azadirachta indica*) leaves extract on the ecdysis and mortality of immature stages of common house mosquito *Culex pipiens fatigans*. Biologia (Pakistan), 2013; 59(2):213-219.
23. Morale R S, Sarnaik D N, Satpute U S and Sadawarte A K. Effect of plant products on growth and development of *Helicoverpa armigera* (Hubner) on cotton. Pestology. 2000; XXIV (1) : 26 - 28.
24. Mordue A J L, Nisbet A J. Azadirachtin from the neem tree *Azadiracta indica* its actions against insects. An. Soc. Entomol. Bras., 2000; 29: 616-632.
25. Nelson S J, Sundarababu P C, Rajvel D S, Sreemannarayana G and Geethanjali Y. Antifeedant and growth inhibiting effects of azadirachtin – rich neem fractions on rice white – backed plant hopper *Sogatella furcifera* Horvath, *Spodoptera litura* FB. And *Helicoverpa armigera* Hb. World Neem Conf*erence.*, 1993; 243 -252.
26. Pathak C S and Tiwari S K. Toxicological effects of neem *Azadirachta indica* A. Juss leaf powder against the ontogeny of *Corcyra cephalonica* (Staint.) (Lepidoptera: Pyralidae). Journal of Biopesticides, 2010; 3(3): 617 – 621.
27. Patnaik N C, Panda N, Bhuyan K and Mishra B K. Developmental aberrations and mortality of the mustard sawfly larvae, *Arthalia luges proxima* (Klug.) by neem oil. Neem News Letter., 1987b; 4(2): 18 - 19.
28. Patnaik N C, Panda N, Patro E R and Mishra B K . Effect of neem (*Azadirachta indica* A.Juss.) oil on mustard web – worm, *Crocidolomia binotalis* Zell. Epidoptera : Pyralidae). Neem News Letter., 1987a; 4(2): 15 - 17.
29. Prabhu S T and Singh R P. Insect growth regulatory activity of different parts of neem (*Azadirachta indica* A.Juss.) against tobacco caterpillar, *Spodoptera litura* (F.). Neem News Letter., 1993; 10: 22.
30. Prodhan S, Jotwani M G and Prakash S. Comparative toxicity of insecticides to the grub and adult of *Epilachna vigintioctopunctata* Fab. (Coleoptera: Coccinellidae). Indian Journal of Entomology, 1990; 24(4): 223.
31. Radha R. Comparative studies on the effectiveness of pesticides for aphid control in cowpea. Res. J. Agriculture and Forestry Sci., 2013; 1(6): 1-7.

32. Ramamurthy R and Venugopal M S. Effect of plant products on the incidence of *Sitotroga cerealella* under field condition. Ind. J. Ent., 1997; 59(1): 8 - 10.
33. Savitri P and Subba Rao C. Studies on the admixture of neem seed powder with paddy in the control of important storage pests of paddy. Andhra. Agric. J., 1976; 23 (3 & 4): 137 - 143.
34. Schmutterer H. The Neem Tree. Edited by VCH Verlagsgesellschaft GmbH. Weinheim, Germany., 1995; 696.
35. Schmutterer H. Properties and potential of natural pesticides from the neem tree, *Azadirachta indica.* Ann. Review Ent., 1990; 35: 271 - 297.
36. Soosaimanickam Maria Packiam, Kathirvelu Baskar, Savarimuthu Ignacimuthu. Feeding deterrent and growth inhibitory activities of ponneem, a newly developed phytopesticidal formulation against *Helicoverpa armigera* (Hubner). Asian Pac J Trop Biomed, 2014; 4 (1): 323-328.
37. Srivastava K P and Butani D. Pest management in vegetable. Research Periodical and Book Publishing House, 19981; 97-225.
38. Syeda Azra Tariq, Muhammad Farhanullah Khan and Habibullah Rana. Detrimental effects of neem seed on different life stages of red flour beetle, *Tribolium castaneum*. Journal of Basic & Applied Sciences, 2013; 9: 468-472.
39. Viglianco A I, Novo R, Cragnolini C and Nassetta M. Actividad biológica de extractos crudos de *Larrea divaricata* Cav. y *Capparis atamisquea* Kuntze sobre *Sitophilus oryzae* (L.). Agriscientia., 2006; 23: 83-89.
40. Weathersbee III and Tang Y. Effect of Neem seed extract on feeding, growth, survival and reproduction of *Diaprepes abbreviatus* (Coleoptera: Curculionidae) J. Eco. Ent., 2002; 95(4): 661-667.
41. Wheeler, D. e Isman M. Antifeedant and toxic activity of *Trichilia americana* extract against the larvae of *Spodoptera litura*. Entomologia Experimentalis et Applicata., 2001; 98: 9-16.
42. Wilps H, Nasseh O and Krall S. The effects of various neem formulations on mortality rate and morphogenetic defects upon *Schistocerca gregaria* (Forskal) larvae. World Neem Conference., 1993; 221 - 236.