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PLANT PROTECTION PRACTICES BY USING BOTANICALS FOR SUSTAINABLE AGRICULTURE

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Abstract

Botanicals are environment friendly, biodegradable, renewable and reliable economically as well. They have proven to be as eco-friendly alternative in organic farming and are rightly termed as Green Pesticides. As they are known to cause less harm to the eco system and have negligible bioaccumulation value. I planned my preliminary research findings of selected botanicals on a polyphagus pest, *Spodoptera litura,* which is known to infest almost all vegetable crops. In order to control its population explosion, the present experiments were conducted. The Crude extracts of the three plants products namely ginger, garlic and neem in different concentrations (0.25%, 0.5%, 0.75% and 1%) were studied for their repellent and antifeedant activity against the third instar larvae of *Spodoptera litura*. The extracts of garlic pods, neem leaves and ginger rhizome were used for this purpose. No-choice feeding preference assays were conducted. The maximum antifeedant activity was noted in garlic extracts while neem and ginger showed a moderate or lesser toxic effects at 1% concentration. Antifeedancy reduced the leaf intake by larvae. The garlic extract was found to be more repellent than neem and ginger extracts. Amongst, the three plant extract tested, maximum and minimum time taken for larval developmental period was recorded. Pupation delay was also found. Adult longevity was maximum which encoded from the larvae fed on ginger food extracts. The natural extracts consumption significantly reduced the larval, pupal and adult emergence but garlic extract performed better as compared to neem and the ginger extract. The treated larvae were smaller in size than its control counterpart and several deformities in head size, body length and darkened colouration on pupal case and wings were observed.

The present findings demonstrate the possible use of these natural extracts to control the polyphagus pests like *S. litura* instead of using the chemical pesticides which are highly toxic, enter into the water bodies and finally into the food chains at different tropic levels.

***Keywords*:** Biopesticides, sustainable, deformity, development period, antifeedancy.

Introduction

The present scenario of synthetic pesticides and their hazardous effect on the terrestrial and aquatic ecosystems have compelled us to harness the natural ways and processes for augmenting agricultural productivity. Biological Pesticides are known to play key roles in ensuring food security, improving human health and rehabilitating as well as and conserving the environment to safeguard the well being of biotic world with emphasis on miraculous organic farming organic seeds, prohibition or minimal use of synthetic pesticides and stop indiscriminate use of fertilizers. "Why to accept the trend of chemical pesticides in our farms, fruit orchards and fields?" is an alarming question. Is it because others are doing it and we are at the side of imitation or we don't think for some natural alternative? If the ancient scripts of Indian agricultural practices are unfolded some primitive measures of natural pesticides may come in limelight. Modern technology has left no stone unturned to reign in the pest menace. Indiscriminate use of synthetic pesticides has led to problems of bioaccumulation and biomagnifications creating a threat to our biological resources. Extensive use of nitrogenous, phosphoric and potassium rich fertilizers has badly affected the soil texture by making soil highly acidic or alkaline. The change in pH of soil creates disbalanced nutrient approach for plants, crops, vegetables and fruits. The humus layer has become devoid of organic minerals necessary for the growth and development of fragile seedlings. Further the inorganic salts present in fertilizers, synthetic pesticides and weedicides too have been the indispensible parts of soil pollution.

Increased agriculture productivity has been the need of every thriving civilization since times immemorial. Within the Indian subcontinent agriculturists have been known to use natural products as insecticides weedicides and manure. The history of Indian subcontinent farmers have been known to maintain a harmony with the mother nature. The concept of Eco-agriculture was born in this soil. The concept of compost making, vermicomposting, use of cattle dung was practiced. The different parts of Neem tree, Tulsi, Acacia, pomegranate garlic, ginger, cumin seeds, coriander etc were the integral part and parcel of Indian agriculture system. The use of traditional ways had made India golden country in term of economy and trade.

To regain the lost ecological status, it is high time to start the eco-agriculture without further delay and be concerned about the devastating effect of indiscriminate use of chemical fertilizers and pesticides since long, and earnestly feel the need for developing an alternative agricultural strategy that is sustainable, productive and environment-friendly.

Biopesticides have a range of attractive properties that make them good components of IPM. Most are selective, produce little or no toxic residue, and development costs are significantly lower than those of conventional synthetic chemical pesticides. Microbial biopesticides can reproduce on or in close vicinity to the target pest, giving an element of self-perpetuating control (Gupta, 2005).

l. Biopesticides can be applied with farmers' existing spray equipment and many are suitable for local scale production. The disadvantages of biopesticides include a slower rate of kill as compared to conventional chemical pesticides, shorter persistence in the environment and susceptibility to unfavorable environmental conditions. As most of the biopesticides are not as efficacious or as conventional as chemical pesticides, that is why they are not

suited for use as stand-alone treatments. However,by their selective attributes and safety means for use, t they can contribute meaningfully to incremental improvements in pest control. A good example is the entomopathogenic fungus *B. bassiana*, which is being used in combination with invertebrate predators against two-spotted spider mites on greenhouse crops. Spider mites are routinely managed using regular releases of predators, but there are often periods in the season when control breaks down. In the past, growers relied on conventional pesticides as a supplementary treatment but this has become ineffective because of pesticide resistance and it can have knock-on effects on other insect natural enemies. *Beauveria bassiana* is effective against spider mites. It has a short harvest interval, and is compatible with the use of predators. So it works effectively as an IPM component and is now considered as the recommended supplementary treatment for spider mite on greenhouse crops across Europe.

My intention of doing this present study is subjected to importance and relevance of Indian natural or botanical products which are easily available in our kitchen garden and have been used since ancient and medival times in Indian agricultural history (Deshpande and Ratnareddy, 1995)

References to plant protection have been found in Vedas (Rigveda c.3700 BC Atharvaveda c.2000 BC), Kautilya's Artha-sastra (c.300 BC), Buddhist literature (c.200 BC), Krishi Parashar (c.100 BC), Sangam literature of Tamils (200 BC-100 AD), Agnipuran (c.400 AD), Brhat Samhita of Varahamira (c.600 AD), Kashyapiyakrisukti (c. 800-900 AD), Surapala's Vrikshayurveda (c.1000AD, Someshwara Deva's Manasollasa (c, 1100A D), Lokopakara) by Chavundaraya (c.1108 AD), Sarangadhara's Upavanavinoda (c.1300 AD), Viswavallabh of Chakrapani Mishra (c.1577 AD), and some documents of the medieval and pre-modern period. But Surapala (c.1000 AD) has given plant protection in a very systemic manner right from seed treatment to the storage of grains. Therefore, this period may be considered as the starting point of systematic plant protection in Indian agricultural history (Chaudary and Nene, 2005).

The larval population can be controlled by the paste of jal (water) and cow dung mixed with water and also by smearing the roots with a mixture of white mustard, vaca (*Zingiber zerumbet* Rosc. Ex Smith.), kusta (*Saussurea lappa* C. B. Clarke), and ativisa (*Aconitum heterophyllum* Wall ex Royle). Likewise the insects on the leaves can be destroyed by sprinkling the powder of ashes and dust. A wound caused by insects heals if sprinkled with milk after being anointed with a mixture of vidanga, sesame, cow's urine, ghee, and mustard. Moreover, wounds of the trees are healed by the paste of bark of nyagrodha (*Ficus bengalensis* Linn.), and udumbara (*F. glomerata* Roxb.), cow dung, honey, and ghee. The oozing can be cured by the use of above paste and covering the part with the bark of dhava (*Anogeissus latifolia*), sriparnika (*Myrica esculenta* Buch-Ham.), syama (*Ichnocarpus frutescens* R. Br.), (Sadbala nalini, 1996) vetasa (*Salix capera* Linn.) and arjuna (*Terminalia arguna* (Roxb.) The mustard is having anti –insect properties due to presence of sinalbin, which has nematicidal properties due to glucosinolates and antifungal activity due to allyl isothiocyanate. Vidanga is antibacterial and insecticidal due to presence of embelin (benxaquinone) which is effective against stored grain pests. Therefore smoking of seeds with mustard and vidanga protects the seeds from various fungal diseases and pest attack and at the same time, the treatment induces disease resistance after germination of the seeds. Chakrapani Mishra (1577 AD) suggested that diseased plants found in the midst of healthy plants should be removed and burned, this again pointing towards existence of infectious entities (FAD, 2005).

However, it is unfortunate that all current textbook on plant pathology credit Tillet, who in 1755 AD dusted wheat seed with 'bunt' spores to produce the disease called wheat bunt. We know that Koch's postulates have to be followed to prove infectious nature of a disease, Here again, Indians have not been given due credit by the authors of the West. Vishavavallabha is an another treatise written by Chakrapani Mishra under the patronage of Maharana Pratap of Mewar on the science of plant life which resembles Surpala's Vrikshayurveda and deals more or less with the same subject but with some additions. For example, several new herbs have been mentioned for the control of disorders, such plant species are, ambu (*Pavonia odorata Willd.*), aragavadha (*Cassia fistula* L.), arishta (*Sapindus emarginatus* Vahl.), ingundi (*Nalanites aegyptiaca* (L.) Delile), karanja (*Pongamia pinnata* (L.) Pierre), katphala (*Myrica esculenta Buch.-Ham, ex D. Don*), katvanga (*Ailanthus excelsa Roxb.*), kuberakshi (*Caesalpinia crista L.*), nimba (*Azadirachta indica A, Juss.*) bark, rohita (*Tecomella undulate* (Smith) Seem.), shatapushppa (*Anethum sowa Kurz.*), tagara (*Valeriana jatamansi Jones)*, vasa (*Adhatoda vasica Nees*), etc. Apart from Vrikshayurveda and Vishvavallabha paramount documents concerning plant protection were Someshwara Deva's Manosollasa (1131 AD), Sarangdhara's Upvanvinoda (1300 AD), Bhavprakash-nighantu (1600AD), Tuzak-i-Jahangiri (1605 AD), Dara Shikoh's Nuskha Dar-FanniFalahat (1650 AD), Jati Jai Chand Diary (1658-1714 AD), an anonymous Rajasthani manuscript from Mewar region of Rajasthan (1877 AD) and Watt's Dictionary of Economic Products of India (1889- 1893). Jahangir, the Mughal Emperor of India (1605-1627) described in his memoir "a disorder of marigold" which could be ascribed today to species of *Alternaria*, Botrytis or Sclerotium. Similarly in Jati Jaichand diary the early blight (*Curvularia penniseti*) of pearl millet and possibly Botrytis gray mold of chickpea have been described. In a document of early 19th century from the Mewar region of Rajasthan, powdery mildew has been described infesting various plants alongwith canker or anthracnose of orange. In this document a number of plant protection practices have been given. Some interesting practices are:

1. Use of oil (probably sesame) for soil and foliar application to trees to protect from frost and termites.
2. Sprinkling of curd (9 L) with asafetida (112 g) on trees to prevent powdery mildew.
3. Use of asafetida and vidanga mixed with curd every 10 days to protect against orange canker. Use of cow dung for smearing the cutting of fig before planting is mentioned in Dara Shikoh's Nuskha Dar Fanni Falahat (1650 AD). Garlic has been mentioned specially for insect control. Control of thrips, aphids, whitefly and other pests as well virus diseases are also the part of ancient and medieval literature.

To prevent thrips and aphids cow dung ash on foliage of vegetables is used. e.g, chilli, onion, garlic, and cucurbits. In

Jodhpur district some farmers use cow urine based bio-pesticide to check whitefly, jassids and other sucking pests of chilli and cumin. In case of soil-borne diseases viz., root rot, collar rot, etc. and termites, the cakes of castor, karanj or neem are used as control measures (Isman *et al*., 1990).

Spinosad, a mixture of two macrolide compounds from *Saccharopolyspora spinosa* has a very low mammalian toxicity and its residues degrade rapidly in the field.

Abamectin is another macrocyclic lactone compound produced by *Streptomyces avermitilis* which has been found active against a range of pest species. (Cited from Wikipedia)

Materials and Methods

The experimental method was adopted to complete the study and initiate the protocol.

Step 1:

Culture of the insects: The stock culture of *S. litura* was obtained from IARI Pusa and then maintained in laboratory for one generation. The culture was maintained on Castor leaves *Ricinus communis* under controlled temperature (26.2±2°C), humidity (65±5% RH) and 14 h light: 10 h dark cycle conditions in (7.5cmdia× 25cm) glass jars. Eggs of the insect were seeded on the soft castor leaves and put in the plastic boxes (10cm dia× 12cm height), covered on top with white muslin cloth. Pupae collected from spools were sexed. Male and female pupae were placed in separate jars that were checked twice daily. In adulthood, the culture had been covered with muslin cloth and continuously supplemented with 10 % honey solution to adults as a food. The neonate larvae were reared on fresh castor leaves to maintain the test culture of *S. litura*. To get homogenous population one generation passed larvae were used for the experiment. (Panwar and Chibber, 2006) Bioassays were performed with third instars of *S. litura* using concentrations of 0.125%, 0.25% 0.5%, and 1.0%. of water soluble garlic pods, neem leaves and ginger rhizome. Sterile castor leaves were sprayed with different concentrations of extracts and air dried for 10 minutes to remove the excess moisture content. Control leaves were treated with sterile distilled water. The treated leaves were placed in the bioassay chamber (9 ×5×4cm) checked with wet cotton and tissue paper which provide humidity and water supply for the leaves. The bioassay chamber was incubated at 28 ±1˚ C with 95% humidity and 15:9 (L: D) photoperiod. A minimum of 20 larvae/concentration were used for all the treatments and these treatments were replicated five times (n¼100). The dried leaves were transferred every 24 h, and replaced with fresh untreated castor leaves. The mortality was observed from the fourth day post treatment to day 10. The percentage mortality was calculated by using the formula (1) and corrections for natural mortality when necessary were done by using Abbott's formula (1925) (Finney, 1971) to calculate the treatment concentrations for bio-logical studies.

Preparation of natural extracts:

The plant materials (garlic pods, neem leaves, and ginger rhizome) were thoroughly washed with tap water and shade dried under room temperature (27.0˚C ± 2˚C). After complete drying the plant materials were powdered using electric blender and sieved through kitchen strainer. 1000 g of plant powder was extracted with distilled water and filtered through Whatman's No. 1 filter paper. The crude extracts were collected in clean borosil vials and stored in the refrigerator at 4˚C for sub-sequent bioassay against *S. litura*.

Step 4:

Antifeedant Activity

Antifeedant activity of crude extracts was studied using leaf disc with no choice method . The stock concentration of crude extracts (5%) was prepared by dissolving in dechlorinated water. Fresh castor leaf discs of 3-cm diameter were punched using cork borer and dipped with 0.125% 0.25%, 0.5%, 0.75% and 1.0% concentrations of crude extracts, individually. Leaf discs treated water were considered as control. After air-drying, each leaf disc was placed in the petridish (1.5 cm × 9 cm) containing wet filter paper to avoid early drying of the leaf disc and a single 2 hrs pre-starved, third instar *S. litura* larvae were introduced. For each concentration five replicates were maintained. Progressive consumption of leaf area by the larva after 24 hrs feeding was recorded in control and treated discs using graph sheet method. Leaf area consumed in plant extract treatment was corrected from the control.

The percentage of antifeedant index was calculated using the formula

$$AFI = \frac{C - T}{C + T} \times 100 \qquad ...(1)$$

Where

AFI = Antifeedant Index;

C = Area protected in control leaf disc;

T = Area protected in treated leaf disc.**:**

Insecticidal Activity: Fresh castor leaves were treated with different concentrations (as mentioned in antifeedant activity) of crude extracts. Castor leaves treated with water were considered as control. In each concentration 10 pre-starved (2 hrs) *S.litura* were introduced individually and covered with muslin cloth. Five replicates were maintained for all concentrations and the number of dead larvae was recorded after 24 hrs up to pupation.

Percentage of larval mortality was calculated and corrected by Abbott's formula (1925)

$$\text{Percentage of mortality} = \frac{\text{Number of dead larvae}}{\text{Number of larvae introduced}} \times 100$$

Formula---(1)

$$\text{Corrected Mortality (\%)} = \frac{\%MT - \%MC}{100 - \%MC} \times 100 \qquad ...(2)$$

%MT = % larval mortality in treatment;

%MC = % larval mortality in control.

Results and Discussion

Botanicals have been the rich source of organic chemicals on the earth. Already 10,000 secondary plant metabolites have been chemically identified. In nature many plants have unpalatable substances like high content of phenols, alkaloids, flavanoids, terpenes, quinone, coumarin etc., which play a defensive role against particularly agriculture insect pests (Ben Jannet *et al.*, 2000).

Success rate of botanicals indeforming the larval stages depends on number of factors such as, ongoing availability of

the botanical extracts within natural resources, adequate biomass to justify deformity and disease the feasibility of extraction near the harvest site and the stability of the extract in storage after preparation (Carvalho, 1996).

Three indigenous plant parts were collected and screened for biological activity against *S. litura* (as mentioned in Materials and Methods). Among the plants screened, *Allium sativum* (garlic*)* showed promising results.

Antifeedant Activity of Crude Extracts

- Antifeedant activity of the crude extracts of cloves of *A. sativum* was studied at different concentrations. Antifeedant activity of natural extracts was assessed based on antifeedant index. Higher antifeedant index normally indicates decreased rate of feeding. The percentage of mortality increased gradually with the increased concentration of extracts from 0.125 to 1.0%. Third instar *S. litura* had the greatest mortality rate (90%), at 1.%. Mortality rates averaged 48%, 38%, 22%, for 3rd instar of *S. litura* with 1.0, 0.5, 0.25% and the control respectively when treated with Garlic extract, neem extract and ginger extract. 3rd instar mortality 1.0%, P<0.001) was significantly different from the other treatments. Third instar mortality for *S. litura* was greatest 90.40% at 1% in garlic treatment.
- The percentage of mortality increased gradually with the increased concentration of extracts from 0.125 to 1.0%. Third instar *S. litura* had the greatest mortality rate (90%), at 1.%. (Table 1, 2 & 3)
- Mortality rates averaged 48%, 38%, 22%, for 3rd instar of *S. litura* with 1.0, 0.5, 0.25% and the control respectively when treated with Garlic extract, neem extract and ginger extract. 3rd instar mortality 1.0%, P<0.001) was significantly different from the other treatments. Third instar mortality for *S. litura* was greatest 90.40% at 1% of garlic treatment (Table 4).

Table 1 : Developmental Index and Reproductive performance in Garlic treated leaves

Conc%	Larval period (days)	Pupal period (days)	Adult emergence (%)	Growth index	Development period
Control	12.8	9.4	84	2.91	28.8
0.25%	13.2	10	72	2.46	29.2
0.5%	14.4	11	62	2.03	30.4
0.75%	14.87	13	58	1.87	31
!.0%	15.21	15	41	1.31	31.12

Table 2 : Developmental Index and Reproductive performance in Neem treated leaves.

Conc%	Larval period days	Pupal period Days	Adult emergence %	Growth index	Development period
Control	12.8	9.2	82.2	2.91	28
0.25%	13.8	9.8	74	2.56	28.8
0.5%	14.6	10.1	66.2	2.21	29.9
0.75%	15.2	12.6	61	2.01	30.2
!.0%	15.5	12.8	51	1.65	30.8

Table 3 : Developmental Index and Reproductive performance in Ginger treated leaves.

Conc%	Larval period (days)	Pupal period (days)	Adult emergence (%)	Growth index	Developmental period
Control	12.8	9.2	84	2.91	28.8
0.25%	13	9.6	80	2.7	28.8
0.5%	13.6	9.9	76	2.54	29.9
0.75%	14.2	10.6	71	2.35	30.2
!.0%	14.5	11	66	2.14	30.8

Developmental time in days for *S. litura*, from 3rd instar and pupae, post treatment was also analysed. It was prolonged in case of garlic with deformities as compared to neem and ginger extract treated leaves.

Table 4 : Morphogenetic effects of natural plant extracts on the third instar larvae of *S. litura.*

Parameters	Garlic extract	Neem extract	Ginger extract	Control
No of larvae	50	50	50	50
dead larvae	24	19	11	6
Mortality (%)	48	38	22	12
Pupation (%)	52	62	78	88
No of deformed pupae	6	7	6	2
No of emerged adults (%)	40	48	66	84

Morphogenetic defects were pronounced in garlic treated leaves. Only 40% larvae could emerge in them as compared to 66% in neem treatment and 84% in ginger treatment (Table 4).

High larval mortality normally indicates potential insecticidal activity of plant extracts. In the present study irrespective of concentration and solvents used for extraction the insecticidal activity varied significantly (Anam *et al*., 2006)

Thus the natural extracts from *Allium sativum* (Garlic) showed higher insecticidal and growing inhibition activities against *S. litura*. Hence, it may be suggested that the garlic extracts can be used for controlling the insect pest, *Spodoptera litura*.

Thus the present findings focus on the vast natural products in our country and their timely use in agriculture can make our farmers sustainable in agriculture and farming. Abundant knowledge resources are present in our ancient literature which need practical approach.

Conclusion

In fact, all development efforts and activities should be within well defined ecological rules rather than within narrow economic gains. (FAD, 2001) (Mishra-2013). Sustainable agricultural systems must be ecologically sound for long-term food sufficiency, equitable in providing social justice, ecological balance and environmental friendly and ethical for our bright and prospering future (Duraippah, 1996).

Chemical fertilizers and chemical pesticides not only contaminate surface water, they also affect fish population and human health as well (Patel and Gajar, 2001). It has been now realized that the techniques adopted for commercial agriculture are unsustainable on long term basis (Gautam, 2003). Therefore, agricultural scientists are diverting their attention to the traditional or indigenous technology and exploring possibilities of using them wherever possible (Deshpande *et al*., 1990).

Our old traditional technologies were scientific and almost eco-friendly (Deshpande *et al.*, 1990) as all the plant protection practices were based on organic materials both of plant and animal origin which includes honey, ghee, milk and milk products, cow dung and urine, and extracts from number of plant species like *Brassica* ssp, *Madhuka indica, Ficus spp., Piper nigrum*, *Azadirachta indica, Vitex nigundo, Embelia ribes* etc. (Nene, 2003)

The biochemical analysis of these materials clearly indicated now that all these materials have antimicrobial activities. A recent report claimed that milk sprays induced systemically acquired resistance in chilli against leaf curl, a viral disease. Milk (10% acqueous suspension) has also been effectively used for controlling powdery mildews. Neem cake application to the field reduces population of soil-borne fungi and nematodes and also reclaims alkaline soil due to presence of calcium and magnesium. The ancient practice of spreading of neem leaves over groundnut in storage has a scientific basis. It has now proved that neem leaves inhibit the growth of *Aspergillus flavus* and thereby prevent aflatoxin production. The utility of neem tree has been recognized long back in Indian agricultural history. Every part of this tree is used for a number of purposes. Now this tree is found to be an effective air filter and protects environment. (Hasley, 1984)

Here the point of discussion is that when we have ample literature available from our medival and ancient era then why do we imitate west in their farming and agriculture practices. By the indiscriminate use of synthetic pesticides, we have threatened our biodiversity including flora, fauna and abiota. The time has come to rise united for our environment, earth and work as well as research for its protection and sustain its natural resources.

Exploration and ecofriendly research is the best way to sustain our existence on this biosphere

References

Anam, M.; Ahmed, M.; and Haque, M.A. (2006). Efficacy of neem oil on the biology and food consumption of epilaichna beetle, *Epilachna dodecastigma* (Wied.). Journal of Agriculture and Rural Development, 4: 132-136.

Abbott, W.S. (1925). A method of computing the effectiveness of an insecticide. Journal of Economic Entomology, 18: 265-266.

Ben Jannet, H.; Skhiri, H.F.; Mighri, Z.; Simmonds, M.S.J. and Blaney, W.M. (2000). Responses of *Spodoptera littoralis* larvae to Tunisian plant extracts and to neo-clerodane diterpenoids isolated from Ajuga pseudoiva leaves. Fitoterapia, 71: 105-112.

Carvalho, S.M. (1996). Effects of sublethal concentrations of azadirachtin on the development of Spodoptera littoralis. 249.

Despande, R. and Ratna Reddy (1990). “Social Dynamics and Farmers Society: A Case Study of Pani Pan dhyats, Indian Journal of Agricultural Economics 45(3): 356-61.

Duraippah, A. (1996). Poverty and Environmental Protection: A Literature Review and Analysis. CREED working paper series No. 8, International Institute for Environment and Development, London. (Retrieved through internet)

FAO (2000). Retrieved through http://www.fao.org

FAD (2001). Report form Andhra Pradesh Tribal Development Project, Asia and pacific Division/IFAD, PCR. (Retrieved through internet)

Gautam, P. (2003). Effect of plant extracts on the growth and development of *Bombyx mori* L. M.Sc. thesis, G. B. Pant University of Agriculture and Technology, Pantnagar, India.

Geetanjaly and Tiwari, R. (2013). Antifeedant and growth regulatory effects of neem leaf and Jatropha seed extracts against *Spodoptera litura* (Fab.). J. Eco-friendly Agriculture. 8: 201-203.

Gupta, M.P. (2005). Efficacy of neem in combination with cow urine against mustard aphid and its effect on coccinellid predators. Natural Product Radiance, 4: 102-106.

Bist, G.S.; Singh, Y.P and Kumar, S. (2005): http://www. ifpri. com

Haasler, C. (1984): Effects of neem seed extract on the post-embryonic development of the tobacco hornworm, *Manduca sexta*. Journal of Insect Physiology, 30: 321-330.

ICAR. (2003): Inventory of Indigenous Technological Knowledge in Agriculture: Document 2. Indian Council

of Agricultural Research, New Delhi 110012, India. 680 pp.

Isman, B.; Koul, O.; Lucyzynski, A. and Kaminski, J. (1990). Insecticidal and antifeedant bioactivities of neem oils and their relationship to Azadirachtin content. Journal of Agricultural and Food Chemistry, 38: 1407-1411.

Koul, O. and Isman, M.B. (1991). Effects of azadirachtin on the dietary utilisation and development of the variegated cut-worm *Peridroma saucia*. Journal of Insect Physiology, 37: 591-598.

Mishra, Mandavi (2013). Role of eco-friendly agricultural practices in Indian agriculture development, International Journal of Agriculture and Food Science Technology (IJAFST) I 4(2): 11-15.

Nene, Y.L. (2003). Crop disease management practices in ancient medieval and pre-modern India, Asian Agri history.

Nene, Y.L. (2005). Rice research in South Asia through ages. Asian Agri-History, 9(2):85–106.

Panwar, S.S. and Chhibber, R.C. (2006). Influence of plant extract on feeding potential of *Spilarctia obliqua*. Indian J. Applied Entomology. 20: 22-24.

Patel, M.B. and Gajjar, S.N. (2001). Bio-efficacy of various plant leaf extracts against *Spodoptera litura* (Fabricius) (Noctuidae: Lepidoptera). Indian J. Applied Entomology. 15: 32-34.

Rao, M.S. Pratibha, G. and Korwar, G.R. (1983). Effect of azadirachtin on *Achaea janata* (Linn.) and *Spodoptera litura* (Fab.) (Noctuidae Lepidoptera). J. Economic Entomology. 11: 166-169.

Sadhale, N. (1996). Surapala's Vrikshayurveda (The Science of Plant Life by Surapala). Agri-History Bulletin No. 1. Asian Agri-History Foundation, 94.

Sharma, R.K. and Bisht, R.S. (2008). Antifeedant activity of indigenous plant extracts against *Spodoptera litura* (Fabricius). J. Insect Science, 21: 56-60.

Choudhary, S.L.; Nene, Y.L. and Khandelwal, Sunil: Ancient and Medieval Plant Protection Practices, AAHF Rajasthan Chapter, 105.

Sharma, A.; Gupta, R. and Kanwar, R. (2009). Larvicidal effect of some plant extracts against *Spodoptera litura* (Fab.) and *Pieris brassicae* (Linn.) J. Entomological Research. 33: 213-218.

Singh, C.P.; Pandey, M.C.; Pant, A.K.; Lackchaura, B.D. (1995). Antifeedant properties of some indigenous plant extract against *Helicoverpa armigera*. Bioved. 6: 171-174.

Sieber, K.P. and Rembold, H. (1983). The effects of azadirachtin on the endocrine control of moulting in *Locusta migratória*. Journal of Insect Physiology, 29: 523-527.

Tanzubil, P.B. and McCaffery, A.R. (1990). Effects of azadirachtin and aqueous neem seed extracts on survival, growth and development of the African armyworm, *Spodoptera exempta*. Crop Protection, 9: 383-386.

Timmins, W.A. and Reynolds, S.E. (1992). Azadirachtin inhibits secretion of trypsin in midgut of *Manduca sexta* caterpillars: reduced growth due to impaired protein digestion. Entomologia Experimentalis et Applicata, 63: 47-54.

Van Lenteren J.C. (2000). A greenhouse without pesticides. Crop Prot. 19: 375–384.