UNIVERSITI PUTRA MALAYSIA

INSECT SPECIES COMPOSITION IN EGGPLANT CULTIVATION WITH SPECIAL EMPHASIS ON LIFE CYCLE AND MANAGEMENT OF EGGPLANT BORER, Leucinodes orbonalis Guenée

ROSTAEE ABDULBAQI

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By

ROSTAEE ABDULBAQI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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DEDICATION

After all the hard works and efforts, I would like to dedicate this study to the following:

To my lovely parents (Burhanuddin and Ashor bibi) and my beloved wife and daughter (Wajiba Qasim and Salwa Rostaee) who always kept praying for me day and night to achieve my goal. To my family members and to all my friends who supported me all these years.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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February 2021

Chairman : Associate Professor Nur Azura Adam, PhD
Faculty : Agriculture

The eggplant (*Solanum melongena* L.), is an important vegetable in Malaysia with the total cultivation area of 2407 ha and a total production of 39311 tonnes. There is a lack of information on the study of insects associated with eggplant cultivation in Malaysia. The knowledge on this subject matter is important in order to have a comprehensive knowledge on the insect pests and beneficial insects in the eggplant cultivation. Special emphasis is given to the eggplant shoot and fruit borer (*Leucinodes orbonalis* Guenée) as it is the major pest that causes serious damage to the fruits that will cause economic loss. The best combination of control methods to control *L. orbonalis* is also highly needed. Therefore, this study was conducted i) to investigate the insect species composition associated with eggplant; ii) to determine the life cycle and morphological description of *L. orbonalis;* and iii) to determine the best combination of control methods for *L. orbonalis*. Four types of Insects sampling were conducted in the organic experimental farm namely visual observation, sweep netting, pitfall trap dan yellow sticky trap. For life cycle study, *L. orbonalis* was cultured in insect laboratory. All stages of life cycle were studied. The experiment on the control methods of eggplant borer comprised of six treatments and laid out in a randomized complete block design (RCBD) with three replications. The effects of six treatments on infestation rate of *L. orbonalis* were studied. A total of 15786 specimens comprised of 136 morphospecies belong to 72 families under 11 orders were recorded. Out of total, 71 morphospecies were pests that belong to three groups of feeding habit namely sap-feeder, leaf-feeder and fruit borer. There were 65 morphospecies composed of four functional groups *viz* predators, parasitoids, pollinators and omnivores. The abundance of insects among the orders were significantly different ($F = 91.42$, d.f = 10, 154; $P < 0.05$). Hemiptera was recorded to be the most abundant order (309.29 ± 40.87). Sap-feeders was significantly ($p<0.05$) most abundant group (307.81 ± 40.92) compared to the others. Life cycle study of *L. orbonalis* showed that the

incubation period was 5.5 ± 0.09 days, larval period was 12.06 ± 0.19 days undergoing five larval instars and pupal stage took 10.36 ± 0.10 days. The mean longevity of adult female was 5.40 ± 0.15 days whereas adult male was 4.45 ± 0.11 days. The life cycle of female and male moth was 33.32 ± 0.53 days and 32.37 ± 0.49 days, respectively. On average, each female produced 174 ± 22.01 eggs with the sex ratio female to male was 2:1. The result showed that a combination of chemical and mechanical controls (chlorantraniliprole 8.77% W/W + thiamethoxam 17.54% W/W + yellow sticky trap + hand picking) was the most effective as the lowest shoot infestation (0.53 ± 0.13%) and maximum healthy fruit (25.42 ± 0.89 t ha^{-1}) was recorded. Result of this research may be helpful to plan an effective pest management strategy.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

KOMPOSISI SPESIES SERANGGA PADA TANAMAN TERUNG DENGAN PENEKANAN TERHADAP KITARAN HIDUP DAN PENGURUSAN PENGOREK TERUNG, *Leucinodes orbonalis* Guenée

Oleh

ROSTAEE ABDULBAQI

Februari 2021

Pengerusi : Profesor Madya Nur Azura Adam, PhD
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Terung (*Solanum melongena* L.) adalah sayuran yang penting di Malaysa dengan jumlah penanaman seluas 2407 ha dengan pengeluaran sejumlah 39311 tan. Maklumat berkenaan kajian komposisi serangga berasosiasi dengan tanaman terung di Malaysia amat terhad. Pengetahuan ini sangat penting bertujuan untuk mengetahui secara komprehensif akan serangga perosak dan serangga berguna bagi tanaman terung. Penekanan khusus adalah kepada pengorek buah dan pucuk (*Leucinodes orbonalis* Guenée) yang menyebabkan kerosakan serius kepada buah terung seterusnya mengakibatkan kerugian ekonomi. Kajian kaedah kombinasi kawalan terbaik bagi *L. orbonalis* juga sangat penting. Oleh itu, kajian ini dijalankan untuk i) menentukan komposisi serangga yang berasosiasi dengn tanaman terung; ii) menentukan kitar hidup dan pengcaman morfologi L. *orbonalis*; dan iii) menentukan kombinasi terbaik kaedah kawalan *L. orbonalis*. Empat kaedah persampelan serangga telah dijalankan di ladang eksperimen iaitu pemerhatian visual, kaedah sapuan, perangkap lubang dan perangkap lekat kuning. Untuk kajian kitaran hidup, *L. orbonalis* telah dikultur di makmal serangga. Semua tempoh dan jangkamasa peringkat hidupnya telah dikaji. Eskperimen kaedah kawalan pengorek terung terdiri daripada enam perlakuan disusun dalam reka bentuk blok lengkap secara rawak (RCBD) dengan tiga replikasi. Kesan enam perlakuan tersebut ke atas kadar serangan *L. orbonalis* dikaji. Sebanyak 15786 spesimen yang terdiri daripada 136 morfospesis tergolong dalam 72 famili di bawah 11 order direkodkan. Daripada jumlah keseluruhan, 71 morfospesis adalah perosak yang tergolong dalam tiga kumpulan tabiat makan iaitu penghisap cecair sap, pemakan daun dan pengorek buah. Terdapat 65 morfospesis yang terdiri daripada empat kumpulan fungsian iaitu pemangsa, parasitoid, pendebunga dan omnivor. Kelimpahan antara order adalah berbeza secara signifikan ($F = 91.42$; $df. = 10,154$; $P < 0,05$). Hemiptera dengan nilai min 309.29 ± 40.87 individu adalah order paling tinggi kelimpahannya. Kelimpahan penghisap cecair

sap adalah paling tinggi secara signifikan ($p<0.05$) berbanding kumpulan lain. Kitaran hidup *L. orbonalis* menunjukkan bahawa tempoh inkubasi adalah 5.5 ± 0.09 hari, tempoh larva adalah 12.06 ± 0.19 hari dengan menjalani lima instar larva dan peringkat pupa mengambil masa 10.36 ± 0.10 hari. Purata tempoh hayat betina dewasa adalah 5.40 ± 0.15 hari sementara jantan dewasa adalah 4.45 ± 0.11 hari. Jangka hayat rama-rama betina dan jantan masing-masing adalah 33.32 ± 0.53 hari dan 32.37 ± 0.49 hari. Secara purata, setiap betina menghasilkan 174 ± 22.01 telur dengan nisbah jantina betina kepada jantan ialah 2:1. Kombinasi kawalan kimia dan mekanikal (chlorantraniliprole 8.77% W/W + thiamethoxam 17.54% W/W + perangkap melekit kuning + kutipan dengan tangan) adalah paling berkesan oleh kerana serangan pucuk terendah (0.53 ± 0.13%) direkodkan dan tanaman terung mencatatkan buah sihat yang maksimum (25.42 ± 0.89 t ha^{-1}). Hasil kajian berguna untuk memastikan strategi pengurusan perosak yang terbaik dapat laksanakan.

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Finally, I would like to thank Allah for giving me the strength and guidance to complete my study on time.

This thesis was submitted to the Senate of the Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science .The members of the Supervisory Committee were as follows:

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Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) were adhered to.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
AVRDC	Asian Vegetable Research and Development Center
EFSB	Eggplant Fruit and Shoot Borer
CABI	Center for Agriculture and Bioscience International
cm	Centimeter
CRD	Completely Randomized Design
DAS	Day After Spray
DAT	Day After Transplanting
df	Degree of Freedom
DOA	Department of Agriculture
FAO	Food and Agriculture Organization of the United Nations
g	Gram
L.	Linnaeus
L	Liter
LSD	Least significant Difference
IPM	Integrated Pest Management
m	Meter
mm	Millimeter
K	Potassium
N	Nitrogen
P	Phosphorous
RCBD	Randomized Complete Block Design
SAS	Statistical Analyses System
SE	Standard Error

CHAPTER 1

INTRODUCTION

1.1 Cultivation Status

Eggplant, (*Solanum melongena* L., Solanaceae), or popularly known as brinjal, aubergine or garden egg is native to India (Kumar et al., 2018). It is an essential non-tuberous plant that is broadly cultivated in different parts of the world, particularly Asia, Africa, Central America, Mediterranean area, and South of the United States (Sihachakr et al., 1993; Collonnier et al., 2001). According to the Food and Agriculture Organization of the United Nations (FAO), global cultivation of eggplant was approximately 1,858,253 ha in 2017 with a total production of 52,309,119 tonnes (FAO, 2017). Compared to other countries, the eggplant production area is substantially less in Malaysia. Based on information released by the Department of Agriculture (DoA), the total cultivation area in Malaysia was 2407 ha with a total production of 39311 tonnes (DoA, 2018).

The crop produces the fruit of different sizes, shapes, and colours (Niño-Medina et al., 2017). It may be cooked, stir-fried, eaten fresh or stiffed in curries. It is an important vegetable known for possessing phytochemical composition that is acknowledged as a nutraceutical (Scalzo et al., 2016). Besides revenue, eggplant is an essential source of nutrition. Its fresh weight is composed of moisture 92.7%, fiber1.3%, fat 0.3%, protein 1.4%, minerals 0.3%, carbohydrates 4% and vitamins A and C (Khan, 1979).

1.2 Problem Statement

Insect pests are the major constraints of vegetable production. During growth, several species of insect pests, such as armyworms, caterpillars, beetles, aphids, whiteflies, mites and thrips, cause severe damage to various vegetable crops (Sani et al., 2020). According to Nayar et al. (1995), 53 species of insect pests recorded in eggplant crop. Another study found that 20 species of pests belonging to six orders and 17 families that are known to damage eggplant (Latif et al., 2009).

Traditionally, In eggplant agroecosystem 27 species of insects were recorded, of which 19 species were pests and eight species were predators and pollinators (Hussain et al., 2019). Nonetheless the most common and major insect pest of eggplant are eggplant shoot and fruit borer (*Leucinodes orbonalis* Guenée), leafhopper (Amrasca biguttula biguttula), white fly (Bemisia tabaci), as well as Epilachna beetle (Epilachna sp.) and aphid (Ahis gossypii) as reported by Bhadauria et al. (1999) and Latif et al. (2009).

As stated, several insect pests infest eggplant, in particular which the eggplant shoot and fruit borer *Leucinodes orbonalis* Guenée (Crambidae: Lepidoptera) is an important pest due to damage cause to eggplant in South and Southeast Asia. This pest can be found throughout the tropics in Asia and Africa (Srinivasan, 2008). It is an internal shoot and fruit borer that infests the young shoots and fruits, causing serious damage. It was stated that the *L. orbonalis* (on shoot) were more prevalent throughout vegetative stage of crop. According to Murgesan et al. (2009) the borer infestation was 78.66% on top shoots in vegetative stage and then shifted to and flowers and fruits with infestation reaching 66.66% in fruiting phase (Yadav et al. 2015). The percent of fruit infestation caused by the pest reached up to 90% (Rahman, 1997; Hegde et al., 2018). This pest caused a yield reduction as much as 70% (Islam and Karim, 1991; Dhandapani et al., 2003).

The life cycle of *L. orbonalis* has been widely investigated by researchers and the findings were highly varied. For instance, in India Rohokale et al. (2018) reported that *L. orbonalis* completes its life cycle in 25.65 days. Meanwhile, studies by Onekutu et al. (2013), Yadav et al. (2015), Laichattiwar et al. (2017), and Singla et al. (2018) found that *L. orbonalis* completes its lifecycle within 28.17, 29.23, 27.43, and 36.72 days respectively. Studies also showed that the larvae underwent five instars stages (Bindu et al., 2013) while some studies (FAO, 2003; Prabhat and Johnsen, 2000) reported that larvae underwent six larval instars stages. Considering the above different findings in the life cycle, the present investigation attempted to determine the complete life cycle and to describe the morphology of *L. orbonalis* on eggplant in laboratory conditions.

Several control measures for *L. orbonalis* including physical and mechanical barriers, chemical and botanical controls were evaluated along with helpful facts and figures with reference to earlier works in this field. The use of Chlorantraniliprole, neem oil and sticky traps are considered as important components of Integrated pest management (IPM) for the control of *L. orbonalis* (Sen et al., 2017; Kushwaha and Painkra, 2016; Rohokale et al., 2018).

1.3 Justification

Eggplant is an important vegetable planted in Malaysia and is severely damaged by insect pests. However, there is a significant lack of research on the prevalence of insects, lifecycle, and control methods of *L. orbonalis* in Malaysia. Therefore, it is expected that this research will find the overall insects associated with eggplant, the lifecycle study of *L. orbonalais* and its management through several control methods.

1.4 Objectives

The main objectives of this study are:

1. To investigate the insect species composition associated with eggplant
2. To determine the life cycle and morphological description of *L. orbonalis*
3. To determine the best combination of control methods for *L. orbonalis*

REFERENCES

Alam, A.Z. and D.L. Sana. 1964. Biology of *Leucinodes orbonalis* Guenee in East Pakistan. In*: Review of Research, Division of Entomology*, 1947–64. Dhaka: Agriculture Information Service, Department of Agriculture.

Alam, S. N., Hossain, M. I., Rouf, F. M. A., Jhala, R. C., Patel, M. G., Rath, L. K., . and Talekar, N. S. (2006). Implementation and promotion of an IPM strategy for control of eggplant fruit and shoot borer in South Asia (Vol. 36). AVRDC.

Alam, S. N., Rashid, M. A., Rouf, F. M. A., Jhala, R. C., Patel, J. R., Satpathy, S., ... and Talekar, N. S. (2003). Development of an integrated pest management strategy for eggplant fruit and shoot borer in South Asia. Retrived from: AVRDC-World Vegetable Center.

Ali, M. I. (1994). Circumstantial evidence supports insect resistance in Bangladesh. *Resistant Pest Management*, 6(1), 5-12.

Ambhure, K., Dubey, V., and Rana, D. (2016). Biology of Brinjal Shoot and Fruit Borer (*Leucinodes orbonalis* Guenee). *Advances in Life Sciences*. 5. 11153-11156.

Amin, M. R., Miah, M. S., Rahman, H., Nancy, N. P., & Bhuiyan, M. K. A. (2018). Functional and group abundance of insects on eggplant. *Bangladesh Journal of Agricultural Research*, *43*(4), 647-653.

Amin, R., Ali, M. R., Akter, T., and Yesmin, M. (2014). Evaluation of some botanical and chemical insecticides for eco-friendly management of brinjal shoot and fruit borer (*Leucinodes orbonalis*). *International journal of sustainable agriculture technology*, 10(11), 15-21.

Anbalagan, V., Paulraj, M. G., and Ignacimuthu, S. (2015). Diversity and abundance of Hymenoptera families in vegetable crops in north-eastern District of Tamil Nadu, India. *International Journal of Fauna and Biological Studies*, 2(3), 100-104.

Ansari, A. M., and Singh, Y. V. (2014). Molecular diversity of brinjal (Solanum melongena L. and S. aethiopicum L.) genotypes revealed by SSR markers. *Electronic Journal of Plant Breeding*, 5(4), 722-728.

Aravinda, M. (2015). *Evaluation of sex pheromone and sticky colour traps for monitoring of shoot and fruit borer (Leucinodes orbonalis Gueene.) in brinjal,* PhD Thesis, University of Agricultural Sciences Dharwad.

Asian Vegetable Research and Development Center, (1994). Eggplant entomology. Control of eggplant fruit and shoot borer. *Progress Report,* Shanhua, Taiwan. 88 p. (AVRDC).

Balvanera, P., Quijas, S., Martı´n-Lo´pez, B., Barrios, E., Dee, L., Isbell, F., ... de Groot, R. (2016). The links between biodiversity and ecosystem services. In: M. Potschin, R. Haines-Young, R. Fish, and R. K. Turner (Eds.). *Routledge handbook of ecosystem services*. London, England: Routledge Taylor and Francis Group.

Baral, K., Roy, B. C., Rahim, K. M. B., Chatterjee, H., Mondal, P., Mondal, D., ... and Talekar, N. S. (2006). *Socio Economic Parameters of Pesticide Use and Assessment of Impact of an IPM Strategy for the Control of Eggplant Fruit and Shoot Borer in West Bengasl, India.* Retrived from: AVRDC.

Bashir, M. A., Alvi, A. M., and Naz, H. (2014). Effectiveness of sticky traps in monitoring insects. *Journal of Environmental and Agricultural Sciences*, 1(5*)*, 1-2.

Bassi, A., Alber, R., Wiles, J. A., Rison, J. L., Frost, N. M., Marmor, F. W., and Marcon, P. C. (2007). Chlorantraniliprole: a novel anthranilic diamide insecticide. *In Proceedings of XVI International Plant Protection Congress,*1, 52-59.

Bhadauria, N. K. S., Bhadauria, N. S., and Jakhmola, S. S. (1999). Insect pest complex of brinjal Solanum melongena Linn. in north-west Madhya Pradesh. *Advances in Plant Sciences*, 12(2), 607-608.

Bin Hussain, Y., and Annamalai, S. (2003). Managing alien invasive species in Malaysia. *Conservation Biology*, 17(1), 24-30.

Bindu, S. P., Pramanik, A., and Padhi, G. K. (2013). Studies on biology and physical measurements of shoot and fruit borer (*Leucinodes orbonalis* Guenee) of brinjal in west bengal, India. *GJBAHS*, 4(1), 215-219.

Borkakati, R. N., Venkatesh, M. R., and Saikia, D. K. (2019). Insect pests of Brinjal and their natural enemies. *Journal of Entomology and Zoology Studies*, 7(1), 932-937.

Borneo, P. (2014). Pesticides: a double-edged sword. Retrived from: https://www.theborneopost.com/2014/03/16/pesticides-a-double-edged-sword/ on 18 Dec 2019.

Bragard, C., Dehnen-Schmutz, K., Di Serio, F., Gonthier, P., Jacques, M. A., Miret, J. A. J., ... and MacLeod, A. (2019). Pest categorisation of Spodoptera litura. *European Food Safety Authority Journal*, 17(7), 57-65.

CABI (2007) Crop protection compendium. CAB International (Available at: http://www. cabicompendium.org/cpc Retrieved on March 15, 2012).

Capps, H. W. (1948). Status of the pyraustid moths of the genus Leucinodes in the New World, with descriptions of new genera and species. *Proceedings of the United States National Museum*.

Cardinale, B. J., Duffy, J. E., Gonzalez, A., Hooper, D. U., Perrings, C., Venail, P., ... and Srivastava, D. S. and Naeem, S. (2012). Biodiversity loss and its impact on humanity. *Nature*, 486(7401), 59-67.

Chang, B. H., Chang, A. H., Lanjar, A. G., Bukero, A., Nizamani, I. A., Rajput, A., ... and Zhang, Z. (2019). Insect Biodiversity in Brinjal Agro-Ecosystem. *Pakistan Journal of Scientific and Industrial Research Series B: Biological Sciences*, 62(3), 199-205.

Cheng L. 1976. Marine insects. Amsterdam: North Holland Publishers

Choudhury, M. A. R., M. M. Rahman, M. Z. Alam, M. M., Hossain, and Q. A. Khaliq and M. S. Hossain. (2016). Relative abundance of different insect pests and their natural enemies in brinjal ecosystem Relative abundance of different insect pest and their natural enemies in brinjal ecosystem. Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural. *Bangladesh Journal of e Entomology*, *26*(1), 59–70.

Collonnier, C., Fock, I., Kashyap, V., Rotino, G. L., Daunay, M. C., Lian, Y., ... and Sihachakr, D. (2001). Applications of biotechnology in eggplant. *Plant Cell, Tissue and Organ Culture*, 65(2), 91-107.

Colwell, R. K., and Coddington, J. A. (1994). Estimating terrestrial biodiversity through extrapolation. *Philosophical Transactions of the Royal Society B*. 345, 101–118.

Cordova, D., Benner, E. A., Sacher, M. D., Rauh, J. J., Sopa, J. S., Lahm, G. P., ... and Rhoades, D. F. (2006). Anthranilic diamides: a new class of insecticides with a novel mode of action, ryanodine receptor activation. *Pesticide Biochemistry and Physiology*, 84(3), 196-214.

Dahatonde, J. A., Pandya, H. V, Raut, S. B., and Patel, S. D. (2014). Seasonal abundance of jassid and whitefly on brinjal (Solanum melongena L .) in relation to major abiotic factors. *International Journal of Plant Prtotection*, 7(1), 257–259.

Danks, H. V. (2007). The elements of seasonal adaptations in insects. *The Canadian Entomologist*, 139(1), 1-44.

Dhandapani, N., Shelkar, U. R. and Murugan, M. (2003). Bio-intensive pest management in major vegetable crops: An Indian perspective. *Journal of Food, Agriculture and Environment*, 1(2), 330-339.

Djiéto-Lordon, C., Aléné, D.C. (2006). Inventaire diagnostique des insectes de quelques cultures dans les exploitations maraîchères périurbaines dans la région de Yaoundé – Cameroun. In «Pôle de compétence en Partenariat (PCP) Grand Sud Cameroun. Actes atelier de présentation des résultats de recherche participative». IRAD/IRAD. Yaoundé, Cameroun pp. 7-17.

DOA. (2018). Vegetables and Cash Crops Statistic: Department of Agriculture, Peninsular Malaysia. Malaysia. Available online: http://www.doa.gov.my/index/resources/aktiviti_sumber/sumber_awam/maklumat_pertanian/perangkaan_tanaman/perangkaan_sayur_tnmn_ladang_2018.pdf

Douglas, W. A. (1939). Studies of rice stinkbug populations with special reference to local migration. *Journal of Economic Entomology*, 32(2), 300-303.

Du, D., Liu, P. J., Shi, Z. P., Ren, G. B., Qi, M. H., Li, Z., and Xu, X. Y. (2018). Three solid forms of chlorantraniliprole: Structure, characterization, and phase transformation. *Journal of Molecular Structure*, 1171, 323-332.

Duca, A. A., Arida, G. S., Punzal, B. S., and Rajatte, E. G. (2004). Management of eggplant fruit and shoot borer, *Leucinodes orbonalis* (guinee): evaluation of farmers' indigenous practices. *Philippine Entomologist (Philippines)*, 18 (2), 172-173.

Dutta, P., Singha, A. K., Das, P., and Kalita, S. (2011). Management of brinjal fruit and shoot borer, *Leucinodes orbanalis* Guenee in agro-ecological condition of West Tripura. *Scholarly journal of Agricultural Science*, 1(2), 16-19.

El-Shafie. (2001). *The use of neem products for sustainable management of homopterous key pests on potato and eggplant in the Sudan*. PhD. Thesis, Institute of Phytopathology and Applied Zoology Experimental station Justus Liebig University of Giessen, Germany.

Esker, P. D., Obrycki, J., and Nutter Jr, F. W. (2004). Trap height and orientation of yellow sticky traps affect capture of Chaetocnema pulicaria (Coleoptera: Chrysomelidae). *Journal of Economic Entomology*, 97(1), 145-149.

Esperk, T., Tammaru, T., and Nylin, S. (2007). Intraspecific variability in number of larval instars in insects. *Journal of Economic Entomology*, 100(3), 627-645.

Food and Agriculture Organization of the United Nations. (2003). Inter-country programme for integrated pest management in vegetables in South and Southeast Asia, pp177. Bangkok, Thailand.

Food and Agriculture Organization of the United Nations. (2017). FAOSTAT. Retrieved on January 15, 2018 from: http://www. fao. org/faostat/en/# data. QC

Free, J. B. (1993). *Insect pollination of crops* (No. Ed. 2). Academic press.

Gaikwad, B. P., Darekar, K. S., and Chavan, U. D. (1991). Varietal reaction of eggplant against jassid. *Journal of Maharashtra Agricultural Universities*, 16(3), 354-356.

Gautam, M., Kafle, S., Regmi, B., Thapa, G., and Paudel, S. (2019). Management of Brinjal Fruit and Shoot Borer (*Leucinodes orbonalis* Guenee) in Nepal. *Acta Scientific Agriculture,* 3(9), 188-195.

Gemmill-Herren, B., and Ochieng, A. O. (2008). Role of native bees and natural habitats in eggplant (Solanum melongena) pollination in Kenya. *Agriculture, Ecosystems and Environment*, 127(1-2), 31-36.

Georghiou G.P. (1980) Insecticide resistance and prospects for its Management. In: Gunther F.A., Gunther J.D. (eds) Residue Reviews. Residue Reviews, vol 76. Springer, New York, NY. https://doi.org/10.1007/978-1-4612-6107-0_6

Getanjaly, V. L. R., Sharma, P., and Kushwaha, R. (2015). Beneficial insects and their value to agriculture. *Research Journal of Agriculture and Forestry Sciences*, 12(3), 60-75.

Ghafoor, M. S. M. (2011). Determination of Larval Instars of Black Cutworm Agrotis ipsilon (Hufnagel) (Lepidoptera, Noctuidae). *Jordan Journal of Biological Sciences*, 147(621), 1-4.

Goulet, H., and Huber, J. T. (1993). Hymenoptera of the world: an identification guide to families.

Grzywacz, D., Rossbach, A., Rauf, A., Russell, D. A., Srinivasan, R., & Shelton, A. M. (2010). Current control methods for diamondback moth and other brassica insect pests and the prospects for improved management with lepidopteran-resistant Bt vegetable brassicas in Asia and Africa. *Crop protection*, *29*(1), 68-79.

Hamid, M.N., Noor, M. R. and Piang, L. 2002. Nonpesticide Methods for controlling diseases and insect. In Ooi, P.A.C. (ed.). *APO Seminar on Nonpesticide Methods for Controlling Diseases and Insect Pests*, pp. 100–111. Japan: Asian Productivity Organization, Tokyo.

Harish, D. K., Agasimani, A. D., Imamsaheb, S. J., and Patil, S. S. (2011). Growth and yield parameters in brinjal as influenced by organic nutrient management and plant protection conditions. *Research journal of agriculture sciences*, 2(2), 221-225.

Harper, J. L., and Hawksworth, D. L. (1994). Biodiversity: *measurement and estimation Preface*. London, UK.

Harrison, P. A., Berry, P. M., Simpson, G., Haslett, J. R., Blicharska, M., Bucur, M., ... and Turkelboom, F. (2014). Linkages between biodiversity attributes and ecosystem services: a systematic review. *Ecosystem Services*. 9, 191–203. doi:10.1016/j.ecoser.2014.05.006.

Hegde, D. R., Nelson, S. J., Natarajan, N., Kumar, S. M., and Arumugam, T. (2018). A Study on growth and development of brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guenee) on different Artificial Diets. *Journal of Entomology and Zoology Studies*, 6(1), 555–559.

Hellpap, C., Dreyer, M., Ermel, K., and Kleeberg, H. (1995). Neem Products for Pest Management, Practical Results of Neem Application against Arthropod Pests, and Probability of Development of Resistance: Section 4.1. *The Neem Tree: Azadirachta indica A. Juss. and Other Meliaceous Plants*, 367-384.

Hölldobler, B., and Wilson, E. O. (1990). *The ants*. Harvard University Press.

Hossain S, Nazim N, Uddin D and Halim M A 2012. Status of ANSOFT Activities in Bangladesh. ANSLFT AFACI PANASIAN Project, Olericulture Devision Horticlusre Research neneter ,BARI ,Gzipur, 1701, 1701.pp:3-6

Islam, M. N., and Karim, M. A. (1991). Integrated management of shoot and fruit borer, *Leucinodes orbonalis* Guen. (Lepidoptera: Pyralidae) at Joydebpur. *Annal Research Report 1993*, 94, 44-46.

Isman, M. B. (2008). Botanical insecticides: for richer, for poorer. *Pest Management Science: formerly Pesticide Science*, 64(1), 8-11.

Jamian, S., Ismail, S.I., Hata, E.M., Saad, N., Sani, I. (2019). Case Study: First Report of Thrips Infestation and Gray Mold Disease on Hydroponically Grown Lettuce in Perak Malaysia. *In Proceedings of the ISSAAS international congress* 2019.; Selengor, p. 99.

Jamian, S., Norhisham, A., Ghazali, A., Zakaria, A., and Azhar, B. (2017). Impacts of 2 species of predatory Reduviidae on bagworms in oil palm plantations. *Insect science*, 24(2), 285-294.

Javed, H., Mukhtar, T., and Javed, K. (2017). Management of eggplant shoot and fruit borer (*Leucinodes orbonalis* Guenee) by integrating different non- chemical approaches. *Pakistan Journal of Agricultural Sciences*, 54(1), 65-70.

Jayaraj, J., and Manisegaran, S. (2010). Management of fruit and shoot borer in brinjal. The Hindu Science and Technology *Agriculture College and Research Institute. Madurai*.

Johnson, N. F., and CA, T. (2005). Borror and DeLong's Introduction to the Study of Insects: Thompson Brooks. *Cole Belmont, CA*.

Kar, A. C., and Khan, M. A. (1995). Homestead bio-intensive gardening and agroforestry. *A technical reference manual. LIFT Project, CARE Bangladesh*.

Kataria, H. R., and Gisi, U. (1990). Interactions of fungicide-herbicide combinations against plant pathogens and weeds. *Crop Protection*, *9*(6), 403-409.

Khan, R. (1979). *Solanum melongena and its ancestral forms. In: Hawkes JC, Lester JGand Skelding AD (eds) The biology and taxonomy of the Solanaceae*, Linean Soc., Academic Press, London

Khorsheduzzaman, A. K. M., Ibrahim Ali, M., Mannan, M. A., Ahmad, A., and Karim, M. A. (1998). Component technologies of IPM package for brinjal shoot and fruit borer for Bangladesh: A Review. *Bangladesh Journal of Agricultural Research*, 23(4), 593-606.

Krishnamoorthy, A. (2012). Exploitation of egg parasitoids for control of potential pests in vegetable ecosystems in India. *Comunicata Scientiae*, 3(1), 1-15.

Kumar, L. R., Ghante, V. N., Chowdary, L. R., and Benki, A. M. (2011). Biology of brinjal shoot and fruit borer (*Leucinodes orbonalis* Guen.) in Raichur district of Karnataka. *International Journal of Plant Protection*, *4*(2), 298-300.

Kumar, S. D., Masarrat, H., and Muntaha, Q. (2012). Comparative potential of different botanicals and synthetic insecticides and their economics against *Leucinodes orbonalis* in eggplant. *Journal of Plant Protection Research*, 52(1), 35-39.

Kumar, S., Sachan, S. K., Kumar, V., and Gautam, M. P. (2019). Abundance of insect pests associated with brinjal (Solanum melongena L.) crop. *Journal of Entomology and Zoology Studies*, 7(3), 1014-1017.

Kumar, S., Singh, S. K., and Malik, Y. P. (2018). Evaluation of several insecticides, against brinjal fruit and shoot borer, *Leucinodes orbonalis* Guen. on brinjal at Kanpur agro climatic region. *Journal of Entomology and Zoology Studies*, 6(6), 336-339.

Kushwaha, T. K., and Painkra, G. P. (2016). Efficacy of certain insecticides against shoot and fruit borer (*Leucinodes orbonalis* gune.) On kharif season Brinjal (Solanum melongena L.) under field condition. *International Journal of Agricultural Science and Research*, 6(2), 383-388.

Laichattiwar, M. A., Meena, R. S., and Raghuraman, M. (2017). Biology and morphometry of shoot and fruit borer, *Leucinodes orbonalis* (Guenee) on Brinjal, Solanum melongena (Mill.). *Journal of Experimental Zoology,* 20(2), 1189-1192.

Lal, O. P. (1975). A compendium of insect pest of vegetables in India. *Bulletin of Entomology*, 16, 31-56.

Landis, J. N. (2002). *Fruit crop ecology and management*. Michigan State University Extension.

Lara, D. P., Oliveira, L. A., Azevedo, I. F., Xavier, M. F., Silveira, F. A., Carneiro, M. A. A., and Fernandes, G. W. (2008). Relationships between host plant architecture and gall abundance and survival. *Revista Brasileira de Entomologia*, 52(1), 78-81.

Larson, D. P. (1996). *Evaluation of sweep sampling as a method for determining grasshopper community composition on rangeland*, PhD Thesis, Montana State University-Bozeman, College of Agriculture.

Latif, M. A., Rahman, M. M., Islam, M. R., and Nuruddin, M. M. (2009). Survey of arthropod biodiversity in the brinjal field. *Journal of Entomology*, 6(1), 28-34.

LeBaron, H. M. 1986. Tactics for prevention and management. In Pesticide resistance. Strategies and tactics for management, pp. 313-326. National Academies Press, Washington, DC.

Liu, J.K. (1999). *Advance hydrobiolo*gy. Beijing, China: China Science Press.

Lucier, G. and Jerardo, A. 2006. *The vegetables and melons outlook*. Electronic Outlook Report from the Economic Research Ser- vice (USDA VGS-318). Reterived from: http://www.ers.usda.gov/publications/ vgs/2006/12dec/vgs318.pdf. on 22 DEC 2019.

Mace, G. M., Norris, K., and Fitter, A. H. (2012). Biodiversity and ecosystem services: a multilayered relationship. *Trends in ecology and evolution*, 27(1), 19-26.

Mainali, B. P., and Lim, U. T. (2010). Circular yellow sticky trap with black background enhances attraction of Frankliniella occidentalis (Pergande) (Thysanoptera: Thripidae). *Applied Entomology and Zoology*, 45(1), 207-213.

Mainali, R. P. (2014). Biology and management of eggplant fruit and shoot borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae). *International Journal of Applied Sciences and Biotechnology*, 2(1), 18-28.

Mainali, R. P., Peneru, R. B., Pokhrel, P., and Giri, Y. P. (2015). Field bio-efficacy of newer insecticides against eggplant fruit and shoot borer, *Leucinodes orbonalis* Guenee. *International Journal of Applied Sciences and Biotechnology*, *3*(4), 727-730.

Mandal, S. K., Randhir, K., Sudhir, D., and Vinod, K. (2009). Field evaluation of integrated pest management modules for the brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee. *Pest Management and Economic Zoology*, 17(2), 121-125.

Manibala, J., and Praveena, A. (2017). A comparative study on the effect of pheromone baited traps and Acalypha indica extract on *Leucinodes orbonalis*. *International Journal of Bioinformatics and Biological Science*, 5(2), 127-134.

Mannan, M. A., Islam, K. S., Jahan, M., and Tarannum, N. (2015). Some biological parameters of brinjal shoot and fruit borer, *Leucinodes orbonalis* guenee (lepidoptera: pyralidae) on potato in laboratory condition. *Bangladesh Journal of Agricultural Research*, 40(3), 381-390.

Mavroeidi, V. I., and Shaw, M. W. (2006). Effects of fungicide dose and mixtures on selection for triazole resistance in Mycosphaerella graminicola under field conditions. *Plant Pathology*, 55(6), 715-725.

Mavi, H. S., & Tupper, G. J. (2004). *Agrometeorology: principles and applications of climate studies in agriculture*. CRC Press.

Maz, M. N., Nur Azura, A., & Muhamad, R. (2014). Determination of larval instar of Bactrocera papayae (Diptera: Tephritidae) on guava, *Psidium guajava*, Linn. based on morphometric characters. *Serangga*, *18*(1), 63-75.

Mazlan, N., and Mumford, J. (2005). Insecticide use in cabbage pest management in the Cameron Highlands, Malaysia. *Crop Protection*, 24(1), 31-39.

Messelink, G. J., Bloemhard, C. M. J., Hoogerbrugge, H., Van Schelt, J., Ingegno, B. L., and Tavella, L. (2015). Evaluation of mirid predatory bugs and release strategy for aphid control in sweet pepper. *Journal of applied entomology*, 139(5), 333-341.

Midwest Fruit Workers Group. (2010). *Midwest tree fruit spray guide*. Purdue University, West Lafay- ette, IN.

Milléo, J., Farago, T. L., de SOUZA, J. M., Barbola, I. D. F., and Castro, J. P. (2011). Entomofauna asociada a flores de berenjena y su papel en la producción de los frutos. *Revista de la Sociedad Entomológica Argentina*, 70(1-2), 17-25.

Mochiah, M. B., Banful, B., Fening, K. N., Amoabeng, B. W., Ekyem, S., Braimah, H., and Owusu-Akyaw, M. (2011). Botanicals for the management of insect pests in organic vegetable production. *Journal of Entomology and Nematology*, 3(6), 85-97.

Murtaza, G., Ramzan, M., Ghani, M. U., Munawar, N., Majeed, M., Perveen, A., and Umar, K. (2019). Effectiveness of Different Traps for Monitoring Sucking and Chewing Insect Pests of Crops. *Egyptian Academic Journal of Biological Sciences.* A, Entomology, 12(6), 15-21.

Murugesan N, Murugesh T. (2009). Bioefficacy of some plant products against brinjal fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera): Pyrallidae. *Journal of Biopesticides*, 2(1), 60-63.

Naresh, J. S., Malik, V. S., and Balan, J. S. (1986). Estimation of fruit damage and larval population of brinjal fruit borer, *Leucinodes orbonalis* Guenee and its parasitism by Trathala sp. on brinjal. *Bulletin of Entomoloy*, 27(1), 44-47.

Natikar, P. K., Balikai, R. A., and Kambrekar, D. N. (2019). Study on biology and physical measurements of shoot borer, *Leucinodes orbonalis* (Guenee) on the potato, Solanum tuberosum (L.) during kharif and rabi season. *Journal of Entomology and Zoology Studies*, 7(1), 1529–1532.

Navasero, M. V. (1983). Biology and chemical control of the eggplant fruit and shoot borer, *Leucinodes orbonalis* Guenée (Pyraustidae: Lepidoptera). University of the Philippines, Los Baños.

Nayar, K. K., Ananthakrishnan, T. N., and David, B. V. (1995). *General and Applied Entomology* 11 01 ed. Tata McGraw-hill Publ Co Ltd, New Delhi

Nazir, T., Basit, A., Hanan, A., Majeed, M. Z., and Qiu, D. (2019). In vitro pathogenicity of some entomopathogenic fungal strains against green peach aphid Myzus persicae (Homoptera: Aphididae). *Agronomy*, 9(1), 7.

Neupane, F. P. (2000). Integrated management of vegetable pest (Nepali language). Centre for Environmental and Agricultural Policy Research Extension and Development (CEAPRED), Bakhundol, Lalitpur, Nepal, 172.

Ngowi, A. V. F., Mbise, T. J., Ijani, A. S. M., London, L., & Ajayi, O. C. (2007). Smallholder vegetable farmers in Northern Tanzania: Pesticides use practices, perceptions, cost and health effects. *Crop protection*, *26*(11), 1617-1624.

Nielson, M. W. (1968). The leafhopper vectors of phytopathogenic viruses (Homoptera, Cicadellidae): taxonomy, biology, and virus transmission (No. 1382, 386 pp). US Agricultural Research Service.

Niño-Medina, G. U. I. L. L. E. R. M. O., Urías-Orona, V. A. N. I. A., Muy-Rangel, M. D., and Heredia, J. B. (2017). Structure and content of phenolics in eggplant (Solanum melongena)-a review. *South African Journal of Botany*, 111, 161-169.

Noda, Y., Kaneyuki, T., Igarashi, K., Mori, A., and Packer, L. (1998). Antioxidant activity of nasunin, an anthocyanin in eggplant. *Research Communications in Molecular Pathology and Pharmacology*, 102(2), 175-187.

Nonita, M., Manmohini, C., Singh, T. K., and Radhakrishore, R. K. (2010). Biodiversity of ants with special reference to aphid, *Aphis gossypii* Glover on eggplant, Solanum melongena local var. Barahmasika. *Uttar Pradesh Journal of Zoology*, 30(1), 1-6.

Ofori, E. S. K., Afful, N., Quartey, E. K., Osae, M., and Amoatey, H. M. (2015). Preliminary Ecological Studies of Insect Species Associated with Different Accessions of Eggplant (Solanum melongena L.) in Southern Ghana. *Journal of Agriculture and Ecology Research International*, 4(4),199-210.

Olckers, T., Medal, J. C., and Gandolfo, D. E. (2002). Insect herbivores associated with species of Solanum (Solanaceae) in northeastern Argentina and southeastern Paraguay, with reference to biological control of weeds in South Africa and the United States of America. *Florida Entomologist*, 85(1), 254-260.

Ollerton, J., Winfree, R., and Tarrant, S. (2011). How many flowering plants are pollinated by animals? *Oikos*, 120(3), 321-326.

Onekutu, A., Omoloye, A. A., and Odebiyi, J. A. (2013). Biology of the eggfruit and shoot borer (EFSB), *Leucinodes orbonalis* Guenee (Crambidae) on the garden egg, Solanum gilo Raddi. *Journal of Entomology*, 10(3), 156-162.

Onekutu, A., Omoloye, A. A., and Odebiyi, J. A. (2014). Integrated pest control of the eggfruit and shoot borer *Leucinodes orbonalis* Guenee on the garden egg Solanum aethiopicum L. *Southwest Nigeria. International Journal of Scientific and Research Publications*, 4(7), 1-4.

Ooi, P.A. 2015. Biological control of agricultural pests. *UTAR Agriculture Science Journal*, 1, 25–31.

Oso, A. A., and Borisade, O. A. (2017). Pest profile and damage assessment on three land races of eggplant (Solanum spp) in ekiti state, Nigeria. *European Journal of Physical and Agricultural Sciences*, 5(1), 21-28.

Patel, R. C., Patel, J. C., and Patel, J. K. (1971). New records of parasites of *Leucinoides orbonalis* Guen. from Gujarat. *Indian Journal of Entomology*, 33(3), 358.

Pessarakli, M. M., and Dris, R. (2004). Pollination and breeding of eggplants. *Journal of Food Agriculture and Environment*, *2*, 218-219.

Philips, C.R., Kuhar, T.P., Hoffmann, M.P., Zalom, F.G., Hallberg, R., Herbert, D.A., Gonzales, C. and Elliott, S. (2014). Integrated Pest Management. In eLS, John Wiley and Sons, Ltd (Ed.). https://doi.org/10.1002/9780470015902.a0003248.pub2

Pimentel D (2007) *Encyclopedia of Pest Management*, vol. II. New York, NY: Marcel Dekker, Inc.

Prabhat, K., and Johnsen, S. (2000). Life cycle studies on fruit and shoot borer (*Leucinodes orbonalis*) and natural enemies of insect-pests of eggplant (Solanum melongena). *Journal of Applied Biology*, 10(2), 178-184.

Purcell, M. F., Johnson, M. W., and Tabashnik, B. E. (1993). Effects of insecticide use on abundance and diversity of tomato pests and associated natural enemies in Hawaii. *Hawaiian Entomological Society,* 32, 45-59.

Queiroz, J. M., and Oliveira, P. S. (2001). Tending ants protect honeydew-producing whiteflies (Homoptera: Aleyrodidae). *Environmental Entomology*, 30(2), 295-297.

Rahman, A. K. M. Z. (1997). Screening of 28 brinjal line for resistance/tolerance against the brinjal shoot and fruit borer. *Annual Report*. Entomology Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh, 32-35.

Rahman, M. M. (2006). Vegetable IPM in Bangladesh. *Radcliffe's IPM world textbook.* University of Minnesota, St. Paul, MN. USA.

Rahman, M. M., Ali, M. R., and Hossain, M. S. (2009). Evaluation of combined management options for managing brinjal shoot and fruit borer. *Academic Journal of Entomology*, 2(2), 92-98.

Rahman, M. S., Alam, M. Z., Haq, M., Sultana, N., and Islam, K. S. (2002). Effect of some integrated pest management (IPM) packages against brinjal shoot and fruit borer and its consequence on yield. *OnLine Journal of Biological Sciences*, 2(7), 489-49.

Ram Babu Peneru1, P. P. and Y. P. G. 1Entomology R. P. M. (2015). Available online at : *International Journal of Applied Sciences and Biotechnology*, 3(4), 727–730. https://doi.org/10.3126/ijasbt.v3i4.13993

Rashid, M. H., Mohiuddin, M., and Mannan, M. A. (2008). Survey and identification of major insect pest and pest management practices of brinjal during winter at Chittagong district. *International Journal of sustainable crop production*, 3(2), 27-32.

Rechcigl, J. E., and Rechcigl, N. A. (Eds.). (2000). *Insect pest management: techniques for environmental protection*. CRC Press.

Rohokale YA, Sonkamble MM, Bokan SC, B. B. (2018). Efficacy of newer insecticide combinations against brinjal shoot and fruit borer. *International Journal of Entomology Research*, 3(5), 36–39.

Saad, K. A., Roff, M. M., Hallett, R. H., and Idris, A. B. (2015). Aphid-induced defences in chilli affect preferences of the whitefly, Bemisia tabaci (Hemiptera: Aleyrodidae). *Scientific Reports*, 5(1), 1-9.

Sandanayake, M. (1987). *Biology of the brinjal shoot fruit borer, Leucinodes orbonalis (Guen.) and its larval parasite Trathala flavoorbitalis (Cam.).* M. Sc. Thesis, University of Sri Jayewardenapura, Nugegoda, Sri Lanka.

Sandanayake, W. M., and Edirisinghe, J. P. (1992). Trathala flavoorbitalis: parasitization and development in relation to host-stage attacked. *International Journal of Tropical Insect Science*, 13(3), 287-292.

Sandanayake, W. R. M., and Edirisinghe, J. P. (1992). Instar determination and larval distribution in brinjal shoot and fruit borer, *Leucinoides orbonalis* (Guen.). *Ceylon Journal of Science, Biological Sciences*, 22, 50-59.

Sangma, C. D., Simon, S., and Nagar, S. (2019). Indigenous pest control practices for the management of Brinjal shoot and fruit borer (*Leucinodes orbonalis* Guen.). *Journal of Pharmacognosy and Phytochemistry*, 8(3), 4221-4223.

Sasikala, K., Rao, P. A., and Krishnayya, P. V. (1999). Comparative efficacy of eco-friendly methods involving egg parasitoid, Trichogramma japonicum, mechanical control and safe chemicals against *Leucinodes orbonalis* Guenee infesting brinjal. *Journal of Entomological Research*, 23(4), 369-372.

Sathe, T. V., Patil, S. S., Bhosale, A. M., Devkar, S. S., Govali, C. S., and Hankare, S. S. (2016). Ecology and Control of Brinjal insect pests from Kolhapur region, India. *Bio life*, 4(1), 147-154.

Satpathy, S., Shivalingaswamy, T. M., Kumar, A., Rai, A. B., and Rai, M. (2005). Biointensive management of eggplant shoot and fruit borer (*Leucinodes orbonalis* Guen.). *Vegetable Science*, 32(1), 103-104.

Sattelle, D. B., Cordova, D., and Cheek, T. R. (2008). Insect ryanodine receptors: molecular targets for novel pest control chemicals. *Invertebrate Neuroscience*, 8(3), 107.

Scalzo, R. L., Fibiani, M., Francese, G., D'Alessandro, A., Rotino, G. L., Conte, P., and Mennella, G. (2016). Cooking influence on physico-chemical fruit characteristics of eggplant (Solanum melongena L.). *Food chemistry*, 194, 835-842.

Schlub, R. L., and Yudin, L. S. (2002). *Eggplant, pepper, and tomato production guide for Guam*. Guam Cooperative Extension, College of Agriculture and Life Sciences, University of Guam.

Sen, K., Samanta, A., Alam, S. F., Dhar, P. P., and Samanta, A. (2017). Field Evaluation of a New Ready-Mix Formulation Ampligo 150 ZC (Chlorantraniliprole 9.3%+ Lambda Cyhalothrin 4.6% ZC) against Shoot and Fruit Borer (*Leucinodes orbonalis* Guen.) infestation in Brinjal. *Journal of Pharmacognosy and Phytochemistry*, 6(5), 1674-1678.

Sharifzadeh, M. S., Abdollahzadeh, G., Damalas, C. A., and Rezaei, R. (2018). Farmers' criteria for pesticide selection and use in the pest control process. *Agriculture*, 8(2), 24.

Sharma, P. K., Jayaram, C. S., and Rana, A. (2019). Population dynamics of wheat aphids and their natural enemies. *Indian Journal of Entomology*, 81(4), 916-920.

Shimizu, Y., Kohama, T., Uesato, T., Matsuyama, T., & Yamagishi, M. (2007). Invasion of solanum fruit fly Bactrocera latifrons (Diptera: Tephritidae) to Yonaguni Island, Okinawa Prefecture, Japan. *Applied entomology and zoology*, *42*(2), 269-275.

Sihachakr, D., Chaput, M. H., Serraf, I., and Ducreux, G. (1993). Regeneration of plants from protoplasts of eggplant (Solanum melongena L.). In *Plant Protoplasts and Genetic Engineering IV, 23,* 108-122. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-78037-0_9.

Singh, H., Kumar, A., and Sahu, R. (2019). Efficacy of certain insecticides against Brinjal shoot and fruit borer [*Leucinodes orbonalis* (Guenee)] under field condition. *Internation Journal of Chemical Studies*, 7(1), 2049–2051.

Singh, S., Choudhary, D. P., Sharma, C., Mehara, R. S., and Mathur, Y. S. (2008). Bioefficacy of IPM modules against shoot and fruit borer *Leucinodes orbonalis* Guen. On eggplant. *Indian Journal of Entomology*, *70*(2), 179-181.

Singh, Y. P., and Singh, P. P. (2001). Biology of shoot and fruit borer (*Leucinodes orbonalis* guen.) of eggplant (Solanum melongena L.) at medium high-altitude hills of Meghalaya. b) Development of shoot and fruit borer. *Indian journal of entomology*, 63(3), 360-368.

Singh, Y., Jha, A., Verma, S., Mishra, V. K., and Singh, S. S. (2013). Population dynamics of sucking insect pests and its natural enemies on okra agro-ecosystem in Chitrakoot region. *African Journal of Agricultural Research*, *8*(28), 3814-3819.

Singla, P., Bhullar, M. B., and Kaur, P. (2018). Biological studies on brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee. *Journal of Entomology and Zoology Studies*, 6(1), 161-165.

Sivapragasam, A. (2009, December). Biopesticides from Malaysian flora–resources for sustainable pest management. In Discovering opportunities, expanding the economic horizon. Proceedings of the National Conference on New Crops and Bioresources, Seremban, Malaysia (pp. 15-17).

Srinivasan, R. (2008). Integrated Pest Management for eggplant fruit and shoot borer (*Leucinodes orbonalis*) in south and southeast Asia: Past, Present and Future. *Journal of Biopesticides*, 1(2), 105-112.

Srivastava, K.P. and D.K. Butani. 1998. *Pest management in vegetables*, Houston, USA: Research Periodical and Book Publishing House.

Stephan, E. A. P., Chantal, A. D., Romandeo, H. C., Pierre, N., and Champlain, D. L. (2016). Diversity, abundance and incidence of fruit pest insects on three Solanum varieties (Solanaceae) in two agro-ecological zones of Southern Cameroon. *African Journal of Agricultural Research*, 11(39), 3788-3798.

Subbaratnam, G. V., and Bhutani, D. K. (1982). Chemical control of insect pest complex of brinjal [eggplant]. *Entomon*, 7(1), 97-100

Sujayanand, G. K., Sharma, R. K., Shankarganesh, K., Saha, S., and Tomar, R. S. (2015). Crop diversification for sustainable insect pest management in eggplant (Solanales: Solanaceae). *Florida entomologist*, 98(1), 305-314.

Susanty, S. C., Haneda, N. F., & Mansur, I. (2018). LIFE CYCLE OF Arthroschista hilaralis (LEPIDOPTERA: PYRALIDAE) ON JABON TREES (Anthocephalus cadamba Miq). *Serangga*, 22(2).

Talekar, N. S. (2002). Controlling eggplant fruit and shoot borer: A simple, safe and economical approach. International Cooperators' Guide, AVRDC, Asian Vegetable Research and Development Center, Shanhua, Taiwan.

Tan, J. L., Ooi, P. A. C., and Khoo, G. (2016). Thrips on eggplant, chilli and bell pepper in Cameron Highlands, Malaysia. *Serangga*, 21(1), 71-85.

Thapa, R. S. (1970). Bionomics and control of Laran defoliator, Margaronia hilaralis Wkr. (Lepidoptera: Pyralidae). *Malayan Forester*, 33(1), 55-62.

Thapa, R. S., & Bhandari, R. S. (1976). Biology, ecology and control of Kadam defoliator Arthroschista hilaralis Walk. (Pyralidae, Lepidoptera) in plantations in West Bengal. Indian Forester, 102(6), 388-401.

Tripathi, S. R., and Singh, A. K. (1991). Some observations on population dynamics of brinjal borer, *Leucinodes orbonalis* (Guen) (Lepidoptera: Puralidae). *Annals of Entomology*, 9(1), 15-24.

Tripura, A., Chatterjee, M. L., Pande, R., and Patra, S. (2017). Biorational management of brinjal shoot and fruit borer (*Leucinodes orbonalis* guenee) in mid hills of meghalaya. *Journal of Entomology and Zoology Studies*, 5(4), 41-45.

Udaiyan, K., and Ramarathinam, S. (1994). Bioefficacy of neem derivatives on the incidence of some major insect pests of rice, jowar, cotton, groundnut, vegetables and tea. *Pestology*, 18(1), 40-42.

Vaishampayan, S. M., Kogan, M., Waldbauer, G. P., and Woolley, J. T. (1975). Spectral specific responses in the visual behavior of the greenhouse whitefly, *Trialeurodes vaporariorum* (Homoptera: Aleyrodidae). *Entomologia experimentalis et applicata*, 18(3), 344-356.

Van lenteren, J. C., Bolckmans, K., Köhl, J., Ravensberg, W. J., and Urbaneja, A. (2018). Biological control using invertebrates and microorganisms: plenty of new opportunities. *Biological Control*, *63*(1), 39-59.

Vijaysegaran, S. (1991). Fruit flies in Peninsular Malaysia: their economic importance and control strategies. In *Proceeding of the International Symposium on the Biology and Control of Fruit Flies,* Okinawa Prefectural Government. 105–115.

Wankhede, S. M., Kale, V. D., and Gangurde, S. M. (2009). Biology of *Leucinodes orbonalis*: an important pest of brinjal. *International Journal of Plant Protection*, 2(2), 258-260.

Wigglesworth, V. B. (1950). The principles of insect physiology. *The Principles of Insect Physiology*., (Edn 4).

Winfree, R., Gross, B. J., and Kremen, C. (2011). Valuing pollination services to agriculture. *Ecological Economics*, 71, 80-88.

Yadav, A., Sachan, S. K., Yadav, A., and Yadav, T. (2015). Biology of brinjal shoot and fruit borer, *Leucinodes orbonalis* G. under lab condition at 35 ºC temperature and 90% relative humidity during 2009 and 2010. *Plant Archives*, 15(2), 889-893.

Yinghua, S., Yan, D., Jin, C., Jiaxi, W., & Jianwu, W. (2017). Responses of the cutworm Spodoptera litura (Lepidoptera: Noctuidae) to two Bt corn hybrids expressing Cry1Ab. *Scientific reports*, 7(1), 1-13.

Yousafi, Q., Afzal, M., and Aslam, M. (2015). Management of Brinjal Shoot and Fruit Borer, *Leucinodes orbonalis* Guenee, with Selected Insecticides. *Pakistan Journal of Zoology*, 47(5), 1413-1420.

Yousafi, Q., Afzal, M., Aslam, M., and Abid, A. D. (2018). Effect of Infested Shoot Removal and Light Trap on Brinjal Shoot and Fruit Borer (*Leucinodes orbonalis* G.) Infestation on Brinjal Fruit Solanum melongena L. *Pakistan Journal of Zoology*, 50(6), 2115-2118.

Yunus, A., and Ho, T. H. (1980). List of economic pests, host plants, parasites and predators in West Malaysia (1920-1978). *Bulletin Ministry of Agriculture, Malaysia*.

Zhou, Z., Chen, Z., and Xu, Z. (2010). Potential of trap crops for integrated management of the tropical armyworm, Spodoptera litura in tobacco. *Journal of Insect Science*, 10(1), 1-11.

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