ISSN 1021-1004

Volume 23 Number 2 December 2013

Bangladesh Journal of ENTOMOLOGY

Bangladesh Entomological Society

www.bdentsoc.org

Bangladesh Journal of Entomology Vol. 23 No. 2 December 2013

BANGLADESH ENTOMOLOGICAL SOCIETY

(Established 1990)

EXECUTIVE COUNCIL FOR 2011-2013

BANGLADESH JOURNAL OF ENTOMOLOGY

An Official Publication of Bangladesh Entomological Society

Bangladesh Entomological Society publishes the Bangladesh Journal of Entomology twice a year (June and December). The Journal is included in the abstracting and indexing coverage of the Entomology Abstracts. Zoological Records and CAB Abstracts.

Subscription Rates for the Bangladesh Journal of Entomology

For Institution	: Inside Bangladesh-	Tk. 500.00 per copy
	Outside Bangladesh-	Us $ 40.00 per copy
For Individuals	: Inside Bangladesh-	Tk. 200.00 per copy
	Outside Bangladesh-	Us $ 20.00 per copy

Payments may be made in favour of Bangladesh Entomological Society through Bank draft or money order. For subscription please write to :

Publication Secretary
Bangladesh Entomological Society
C/O Entomology Division
Bangladesh Agricultural Research Institute
Gazipur-1701, Bangladesh.
Tel. 9257400, 9256404, E-mail: entoipm@bdcom.com

Printed by :
Sowrov Media Products
Phone : 9615624, Cell : 01718419001, E-mail : sowrovmp@yahoo.com

Acknowledgement

The publication of this issue of the journal has been funded by the Ministry of Science and Information & Communication Technology, Government of the People's Republic of Bangladesh.

NOTES FOR AUTHORS

The **Bangladesh Journal of Entomology** publishes original research papers, review articles and scientific notes concerning insects, other arthropods and vertebrate pests of economic importance in agriculture, medical and veterinary fields. Papers on taxonomy and descriptive morphology should primarily concern insects and arthropods from Bangladesh. Papers intended for publication in the Journal must not have been submitted for publication elsewhere. Manuscript will normally be sent to referees for confidential and critical appraisal. The Editorial Board reserves the right to edit all manuscripts as it deems fit. For general guidance authors are urged to pay attention to the following:

Manuscript must be typed in standard type size (10 or 12), double-spaced on 28 cm x 21.5 cm paper with 2.5 cm margins all around and on one side of the paper only. The text should not exceed 12 typed pages. **Scientific Notes** should not exceed four typed pages.

Manuscript should generally be organized in the following style and format: **Title, Running Title** (not more than 10 words), **Author(s) Name and address, Abstract, Keywords** (not more than six), **Introduction, Materials and Methods, Results, Discussion, Acknowledgements** (if any), **References.** For **Scientific Note** separate Introduction, Materials and Methods etc., are not required but References should be listed as usual and an Abstract added. Taxonomic description should be given in telegraphic styles.

Title should be concise but informative. **Author**(s) **Name**(s) and address follow the title. **Abstract** should be carefully prepared in one paragraph but complete in itself and should not exceed 250 words. the first page of the manuscript should contain only Title and the name and address of the author; the second page, the Title and Abstract. Tables must be kept to a minimum and should not be used where text or illustration gives the same information. Tables should be typed on separate sheets and should have a clear and self explanatory caption. All measurements should be in metric units.

Drawings and graphs must be in black water-proof ink on drawing or tracing papers of sufficient size and quality to allow reduction to half or more. Only **Black and white** glossy prints of **photographs** are acceptable when they become indispensable to the text.

To partly cover the rising printing cost, authors are required to pay **Taka 600.00 (Tk. 200+400)** for **full paper** (up to 12 typed pages) and **Taka 300.00 (Tk. 200+100)** for **Scientific Note** (up to 4 typed pages) for publication in the Journal. Additional pages will be charged at the rate of **Taka 100.00** per typed page. The total page of the manuscript should not exceed 20 typed pages for a full paper and 5 typed pages for a Scientific Note.

References. Only references cited in the text should be included and arranged in alphabetical order of the author's surname. Title of the Periodical should be abbreviated as in the World List of Scientific Periodicals. The following style should be used.

ANON. 2010. BARI *Annual Report* (2009-10). Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. pp.181-211.

AFSANA, N, & ISLAM, Z. 2001. Predation potential of *Micraspis discolor* Fabricius (Coleoptera: Coccinellidae) on rice leafhopper and planthopper. *Bangladesh j. entomol.* **11** (1&2), 67-74.

DIXON, A.F.G. 2000. Insect Predator-Prey Dynamic, Ladybird Beetle and Biological Control. Cambridge University Press, Cambridge. 257 pp.

WALKER, P. T. 1991. Measurement of insect pest population and injury, pp. 19 - 29. In: TENG, P. S. (ed.). *Crop loss assessment and pest management.* APS Press, St. Paul, Minnesota.

Reprints. Authors will be provided 15 reprints free.

Manuscript should be sent in **Duplicate** to:

Editor
Bangladesh Journal of Entomology
C/O Entomology Division
Bangladesh Agricultural Research Institute
Gazipur-1701, Bangladesh.
Tel. 9257400, 9256404; E-mail: entoipm@bdcom.com

BANGLADESH JOURNAL OF ENTOMOLOGY

Volume 23	Number 2	December 2013

CONTENTS

Bangladesh j. entomol. (2013) **23**(2), 1-11 ISSN 1021-1004

EFFECT OF GEOGRAPHICAL VARIATIONS ON JACKFRUIT TRUNK BORER INFESTATION IN THREE SELECTED DISTRICTS OF BANGLADESH

K. U. AHMED[1*], M. M. RAHMAN[2], M. Z. ALAM[3], M. M. HOSSAIN[4] & M. G. MIAH[5]

[1]Tuber Crops Research Centre, Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh, [2&3]Department of Entomology, [4]Department of Horticulture, [5]Department of Agroforestry and Environment, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706, Bangladesh

ABSTRACT

The geographical influence on the incidence of trunk borer was studied in terms of infestation level in jackfruit orchards under Gazipur (Kapasia Upazilla), Gaibandha (Palashbari and Sadullapur Upazilla) and Khagrachhari (Ramgarh Upazilla) districts of Bangladesh. The infestation by trunk borer on jackfruit tree varied significantly ($P<0.05$) among three different regions. Trunk borer infestations were consistently the highest (37.78 %) in Gazipur, followed by Khagrachari (24.44 %) while it was the lowest (18.89 %) in Gaibandha. As per the farmers' opinion of Gazipur, Gaibandha and Khagrachari districts, severe attack by the trunk borer was first noticed in the year 2001, 2003 and 2002, respectively. Primary stage infestation (PSI) and old stage infestation (OSI) was the highest in Gazipur (14.44 %, 10.00%) followed by Khagrachari (12.22 %, 7.78%) while it was the lowest in Gaibandha (8.89 %, 4.44%). On the other hand, middle stage infestation (MSI) was the highest in Gazipur (13.33%), followed by Gaibandha (5.56 %) while it was the lowest in Khagrachari (4.44 %). The yield performance of jackfruit trees was the highest (15.00 tons/ha) in Gazipur, followed by Khagrachari (12.66 tons/ha) while it was the lowest in Gaibandha (6.33 tons/ha).

Keywords : Geographic variation, Jackfruit trunk borer, incidence.

INTRODUCTION

Bangladesh is geographically a subtropical region and suitable for production of delicious tropical fruits like jackfruit (*Artocarpus heterophyllus*). Jackfruit plant requires a soil, which is well drained but moist, with a PH of 5.0 to 7.5 and with

*Corresponding author: E-mail: kabkabir@yahoo.com

medium soil fertility and temperature of 19°C to 29°C, altitude at approx. 1600 meters above sea level and the annual rain fall between 1000 and 2400 mm (Haq 2006). In summer, the maximum temperature is 35°C although in some places this occasionally rises up to 40°C or more. In winter, the minimum temperature ranges from 7°C -12°C (Anon. 2009). Many factors govern insect-pest attack in agroforestry and each factor may have a different effect on pests at different times and under different situations. Tropical forests are likely to be cradles of highly specialized interactions (McKenna & Farrell 2006). In the Neotropics, such topographic diversity and climatic variation can produce heterogeneous selective pressures across relatively short geographic distances. For example, plants in high rainfall forests are thought to be better defended against herbivores than plants in drier forests, due to greater leaf longevity, mechanical toughness and lower nutritional value (Coley & Aide 1991). It is also possible that natural enemies increase with greater rainfall and reduced climate variability, causing lower herbivore density in wetter tropical forests (Coley & Barone 1996, Stireman *et al.* 2005, Dyer 2007). Changes in plant characteristics along rainfall or altitudinal gradients might have important effects on herbivore specialization and potential co-evolutionary relationships with their host plants and natural enemies. Plants belonging to the same or a very close taxonomic group have the tendency to share common pests (Rathore 1995, Bernays & Graham 1988, Gratton & Welter 1999). The dynamics of insect pests and their natural enemies are governed by the complexity and composition of the Agroforestry system. The pest situation in these systems will be influenced by the degree of interaction between the components, the type of Agroforestry system and the composition of the plant communities in each component (Rathore 1995). Ehrlich & Raven (1964) postulated that herbivore specialization is an adaptation to specific host-plant secondary metabolites. An alternative view is that specialist herbivores benefit by escaping natural enemies or sequestering toxic plant compounds for their own defenses (Bernays & Graham 1988, Dyer 1995, Gratton & Welter 1999, Termonia *et al.* 2002, Vencl *et al.* 2005).

A recent study reported that in some parts of Bangladesh the wood boring insects are the major constraints to jackfruit production (Ahmed 2008, Rasel 2004, Kabir & Khorsheduzzaman 2011). Prakash *et al.* (2009) found in southwestern and southern Asia, boring insects seemed to be the major pests of jackfruit. Kulkarni (2010) reported both *Batocera rufomaculata* and *Apriona germari* are polyphagous pests and removal of mango orchards and other host plants would have forced the insects to move towards eucalyptus, due to ecological disturbance. Several species of wood borer are key pests of fruit crops and reduced yields by direct and indirect damage. Thus farmers lose their interest to establish new jackfruit orchards due to trunk borer infestation.

Jackfruit is grown in different regions of the country in different ecological conditions and different agroforestry system. It is assumed that there might exist some relations of variability in distribution of trunk borer to biotic and abiotic factors such as natural enemy, climate, geography and cropping practices. The information relating to geographical distribution of trunk borer and effect of ecological and environmental factors on them in Bangladesh is very limited due to lack of adequate research in this field. Therefore, considering the above points, the present study was undertaken to compare the incidence and intensity of infestation of trunk borer on jackfruit trees in three selected districts of Bangladesh in geographical aspects.

MATERIALS AND METHODS

The geographical influence on jackfruit trunk borer was studied in terms of its incidence of infestation in jackfruit orchard under farmers' management practices in three selected districts of different agroecological zones (AEZ) of Bangladesh, namely Gazipur (AEZ-28: Madhupur Tract, Red-brown terrace soil), Gaibandha (AEZ-25: Level Barind Tract, Grey flood plain soils and Noncalcareous brown flood plain soil, Gray terrace soil) and Khagrachhari (AEZ-29: Northern and Eastern Hills, Brown hill soils) during 2009-2010. In each district, data were recorded from three villages and in each village thirty jackfruit trees were randomly selected from an orchard. Thus a total of ninety sample trees were studied in each district. Data were collected from three villages viz., Charbaria, Nakachini and Jamirar char under Kapasia Upazilla of Gazipur, three villages viz., Katuli and Andua under Palashbari Upazilla and Arajisatargacha under Sadullapur Upazilla in Gaibandha and the three villages viz., Bairagi tila, Master para and Taichalapara under Ramgarh upazilla in Khagrachhari district. Data were recorded on first notice of infestation, per cent infestation, yield, soil characteristics and weather data such as temperature, rainfall and relative humidity. All weather data and information of soil characteristics were collected from the respective Upazilla Agriculture Office. Collected data were summarized and scrutinized carefully for statistical analysis using SPSS 13 and MSTAT-C software.

Infestation stage classification

1. Primary stage infestation (PSI) - Recently infested (1 or 2 yrs) with oozing hole and sawdust found in the ground.
2. Middle stage infestation (MSI) - Infestation 3 to 4 yrs, holes were dry and the bark was loose and lifted.
3. Old stage infestation (OSI) - Infestation was above 4 yrs, maximum branches were dead from top like die back, ultimately became dead.

RESULTS AND DISCUSSION

Incidence of infestation: The geographical distribution of jackfruit trunk borer in terms of infestation determined by percentage of the tree infestation during 2009-2010 at three selected districts of Bangladesh was found significant ($p < 0.05$) and presented in Fig. 1. The rate of infestation was significantly highest in Gazipur (37.78 %) and the lowest in Gaibandha (18.89 %) which was statistically similar with Khagrachari (24.44 %). The trunk borer infestation was first noticed by farmers of Gazipur in 2001 and in Gaibandha and Khagrachari in 2003 and 2002, respectively.

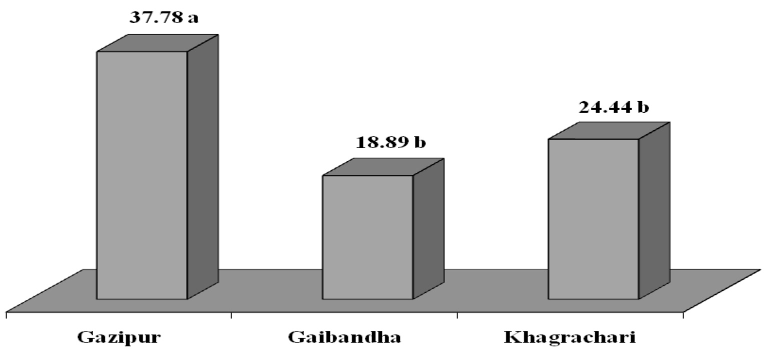

Fig. 1: Percent tree infestation by trunk borer in three districts of Bangladesh during 2009-2010

Infestation status of different regions: The infestation was categorized into three stages in terms of age of infestation and damage severity among the infested jackfruit trees of different districts as shown in Fig. 2. The highest primary stage infestation (PSI) and old stage infestation (OSI) were observed in case of infested trees in Gazipur (14.44%, 10.00%), followed by Khagrachari (12.22%, 7.78%) while it was the lowest (8.89%, 4.44%) in Gaibandha. On the other hand, middle

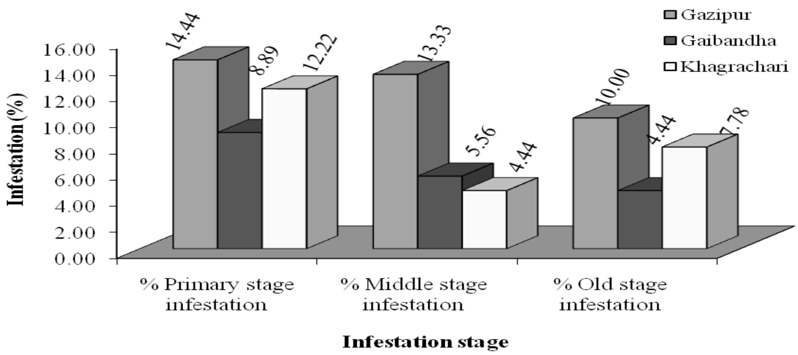

Fig. 2: Stage of infestation of infested jackfruit trees in three selected districts of Bangladesh during 2009-2010

stage infestation (MSI) was the highest in Gazipur (13.33%) followed by Gaibandha (5.56%) and Khagrachari (4.44%). From the above results, it may be inferred that in all cases the rate of infestation of all stages was much higher in Gazipur district as compared to Gaibandha and Khagrachari. It may be due to geographical suitability for the pest supporting favourable host pest interaction. Because characteristic of Gazipur district particularly the study area, which is situated within and around the forest ecosystem which is very important in respect of jackfruit based agroforestry. Especially, this area has its own agroecological identity and is included in Agro-Ecological Zone (AEZ-28: Madhupur Tract) (Anon. 1997, Rahman 2001). The area is dominated by jackfruit trees with pineapple beneath the trees and has deciduous type of vegetation. A report was published in "The Daily Star" on 13 August, 2009 that most of the jackfruit trees were seriously infested by trunk borer in Shreepur upazila as well as Gazipur district. Arannak Foundation - an NGO reported that trunk borer seriously destroyed the trees and caused reduction of yield in the jackfruit growing areas of B.-Baria, Sreepur, Kapasia and Tangail (Kabir & Khorsheduzzaman 2011). Plants belonging to the same or a very close taxonomic group have the tendency to share common pests. Uniformity in plant genetic material has been recognized as one of the main causes of an increase in pest problems in monoculture fields (Rathore 1995). The rate of infestation was found the lowest in Gaibandha because this region is agroecologically different from Gazipur and Khagrachari. This might have contributed to the result, as found in the present study. Another reason might be the number of farmers (few farmers found in Gaibandha) who grew jackfruit tree as monoculture orchard in Gaibandha. Maximum number of jackfruit trees were found in homestead area of farmers with other fruits trees. Thus jackfruit trees were found scattered rather than concentrated as was in Gazipur, which also might be the reason of lower infestation.

Table 1. Yield performance of jackfruit trees in farmers' orchard at three selected districts during 2009-2010

Districts	Mean fruit bearing per healthy tree	Mean fruit bearing per infested tree	Mean yield (tons/ha)
Gazipur	16.00 a	2.67	15.00a
Gaibandha	8.00 b	4.00	6.33 b
Khagrachhari	14.67 a	3.33	12.66 a
P< (ANOVA)	0.05	Ns	0.05
LSD (0.05)	5.289	1.308	4.89
CV%	18.10	17.32	19.06

Means followed by common letter(s) in a column are not significantly different at 5% level by DMRT. Values are the averages of three replications.

The comparison of weather parameters of three districts in 2009-2010 (Table 2) reveals that the maximum, minimum and average temperature was the highest (35.6ºC, 14.8ºC and 25.2ºC, respectively) in Gazipur followed by, 33.2ºC, 12.9ºC and 23.05ºC, respectively in Gaibandha and 32.5ºC, 14.9ºC and 23.70ºC, respectively in Khagrachari. But the average relative humidity was the highest in Gaibandha (78 %), followed by Khagrachari (74 %), and the lowest in Gazipur (67.50 %). Porter *et al.* (1991) in their study mentioned the effects of temperature on insects, including limitation of geographical range, over wintering, pest synchronization, dispersal and migration, and availability of host plants. Kulkarni (2010) reported that trees suffered from severe infestation in Krishna District of Andhra Pradesh, India where mango was cultivated on large scale while in other places the infestation was not so serious. High temperature and low relative humidity were the major limiting factors in the movement of any pest and infestation as well. The weather condition, AEZ, soil characteristic and plantation of fast growing woody plant (alternate host) under Moraceae family in agroforestry system might have attributed to the highest level of infestation of jackfruit trunk borer in Gazipur (37.78%) district and conversely the lowest in Gaibandha (18.89%) and Khagrachari (24.44%) respectively (Fig. 1). Uniformity in plant genetic material has been recognized as one of the main causes of an increase in pest problems in monoculture fields (Rathore, 1995). Jackfruit based agroforestry is found in Gazipur district, which is well known as intensive jackfruit growing area. Thus this may be the probable reason of high infestation compared to other two districts. However, present study provided a clear picture of infestation of trunk borer in three selected districts due to different climates.

Table 2. Variations in weather parameters in three selected jackfruit growing districts during 2009-2010

Districts	Weather parameter of study period								
	Mean temperature (^{O}C)			Mean rainfall (mm)			Mean humidity (%)		
	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
Gazipur	35.6	14.8	25.2	676	1	160.00	82	53	67.5
Gaibandha	33.2	12.9	23.05	832	9	184.92	89	67	78.0
Khagrachhari	32.5	14.9	23.7	1244	2	288.42	86	62	74.0

Altaf Hussain *et al.* (2007) found similar result of *Apriona germari* emergence in Jammu and Kashmir state in India due to the variation of climatic factors viz., temperature, rainfall and relative humidity of those regions.

In general, three selected districts differing in temperature, humidity, rainfall, spatial and temporal attributes and other biological factors might have been influenced in trunk borer population fluctuation and synchrony. The last five years climatic condition (temperature, rainfall and humidity) of Gazipur, Gaibandha and

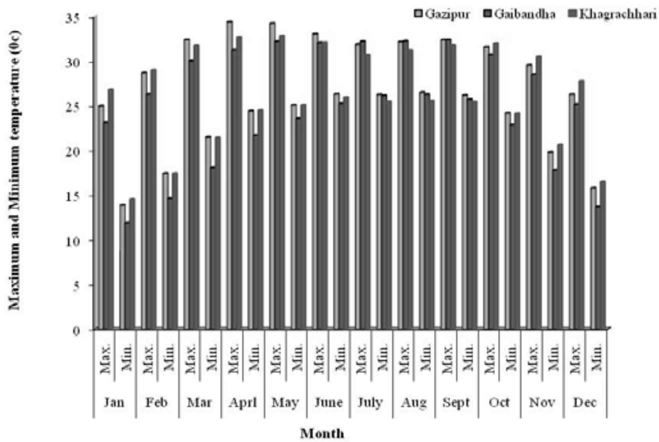

Fig. 3. Comparison of last five years (2005-2009) average temperature of three selected districts of Bangladesh

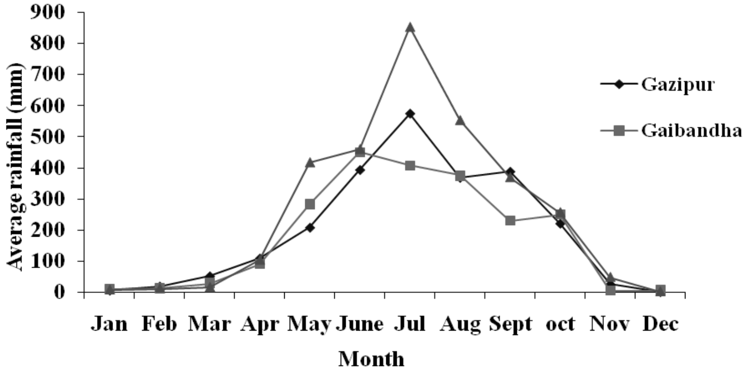

Fig. 4: Comparison of last five years (2005-2009) average rainfall of three selected districts of Bangladesh

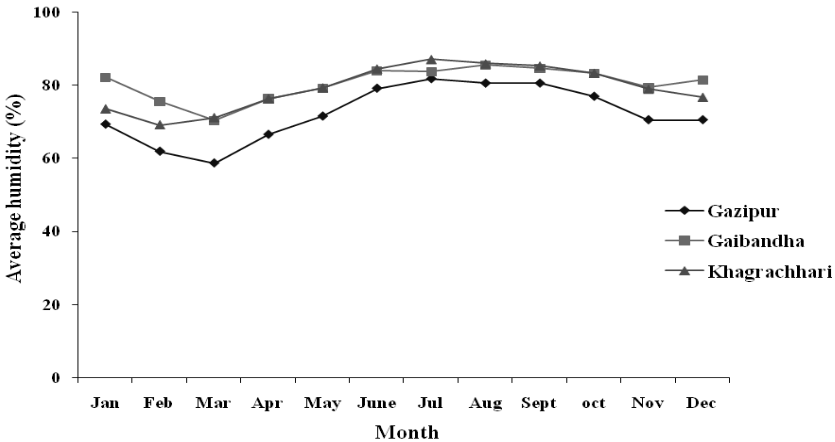

Fig. 5: Comparison of last five years (2005-2009) average humidity of three selected districts of Bangladesh

Khagrachari are presented in Fig. 3, Fig. 4 and Fig. 5, respectively. It is revealed that the maximum and minimum temperature were higher in March to June in Gazipur as compared to the other two districts. But average rainfall was higher in Gazipur than in Gaibandha and lower than Khagrachari in rainy season (June to September).

Humidity in Gazipur was always lower than Gaibandha and Khagrachari. Although a subtropical country, different geographical regions under different AEZ of Bangladesh varied in its soil type and also in climatic condition, which might regulate the incidence of insect pest of specific vegetation in a specific region.

Yield performance: The yield of jackfruit trees of three districts showed significant ($P < 0.05$) variation (Table 1). Mean fruit numbers from healthy tree were the highest (16 fruits/tree, 15.00 tons/ha) in Gazipur, which was statistically similar with Khagrachari (14.67 fruits/tree, 12.66 tons/ha). The lowest yield was found in Gaibandha (8.00 fruits/tree, 6.33 tons/ha). Bhuiyan (1999) reported that the leading jackfruit growing areas of Bangladesh are high lands of greater Dhaka (included Gazipur), Savar, Bhaluka, Madhupur, hilly areas of greater Sylhet districts, Rangamati and Khagrachhari. The yield of infested jackfruit trees varied from 2.67 to 4.00 fruits/tree and was non significant.

REFERENCES

ANON., 1997. *Fertilizer Recommendation* Guide. BARC, Farmgate, Dhaka. pp. 169-170.

ANON., 2009. A pest report. Plant Protection Service of the Netherlands. Division of Plant Health Advice & International Affairs, Geertjesweg 15, 6700 HC Wageningen, P.O.Box 9102, 6700 HC Wageningen. www.minlnv.nl.

AHMED, F. U. 2008. Diseased jackfruit trees. *The Daily Star, August* **13**, 2009.

HUSSAIN, A., CHISHTI, M. Z., BUHROO, A. A. & KHAN, M. A. 2007. Adult population of *Apriona germari* Hope (Coleoptera: Cerambycidae) in mulberry farms of Jammu and Kashmir state (India). *Pak. Entomol*. **29** (1): 15 p.

BERNAYS, E. A. & GRAHAM, M. 1988. On the evolution of host specificity in phytophagous arthropods. *Ecology*. **69**: 886-892.

BHUIYAN, A. J. 1999. Fruit tree management and development, Lift-project CARE, Bangladesh. 33p.

COLEY, P. D & AIDE T. M. 1991. *Comparison of herbivory and plant defenses in temperate and tropical broad-leaved forests*. pp. 25-49 *In: Price*, PW, Lewinsohn, TM, Fernandes GW, Benson WW, editors. Plant-Animal Interactions Evolutionary Ecology in Tropical and Temperate Region, John Wiley and Sons Inc.

COLEY, P. D. & BARONE J, A. 1996. Herbivory and plant defenses in tropical forests. *Annu. Rev. Ecology & Systematics*. **27:** 305-335.

DYER, L. A. 1995. Tasty generalists and nasty specialists - antipredator mechanisms in tropical lepidopteran larvae. *Ecology*. **76**: 1483-1496.

DYER, L, A. 2007. In: Carson WP, Schnitzer SA, editors. *Tropical tritrophic interactions*: Nasty hosts and ubiquitous cascades. *Tropical Forest Community Ecology*. Blackwell Science.

EHRLICH, P. R. & RAVEN P. H. 1964. Butterflies and plants: a study in coevolution. *Evolution*. **18**: 586-608.

GRATTON, G. & WELTER S. C. 1999. Does "enemy-free space" exist? Experimental host shifts of an herbivorous fly. *Ecology*. **80**(3): 773-785.

HAQ, N. 2006. Jackfruit (*Artocarpus heterophyllus*). Southampton Centre for Underutilised Crops, University of Southampton, Southampton, SO17 1BJ, UK. 61-62 pp.

KULKARNI, H. D. 2010. Indigenous insect pests - Batocera and Apriona beetle attack on eucalyptus. *Karnataka J. Agric. Sci*., **23**(1): 207-210

KABIR, K. H. & KHORSHEDUZZAMAN, A. K. M. 2011. Insect pests of jackfruit and their management in Bangladesh-progress, limitations and prospect. Paper presented in a National workshop held at Bangladesh Agricultural Research Council in 02 March 2011.

MCKENNA, D. D. & FARRELL, B. D. 2006. Tropical forests are both evolutionary cradles and museums of leaf beetle diversity. Proceedings of the National Academy of Sciences of the United States of America **103**: 10947-10951.

PORTER, J. H., PARRY, M. L. & CARTER, T. R. 1991. The potential effects of climatic change on agricultural pest insects. *Agric. For. Meterology* **57**(1/3): 221-240.

PRAKASH, O., KUMAR, R., MISHRA, A. & GUPTA, R. 2009. *Artocarpus heterophyllus* (Jackfruit): An overview. Phcog Rev [serial online] [cited 2011 Aug 25], 3: 353-8. http://www.phcogrev.com/text.asp?2009/3/6/353/59534

RAHMAN, M. M. 2001. *Upazila land and soil resource use guidebook*. Gazipur Sadar Upazila. Gazipur District (In Bangla). Soil Resources Development Institute. Ministry of Agriculture. Dhaka. 191 p.

RASEL, S. M. M. 2004. Identification of borer infesting jackfruit trunk and assessment of its damage severity. *MS Thisis*. Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706.

RATHORE, M. P. S. 1995. *Insect Pests in Agroforestry*. Working Paper No. 70 report of a GTZ Fellowship. International Centre for Research in Agroforestry, PO Box 30677 Nairobi, Kenya. <www.bugwood.caes.uga.edu>

STIREMAN, J. O., DYER L. A., JANZEN D. H., SINGER M. S., LILL J.T., MARQUIS, R. J., RICKLEFS, R. E., GENTRY, G. L., HALLWACHS, W., COLEY, P.D., BARONE, J. A., GREENEY, H. F., CONNAHS, H., BARBOSA, P., MORAIS, H. C. & DINIZ, I. R., 2005. Climatic unpredictability and parasitism of caterpillars: Implications of global warming. Proceedings of the National Academy of Sciences of the United States of America **102**: 17384-17387.

TERMONIA, A., PASTEELS, J. M., WINDSOR, D. M. & MILINKOVITCH M, C., 2002. Dual chemical sequestration: a key mechanism in transitions among ecological specialization. Proceedings of the Royal Society of London, B **269**: 1-6.

VENCL, F.V., NOGUEIRA-DE-SA? F., ALLEN, B. J., WINDSOR, D. M. & FUTUYMA, D. J., 2005. Dietary specialization influences the efficacy of larval tortoise beetle shield defenses. *Oecologia*. **145**: 404-414.

(MS received for publication 02 July 2013)

Bangladesh j. entomol. (2013) ***23****(2), 13-26* *ISSN 1021-1004*

EVALUATION OF DISACCHARIDE BROWN SUGAR AS A SOURCE OF CARBOHYDRATE FOR BUMBLEBEE, *BOMBUS TERRESTRIS* REARING

MD RUHUL AMIN[1], KYI KYI THAN[2], SANG JAE SUH[2,3] & YONG JUNG KWON[2,3*]

[1]Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706, Bangladesh

[2]School of Applied Biosciences, [3]Institute of Plant Medicine, Kyungpook National University, Daegu 702-701, Korea

ABSTRACT

This study evaluated the effects of different concentrations of the disaccharide brown sugar solutions (1.25: 1, 1.5: 1, 1.75: 1 and 2.0: 1 w/v) as a source of carbohydrate on colony parameters of the 2, 3, 4 and 5 months old diapaused *Bombus terrestris* queens. A control treatment was designed with the queens diapaused for 3 months and fed on 1.5:1 w/v disaccharide white sugar solution. The percentages of queens initiated colonies, development of first brood workers and production of sexual gynes varied significantly, and the queens diapaused for 3 months and fed 1.75:1 w/v brown sugar solution exhibited similar results as appeared in control. The treatments also exerted significant effects on colony initiation periods, duration of the emergence of first brood workers, initiation of competition point, duration of the emergence of sexual males and gynes, and production of the number of first brood egg cups, first brood worker population, total number of sexual males and gynes, queen lifespan and colony longevity. The queens diapaused for 3 months and fed on 1.75:1 w/v brown sugar solution initiated and subsequently founded colonies earlier with higher number of first brood egg cups and first brood worker population. The queens took significantly longer time to develop sexuals and produced higher number of gynes. Initiation of competition point was found to be later in their colonies and the queens showed longer lifespan as well as colony longevity. Their colony characteristics revealed very similar performances to the queens diapaused for 3 months and fed on 1.7:1 w/v white sugar solution indicated that 1.75: l w/v brown sugar solution could be used as a source of carbohydrate for commercial rearing of *B. terrestris*.

Keywords: Bumblebee, disaccharide sugar, diapause, foundress queen, sexual production

*Corresponding author: E-mail: yjkwon@knu.ac.kr

INTRODUCTION

There are more than 20000 species of bees in the world and all but the parasitic ones play a vital role in the production of fruits and seeds through pollination (Michener 2000). Among the bee species, bumblebees are well recognized as potential pollinators for a long time. They have longer tongues than those of honeybees and they perform better pollination to flowers having deep corollas (Velthuis & Doorn 2006). To date, five species of bumblebees are reared commercially and the most widely used species is *Bombus terrestris* L (Gruel *et al*. 2012). This species produces large colonies and adapts quite well to artificial conditions. But, there are still problems in commercial breeding because the bees show much variation in colony initiation, colony foundation, periods of sexual males and gynes production, and their population in the colony (Beekman & van Stratum 2000, Kwon *et al*. 2007, Amin *et al*. 2007a, Amin *et al*. 2007b, Amin *et al*. 2008). However, these colony characteristics are affected by food quality, diapause duration of the foundress queen and environment conditions in the rearing room (Kwon *et al*. 2007, Amin *et al*. 2007a, Amin *et al*. 2007b, Amin *et al*. 2008).

In nature, bumblebees feed on pollen and nectar from flowering plants. Nectars are primarily in the form of simple monosaccharide sugars namely glucose, fructose, sucrose and xylose. Commercial breeders use pollen as a source of protein and disaccharide white sugar solution as a source of carbohydrate for the bees. Pollen plays role in larval growth and production of eggs by females, whereas sugar solution supply energy for activity and thermoregulation of the bees (Sutcliff & Plowright 1990) and provide adequate nutrition for good colony development (Ribeiro *et al*. 1999, Rasmont *et al*. 2005).

Diapause is an essential physiological state for bumblebees which influences the survival and offspring production of the foundress queens (Beekmand & van Stratum 2000, Amin *et al*. 2007a, Amin *et al*. 2008). The amount as well as quality of the foods consumed by the queens prior to diapause and postdiapause periods play significant role on their survival and longevity and also colony productivity (Spaethe & Weidenmüller 2002).

Bumblebee producers and researchers use disaccharide white sugar solutions (99.5 to 99.9 % pure sugars) in various concentrations such as 40, 50 and 55%, or 1.5:1 (Hannan *et al*. 1998, Yeninar *et al*. 2000, Lǿpez-Vaamonde *et al*. 2009, Kwon *et al*. 2006, Amin *et al*. 2009). Disaccharide brown sugar contains high nutrients as well as white sugar and is cheaper. Therefore, substitution of brown sugar in bombiculture can be a point. But there is scarcity of information of this kind of sugar on colony production. So, the objective of this study was to evaluate the colony characteristics of different lengths of post diapaused *B. terrestris* queens fed on different concentrations of disaccharide brown sugar solutions as a source of carbohydrate.

MATERIALS AND METHODS

Source of insects: Mated bumblebee queens that had diapaused in a refrigerator at 4 °C for a period of 2, 3, 4 and 5 months were obtained from the mass culture stock of the School of Applied Biosciences, Kyungpook National University, Daegu, Korea. These queens were the 7th generation of the insects that were imported from Koppert B. V., The Netherlands in the year 2004.

Activation of queens and colony development: The 2, 3, 4 and 5 months diapaused queens were introduced into different flight cages (40 × 40 × 60 cm) having illumination facility. The cages were provided with *ad libitum* pollen grain of the Korean Kiwi, *Actinidia arguta* Planch and disaccharide brown sugar solutions of 1.25: 1, 1.5:1, 1.75: 1 and 2.0: 1w/v. So, the experimental treatments were 2 m 1.25:1, 2 m 1.5:1, 2 m 1.75:1, 2 m 2.0:1, 3 m 1.25:1, 3 m 1.5:1, 3 m 1.75:1, 3 m 2.0:1, 4 m 1.25:1, 4 m 1.5:1, 4 m 1.75:1, 4 m 2.0:1, 5 m 1.25:1, 5 m 1.5:1, 5 m 1.75:1 and 5 m 2.0:1. A control treatment consisted of 3 m 1.5: 1 white sugar solution. The cages with queens were kept one week in a growth chamber at 28±1 °C (Duchateau & Marien, 1995), 60±2% RH and 08:16 light: dark condition. Light was provided with 220/240V fluorescent white light (Philips MX204HF136, 40 Hz, λ = 0.96-0.17) at an intensity of ~ 700 lux on the floor of the flight cages. The intensity of light was measured with a digital lux meter and the photophase was regulated with timer.

For each treatment, a total of 28 activated queens were allowed for oviposition in small transparent plastic boxes (16 cm × 11 cm ×7 cm). In each box, one queen was kept along with respective concentration of sugar solution in a perforated plastic tube (0.35 cm^3), and frozen pollen grain in a 4 cm diameter Petri dish. One anesthetized *B. terrestris* worker and 1-2 day-old frozen queen pupa were put to each rearing box to stimulate the queens for oviposition (Duchateau & Marien 1995). Each pupa was horizontally fixed with paraffin on hard drawing paper, so that the pupa could not roll and the queen could sit for oviposition (Kwon *et al*.

2003). Pollen grains were supplied daily into the rearing boxes and sugar tube was changed weekly. The frozen pupa and anesthetized worker were substituted once a week unless the queen laid eggs on the cocoon or on the hard drawing paper. If a queen did not lay eggs within 4 weeks then they were discarded from calculation. When the queen laid eggs, the narcotized worker was removed from that rearing box. The boxes were kept in these conditions until the workers of the first brood cells emerged. In this condition, data were recorded to know the duration of colony initiation (number of days required to lay first eggs by the female after supported pupae), number of first brood egg cups, timing of the emergence of first brood worker (number of days required to lay first egg until the emergence of first brood cell workers) and number of first brood workers. For further development, the colonies were shifted to larger colony boxes (27 cm × 18 cm × 13 cm) that were connected with cotton filter to sugar tanks (30 cm × 20 cm × 4 cm) filled with respective concentrations of sugar solution. The colonies completed their development in the same room with environmental condition. The colonies were monitored daily to record the date of initiation of competition point (the first signs of the reproductive activity of workers, i.e., workers' egg laying or egg eating, presence of two hollow egg cells at a time and or queen-worker competition), and emergence of sexual males and gynes. The competition point was calculated by the number of days between emergence of the first worker and the first reproductive activity of workers. Timing of the emergence of sexual gynes and males was calculated from the day after pupa supply (DAPS) to the day of their eclosion. Newly emerged males and gynes were harvested daily. Colonies were destroyed when there was no queen and or male pupa in the colony. The lifetime of a colony was calculated as days from DAPS to the day of destruction. Numerical sex ratio was calculated with the formula suggested by Duchateau & Velthuis (1988). According to this, the numerical sex ratio=nQ/(nQ+nM); where nQ=number of queens, nM=number of males.

Data analysis: Data were analyzed by χ^2 test and one way ANOVA, and expressed as mean ± se. The means were separated by DMRT. All the analyses were performed using IBM SPSS statistics 19.

RESULTS AND DISCUSSION

Colony initiation characteristics in relation to diapause lengths and sugar solution concentrations are presented in Table 1. The rate of queens initiated colonies varied from 60.7 to 88.9% and the results showed significant difference (χ^2 = 27.9, df = 16, p < 0.05). There were significant differences in colony initiation periods ($F_{16, 352}$ = 2.9, p < 0.001) which ranged from 6.3± 3.6 to 13.7 ± 9.5 days. Number of egg cups in the first brood varied from 3.3±1.3 to 4.7±1.4 and the results were significantly different ($F_{16, 352}$= 2.2, p < 0.05). Table 1 shows that 3 months diapaused queens when fed on 1.75:1w/v disaccharide brown sugar solution exerted statistically identical but numerically higher rate of colony initiation, tended shortest periods for colony initiation and produced higher number of egg cups. Oviposition by the foundress queens reflects the sign of colony initiation which varied significantly with the state and length of diapause food and rearing conditions. Yoon *et al*. (2012) studied the effect of white sugar solution, brown sugar solution and dark brown sugar solution on 2.0 months diapaused *B. terrestris* queens and found 75.0% oviposition rate when the queens fed white sugar solution. They also reported that sugar solutions did not affect colony initiation rate. Amin *et al*. (2007b) observed 88.2% colony initiation by 3.0 months diapaused *B. terrestris* queens when reared under L8:D16 condition and fed on 1.5:1 w/v white sugar solution. In another study, Amin *et al*. (2008) reported that 3.0 months diapaused queens initiated colonies earlier (3.8±0.7 days) by producing higher number of egg cups (5.2±0.2). Yeninar *et al*. (2000) found a range of pre-oviposition period from 2.44 ±0.6 to 5.75 ±0.8 days and egg cups 5.33 ± 0.16 from the field collected queens. Gosterit & Gurel (2005) observed 4.9±0.32 and 4.4±0.23 cells in queens collected from the field and queens from commercial companies, respectively.

Production of workers from the first brood cells indicates the colony foundation which is one of the major criteria for proper colony development. Colony foundation in relation to diapause lengths and sugar solution concentrations are shown in Table 2. The rate of queens founded colonies varied from 50.0 to 67.3% and the results differ to a significant level (χ^2 = 5.6, df = 16, p > 0.05). Timing of the emergence of first brood workers ($F_{16, 258}$ = 1.7, p > 0.05) and the number of workers developed from the first brood cells ($F_{16, 258}$ = 3.2, p < 0.001) showed significant differences. The queens diapaused for 3.0 months and fed on 1.75:1 w/v brown sugar solution provided higher rate of colony foundation by producing higher number of first brood workers within a period similar to control treatment. This study showed agreement with Amin *et al*. (2007b) who observed 67.6% colony foundation by 3.0 months diapaused *B. terrestris* queens when reared under

L8:D16 condition and fed 1.5:1 w/v white sugar solution. Colony initiation and colony foundation are two important criteria in the large-scale production of commercial colonies because early initiated colonies developed first brood workers comparatively in shorter duration produced stronger colonies and reduced production costs (Yoon *et al*. 2004, Amin *et al*. 2008).

Table 1. Effect of diapause length (month) and concentration of disaccharide sugar solution (w/v) on colony initiation characteristics of *B. terrestris*

Diapause and sugar solution	Colony initiation characteristics		
	% Queens laid eggs	Preoviposition period (day)	Number of first brood egg cups
Control	88.9	6.4±4.5 c	4.6±1.5 a
2 m 1.25:1	60.7	13.4 ± 7.9 a	3.8±1.2 ac
2 m 1.5:1	60.7	13.7 ± 9.5 a	3.9±1.6 ac
2 m 1.75:1	71.4	10.3 ± 4.4 ac	3.9±1.5 ac
2 m 2.0:1	64.3	10.7 ± 6.1 ab	3.2±1.3 c
3 m 1.25:1	71.4	8.0 ± 5.6 bc	3.8±1.9 ac
3 m 1.5: 1	85.7	7.6 ± 4.6 bc	4.8±1.6 a
3m 1.75 :1	88.9	6.3 ± 3.6 c	4.7±1.4 a
3 m 2.0 :1	85.7	8.9 ± 6.0bc	3.3±1.3 c
4 m 1.25 :1	85.7	8.1 ± 6.1 bc	4.1±1.6 ac
4 m 1.5:1	85.7	8.0 ± 5.4 bc	4.1±1.4 ac
4m 1.75 :1	85.7	7.2 ± 5.5 bc	4.4±1.4 ab
4 m 2.0 :1	78.6	8.2 ± 3.9 bc	3.5±1.1 bc
5 m 1.25 :1	67.9	8.6 ± 6.2 bc	3.8±0.9 ac
5 m 1.5 :1	71.4	7.5 ± 5.3 bc	3.9±1.3 ac
5m 1.75 :1	71.4	7.1 ± 4.0 bc	4.2±1.2 ac
5 m 2 :1	67.7	8.1 ± 5.7 bc	4.1±1.0 ac

χ^2 values for %queens laid eggs = 27.9 with df = 16, $p > 0.05$. Means within a column followed by same letter(s) are not significantly different by DMRT ($p \leq 0.05$).

Table 2. Effect of diapause length (month) and concentration of disaccharide sugar solution (w/v) on colony foundation characteristics of *B. terrestris*

Diapause and sugar solution	Colony foundation characteristics		
	% Queens produce 1st workers	1st worker emergence (day)	Number of 1st workers
Control	67.3	22.2±2.8 c	12.6±2.2 a
2 m 1.25:1	50.0	23.9±3.1 ac	8.3±3.0 d
2 m 1.5:1	57.1	23.4±2.4 ac	9.3±2.5 bd
2 m 1.75:1	57.1	24.8±2.9 ab	9.2±2.0 cd
2 m 2.0:1	53.6	25.8±3.0 a	8.7±3.4 cd
3 m 1.25:1	57.1	24.6±2.7 ac	10.1±3.6 bd
3 m 1.5: 1	67.3	22.4±2.7 bc	11.5±2.1 ab
3m 1.75 :1	67.3	22.4±2.5 c	12.4±2.4 a
3 m 2.0 :1	57.1	24.8±3.3 ab	10.1±2.7 bd
4 m 1.25 :1	57.1	24.3±3.0 ac	10.8±2.9 ac
4 m 1.5:1	60.7	23.7±3.3 ac	10.9±3.2 ac
4m 1.75 :1	60.7	24.1±2.1 ac	11.0±2.4 ac
4 m 2.0 :1	53.6	24.3±3.2 ac	9.5±3.7 bd
5 m 1.25 :1	53.6	24.8±3.0ab	9.6±2.4 bd
5 m 1.5 :1	57.1	23.9±2.8 ac	9.8±2.5 bd
5m 1.75 :1	57.1	23.1±2.2 bc	10.2±2.8 bd
5 m 2 :1	53.6	24.7±3.3 ab	9.5±2.2 bd

χ^2 values for %queens developed first brood worker = 5.6 with df = 16, $p > 0.05$. Means within a column followed by same letter(s) are not significantly different by DMRT ($p \leq 0.05$).

Colony development characteristics in relation to diapause lengths and concentration of sugar solution are shown in Table 3. Production of sexuals in the colony depicts the successful colony development. The present study indicated that 21.4 to 42.9% queens produced sexual gynes and the results showed significant difference ($\chi^2 = 26.7$, df = 16, $p < 0.05$). The queens diapaused for 3.0 months and fed on 1.75:1 w/v brown sugar solution exhibited similar result to that of control treatment. These findings agreed to those of Amin *et al*. (2007b) who reported that 38.2% foundress queens produced sexual gynes when the colonies were developed from 3.0 months diapaused queens under L8:D16 condition and fed on 1.5:1 w/v white sugar solution. Timing of the initiation of competition points ($F_{16, 129} = 1.8$, $p < 0.05$), emergence of sexual males ($F_{16, 173} = 1.7$, $p < 0.05$) and sexual gynes ($F_{16, 147} = 1.7$, $p < 0.05$) showed significant differences. The results showed that the competition points varied from 21.3±5.8 to 31.7±6.8 days, sexual male emergence period from 70.1± 10.1 to 85.3 ± 11.9 days, and gyne emergence period from 72.2±9.5 to 89.4±9.2 days (Table 3). Competition point is a remarkable factor in *B. terrestris* colonies at which workers with developed ovaries laid haploid male eggs (Estoup *et al*. 1995, Schmid-Hempel & Schmid-Hempel 2000) and destroyed most of the eggs laid by the queen (van der Blom 1986, Duchateau &Velthuis 1988, Bloch & Hefetz 1999). The physical conflict between workers and queens may result in killing the queen by the workers and reduces colony lifetime (Amin *et al* 2007a). In the present study competition point was found to be earlier in the colonies that were developed by the queens diapaused for 5 months and fed on 1.75:1 w/v brown sugar solution. Timing of the emergence of sexuals determines the pollination activity of the colony population. If a colony produces sexuals early and those cannot be used for longer time for pollination, because the workers spend more time to take care of the broods in the colonies. The current study showed that the queens diapaused for 3 months and fed on 1.75:1 w/v white or brown sugar solution spent significantly longer time to produce sexual males and gynes.

Table 3. Effect of diapause length (month) and concentration of disaccharide sugar solution on colony development characteristics of *B. terrestris*

Diapause and sugar solution	Colony development characteristics			
	% Queens produced sexual gynes	Competition point initiation (day)	Male emergence (day)	Gyne emergence (day)
Control	42.9	24.3±7.6 ae	85.3±11.9 a	89.4±9.2 a
2 m 1.25:1	21.4	31.7±6.8 a	70.2±9.4 c	79.6±9.9 ab
2 m 1.5:1	25.0	31.1±7.3 ab	77.2±13.5 ac	82.7±14.7 ab
2 m 1.75:1	28.6	29.8±7.3 ad	77.7±12.6 ac	83.8±12.6 ab
2 m 2.0:1	28.6	30.0±7.2 ac	70.5±10.2 bc	81.7±14.7 ab
3 m 1.25:1	35.7	26.1±7.8 ae	81.4±12.7 ac	85.6±15.5 ab
3 m 1.5: 1	35.7	25.1±6.1 ae	82.4±12.2 ac	89.2±7.7 a
3m 1.75 :1	42.9	24.4±6.8 ae	84.9±10.8 a	88.9±7.8 a
3 m 2.0 :1	32.1	25.3±6.4 ae	79.5±13.1 ac	83.6±8.4 ab
4 m 1.25 :1	28.6	26.4±8.8 ae	78.7±11.8 ac	81.5±13.3 ab
4 m 1.5:1	39.3	25.2±6.0 ae	79.5±12.3 ac	84.6±12.4 ab
4m 1.75 :1	39.3	24.5±8.1 ae	82.8±12.2 ab	85.6±11.0 ab
4 m 2.0 :1	25.0	26.1±7.8 ae	77.4±13.5 ac	83.1±13.8 ab
5 m 1.25 :1	25.0	22.8±6.5 be	78.5±12.4 ac	73.1±14.2 b
5 m 1.5 :1	25.0	21.7±3.8 de	74.9±13.1 ac	74.7±15.2 b
5m 1.75 :1	28.6	21.3±5.8 e	77.4±12.7 ac	74.6±14.9 b
5 m 2 :1	21.4	22.5±7.3ce	70.1±10.1 c	72.2±9.5 b

χ^2 values for %queens produced sexual gynes = 26.7 with df = 16, $p > 0.05$. Means within a column followed by same letter(s) are not significantly different by DMRT ($p \leq 0.05$).

Total sexual males and gynes produced in a colony are important factors in the year-round rearing of bumblebees. Number of sexual males ($F_{16, 173} = 1.7$, $p < 0.05$) and gyne ($F_{16, 147} = 2.0$, $p < 0.05$) production in relation to diapause length and concentration of sugar solution were significantly different (Table 4). The treatments showed that the foundress queens produced 145.5± 64.7 to 251.7±81.0 males and 66.6± 15.6 to 110.8±39.3 gynes. The queens diapaused for 3 months and fed on 1.75:1 w/v brown sugar solution produced higher number of sexual gynes which showed similar result to that of control treatment. The 3 months diapaused quens fed on 1.75:1 w/v brown sugar solution also produced considerably higher number of sexual males along with control treatment. Amin *et al*. (2011) found 264.6±127.9 males and 112.4±21.9 gynes production in *B. terrestris* colonies by 3 months diapaused queens with colonies populated with 100 and 150 workers, respectively. They reported that diapause lengths and worker population in the colonies are determining factors for sexual production in *B. terrestris* queens. Table 5 shows that the sex ratio within a colony is male biased for all queens and the results agreed with those of Amin *et al*. (2009).

Table 4. Effect of diapause length (month) and concentration of disaccharide sugar solution on colony productivity of *B. terrestris*

Diapause and sugar solution	Colony productivity characteristics		
	Total sexual gyne production	Total sexual male production	Numerical sex ratio
Control	110.8±39.3 a	193.1±88.1 ad	0.39±0.13
2 m 1.25:1	67.3±40.5 b	147.5±82.0 d	0.32±0.14
2 m 1.5:1	72.3±26.0 b	162.3±85.4 bd	0.34±0.13
2 m 1.75:1	82.6±31.8 ab	176.4±86.5 ad	0.34±0.10
2 m 2.0:1	66.6±15.6 b	145.5±64.7 d	0.34±0.11
3 m 1.25:1	75.8±15.7 b	170.4±88.2 ad	0.33±0.12
3 m 1.5: 1	94.4±24.6 ab	194.9±91.6 ad	0.34±0.11
3m 1.75 :1	110.1±30.2 a	189.4±87.2 ad	0.39±0.09
3 m 2.0 :1	78.2±16.0 ab	155.7±82.1 cd	0.35±0.13
4 m 1.25 :1	89.6±29.7 ab	170.9±84.7 ad	0.38±0.10
4 m 1.5:1	89.2±41.6 ab	234.0±80.2 ac	0.28±0.08
4m 1.75 :1	89.9±34.8 ab	223.2±80.0 ad	0.30±0.10
4 m 2.0 :1	77.1±25.5 b	182.6±86.4 ad	0.33±0.16
5 m 1.25 :1	76.7±17.5 b	209.2±77.3 ad	0.29±0.08
5 m 1.5 :1	82.7±43.4 ab	244.7±77.8 ab	0.26±0.14
5m 1.75 :1	90.4±26.4 ab	251.7±81.0 a	0.29±0.10
5 m 2 :1	75.2±18.1 b	211.0±74.9 ad	0.27±0.06

Means within a column followed by same letter(s) are not significantly different by LSD ($p \leq 0.05$)

Table 5. Effect of diapause length (month) and concentration of disaccharide sugar solution on foundress queen and colony longevity of *B. terrestris*

Diapause and sugar solution	Longevity (mean ± SD day)	
	Queen	Colony
Control	128.4±18.2 a	148.8±19.0 a
2 m 1.25:1	110.8±17.4 ac	124.9±19.6 ab
2 m 1.5:1	113.5±20.6 ac	139.5±24.0 ab
2 m 1.75:1	124.2±19.2 ab	137.9±21.6 ab
2 m 2.0:1	102.2±20.0 c	119.8±33.9 b
3 m 1.25:1	112.5±15.9 ac	123.5±21.3 b
3 m 1.5: 1	115.8±17.7 ac	141.2±23.7 ab
3m 1.75 :1	130.6±19.8 a	149.1±17.8 a
3 m 2.0 :1	113.4±18.7 ac	122.8±21.6 b
4 m 1.25 :1	115.5±10.8 ac	124.9±17.8 ab
4 m 1.5:1	116.4±20.6 ac	135.5±25.1 ab
4m 1.75 :1	119.6±21.8 ac	137.4±23.1 ab
4 m 2.0 :1	106.7±18.9 bc	121.9±24.6 b
5 m 1.25 :1	114.7±21.5 ac	121.3±22.1 b
5 m 1.5 :1	110.7±20.3 ac	124.6±25.2 ab
5m 1.75 :1	111.4±19.8 ac	131.4±24.1 ab
5 m 2 :1	103.5±14.5 bc	118.2±16.4 b

Means within a column followed by same letter(s) are not significantly different by LSD ($p \leq 0.05$).

Table 5 shows a significant effect of diapause length and concentration of sugar solution on the lifespan of foundress queen ($F_{16, 147} = 1.7$, $p < 0.05$) and colony longevity ($F_{16, 147} = 2.0$, $p < 0.05$). The lifespan of the queen and colony longevity varied from 102.2±20.0 to 130.6±19.8 days and 118.2±16.4 to 149.1±17.8 days, respectively. The queens diapaused for 3 months and fed on 1.75: 1 sugar solution showed longer lifespan and colony longevity compared to those queens diapaused for 3 months and fed on 1.5:1 white sugar solution. Amin *et al* (2011) observed queen lifespan 152.8±10.2 days and colony longevity 154.6±12.0 days when the colonies were developed from 3 months diapaused queens and the colonies were fixed with 100 worker population. In the present study queen lifespan and colony longevity were dependent on diapause lengths and concentration of sugar solution.

Ono *et al*. (1994) reported that sucrose was converted into fructose and glucose within a few minutes in the body of *B. terrestris* species. The bumblebees chose sweeter sucrose because different concentrations of sucrose have different degrees of warm (Whitney *et al*. 2008). In this study the highest rate of colony initiation, colony foundation, and colony productivity were found by 3 months diapaused queens reared on 1.5:1w/v white sugar and 1.75:1 w/v brown sugar solution containing 99.9 % and 87.7 % sucrose, respectively. So, brown sugar may be substituted for commercial culture of *B. trrestris*.

REFERENCES

AMIN, M.R., KWON, Y.J. & SUH, S.J. 2007a. Effect of photoperiod and hibernation duration on the lifespan of *Bombus terrestris. Entomol. Res*. **37**, 89-94.

AMIN, M.R., KWON, Y.J. & SUH, S.J. 2007b. Impact of artificial photoperiodism on the colony development of bumblebee *Bombus terrestris. Entomol. Sci*. **10**: 315-321.

AMIN, M.R., KWON, Y.J. & SUH, S.J. 2008. Reproductive responses to photoperiod and temperature by artificially hibernated bumblebee *Bombus terrestris* queens. Entomol. Res. **38**: 250-256.

AMIN, M.R., KWON, Y.J. & THET, Z.M. 2011. Effect of worker number and diapause duration on the colony parameters of bumblebee, *Bombus terrestris* (Hymenoptera: Apidae). *J. Asia-Pacific Entomol*. **14**: 455-458.

AMIN, M.R., THAN, K.K. & KWON, Y.J. 2009. Copulation duration of bumblebee *Bombus terrestris* (Hymenoptera: Apidae): impacts on polyandry and colony parameters. *J. Asia-Pacific Entomol*. **12**: 141-144.

BEEKMAN, M. & van STRATUM, P. 2000. Does the diapause experience of bumblebee queens *Bombus terrestris* affect colony characteristics? Ecol. Entomol. **25**: 1-6.

BLOCH, G. & HEFETZ, A. 1999. Regulation of reproduction by dominant workers in bumblebee (*Bombus terrestris*) queen right colonies. Behav. Ecol. Sociobiol. **45**: 125-135.

DUCHATEAU, M.J. & MARIEN, J. 1995. Sexual biology of haploid and diploid males in the bumblebee, *Bombus terrestris* . Insectes. soc. **42**: 255-266.

DUCHATEAU, M.J. & VELTHUIS, H.H.W. 1988. Development and reproductive strategies in *Bombus terrestris* colonies. *Behavior*. **107**: 186-207.

ESTOUP, A., SCHOLL, A., POUVREAU, A. & SOLIGNAC, M. 1995. Monandry and polyandry in bumblebees (Hymenoptera: Bombidae) as evidenced by highly variable microsatellites. *Mole. Ecol*. **4**: 89-93.

GOSTERIT, A. & GUREL, F. 2005. Comparison of developmental patterns of imported and native *Bombus terrestris* L. (Hymenoptera: Apidae) colonies in the Mediterranean coastal region. *Turk. J. Vet. Anim. Sci*. **29**: 393-398.

GUREL, F., KARSLI, B.A. & GOSTERIT, A. 2012. Effects of three kinds of sugar syrups on colony development of bumblebee (*Bombus terrestris* L.). *J. Apic. Sci*. **56**, 13-18.

HANNAN, M.A., MAETA, Y. & HOSHIKAWA, K. 1998. Feeding behavior and food consumption in *Bombus ignitus* under artificial condition (Hymenoptera: Apidae). *Entomol. Sci*. **1**, 27-32.

KWON, Y.J., AMIN, M.R. & SUH, S.J. 2006. Mating propensity of *Bombus terrestris* reared in different photoperiodic regimes. *Apidologie*. **37**: 679-686.

KWON, Y.J., SAEED, S. & DUCHATEAU, M.J. 2003. Stimulation of colony initiation and colony development in *Bombus terrestris* by adding a male pupa: the influence of age and orientation. *Apidologie*. **34**: 429-437.

KWON, Y.J., THAN, K.K. & SUH, S.J. 2007. New method to stimulate the onset of *Bombus terrestris* (Hymenoptera: Apidae) rearing: using worker helpers in the presence of frozen pupae. *Entomol. Res*. **36**: 202-207.

LOPEZ-VAAMONDE, C., RAINE, N.E., KONING, J.W., BROWN, R.M., PEREBOOM, J.J.M., INGS, T.C., RAMOS-RODRIGUEZ, O., JORDAN, W.C. & BOURKE, A.F.G. 2009. Lifetime reproductive success and longevity of queens in an annual social insect. *J. Evol. Biol*. **22**: 983-996.

MICHENER, C.D. 2000. *The bees of the world*. John Hopkins, Baltimore.

ONO, M., SUZUKI, N., SASAKI, M. & MATSUKA, M. 1994. Food processing strategy of bumblebees (Hymenoptera: Apidae). In: *Les Insectes Soxiaux* (Lenoir, A., Amold, G. and Lepage, M., Eds.). Univ. Paris, Nord. pp. 487.

RASMONT, P., REGALI, A., INGS, T.C., LOGNAY, G., BAUDART, E., MARLIER, M., DELCARTE, E., VIVILLE, P., MAROT, C., FALMAGNE, P., VERIIAEGIIE, J.C. & CHITTKA, L. 2005. Analysis of pollen and nectar of *Arbutus unedo* as a food source for *Bombus terrestris* (Hymenoptera: Apidae). J. Econ. Entomol. **98**: 656-663.

RIBEIRO, M.F., VELTHUIS, H.H.W., DUCHATEAU, M.J. & van der TWEEL, I. 1999. Feeding frequency and caste differentiation in *Bombus terrestris* larvae. Insect soc. **46**: 306-314.

SCHMID-HEMPEL, R. & SCHMID-HEMPEL, P. 2000. Female mating frequencies in Bombus spp. from Central Europe. *Insect. soc*. **47**: 36-41.

SPAETHE, J. & WEIDENMÜLLER, A. 2002. Size variation and foraging rate in bumblebee (*Bombus terrestris*). *Insect. soc*. **19**: 142146.

SUTCLIFFE, G.H. & PLOWRIGHT, R.C. 1990. The effects of pollen availability on development time in the bumblebee Bombus terricola Kirby (Hymenoptera: Apidae). *Can. J. Zool*. **68**: 11201123.

VAN DER BLOM, J. 1986. Reproductive dominance within colonies of *Bombus terrestris* (L.). *Behavior*. **97**: 37-49.

VELTHUIS, H.H.W. & DOORN, N.A.V. 2006. A century of advances in bumblebee domestication and the economic and environmental aspects of its commercialization for pollination. *Apidologie*. **37**: 421-451.

WHITNEY, H.M., DYER, A., CHITTKA, L. & RANDS, S.A. 2008. The interaction of temperature and sucrose concentration on foraging preference in bumblebees. *Naturwissenschaften*. **95**: 845850.

YENINAR, H., DUCHATEAU, M.J., KAFTANOGLU, O. & VELTHUIS, H. 2000. Colony developmental patterns in different local populations of the Turkish bumblebee, *Bombus terrestris dalmatinus. J. Apic. Res*. **39**:107-116.

YOON, H.J., KIM, S.E., KIM, Y.S. & LEE, S.B. 2004. Colony developmental characteristics of the bumblebee queen, Bombus ignites by the first ovipositon day. *Intl. J. Indust. Entomol*. **8**: 139-143.

YOON, H.J., LEE, K.Y., KIM, M.A.., HAN, S.M., AHN, M.Y. & PARK, I.G. 2012. Availability of sugar solutions for colony development and progeny queen production of the European bumblebee, *Bombus terrestris . Intl. J. Indust. Entomol*. **24**: 29-35.

(MS received for publication 08 July 2013)

Bangladesh j. entomol. (2013) **23**(2), 27-37 ISSN 1021-1004

FECUNDITY AND SEX RATIO OF LARVAL PARASITOID *BRACON HEBETOR* SAY (HYMENOPTERA: BRACONIDAE) IN RELATION TO PARASITOID AGE

M. S. ALAM[1]*, M. Z. ALAM[2], S. N. ALAM[3], M. R. U. MIAH[2], M. I. H. MIAN[2] & M. M. HOSSAIN[2]

[1]Vertebrate Pest Division, Bangladesh Agricultural Research Institute, Gazipur
[2]Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur
[3]Entomology Division, Bangladesh Agricultural Research Institute, Gazipur

ABSTRACT

A study was undertaken to observe the age specific fecundity and oviposition dynamic of the ecto-endo larval parasitoid, *Bracon hebetor* Say on the wax moth, *Galleria mellonella* (F.) larva at 25±2°C, 75±5% RH and 16:8 (L:D) h photoperiod. Female *B. hebetor* were divided into four age groups following 5 days interval ranging from 1 to 15 days. Female *B. hebetor* age had significant effect on the mean number of eggs laid by the parasitoids and the highest fecundity was recorded by one day old female (157.8 eggs/female) and lowest by 15 day old female (73.8 eggs/female). Maximum eggs (76%) were laid within 1 and 10 days of oviposition. Age-specific daily fecundity was significantly affected by the age of female wasp over 14 days of oviposition period. Age-specific daily fecundity was higher at third day of oviposition (18 eggs), followed by 4th (15.4 eggs) and the lowest at 14th day of oviposition (3.6 eggs).

Keywords: Fecundity, sex ratio, oviposition dynamic, larval parasitoid, *Bracon hebetor*.

INTRODUCTION

The parasitic wasp, *Bracon hebetor* Say (Hymenoptera: Braconidae), an ecto-endo- larval parasitoid is medium in size on later instars of non-hairy larvae of wide range of insect pests. It is a gregarious, idiobiont (prevents any further development of the host after initial parasitization) and cosmopolitan parasitoid which attacks many lepidopterous larvae (Heimpel *et al*. 1997, Darwish *et al*. 2003), mainly moths in the family of Pyralidae (Brower *et al*. 1996). *B. hebetor* paralyses its host larvae prior to oviposition (Antolin *et al*. 1995). It has been

*Corresponding author: E-mail: alamvpd@yahoo.com

widely used in studies of hostparasitoid interactions because of its high reproductive rate, short generation time and considerable range of host species (Gul & Gulel 1995). The gregarious parasitoid *B. hebetor* is a natural enemy of the Indian meal moth, Plodia interpunctella (Milonas 2005), almond moth, *Ephestia cautella* (Press *et al*. 1982), Mediterranean flour moth, Ephestia kuehniella (Strand *et al*. 1989, Darwish *et al*. 2003), Wax moth, *Galleria mellonella* (Awadallah *et al*. 1985) and tomato fruit worm, *Helicoverpa* sp. (Attaran 1996). *B. hebetor* can be found parasitizing its hosts in both grain storages and field habitats (Puttarudriah & Channabasavanna 1956).

Wax moth, *Galleria mellonella* L. (Lepidoptera: Galleridae)is preferred for entomological studies, because of its nutritional needs, ecological adaptation and developmental characteristics. It was used as a host in favor of many hymenopteran species (Coskun *et al*. 2006). *B. hebetor* is an important biological control agent of several lepidopterous pests due to its rapid growth and development rates (Keever *et al*. 1985, Prozell & Scholler 1998). As an ideal biological control agent, parasitoids would be able to regulate a pest species population at a level that is economically acceptable (Hentz *et al*. 1998). Therefore, sufficient number of parasitoids must be present in the management area. Knowledge of the fecundity and sex ratio of the parasitoid is important for the implementation of an efficient mass-rearing system (Hentz *et al*. 1998).

In haplodiploid hymenopteran parasitoids, the offspring sex ratio is determined by females controlling the fertilization of eggs (Godfray 1994, Harvey & Gols 1998, Jarosik *et al*. 2003). Females develop from fertilized eggs and males develop from unfertilized eggs (Harvey & Gols 1998, Damiens *et al*. 2003, Fuester *et al*. 2003, Jarosik *et al*. 2003). It has been shown that various abiotic and biotic factors such as temperature, humidity, parasitoid age, host type, host size and host di*et al*so influence the fecundity and the offspring sex ratio of parasitoid species (Smith & Pimentel 1969, Tillman & Cate 1993, Harvey & Gols 1998, Honda & Kainoh 1998, Ueno 1998, Ueno 1999, Harbison *et al*. 2001, King 2002, Uckan & Gulel 2002, Jarosik *et al*. 2003). Considering the above facts the present study was undertaken to evaluate the age specific fecundity, sex ratio and oviposition dynamic of *B. hebetor*.

MATERIALS AND METHODS

The study was conducted in the IPM laboratory of the Division of Entomology, Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh. The climatic condition in the laboratory was maintained at 26 ± 2^{O}C, 65 ± 5 % RH and 16:8 (L: D) h photoperiod.

Age dependent fecundity and sex ratio: *Bracon hebetor* was used as the parasitoid and late stage larvae of *Galleria mellonella* were used as the host. A newly emerged female parasitoid was introduced into a vial (10 cm x 2 cm) containing a male and a honey saturated (50%) cotton pad. The female was provided with a healthy host and allowed to attack it. Parasitized hosts were kept at 26±2^{O}C and 60±5% RH under continuous illuminated laboratory conditions until the wasps emerged. The treatment was maintained until the female parasitoid died. Newly emerged wasps were used for the fecundity and sex ratio studies.

To investigate the age dependent fecundity and sex ratio of adult females of B. hebetor, 40 newly emerged females were divided into four age groups at 5 day intervals, ranging from 1 to 15 days old. A female parasitoid was placed in a vial provided with a male and a honey saturated cotton pad. In the first age group (1-day old), a female was exposed to one host on the first day of emergence. In others (5-day-old, 10- day-old and 15 day-old), a female was provided with a honey saturated cotton pad and a male of 4, 9 and 14 days old, respectively. One host was placed into each vial on the 5th, 10th and 15th day of emergence. Every alternate day, the female was removed and transferred into a new vial containing a healthy host and a honey saturated cotton pad. Treated vials were then maintained under the same conditions until the progeny of the parasitoid emerged. Vials were examined regularly and the number of wasps emerged and sexes were recorded. The study was replicated 8 times for each host type.

Bracon hebetor **oviposotion dynamic:** Studies were conducted in the laboratory in a no-choice design using Petri dishes (100 × 15 mm) as experimental units with a single full-grown 5th instar larva of each host species. A representative sample of full-grown larvae of each host species were randomly taken from the rearing jars. The fresh weights of larvae were measured using an electronic balance. *B. hebetor* females within 24 of emergence were kept with males for another 24 h in 500 ml glass jar and were provided with honey saturated cotton pads and water for mating. It was noted that 80% of virgin *B. hebetor* females mated within the first 15 min after pairing with a male as reported by Ode *et al*. (1995). A female parasitoid was placed in a Petri dish (10 cm x 2 cm) provided with a male and a honey saturated cotton pad and introduced individually into experimental arenas containing a single full grown host larva. After 24 h, females were carefully moved to a new experimental units containing a fresh larva of a given host species. The procedure was repeated until parasitoids died. There were 5 replicates for each host species. Observations were made consistently on 24 h period for each female parasitoid until her death, and number of eggs laid were recorded on each host/day and the life time fecundity.

Statistical Analysis: The effect of parasitoid age on offspring production and sex ratio were compared using one-way ANOVA and means were compared using the LSD test ($P < 0.05$). Oviposition dynamic was compared by DMRT. Before ANOVA the percentage data were transformed following standard method when necessary (Sokal & Rohlf, 1981) before analysis.

RESULTS AND DISCUSSION

Effect of parasitoid age on the fecundity and sex ratio: Significantly the highest number of eggs was laid by one day old female (157.8 eggs/female) *B. hebetor,* followed by 5, 10 and 15 days old females. Significantly the highest average number of total adult progeny per host female (126.40), total number of female (61.80) and male (64.60), and occurrence of females (%) among total progeny (48.82) were obtained when youngest (1 day old) female was parasitized, followed by 5, 10 and 15 days old females. The findings clearly showed that egg production and populations of total progeny, female, male and sex ratio decreased gradually with the increase of female age (Table 1). The relationship between fecundity and female sex ratio with female ages were negative and linear (Figs. 1 & 2)

This result was consistent with the findings of Gunduz & Gulel (2005). They observed that the decrease in offspring production during first 5 days of the females' life span was not significant. Similar results also have been reported for *Dibrachys boarmiae*, *Catolaccus grandi*s and *Apantales galleriae* (Gulel 1982, Morales-Ramos & Cate 1992, Uckan & Gulel 2002).

As older females laid fewer eggs than younger ones (Gul & Gulel 1995), the decrease in fecundity during the female's lifespan was physiologically age-dependent. Age-dependent fecundity in insects is generally divided into 3 general periods: the pre-oviposition period, the fecundity plateau and the period of declining fecundity. The pre-oviposition period started at emergence and ends with the first oviposition (Morales-Ramos & Cate 1992). During the fecundity plateau, fecundity is at a maximum level and it starts when ≥ 50% of the females reach maximum fecundity and ends when the females have oviposited ≥ 60% of their total oviposition potential. The period of declining fecundity started when the females oviposited approximately 60% of their total oviposition potential and ended with their death (Morales-Ramos & Cate 1992, Medeiros *et al*. 2000). It was determined that the declining fecundity period started at the 10th day of age and ended with the death of females. This result was similar to those of Gul & Gulel (1995).

Table 1. Age specific fecundity, offspring production and sex ratio of *Bracon hebetor* reared on *Galleria mellonella* larvae

Female age (Days)	Fecundity (total eggs/female (mean ± SE)	Total adult (mean ± SE)	Number of offspring		% Female of total offspring (mean ± SE)
			Total female (mean ± SE)	Total male (mean ± SE)	
1	157.80 ± 6.69 a	126.40 ± 6.86 a	61.80 ± 4.04 a	64.60 ± 3.19 a	48.82 ± 0.96 a
5	108.60 ± 3.40 b	74.60 ± 4.89 b	31.60 ± 2.44 b	43.00 ± 2.49 b	42.26 ± 0.59 b
10	90.80 ± 9.68 bc	65.00 ± 7.27 b	24.80 ± 2.65 b	40.20 ± 5.43 b	38.69 ± 2.49 b
15	73.80 ± 7.08 c	56.40 ± 8.15 b	21.00 ± 3.29 b	35.40 ± 4.91 b	37.00 ± 0.74 b

Means within the same column followed by the same letter are not statistically different using LSD

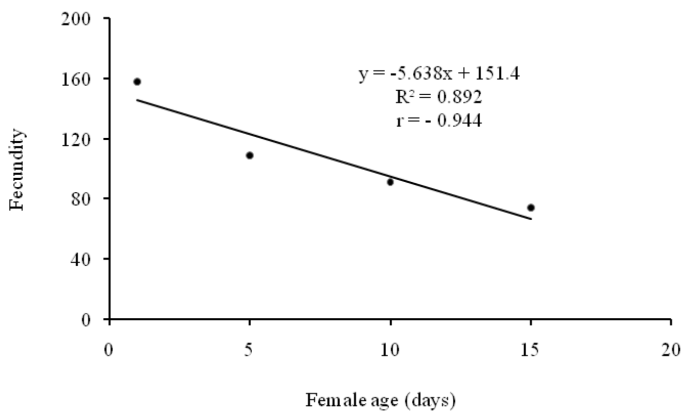

Fig. 1. Relationship between fecundity and female age of larval parasitoid, *Bracon hebetor* reared on wax moth, *Galleria mellonella* larvae

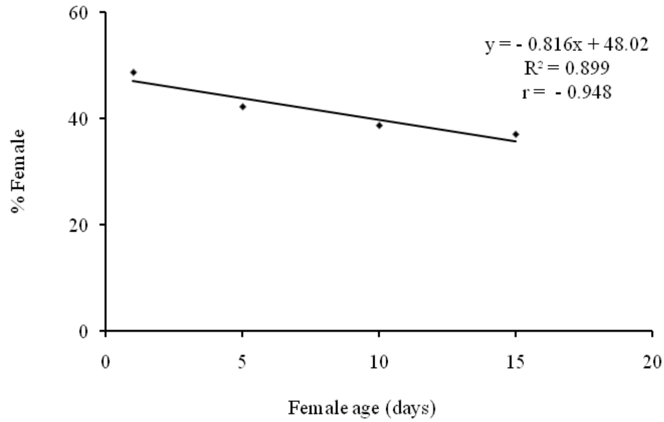

Fig. 2. Relationship between sex ratio (% female) and female age of larval parasitoid, *Bracon hebetor* reared on wax moth, *Galleria mellonella* larvae.

The progeny sex ratio of *B. hebetor* found in this study was male biased. Fuester *et al*. (2003) reported similar results for the braconid *Glypapantales flavicoxis*. The male biased sex ratio may be the result of a variety of factors, including sperm depletion, sperm death, physiological aging, active sperm digestion by the female, sperm disintegration while stored in the spermathecae, the number of copulations and the differential mortality of the sexes during larval development (Uckan & Gulel 2002, Damiens *et al*. 2003, Fuester *et al*. 2003).

Oviposition dynamic of *Bracon hebetor*: Age-specific daily fecundity was significantly affected by the age of female wasp (F13, 56 = 6.814; $P < 0.0001$) over 14 days of oviposition. Egg production per female per day was maximum when female age was 3 days, which was statistically similar to the egg number produced by 1, 2, 4, 5, 6, 7, 9 and 10 days old females. The lowest egg production was recorded when the female age was 14 days followed by 13, 12, 11, 8, 6 and 2 days old female. The findings reveal that the egg laying capacity gradually declined with age of female until the death of the parasitoid. Female oviposited up to 14 days; and over 76% of the eggs were laid within first 10 days (Fig. 3).

Furthermore, average daily fecundity was much higher on *G. mellonella* (>27 eggs) as compared to 17 eggs on *Plodia interpunctella* as reported by Yu *et al*. 1999. The differences may be explained by the possibility that *B. hebetor* females prefered to attack larger hosts and lay more eggs on them, because large host should have available resources to support their progeny (Gimire 2008). Yu *et al*.

(1999) studied the life-history of B. hebetor, on Indian meal moth, *P. interpunctella* and found that the females started laying eggs from first day after emergence and the oviposition period lasted upto 11 to 27 day. However, 65% of the total number of eggs were laid within first 10 days of the female life. Egg production rate and daily fecundity were highest when hosts were encountered daily. An average-size female, with a head capsule of 0.5-0.6 mm width that has encountered a host every day will have daily fecundity of 10-20 and a lifetime fecundity of 250-350 (Hagstrum & Smittle 1977). Host encounter rate and host feeding frequency had a greater impact on daily and lifetime fecundity.

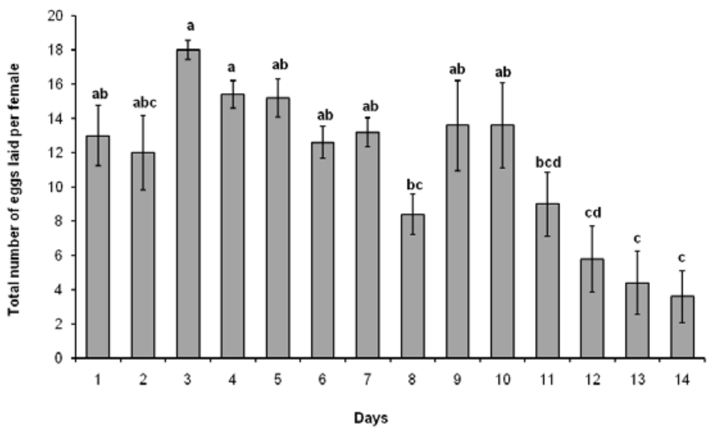

Fig. 3. Total Number of eggs (mean ± SE) laid/female/day by *Bracon hebetor* over 14-days period. Bars followed by the same letter(s) are not significantly different at 0.05 level using DMRT.

Thus the age was a critical factor affecting the progeny production and sex ratio of *Bracon hebetor*. Moreover, it was determined that the sex ratio of *B. hebetor* was male biased under laboratory conditions as only female wasps killed hosts for feeding and/or oviposition.

REFERENCES

ANTOLIN, M. F., ODE, P. J. & STRAND, M. R. 1995. Variable sex ratio and ovicide in an outbreeding parasitic wasp. *Anim. Behav*. **17**: 1-7.

ATTARAN, M. R. 1996. Effect of laboratory hosts on biological attributes of parasitoid wasp *Bracon hebetor* Say. M.S. thesis, Tarbiat Modarres University, Iran.

AWADALLAH, K. T., TAWFIK, M.F.S & ABDELLA, M.M.H. 1985. Biocycle of *Bracon hebetor* Say (Hymenoptera: Braconidae) on the wax moth *Galleria mellonella* L. (Lepidoptera: Galleridae). *Ann. Agric. Sci. Moshtohor*. **23**: 343- 350.

BROWER, J. H, SMITH, L., VAIL, P. V. & FLINN, P.W. 1996. Biological control, pp. 223- 286. In B. Subramanyam and D.W. Hagstrum (eds.), Integrated Management of Insects in Stored Products. Marcel Dekker, New York, USA.

COSKUN, M., KAYIS, T., SULANC, M. & OZALP, P. 2006. Effects of different honeycomb and sucrose levels on the development of greater wax moth *Galleria mellonella* larvae. *Int. J. Agri. Biol*. **8**(6): 855-858.

DAMIENS, D., BRESSAC, C. & CHEVRIER, C. 2003. The effect of age on sperm stock and egg laying in the parasitoid wasp, Dinarmus basalis. J. Insect Sci. **3**: 22.

DARWISH, E., EL-SHAZLY, M. & EL-SHERIF, H. 2003. The choice of probing sites by *Habrobracon hebetor* Say (Hymenoptera: Braconidae) foraging for Ephestia kuehniella Zeller (Lepidoptera: Pyralidae). *J. Stored. Prod. Res*. **39**: 265-276.

FUESTER, R.W., SWAN, K.S., DUNNING, K., TAYLOR, P.B. & RAMASESHIAH, G. 2003. Male-biased sex ratios in Glyptapantales flavicoxis (Hymenoptera: Braconidae), a parasitoid of the gypsy moth (Lepidoptera:Lymantriidae). *Ann. Entomol. Soc. Am*. **96**: 553-559.

GHIMIRE, M. 2008. Reproductive performance of the parasitoid *Bracon hebetor* say (Hymenoptera: Braconidae) on various host species of Lepidoptera, Ph.D. Dissertation, Oklahoma State University, Oklahoma, USA. 130 pp.

GODFRAY, H. C. J. 1994. Parasitoids. Behavioral and evolutionary ecology. Princeton University Press, New Jersey, U.S.A.

Gul, M. & Gulel, A.. 1995. Effect of super parasitism in the parasitoid *Bracon hebetor* (Say) (Hymenoptera: Braconidae) and the effect of host larvae size on fecundity and sex ratio. *Turkish. J. Zool* **19**: 231-235.

GULEL, A. 1982. Studies on the biology of the *Dibrachys boarmiae* (Warker) (Hymenoptera: Pteromalidae) parasitic on *Galleria mellonella* (L.). *Z. Ang. Ent*. **94**: 138-149.

GUNDUZ, E. A. & GULEL, A. 2005. Investigation of fecundity and sex ratio in the parasitoid *Bracon hebetor* Say (Hymenoptera: Braconidae) in relation to parasitoid age. *Turk J. Zool*. **29**: 291-294.

HAGSTRUM, D. W. & SMITTLE, B. J. 1977. Host finding ability of *Bracon hebetor* and its influence upon adult parasite survival and fecundity. *Environ. Entomol*. **6**: 437- 439.

HARBISON, J.L., LEGASPI, J.C., FABRITIUS, S.L., SALDA, R.R., LEGASPI, JR.B.C. & ENKEGAARD, A. 2001. Effects of age and host number on reproductive biology of *Allorhogas pyralophagus* (Hymenoptera: Braconidae) attacking the Mexican rice borer (Lepidoptera: Pyralidae). *Environ. Entomol*. **30**: 129-135.

HARVEY, J.A. & GOLS, G.J.Z. 1998. The influence of host quality on progeny and sex allocation in the pupal ecto parasitoid, *Muscidifurax raptellus* (Hymenoptera: Pteromalidae). *Bull. Entomol. Res*. **88**: 299-304.

HEIMPEL, G. E., ANTOLIN, M. F., FRANQUI, R. A. & STRAND, M. R. 1997. Reproductive isolation and genetic variation between two "strains" of *Bracon hebetor* (Hymenoptera: Braconidae). *Biol. Control*. **9**: 149- 156.

HENTZ, M.G., ELLSWORRTH, P.C., NARANJO, S.E. & WATSON, T.F. 1998. Development, longevity and fecundity of Chelonus sp. nr. curvimaculatus (Hymenoptera: Braconidae), an egg-larval parasitoid of pink bollworm (Lepidoptera: Gelechiidae). *Environ. Entomol*. **27**: 443-449.

HONDA, T. & KAINOH, Y. 1998. Age-related fecundity and learning ability of the egg-larval parasitoid *Ascogaster reticulates* Watanabe (Hymenoptera: Braconidae). *Biol. Control*. **13**: 177-181.

JAROSIK, V., HOLY, I., LAPCHIN, L. & HAVELKA, J. 2003. Sex ratio in the aphid parasitoid *Aphidius colemani* (Hymenoptera: Braconidae) in relation to host size. *Bull. Entomol. Res*. **93**: 255-258.

KEEVER, D.W., ARBOGAST, R.T. & MULLEN, M.A. 1985. Population trends and distributions of *Bracon hebetor* Say (Hymenoptera: Braconidae) and lepidopterous pests in commercially stored peanuts. *Environ. Entomol*. **14**: 722-725.

KING, B.H. 2002. Offspring sex ratio and number in response to proportion of host sizes and ages in the parasitoid wasp *Spalangia cameroni* (Hymenoptera: Pteromalidae). *Environ. Entomol*. **31**: 505-508.

TILLMAN, P.G. & CATE, J.R., 1993. Effect of host size on adult size and sex ratio of Bracon mellitor (Hymenoptera: Braconidae). *Environ. Entomol*. **22**: 1161-1165.

UCKAN, F. & GULEL, A. 2002. Age-related fecundity and sex ratio variation in *Apantales galleriae* (Hym., Braconidae) and host effect on fecundity and sex ratio of its hyperparasitoid *Dibrachys boarmiae* (Hym., Pteromalidae). *J. Appl. Ent*. **126**: 534-537.

UENO, T. 1998. Sex allocation by a parasitoid wasp (Hymenoptera: Ichneumonidae) to different host species: a question for the mechanism of host size estimation. *J. Insect Behav*. **11**: 811-821.

UENO, T. 1999. Host-size-dependent sex ratio in a parasitoid wasp. *Res. Popul. Ecol*. **41**: 47-57.

YU, S. H., RYOO, M. I. & NA, J. H. 1999. Life History of *Bracon hebetor* (Hymenoptera: Braconidae) on Plodia interpunctella (Lepidoptera: Pyralidae) on a dried vegetable commodity. *J. Asia-Pacific Entomol*. **2**(2): 149-152.

(MS received for publication 02 August 2013)

MEDEIROS, R.S., RAMALHO, F.S. LEMOS, W.P. & ZANUNCIO, J.C. 2000. Age-dependent fecundity and life-fertility tables for *Podisus nigrispinus* (Dallas) (Heteroptera: Pentatomidae). *J. Appl. Ent*. **124**: 319-324.

MILONAS, P. G. 2005. Influence of initial egg density and host size on the development of the gregarious parasitoid *HabroBracon hebetor* on three different host species. *Biocontrol*. **50**: 415-428.

MORALES-RAMOS, J.A. & CATE, R.C. 1992. Laboratory determination of age-dependent fecundity, development, and rate of increase of *Catolaccus grandi*s (Burks) (Hymenoptera: Pteromalidae). *Ann. Entomol. Soc. Am.* **85**: 469-476.

ODE, P. J., ANTOLIN, M. F. & STRAND, M. R. 1995. Brood-mate avoidance in the parasitic wasp *Bracon hebetor* Say. *Anim. Behav*. **49**: 1239-1248.

PRESS, J. W., CLINE, L. D. & FLAHERTY, B. R. 1982. A comparison of two parasitoids, *Bracon hebetor* (Hymenoptera, Braconidae) and *Venturia canescens* (Hymenoptera, Ichneumonidae), and a predator *Xylocoris flavipes* (Hemiptera, Anthocoridae) in suppressing residual populations of the almond moth, *Ephestia cautella* (Lepidoptera, Pyralidae). *J. Kans. Entomol. Soc*. **55**: 725-728.

PROZELL, S. & SCHÖLLER, M. 1998. Insect fauna of a bakery, processing organic grain and applying *Trichogramma evanescens* Westwood. Integrated Protection of Stored Products IOBC Bull. **21**: 39-44.

PUTTARUDRIAH, M. & CHANNABASAVANNA, G. 1956. A study on the identity of Habro*Bracon hebetor* Say and Bracon brevicornis Wesmael. *Bull. Entomol. Res*. **47**: 183-191.

SMITH, G.J.C. & PIMENTEL, D. 1969. The effect of two host species on the longevity and fertility of Nasonia vitripennis. *Ann. Entomol. Soc. Am*. **62**: 305-308.

SOKAL, R.R & ROHLF, F.J. 1981. *Biometry: The Principles and Practice of Statistics in Biological Research*, W. H. Freeman and Co., New York.

STRAND, M. R., WILLIAMS, H. J., VINSON, S. B. & MUDD, A. 1989. Kairomonal activities of 2-acylcyclohexane-1,3 diones produced by Ephestia kuehniella Zeller in eliciting searching behavior by the parasitoid *Bracon hebetor* (Say). *J. Chem. Ecol*. **15**: 1491-1500.

*Bangladesh j. entomol. (2013) **23**(2), 39-50* *ISSN 1021-1004*

EFFECTIVENESS OF SOME BOTANICALS AND WOOD ASH FOR THE MANAGEMENT OF ANGOUMOIS GRAIN MOTH, *SITOTROGA CEREALELLA* (OLIVER)

T. AKTER[1], M. JAHAN[2] & M. S. I. BHUIYAN[3]

[1&3]Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh. [2]Department of Entomology, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

ABSTRACT

Effectiveness of some botanicals (like neem, *Azadirachta indica*; Biskataly, Polygonum hydropiper Linn. karanja, *Pongamia pinnata*, arjun and tobacco, *Nicotina tabacum*) and wood ash for the management of Angoumois grain moth, *Sitotroga cerealella* (Olivier) in stored rice grain was studied in the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from June 2009 to November 2009. De-infested rice variety BR-11 was collected from university farm store house. The treatments were: Neem leaf powder @ 10gm / kg of rice grain (T_1); Biskatali leaf powder @ 10gm/kg of rice grain (T_2); Karanja leaf powder @ 10gm / kg of rice grain (T_3); Arjun leaf powder t @ 10gm / kg of rice grain (T_4); Tobacco leaf powder @ 10gm / kg of rice grain (T_5); Wood ash @ 10gm / kg of rice grain (T_6) and untreated control (T_7). The study was laid out in a Completely Randomized Design (CRD) with four replications. In 1st generation, the lowest percent of infestation by weight (0.00%) were observed in T_5 treated grains. The highest percent of infestation of rice grains (4.35%) were recorded from untreated grains (T_7), whereas the lowest percent of infestation of rice grains by number (0.00%) was obtained from T_2 treated rice grains. The highest percent of infestation of rice grains (16.41 %) was recorded from untreated control grains (T_7). Similar trend of infestation was also observed in 2nd and 3rd generation of the pest.

Keywords: Botanicals, Wood ash, Angoumois grain moth (*Sitotroga cerealella*), Management

INTRODUCTION

Rice is the most important cereal crop and staple food in Bangladesh. The demand for rice is constantly rising in Bangladesh with nearly 2.3 million people being added each year (Anon 2001). Maintenance of reserve food grain stocks is necessary to ensure a continuous supply at stable price. Losses due to insect infestation are the most serious problem in grain storage, particularly in the developing countries like Bangladesh. The stored grains suffer seriously from the attack of a number of stored grain insect pests. Now a-days, pest control by botanicals have been proposed as potential pest control measures in the world. Many preventive and effective control measures have been reported to minimize the loss of stored grains due to insect pests attack. At present, in many areas of the world locally available plants and plant materials have been widely used to protect stored product against damage caused by insect pest attack (Golob and Webley 1980, Talukder and Howse 1993).

Because of undesirable side effects of synthetic or chemical pesticides, this awareness has created a global interest in the development of alternative strategies, including the search for new types of insecticides including use of age-old traditional botanicals pest control agents (Heyda *et al.* 1983). In ancient times, Egyptian farmers used to mix the stored grains with fine kitchen ashes (Abdel-Gawaad and Khatab 1985). During 1690, tobacco was used as contact insecticides and in 1773 nicotine fumigation was tried (Famulu 1992). Indo-Pakistani farmers use biskatali for the control of stored grain pests, while various Nigerian tribes use roots, stems and leaves of plants (Ahmed and Khatab 1985, Ahmed and Grainge 1986).

The main advantages of botanical are that these can be easily produced by farmers, less expensive, biodegradable, broad spectrum, safe to apply and unique in action. Most of the botanical insecticides are non-hazardous and non-toxic to human. The earlier studies by different authors (Islam, 1987; Talukder and Howse 1993, 1994, Haque and Husain 1993) also reported effective performance of different plant parts and extracts against different major stored product insect pests of Bangladesh.

Few scientific research works have been done to explore locally available plant materials for the management of harmful insect pests in storage like angoumois grain moth. Present studies were undertaken to evaluate the effectiveness of some botanicals and wood ash for the management of angoumois grain moth, *Sitotroga cerealella* Olivier.

MATERIALS AND METHODS

The present study was conducted in the laboratory of the Department of Entomology, Sher-e- Bangla Agricultural University (SAU), Dhaka, Bangladesh during the period from April 2010 to September, 2010. For the study the de-infested rice variety BR-11, collected from farm's store house of SAU was used. The leaves of neem (*Azadirachta indica*), biskatali (Polygonum hydropiper Linn), karanja

(*Pongamia pinnata*) and arjun (*Terminalia arjuna*) were used for the study. These were collected from trees grown around the university campus. The tobacco leaves were purchased from the local market. The wood ash was collected from farmer's house. The insect *S. cerealella* (Olivier) was reared from pure culture on rice of BR-11 to ensure the continuous supply of adults in the laboratory of Entomology Department. The details of the experiments including the rearing of the test insect on de-infested grains and application of different botanicals are furnished below:

Male and female moths were sorted under a simple microscope by their abdominal tergites and size of the body. One hundred pairs of *S. cerealella* (Olivier) were introduced into a plastic containers (26 cm height x 110 cm diameter) containing1 kg of de-infested rice grains. The mouth of the container was covered by fine mesh nylon nets and kept in the laboratory at prevailing temperature and relative humidity. The insects were allowed to mate and lay eggs for seven days and then the adults were removed. The rice grains with eggs were kept for 25 days to develop into adults. One- day old adults were separated from rice grains and were used for the study. Before artificial infestation of rice grains with moths, the rice grains of BR-11 variety was dried in the sun for de-infestation as suggested by Nawab *et al.* (1980). Petri-dishes (1.0 cm height X 6 cm diameter) were used for the study. Fifty gram rice seeds were taken in each Petri-dish. Firstly, leaves were washed in running water in the laboratory. Then the plant materials were kept in the shady open place for air-drying and then were dried in the oven at 60^{o}C to gain constant weight. Dusts were prepared by grinding the dried leaves with the help of a grinder. Then dusts were passed through a 25-mesh sieve to obtain fine and uniform dust. The dusts were preserved in airtight condition in polythene bags till its use for extract preparation as described by Chitra *et al.* (1993).

Treatments were: T_1: Neem leaf powder @ 10gm / kg of rice grains were mixed with seeds on the upper layer; **T_2**: Biskatali leaf powder @ 10gm/kg of rice grains were mixed with seeds on the upper layer; **T_3**: Karanja leaf powder @ 10gm / kg of rice grains mixed with seeds on the upper layer; **T_4**: Arjun leaf powder @ 10gm / kg of rice grains mixed with seeds on the upper layer; **T_5**: Tobacco leaf powder @ 10gm / kg of rice grains mixed with seeds on the upper layer; **T_6**: Wood ash @ 10gm / kg of rice grains mixed with seeds on the upper layer; **T_7**: untreated control.

Leaves powder were mixed with rice grains on the upper layer of seeds in each Petri dish at the rate of 10 gm/kg. Afterwards 5 pairs of adult moth (male & female) were released in each Petri dish. There were 4 replications considering each Petridis as a replication. The significance of the difference among the treatment means was estimated by the least significant difference (LSD) test at 5% level (Gomez and Gomez 1984). Data on healthy and infested rice grain by weight and by number were recorded and % infestation and reduction of infestation over control was estimated. The study was made in three consecutive generations of insects separately. So in this study two more sets with 4 replications were taken. First set for 1st generation, 2nd set for 2nd generation and 3rd set for 3rd generation were observed, respectively.

To determine the per cent of damaged rice seeds, number of seeds having hole and normal seeds were counted per Petri dish or replicate and per cent of damaged seeds were calculated by using the following formula:

$$\% \text{ of damaged seeds in no.} = \frac{\text{Total no. of seeds - no .of healthy seeds}}{\text{Total no. of seeds}} \times 100$$

$$\% \text{ Infestation (by Number)} = \frac{\text{Number of infested seeds}}{\text{Total Number of seeds}} \times 100$$

$$\% \text{ Infestation (by weight)} = \frac{\text{Weight of infested seeds}}{\text{Total weight of seeds}} \times 100$$

$$\% \text{ Infestation reduction} = \frac{(\% \text{ Infestation in control - \% Infestation in the concerned treatment})}{\% \text{ Infestation in control}} \times 100$$

RESULTS

A statistically significant variation was recorded for healthy, infested and percent of infestation by weight and number of rice grain for 1st generation of Angoumois grain moth in stored rice grain due to application of botanicals and wood ash (Table 1). The highest weight of healthy rice grain (50.00 g) was recorded from T_5 (Tobacco leaf powder @ 10gm / kg of rice grains mixed with seeds on the upper layer) treated grain, while the lowest weight (41.75 g) was found in untreated control (T_7). Accordingly the lowest weight of infested rice grains (0.0 g) was obtained from T_5 treated grains and the highest weight (1.90 g) from untreated control treatment (T_7). The percent grain infestation by weight was the lowest (0.00%) in T_5 treated grains which was followed by T_1 (Neem leaves dust @ 10 gm/kg of rice grains) and T_6 (Wood ash @ 10gm / kg of rice grains mixed with seeds) treatment (1.02%), respectively. The highest infested grains (4.35 %) were recorded in untreated control grain which was followed by T_4 (Arjun leaves dust @

10 gm/kg of rice grains), (3.08 %). Rice grain infestation reduction over control by weight was estimated and the highest value (100 %) was found from the T_5 treated grains and the lowest value (85.37%) from T_6 (Wood ash @ 10gm / kg of rice grains mixed with seeds) treated grains. Significantly the highest number of healthy grain (1452) was recorded from T_5, while the lowest number (1219) was in untreated control.

Table 1. Effect of botanicals and wood ash for the management of Angoumois grain moth in stored rice grain in 1st generation

*Treatments	Total weight of seeds				Total number of seeds			
	Healthy (gm)	Infested (gm)	Infestation (%)	Infestation reduction over control (%)	Healthy (No.)	Infested (No.)	Infestation (%)	Infestation reduction over control (%)
T_1	48.63 b	0.50 e	1.02 e	76.55	1414 b	36 d	2.50 d	84.77
T_2	46.75 c	1.00 d	2.09 d	51.95	1360 c	95 c	6.50 c	60.39
T_3	46.25 c	1.15 c	2.43 c	44.14	1358 c	98 c	6.71 c	59.11
T_4	44.85 d	1.42 b	3.08 b	29.20	1310 d	149 b	10.21 b	37.78
T_5	50.00 a	0.00 f	0.00 f	100.00	1452 a	0.00 e	0.00 e	100.00
T_6	48.75 b	0.50 e	1.02 e	76.55	1419 b	36 d	2.4 d	85.37
T_7	41.75 e	1.90 a	4.35 a	--	1219 e	239 a	16.41 a	--
$LSD_{(0.05)}$	0.759	0.133	0.290	--	11.08	11.12	0.764	--
Significance level	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV (%)	8.09	9.41	9.80	--	6.55	8.11	8.12	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 levels of probability and numeric data represent the mean value of 4 replications

*T_1: Neem leaves dust @ 10 gm/kg of rice grains
T_2: Biskatali leaves dust @ 10 gm/kg of rice grains
T_3: Karanja leaves dust @ 10 gm/kg of rice grains
T_4: Arjun leaves dust @ 10 gm/kg of rice grains
T_5: Tobacco leaves dust @ 10 gm/kg of rice grains
T_6: Wood ash @ 10 gm/kg of rice grains
T_7: Control

The lowest number of infested rice grain (0.00) was recorded from T_5 treated grains and the highest number (239) obtained from untreated control grains. The lowest infested rice grains by number (0.00 %) were observed from T_5 (Tobacco leaf powder @ 10gm / kg of rice grains were mixed with seeds) treatment which was closely followed by that of T_6 (2.4%). The highest infested grains (16.41%) was obtained in the grains of untreated control (T_7) and this was statistically different form that of T_4 (10.21%), T_3 (6.71%) and T_2 (6.50%). Rice grain infestation reduction over control by number was estimated and the highest value (100%) was found from the T_5 treated grains and the lowest value (37.78%) from T_4 (Arjun leaf powder @ 10gm / kg of rice grains mixed with seeds on the upper layer) treated grains.

In case of 2nd generation by weight basis, the highest healthy seeds was recorded from T_5 (50.00 g) treatment which was closely followed by those of T_1 and T_6 (47.25 g and 47.13 g, respectively). The lowest was in untreated control (34.88 g) which was again closely followed by T_4 (43.75 g) treatment. In case of infested seeds, there were no infested seeds recorded from T_5 which was followed (1.00 g) by T_1 and T_6, respectively. The highest was recorded from untreated control (T_7), (3.13 g) which was followed by T_4, T_2 and T_3 (1.95 g, 1.88 g and 1.77 g, respectively treated grains. In case of % infestation, the highest infestation was found from untreated control T_7 (8.24%) treatment which was compareable to that of T_4, T_2 and T_3 (4.27%, 3.98% and 3.78%) respectively treatments, whereas no infestation was observed in T_5 treatment which was followed by T_1 and T_6 (2.07% and 2.08%, respectively) treatments. The highest infestation reduction over control was recorded in T_5 (100.00%) treatment and lowest was in T_4 (48.18%) treatment (Table 2).

In 2nd generation by number basis, the highest number of healthy seeds was recorded from T_5 (1453) treatment which was followed by (1373 and 1371) in T_6 (1373) and T_1 (1371) treated grains. The lowest (1018) was recorded in untreated control treatment and this was followed by T_4 treatment (1275). In case of infested seeds, there were no infested seeds were recorded from T_5 treatment and this was followed by T_1 (81) and the highest number was recorded in T_7 (439) treatment which was followed by T_4 treatment (181). In case of % infestation, the highest infestation (30.13%) was found from untreated control which was followed (12.45%) by T_4, there was no infestation observed in T_5 treated grains. Accordingy the highest infestation reduction over control (100.00%) was recorded in T_5 treatment, while the lowest was in T_4 treatment (58.68%) (Table 2).

Table 2. Effect of botanicals and wood ash for the management of Angoumois grain moth in stored rice grain in at 2nd generation

	Total weight of seeds				Total number of seeds			
*Treatments	Healthy (gm)	Infested (gm)	Infestation (%)	Infestation reduction over control (%)	Healthy (No.)	Infested (No.)	Infestation (%)	Infestation reduction over control (%)
T_1	47.25 b	1.00 c	2.07 c	74.88	1371 b	81 d	5.56 d	81.55
T_2	45.25 c	1.88 b	3.98 b	51.70	1318 c	137 c	9.39 c	68.84
T_3	45.13 c	1.77 b	3.78 b	54.13	1314 c	141 c	9.71 c	67.77
T_4	43.75 d	1.95 b	4.27 b	48.18	1275 d	181 b	12.45 b	58.68
T_5	50.00 a	0.00 d	0.00 d	100.00	1453 a	0.00 e	0.00 e	100.00
T_6	47.13 b	1.00 c	2.08 c	74.76	1373 b	85 d	5.83 d	80.65
T_7	34.88 e	3.13 a	8.24 a	--	1018 e	439 a	30.13 a	--
LSD(0.05)	0.836	0.225	0.602	--	24.83	24.13	1.670	--
Significance level	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV(%)	7.26	9.83	11.62	--	5.28	10.68	10.77	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability and numeric data represents the mean value of 4 replications

*T_1: Neem leaves dust @ 10 gm/kg of rice grains
T_2: Biskatali leaves dust @ 10 gm/kg of rice grains
T_3: Karanja leaves dust @ 10 gm/kg of rice grains
T_4: Arjun leaves dust @ 10 gm/kg of rice grains
T_5: Tobacco leaves dust @ 10 gm/kg of rice grains
T_6: Wood ash @ 10 gm/kg of rice grains
T_7: Control

Incase of 3rd generation by weight basis, the highest healthy seeds was recorded from T_5 (50.00 g) treated grains which was closely followed by T_6 (46.00 g) and T_1 (45.88 g) treatments. The lowest was recorded in untreated control (28.25 g) treatment which was followed by T_4 (40.13 g) treatment. In case of infested seeds, no infested seeds were found in T_5 which was followed by T_6 (1.35g) and T_1 (1.42 g) treatments. The highest was recorded in untreated control (4.50 g) treatment which was followed by T_4 (2.85 g) treatment. In case of % infestation, the highest infestation was attained in T_7 (13.74%) treatment. which was closely followed by T_4 (6.63%) treatment. There was no infestation was recorded in T_5 treatment which was followed by T_1 (3.01%) and T_6 (2.85%) treatments. The highest infestation reduction over control was found in T_5 (100.00%) and lowest from T_4 (51.75%) treatment (Table 3).

Table 3. Effect of botanicals and wood ash for the management of Angoumois grain moth in stored rice grain in at 3rd generation

	Total weight of seeds				Total number of seeds			
*Treatments	Healthy (gm)	Infested (gm)	Infestation (%)	Infestation reduction over control (%)	Healthy (No.)	Infested (No.)	Infestation (%)	Infestation reduction over control (%)
T_1	45.88 b	1.42 d	3.01 d	78.09	1371 b	81 d	5.56 d	81.55
T_2	43.88 c	2.30 c	4.98 c	63.76	1318 c	137 c	9.39 c	68.84
T_3	43.70 c	2.28 c	4.95 c	63.97	1314 c	141 c	9.71 c	67.77
T_4	40.13 d	2.85 b	6.63 b	51.75	1275 d	181 b	12.45 b	58.68
T_5	50.00 a	0.00 e	0.00 e	100.00	1453 a	0.00 e	0.00 e	100.00
T_6	46.00 b	1.35 d	2.85 d	79.26	1373 b	85 d	5.83 d	80.65
T_7	28.25 e	4.50 a	13.74 a	--	1018 e	439 a	30.13 a	--
LSD(0.05)	0.519	0.215	0.486	--	24.83	24.13	1.670	--
Significance level	0.01	0.01	0.01	--	0.01	0.01	0.01	--
CV(%)	9.82	6.98	6.32	--	6.91	4.78	4.84	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability and numeric data represents the mean value of 4 replications

* T_1: Neem leaves dust @ 10 gm/kg of rice grains
T_2: Biskatali leaves dust @ 10 gm/kg of rice grains
T_3: Karanja leaves dust @ 10 gm/kg of rice grains
T_4: Arjun leaves dust @ 10 gm/kg of rice grains
T_5: Tobacco leaves dust @ 10 gm/kg of rice grains
T_6: Wood ash @ 10 gm/kg of rice grains
T_7: Control

On the other hand at 3rd generation by number basis, the highest number of healthy seeds (1453) was recorded from T_5 treatment which was closely followed by T_6 (1339) and T_1 (1331). The lowest (825) was found in T_7 (untreated control) treatment. In case of infested seeds, there were no infested were recorded from T_5 which was followed by 115 and 120 in T_6 and T_1, respectively and the highest number (630) was observed in T_7 which was followed by 285 in T_4 treatment. In case of % infestation, the highest infestation (43.31%) was recorded from T_7 (untreated control) which was followed by 19.60% in T_4, while no infestation was recorded from T_5 treated grains and this was followed by (7.96%) by in T_6 treatment. The highest infestation reduction over control (100.00%) was observed in T_5 and lowest (54.74%) was recorded from T_4 treatment (Table 3).

DISCUSSION

From the present study it was observed that tobacco leaves powder @ 10 gm/kg of rice grains (T_5) treatment was the most effective than all other treatments for the management of *S. cerealella*. But rests this treatments of the present study were also to some extent effective for the suppressing of this pest.

Considering the results of the study the effectiveness of different botanicals and wood ash for the management of angoumois grain moth, *Sitotroga cerealella* (Olivier) in stored rice grain were in order of Tobacco leaves powder > wood ash > neem leaves powder > Biskatali leaves powder > Karanja leaves powder > Arjun leaves powder.

The effectiveness of botanicals and wood ash obtained in the present investigation is in agreement with the results obtained by Siddika (2004), Hill (1990), Chatterjee (1984), Facknath and Sunita (2006). Siddika (2004) reported that neem leaves powder reduced the loss of grain weight and percentage of infestation by angoumois grain moth in unhusked rice grain in storage. Hill (1990) reported that wood ash was useful as a physical barrier on the grain, but it can also possess various chemical properties according to its botanical source. Chatterjee (1984) revealed that the ashes and sand which were widely used acted as hygroscopic substances and reduced the moisture content of the commodities to some extent with which they were mixed and indirectly affected the insect multiplication. Facknath and Sunita (2006) reported that neem (*Azadirachta indica* A. Juss.) has been demonstrated to reduce insect populations infesting stored products through its toxic and growth- disrupting and other effects on the pests. These results were different from the findings observed by some others researchers (Akter 2009, Rahman *et al.* 1999). Akter (2009) also reported that neem oil was most toxic and effective and ranking next to Malathion for suppressing of angoumois grain moth, *S. cerealella*. Rahman *et al.* (1999) evaluated the extracts and powder of Urmoi, Neem and Turmeric for their repellency, feeding deterrence, direct toxicity and residual effects against the storage grain pests.

In the present study, the results obtained are very encouraging and there is a great potential for the use of tobacco, neem leaf powder and wood ash as a botanical agents in storage pest like *Sitotroga cerealella* management in our country.

CONCLUSION

Considering the percent healthy and infested rice grain both by weight and by number and percent infestation reduction over control the treatment with tobacco leaf powder @ 10gm / kg of rice grains mixed with seeds on the upper layer (T_5) was the most effective among the all other treatments for the management of angoumois grain moth infesting stored rice grains.

REFERENCES

ABDEL-GAWAAD, A.A. & KHATAB, H.A. 1985. Soil and Plant protection methods in ancient Egypt. Second Inter. Congr. *Soil Poll. Part II*. pp. 19 - 20.

AHMED, S., GRAINGE, M., HYLIN, J.W., MITCHEL, W. C. & LITSINGER, J. A. 1984. Some promising plant species for use as pest control agents under traditional farming systems. *In Proc. 2nd Int. Neem Conf. Rauisch Halzhousen Castle, W. Germany*, pp. 565-580.

AKTER, A. 2009. Efficacy of different plant oils and Malathion for the control of rice moth (*S. cerealella* oliv.) on stored rice grain. *MS thesis*. Department of Entomology. Bangladesh Agricultural University. Mymensingh.

ANON. *2001.Year Book of Statistics of Bangladesh*. Bureau of Statistics. Statistics Division, Ministry of Planning, Government of the People's of Bangladesh, 136 p.

BBS (Bangladesh Bureau of Statistics). 2006. *Statistical Yearbook of Bangladesh* (26th ed.). Bangladesh Bureau of Statistics, Planning Division, Ministry of Planning, Government of the people's republic of Bangladesh, Dhaka. 614 pp.

CHATTERJEE, S. 1984. Effect of some inert dusts on *Trogoderma granaria* Evert, *Indian J. Ent*. **16**: 423 - 425.

CHITRA, K.C., RAO, K.P. & NAGALAH, K. 1993. Field evaluation of certain plant products in the control of brinjal pest complex. *Indian J. Entomol*. **55**(3): 237-240.

FACKNATH, J. & SUNITA, D. 2006. Combination of neem and physical disturbance for the control of four insect pests of stored products. *International J. Trop. Insect Sci*., **26** (1): 16 -17.

FAMULU, B.J. 1992. Residual toxicity of three plant materials against three storage insect pests. College Languna, Philippines. Dept. of Entomology. 29p.

GOLOB, P. & WEBLEY, D. J. 1980. The use of plants and minerals as traditional protectants of stored products. *Tropical Products Institute*, London.32p.

HAQUE MA. & HUSSAIN M 1993. Oviposition preference and growth of pulse beetle on some species of pulses. *Bangladesh J. Nuclear Agric*. **9**: 47 - 53.

HEYDE, J.V.D., SAXENA, R.C. & SCHUMUTTERER, H.1983. Neem oil and Neem extracts as potential insecticides for control of Hemipterous rice pests. In: Proc. 2^{nd} Int. Neem Crof. Rauischholzhausen, Germany, 1982, pp. 337-390.

HILL, D. S. 1990. Pests of stored products and their Control. Belhaven Press. London. pp. 206 - 261.

ISLAM, S. 1997. Field Ecology Pest Status and Management of Rice hispa (*Dicladispa armigera*) in Bangladesh. PhD thesis, School of Environment Resources and Development, *Asian Ins. of Technology*, Bangkok, Thailand. pp. 130.

NAWAB, A., LIYAS, S. M & ALAM, A. 1980. Crop dryers, use of solar energy and agricultural waste. *Tech. Bull.* CIAF, Bhopal (India) No. CIAF/80 - 12, 67p.

RAHMAN, M.L. HOSSAIN, M. & AHMED, M.1999. Repellent effect of urmoi, neem and turmeric extracts against rice weevil and granary weevil. *Bangladesh J. Entomol*. **9**(1-2): 9 -16.

SIDDIKA, A. 2004. Efficacy of some additives for suppressing Rice moth (*S. cerealella*) in stored rice. MS thesis. Department of Entomology. Bangabandhu Shekh Mojibur Rahman Agricultural University. Salna Gazipur.

TALUKDER, F.A. & HOWSE, P.E. 1993. Deterrent and insecticidal effects of extract of pithraj, *Aphanamixis polystachya against Tribolium castaneum* in storage. *J. Chem. Ecol*. **19**(11): 2463-2471

TALUKDER, F.A.&HOWSE, P.E. 1994. Laboratory evaluation of toxic and repellent properties of the pithraj, *Aphanamixis polystachya* wall. against *Sitophilus oryzae* L. *Int. J. Pest Management*. **41**(3):274 - 279.

(MS received for publication 18 August 2013)

Bangladesh j. entomol. (2013) ***23****(2), 51-64* *ISSN 1021-1004*

EFFECT OF DIFFERENT TRAPS ON THE INCIDENCE AND MANAGEMENT OF CUCURBIT FRUIT FLY, *BACTROCERA CUCURBITAE*

M. ISLAM, M. A. LATIF*, M. ALI & S. YEASMIN

Department of Entomology, Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh.

ABSTRACT

A field study was conducted at Sher-e-Bangla Agriculture University farm to find out effect of different traps on the incidence and management of cucurbit fruit fly, *Bactrocera cucurbitae* during November 2012 to April 2013. The treatments of the experiment were Pheromone trap (Plastic pot), GME pheromone water trap, Sticky trap, Bait trap, Funnel Pheromone trap, Light trap, Bait trap + Pheromone trap (Plastic pot) and Untreated control. The study was laid out in Randomized Complete Block Design (RCBD) with three replications. Results showed that, Bait trap + Pheromone trap (plastic pot) was the most effective treatment for early (1.88), mid (3.00), late (1.92) and total (6.80) number of adult trapped/plot and no adult was caught in Control plot, Sticky trap and Light trap. Bait trap in combination with Pheromone trap (plastic pot) gave the best result for total number of healthy fruit/plot (6.33), highest percent increase of yield by number (111.11%), weight of healthy fruit/plot (8.61kg) and percent increase of yield by weight (438.9%) followed by Funnel Pheromone trap, Pheromone trap (plastic pot), Bait trap and GME water Pheromone trap. The lowest number of healthy fruit/plot (3.00/plot) and healthy fruit weight (1.64 kg/plot) was obtained from untreated control plot. Sticky trap and Light trap had no effect on capturing adult fruit fly and gave the similar yield to that of untreated control. Pheromone trap (plastic pot) in combination with Bait trap may be used for the management of fruit fly attacking cucurbitaceous vegetables.

Keywords: Fruit fly, Different traps, Management, Yield

INTRODUCTION

Bangladesh is predominantly an agriculture based country. But it has a huge deficit in vegetable production. A large number of cucurbit vegetables, viz., bottle gourd, bitter gourd, sweet gourd, snake gourd, sponge gourd, kakrol, cucumber etc. are grown in Bangladesh. Bangladesh produced 103 thousand tons of sweet gourds in

*Corresponding author: E-mail: mdalatif15@yahoo.com

the winter season and 77 thousand tons in the summer season of 2006-2007 (BBS 2010).

Insect pest infestation is a major problem of crop production in Bangladesh. It reduces yield and marketable quality of the produce and thereby farmers face huge financial loss. Fruit fly, *Bactrocera cucurbitae* (*Coquillett*) is a major pest causing yield loss in cucurbits, and infests 15 kinds of cucurbit vegetables grown in Bangladesh (Rakshit *et al*. 2011). The Cucurbit fruit fly, *B. cucurbitae* represents 74.5% of the total number of flies infesting different vegetables growing areas in Bangladesh (Akhtaruzzaman *et al*. 1999). It prefers young, green, and tender fruits for egg laying. The fruits attacked in early stages fail to develop properly, and drop or rot on the plant. Considering previous facts and reports, it is apparent that more than 50% of the cucurbits are either partially or totally damaged by fruit flies and are unsuitable for human consumption. Due to its nature of infestation, it is very difficult to control the pest. A cluster method have been developed and suggested by Kapoor (1993) to control these pests using various cultural, physical, chemical, biological and legal methods. Among all these methods, the chemical control method is still popular to the Bangladeshi farmers for its quick and visible results. The increasing use of synthetic insecticides has led to a number of problems such as development of resistance to insecticides, high insecticide residues in market produce, resurgence, ecological imbalance and danger to health of the pesticide applicator. Considering the alarming consequences of pesticide usage and residual effect on the environment, pragmatic programme is now needed worldwide to minimize the dependency on insecticides without hampering crop production. Although, several management options, such as hydrolyzed protein spray, para-Pheromone trap, spraying of ailanthus and cashew leaf extract, neem products, bagging of fruits, field sanitation, food baits, and spray of chemical insecticides (Dhillon *et al*. 2005, Akhtaruzzaman *et al*. 2000, Neupane 2000, YubakDhoj & Mandal 2000, Pawar *et al*. 1991) have been in use for the management of cucurbit fruit fly, some of them either fail to control the pest and/or are uneconomic and hazardous to non-target organisms and the environment (Dhillon *et al*. 2005, Neupane 2000).

However, an effective and cheap management strategy against this pest has already been developed, which comprises of sanitation and use of pheromone mass trapping. Fruit fly infestation was reduced by 53 to 73 percent and yields were raised up to 1.4 to 2.3 times using the traps (Anon. 2003). Farmers in Bangladesh have shown strong interest in adopting the pheromone lure for monitoring of peak pest infestation periods as well as for mass trapping. These are effective to minimize fruit fly damage, and reduce the use of toxic insecticides. To monitor the fruit fly population, Pheromone trappings have been successfully used in different countries (Gillani *et al*. 2002, Marwat & Baloch 1986). Therefore, the present study was undertaken to identify the most effective trap for the management of fruit fly in the field and to establish an environmentally safe control measure against the pest.

MATERIALS AND METHODS

Experimental design and crop cultivation: The present study was conducted in the experimental farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207, during November 2012 to April 2013. The soil of the experimental field was a medium high land, clay loam having PH of 5.47-5.63. It had shallow red brown terrace soil. The study was conducted with eight treatments. The experiment was laid out in a Randomized Complete Block Design (RCBD). The entire experimental field was divided into three blocks. Each block was divided into eight plots. Two adjacent unit plots and blocks were separated by 1m. Each experimental plot comprised of 3m × 3m area and the total area covered 12m x 20.5m. Each treatment was allocated randomly within the block and replicated three times. Seeds of sweet gourd (local) were collected from Agargoan Bazar, Dhaka. Seeds were sown in the plots at the rate of 6seeds/plot (three seeds per pit and 2 pits per plot). Regular irrigation was done after sowing. Finally three healthy plants were kept in each pit. Damaged and virus infected seedlings were replaced by new one.

Treatments: The comparative effectiveness of the following eight treatments against Cucurbit fruit fly was evaluated for their incidence and management: 1.Pheromone trap (Plastic pot), 2. GME pheromone water trap, 3. Sticky trap, 4. Bait trap, 5. Funnel Pheromone trap, 6. Light trap, 7. Bait trap + Pheromone trap (Plastic pot), 8. Only water in plastic pot as untreated control. The pheromone, Cuelure and GME pheromone water traps were collected from SAFE Agro Ltd. Other trap materials were collected from local market. The poison bait was prepared from mashed sweet gourd mixed with water and Sevin 50WP at the rate of 2g per 100g of mashed sweet gourd. Cuelure was set for three months, mashed sweet gourd and grease was changed twice a week. The soap water in the Pheromone traps was changed weekly.

Data collection and analysis: After each harvest the data on the number of healthy and infested fruits were recorded from each treatment. After harvesting the healthy fruits (HF) and the infested fruits (IF) were separated by visual observation. After harvesting, the weight of healthy fruits and infested fruits were separately recorded. The total yield under each treatment was finally converted to determine the yield (t/ha). The percent increase and decrease of yield over control was also calculated. The number of adult fly captured twice per week in different traps and recorded. Data were analyzed by MSTAT software and the means were compared according to Duncan's Multiple Range Test (DMRT) at 5% level of significance. Moreover, the graphical work was done using Microsoft Excel program.

RESULTS AND DISCUSSION

Trends of adult fruit fly captured in different traps: The number of adult fruit fly captured/trap in the experimental plot in different dates in different traps was shown in Fig. 1. The graph demonstrated that Bait trap + Pheromone trap (Plastic pot) showed the best performance capturing adult fruit fly throughout the cropping season. Almost same levels of adult fruit fly were caught in Funnel Pheromone trap. Pheromone trap (Plastic pot), GME pheromone water trap and Bait trap showed intermediate level of catch among different traps. No adult fruit fly was caught in Sticky trap and Light trap during the study period.

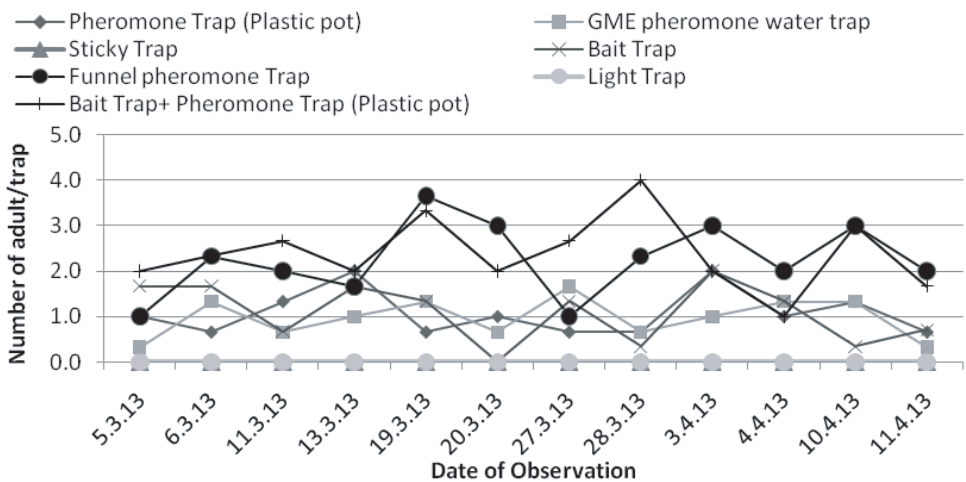

Fig. 1. Trends of adult fruit fly captured per trap in different dates of March and April 2013.

Effect of different traps on capturing adult cucurbit fruit fly: The result revealed that the highest number of adult fruit fly (1.88) was captured at early fruiting stage in Bait trap+ Pheromone trap (Plastic pot) followed by 1.57 in Funnel Pheromone trap, 1.42 in Bait trap and 1.25 in Pheromone trap (plastic pot) having no significant difference among them (Table 1). The data in Table 1 also expressed that the highest number of adult fruit fly (3.00) was captured at mid fruiting stage in Bait trap+ Pheromone trap (Plastic pot) followed by 2.50 in Funnel Pheromone trap and 1.50 in Bait trap having no significant difference among them. Similarly, the highest number of adult fruit fly (2.50) was trapped in Funnel Pheromone trap during late fruiting stage followed by 1.92 in Bait trap + Pheromone trap (Plastic

Table 1. Number of adult fruit fly captured per plot in various traps at different growing stages of sweet gourd

Treatments	Number of adult/plot at early fruiting stage	Number of adult/plot at mid fruiting stage	Number of adult/plot at late fruiting stage	Total number of adult/ plot
Pheromone trap (Plastic pot)	1.25 ab	0.75 cd	1.25 abc	3.25 b
GME pheromone water trap	0.83 b	1.08 cd	1.00 bc	2.92 bc
Sticky trap	0.00 c	0.00 d	0 .00 c	0.00 c
Bait trap	1.42 ab	1.50 bc	1.08 bc	4.00 ab
Funnel Pheromone trap	1.57 a	2.50 ab	2.50 a	6.57 a
Light trap	0 .00 c	0.00 d	0 .00 c	0.00 c
Bait trap+ Pheromone trap (Plastic pot)	1.88 a	3.00 a	1.92 ab	6.80 a
Only water in plastic pot (Control)	0.00 c	0.00 d	0.00 c	0.00 c
LSD(0.05)	0.59	1.29	1.29	2.75
Level of significance	*	*	*	*

In a column, means with same letter(s) are not significantly different by DMRT at 5% level of significance.

* indicates significant at 5% level.

pot) and 1.25 in Pheromone trap (plastic pot) having no significant differences among them. But no adult fruit fly was trapped in Sticky trap, Light trap and Untreated control plot at early, mid or late fruiting stage. Considering total cropping period, the highest number of adult fruit flies (6.80) were trapped in Bait trap+ Pheromone trap (Plastic pot) followed by 6.57 in Funnel Pheromone trap and 4.00 in Bait trap having no significant difference among them. The intermediate number of adult fruit flies (3.25) recorded from Pheromone trap (plastic pot) which was statistically similar to that of other traps. No adult fruit fly was trapped in Sticky trap, Light trap and untreated control plot which was statistically similar to that of GME pheromone water trap (2.92).

The result partially agrees with the findings of Verghese *et al*. (2005) who reported that cuelure attracted the fruit flies 13.5 flies/day/trap. It also agrees with the reports of Hossen (2012) who observed that Pheromone trap with funnel + Bait trap was the most effective in capturing the adult fruit fly and Pheromone trap with funnel showed the second highest performance.

Effect of different traps on healthy and infested fruit production during total cropping season: The highest number of healthy fruits/plot (6.33) was recorded from Bait trap + Pheromone trap (plastic pot) treated plot followed by 5.67 in Funnel Pheromone trap with no significant difference between them. The intermediate number of healthy fruits/plot (4.33 - 4.67) was recorded from Pheromone trap (Plastic pot), Bait trap and GME pheromone water trap (4.67) having no significant difference among them. The equal number of healthy fruits/plot (3.00) was obtained from Sticky trap, Light trap and Untreated control plot which was significantly lower than other treatments. Similarly in case of per cent increase of number of fruits over control, Bait trap + Pheromone trap (plastic pot) gave the best result (111.1%) having no significant variation from that of Funnel Pheromone trap (88.89%) (Table 2) but significantly differed from others. On the other hand, no increment occurred in Sticky trap and Light trap. Further, 55.55% increase of fruit over control was obtained from Pheromone trap (Plastic pot), and Bait trap which was statistically similar that of GME pheromone water trap (44.44%) but significantly higher than that of Sticky trap and Light trap and lower than Bait trap + Pheromone trap (plastic pot) and Funnel Pheromone trap.

The lowest number of infested fruits/plot (1.00) was recorded from Funnel Pheromone trap which was statistically identical to that of Bait trap + Pheromone trap (plastic pot), Bait trap and Pheromone trap (Plastic pot) (Table 2). The highest number of infested fruit/plot (3.33) was recorded from untreated control plot. The intermediate number of infested fruit/plot (2.67) was recorded from Light trap and Sticky plot followed by 1.67 in GME pheromone water trap) which were statistically similar. The data (Table 2) also expressed that the highest per cent decrease of fruit infestation (69.44%) was found in Funnel Pheromone trap followed by 61.80% in Bait trap + Pheromone trap (plastic pot), 61.11% in T_1 (Pheromone trap (Plastic pot)) and T_4 (Bait trap), and 47.22% from GME pheromone water trap which were statistically similar. The lowest result (16.67%) was observed in Sticky trap plot and Light trap (19.44%) having no significant difference between them but significantly lower than others.

Table 2. Effect of different traps on the production of healthy and infested fruit caused by cucurbit fruit fly during total cropping season

Treatments	Number of healthy fruit/plot	% increase of healthy fruit over control by number	Number of infested fruit/plot	% decrease of infested fruit over control by number
Pheromone trap (Plastic pot)	4.67 b	55.55 b	1.33 c	61.11 a
GME pheromone water trap	4.33 b	44.44 b	1.67 bc	47.22 ab
Sticky trap	3.00 c	0.00 c	2.67 ab	16.67 b
Bait trap	4.67 b	55.5 b	1.33 c	61.11 a
Funnel Pheromone trap	5.67 a	88.89 a	1.00 c	69.44 a
Light trap	3.00 c	0.00 c	2.67 ab	19.44 b
Bait trap+ Pheromone trap (Plastic pot)	6.33 a	111.1 a	1.33 c	61.8 a
Only water in plastic pot (Control)	3.00 c	----	3.33 a	------
LSD(0.05)	0.81	29.42	1.00	30.48
Level of significance	*	*	*	*

In a column, means with same letter(s) are not significantly different by DMRT at 5% level of significance.

* indicates significant at 5% level.

Result of this experiment agrees with the findings of Hossen (2012) who reported that Pheromone trap with funnel + Bait trap showed the best performance and Pheromone trap with funnel only showed the second highest performance in terms of healthy, infested and total fruit production by controlling cucurbit fruit fly.

Relationship between numbers of adult trapped/plot and total number of infested fruit by different traps: The relationship between the number of adult trapped/plot and total number of infested fruit in different traps is shown in Fig. 2. The result revealed that there was negative relationship between the numbers of adult trapped/plot and total number of infested fruit in different trap. This suggested that with the increase of average fruit fly captured by different traps there was a decrease of total number of infested fruits.

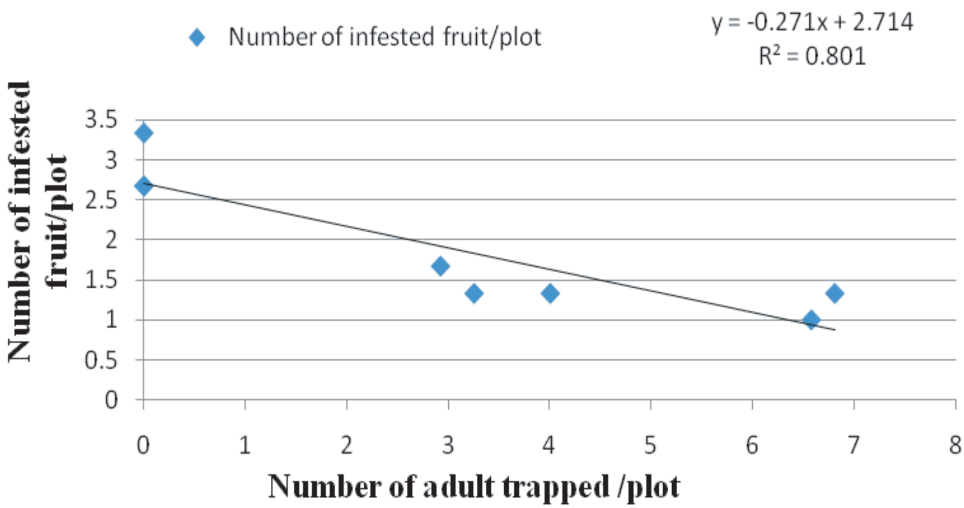

Fig. 2. Relationship between number of adult trapped /plot and total number of infested fruit by different traps.

Relationship between number of adult trapped/plot and number of healthy fruit by different traps: The relationship between the number of adult trapped/plot and total number of healthy fruit in different trapped plot was shown in Fig. 3. It revealed that strong positive relationship was observed between the numbers of insect trapped/plot and total number of healthy fruit in different trapped plots. This suggested that with the increase of fruit fly trapped there was increase of total number of healthy fruits. In the present study, it was observed that the cucurbit fruit fly prevented plants produced healthy fruits.

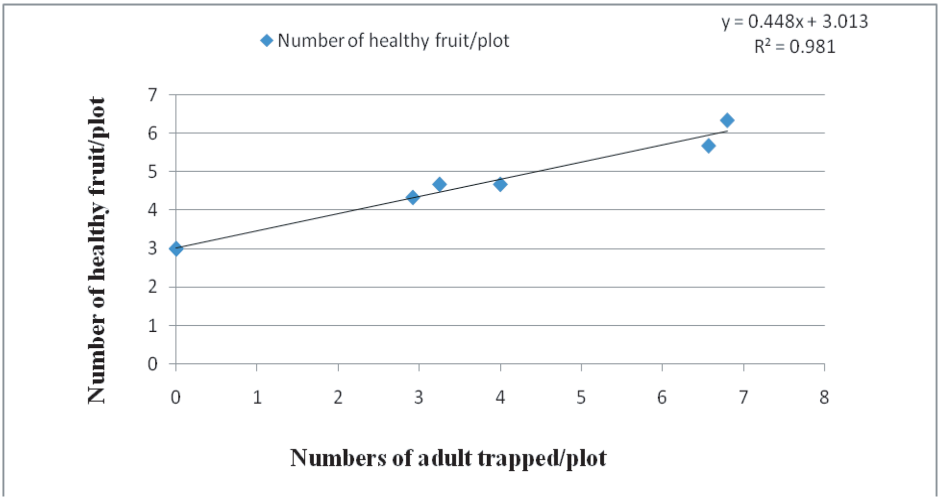

Fig. 3. Relationship between numbers of adult fruit fly trapped/plot and total number of healthy fruit as affected by installing different traps.

Effect of different traps on weight of healthy and infested fruits: Table 3 revealed that significant variation was observed in terms of healthy fruit weight and increase of healthy fruit weight over control at early fruiting stage. Result showed that the highest amount of healthy fruits/plot (3.89 kg) was observed in Bait trap + Pheromone trap (plastic pot) treated plot followed by 2.52 kg in Funnel Pheromone trap and 2.44 kg in Bait trap having no significant differences among them. The lowest quantity of healthy fruit/plot (0.50 kg) was observed in untreated control treatment. Similarly, the per cent increase of healthy fruit weight over control at early fruiting stage was 719.8% in treatment Bait trap + Pheromone trap (plastic pot) followed by 410.2% in Funnel Pheromone trap having no significant difference between them. The intermediate percent increase of weight over control was found in Bait trap (390.8%), Pheromone trap (Plastic pot) (288.6%) and GME Pheromone trap (270.6%) having no significant difference (Table 3). Plots treated with other traps gave the lowest result (16.25% in Sticky trap and 81.67% in Light trap) in terms of per cent increase of healthy fruit weight per plot.

At mid flowering stage, the highest weight of healthy fruit (2.50kg) was observed in Bait trap + Pheromone trap (plastic pot) treated plot followed by 2.17kg in Funnel Pheromone trap 2.13kg in Pheromone trap and 1.52kg in Bait trap having no significance differences among them (Table 3). The lowest weight of

Table 3. Effect of different traps on fruit weight, percent increase and decrease of yield over control (by weight of sweet gourd) at early, mid and late fruiting stages including total healthy weight of fruit/plot.

Treatments	At early fruiting stage		At mid fruiting stage		At late fruiting stage		Total	
	Weight of healthy fruit/plot (kg)	% increase of healthy fruit weight over control	Weight of healthy fruit/plot (kg)	% increase of healthy fruit weight over control	Weight of healthy fruit/plot (kg)	% increase of healthy fruit weight over control	Weight of healthy fruit/plot (kg)	% increase of healthy fruit weight over control
Pheromone trap (Plastic pot)	1.98 bc	288.6 bc	2.13	281.27	2.03	250.37	6.15 bc	278.5 bc
GME pheromone water trap	1.88 bc	270.6 bc	1.06	96.19	1.64	189.75	4.59 c	181.5 c
Sticky trap	0.58 c	16.25 c	0.96	137.54	0.83	38.91	2.38 d	44.89 d
Bait trap	2.44 ab	390.8 b	1.52	262.42	1.62	218.39	5.57 bc	242.1 bc
Funnel Pheromone trap	2.52 ab	410.0 ab	2.17	282.17	2.36	368.68	7.05 ab	330.6 ab
Light trap	0.91 bc	81.67 bc	0.73	38.62	1.02	66.00	2.65 d	62.12 d
Bait trap+ Pheromone trap (Plastic pot)	3.89 a	719.8 a	2.50	332.40	2.22	367.37	8.61 a	438.9 a
Only water in plastic pot (Control)	0.50 c	-------	0.50	------	0.63	------	1.64 d	-------
LSD(0.05)	1.59	314.9	----	-------	------	-------	1.72	118.9
Level of significance	*	*	NS	NS	NS	NS	*	*

In a column, means with same letter(s) are not significantly different by DMRT at 5% level of significance.

* indicates significant at 5% level

NS indicates non significant.

healthy fruit (0.50kg) was obtained from untreated control plot followed by 0.73kg in Light trap, 0.96 in Sticky trap and 1.06kg in GME pheromone water trap and they are not significantly different from other. The per cent increase of yield over control by weight at mid fruiting stage (332.40%) was obtained from treatment having Bait trap + Pheromone trap (plastic pot) followed by 282.17% in Funnel Pheromone trap, 262.2% in Bait trap and (282.17%) in Pheromone trap having no significant difference among them (Table 3). The lowest percent increase of healthy fruit weight over control (38.62%) was obtained from Light trap treated plot followed by 96.19% in GME pheromone water trapped treated plot and 137.54% in Sticky trap treated plot which were statistically similar.

At late fruiting stage, the highest weight of healthy fruit (2.36kg) was recorded from Funnel Pheromone trapped plot followed by 2.22kg in Bait trap + Pheromone trap (plastic pot) and 2.03kg in Pheromone trap having no significant differences among them (Table 3). The lowest weight of healthy fruit observed from the untreated control plot followed by Light trap and Sticky trap treated plot having no significant differences among them. The percent increase of yield over control by weight at late fruiting stage (368.68%) was obtained from treatment Funnel Pheromone trap followed by 367.37% in Bait trap + Pheromone trap (plastic pot), 250.37% in Pheromone trap having no significant differences among them. Among the plot, the lowest percent increase of yield over control (38.91%) was obtained from Sticky trap followed by 66.00% in Light trap having no significant differences between them (Table 3).

Data in Table 3 also revealed that significant variation was observed in terms of total weight of healthy fruit/plot. It was observed that the highest weight of healthy fruit/plot (8.61kg) was obtained from Bait trap + Pheromone trap (plastic trap) followed by 7.05 kg from Funnel Pheromone trap having no significant difference between them (Table 3) but variation was existed with other treatments. Intermediate result was obtained from Pheromone trap (plastic trap) (6.15kg), Bait trap (5.57kg) and GME pheromone water trap (4.59 kg). No significant variation was found among them in terms of producing healthy fruit/plot. Statistically similar result was found in untreated control plot (1.64kg), Sticky trap (2.38kg) and Light trap (2.65kg) which were significantly lower than other treatments.

The total per cent increase of weight over control (438.9%) was obtained from Bait trap + Pheromone trap (plastic pot) followed by 330.6% in Funnel Pheromone trap having no significant difference between them (Table 3). The intermediate result was shown 278.5% in Pheromone trap (plastic pot) and 242.1% Bait trap which was statistically similar with that of Funnel Pheromone trap. The lowest result (44.89% increase of healthy fruit weight) was found in Sticky trap treated plot followed by (62.12%) in Light trap having no significant difference between them but significantly lower than all other treatments.

The result of the present study agree with the findings of Hossen (2012) who reported that Pheromone trap with funnel + Bait trap showed best performance and Pheromone trap with funnel showed the second highest performance in terms of healthy, infested and total fruit yield by controlling cucurbit fruit fly. It partially contradicts with the findings of Anon. (2002-2003) who mentioned that Bait traps of cuelure pheromone and mashed sweet gourd (MSG) was resulted 40% to 65% reduction in fruit fly infestation and damage to the fruits and producing 2-4 times higher yield.

Relationship between number of adult trapped/plot and total fruit yield among different traps: The relationship between the number of insect trapped/plot and total fruit yield in different trapped plots was shown in Fig. 4. It demonstrated that there was strong positive relationship between the number of insect trapped/plot and total fruit yield in different trap treated plots which suggested that with the increase in number of trapped fruit fly there was a significant increase in total fruit yield.

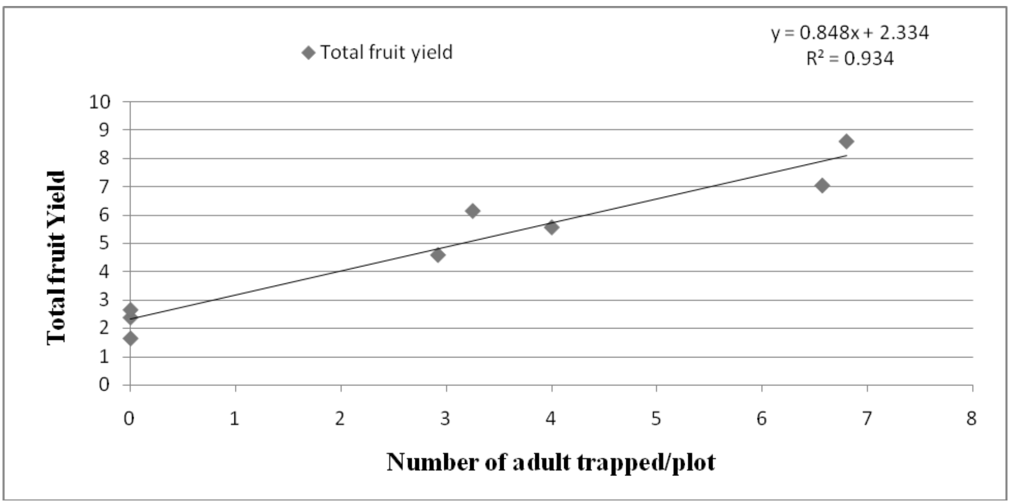

Fig. 4: Relationship between number of adult fruit fly trapped/plot and total fruit yield as influenced different traps.

The overall study revealed that the highest performance was achieved from Bait trap + Pheromone trap (plastic trap) and the Funnel Pheromone trap showed the second highest performance in terms of healthy, infested and total fruit yield by controlling cucurbit fruit fly. The Pheromone trap (Plastic pot), GME pheromone water Trap, Bait trap showed intermediate level of performance and Sticky trap and Light trap showed least effectiveness against fruit fly.

REFERENCES

AKHTARUZZAMAN, M., ALAM, M.Z. & SARDER, M.A. 1999. Identification & distribution of fruit cucurbits in Bangladesh. *Bangladesh J. Entomol*. **9** (1 & 2): 93-101.

AKHTARUZZAMAN, M., ALAM, M.Z. & SARDAR, M.A. 2000. Efficacy of different bait sprays for suppressing fruit fly on cucumber. *Bulletin of the Institute of Tropical* Agriculture, Kyushu University. **23**: 15-26.

ANONYMOUS. 2003. Technical Bulletin, USAID funded integrated pest management collaborative research support programme (IPM CRSP), Bangladesh Agricultural Research Institute, Gazipur, Bangladesh. p.8.

BBS. 2010. Year Book of Agricultural Statistics of Bangladesh. Statistics Division, Bangladesh Bureau of Statistics, Ministry of Planning, Government of the Peoples Republic of Bangladesh,Dhaka. p.97 .

DHILLON, M.K., NARESH, J.S. & SHARMA, N.K. 2005. Influence of physico-chemical traits of bitter gourd, *Momordica charantia* L. on larval density and resistance to melon fruit fly, *Bactrocera cucurbitae (Coquillett). J. Appl. Entomol*. **129**: 393-399.

GILLANI, W.A., BASHIR, T. & ILYAS, M. 2002. Studies on population dynamics of fruit flies (Diptera:Tephritidae) in guava & nectrin orchards in Islamabad. *Pakistan J. Biol. Sci*. **5**(4): 452-454.

HOSSEN, S. 2012. Effectiveness of different pheromone-trap design for management of cucurbit fruit fly. M.S. Thesis, Department of Entomology, Sher-e-Bangla Agricultural University, Sher-e-Banglanagar, Bangladesh. pp. 29-52.

KAPOOR,V.C. 1993. Indian Fruit Flies Oxford & IBH Publishing Co. Ltd. New Delhi, India. p. 228.

MARWAT, N.K. & BALOCH, U.K. 1986. Methyl eugenol, a male fruit fly sex-attractant. *Pakistan J. Agric. Res*. **7**: 234.

NEUPANE, F.P. 2000. Integrated management of vegetable insects. CEAPRED, Bakhundol, Lalitpur, Nepal. p. 172.

PAWAR, D.B., MOTE, U.N. & LAWE, K.E. 1991. Monitoring of fruit fly population in bitter gourd crop with the help of lure trap. *J. Maharashtra Agril. Univ*. **16**(2): 281.

RAKSHIT, A., REZAUL KARIM, A.N.M., HRISTOVSKA, T. & GEORGE W.N. 2011. Impact Assessment of Pheromone traps to Manage Fruit Fly on Sweet Gourd Cultivation. *Bangladesh J. Agric. Res*. **36**(2):197-203.

VERGHESE, A., NAGARRAJU, D.K. & SREEDEVI, K. 2005. Comparision of three indigenous lures/baits with three established attractants in case of fruit flies (Diptera: Tephritidae). *Pest Manage. Hort. Ecosyst*. **11**(1): 75-78.

YUBAKDHOJ G.C. & MANDAL, C.K. 2000. Integrated management of fruit fly (*Bactrocera cucurbitae*) on bitter gourd (*Momordicha charantia*) during the summer of 1998/99. IAAS Research Reports (1995-2000): 171-175.

(MS received for publication 27 August 2013)

Bangladesh j. entomol. (2013) **23**(2), 65-82 ISSN 1021-1004

DIVERSITY OF INSECT PESTS IN SOYBEAN CROP AND THEIR INTEGRATED MANAGEMENT

M. A. LATIF

Department of Entomology, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh.

ABSTRACT

Two field experiments were conducted at Sher-e-Bangla Agricultural University (SAU) experimental field during July 2012 to June 2013 to observe the diversity of insect pest complex of soybean, population dynamics of some major insect pests and develop their integrated management. Diversity of insect pest complex and population dynamics of five major insect pests were recorded from unsprayed field. Effectiveness of plant materials, chemical insecticides as integrated management practices were evaluated based on population incidence of insect pests and yield of soybean. Nineteen insect pests of 16 families under six Orders were recorded from soybean field. Leaf beetle and semilooper were found as major leaf feeding, and aphid, jassid and whitefly were observed as major sucking insect pests of soybean. Incidence of these insect pests increased with temperature, humidity and age of the crop and reached to a peak at 40-50 days after sowing and then declined with age of the crop. Among the plant materials neem oil showed the best performance against leaf feeding and sucking insect pests and gave higher yield. Carbosulfan gave the best result in reducing insect pests and increasing yield of soybean over control. Plant Revitalization Hormone (PRH) alone showed the better performance in reducing insect pests and increasing yield of soybean than Carbosulfan, neem oil and/or combined use of them. Although Carbosulfan gave the best effectiveness for the management of soybean insect pest, neem oil or PRH may be included in integrated pest management for soybean considering the health hazard and environmental safety point of view.

Keywords: Semilooper, leaf beetle, aphid, whitefly, jassid, PRH.

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is a fascinating crop with innumerable possibilities in the field of agriculture as well as in other industries. Soybean is a major source of edible oil (20%) and high quality protein (40%). It is a rich source of amino acids, vitamins and minerals. Soybean oil is used as a raw material in manufacturing antibiotics, paints, varnishes, adhesives, lubricants etc. Soybean meal is used as protein supplement in human diet, cattle and poultry feeds. It is a major oil seed crop of world grown in an area of 91 million ha with production of 204 million tones and productivity of 2,233 kg/ha (Anon. 2006). The crop is mainly cultivated in USA, China, Brazil, Argentina and India. In Bangladesh, in terms of area and production, soybean is a minor crop concentrated only in few districts and the total cropped area of soybean was 67,000 ha and the total production of the country was 116,000 tons (Anon. 2014).

The production of soybean is very low in this country due to many abiotic and biotic factors like, drought, weeds, insect pests and diseases. Among these, insect pests often become a serious problem for soybean production in Bangladesh and elsewhere by increasing cost of cultivation and impairing quality of produce in many ways (Singh & Singh 1998). Rapid growth, soft and succulent foliage of soybean attracts many insects and provides unlimited source of food, space and shelter. Biswas (2013) reported 39 insect pests which attack soybean crop from cotyledon to harvesting stage in Noakhali district. These pests are grouped as leaf feeders, pod feeders, and stem and root feeders. Among them some are very harmful due to severity of damage.

To combat the obnoxious insects various control measures have been recommended by the researchers. Of which chemical control measures are reported to be more effective (Latif *et al*.1996). Dhaliwal & Arora (1998) reported that development of synthetic organic insecticides during 20th century initially results in suppressing the insect pests which led to avoid of traditional pest control practices. Moreover, indiscriminate use of insecticides has led to problems like health hazards, insecticide resistance, pest resurgence and environmental pollution besides upsetting the natural ecosystem (Lakshmi & Verma 1998). The researchers later recognized the harmful effects of pesticides and tried to bring ecofriendly approaches to reduce pesticide load in environment by using botanicals and bio-pesticides (Kundu & Trimohan 1992, Kumar *et al*. 2009). However, botanicals and bio-pesticides are quickly degradable, less hazardous to human health and not so harmful for the environment (Singh *et al*. 2006). Moreover, reports are available on integrated pest management practices of soybean insect pests using plant extracts in India (Lakshmi & Verma 1998, Leatemia & Isman 2004). Plant revitalization hormone (PRH) enhances plant growth as well as resists insect pests and diseases which might be an IPM tool for pest management. Few studies have been done in Bangladesh on insect pest diversity in soybean and their management. Therefore, it is an urgent need to study insect pests of soybean, their pest status and to develop management practices against insect pests of soybean utilizing plant products.

MATERIALS AND METHODS

Two field studies were carried out separately during July 2012 to June 2013 at the experimental farm of Sher-e-Bangla Agricultural University. Three botanicals and five chemical insecticides were evaluated against major insect pests of soybean in first experiment. Based on the effectiveness against five major insect pests of soybean, neem oil and carbosulfan were selected for second field trail. Both the trials were laid out in Randomized Complete Block Design (RCBD) with three replications. The whole experimental field was divided into three equal blocks having 1.0 m space between them. Each block was again subdivided into plots (3.0 m × 2.0 m) as per number of treatments with 1.0 m distance between the plots. Seeds of BARI soybean 6 variety were collected from Oilseed Research Center (ORC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. The spacing was 30 cm between rows and 15 cm between plants. Seeds were sown on 10 August 2012 and on 25 January 2013 for first and second trials respectively. After sowing seeds light irrigation was applied to each plot for proper germination. Supplementary irrigation was given as and when needed. Weeding and mulching was done to keep the plot free from weeds and to break the soil crust. Manures and Fertilizers were applied as per recommended for soybean (Mondal & Wahhab 2001).

Treatments and dose: The following treatments were used in first trial:

T_1 = Neem leaf extract @ 30.0 g/l water
T_2 = Neem oil @ 10.0 ml/l water + 0.5 g detergent powder
T_3 = Tobacco leaf extract @ 2.0 g/l water
T_4 = Marshal (Carbosulfan) 20EC @ 2.0 ml/l water
T_5 = Dursban (Clorpyriphos) 20EC @ 2.0 ml/l water
T_6 = Ripcord (Cypermethrin) 10EC @ 1.0 ml/l water
T_7 = Fiter (Lambdacyhalothrin) 2.5EC @ 1.0 ml/l water
T_8 = Actara (Thiamethoxam) 25WG @ 0.5 g/l water
T_9 = Untreated control (water)

First application was done at 20 days after germination of seeds and it was continued at 10 days interval up to pod formation. Only water was sprayed for untreated control plot.

In second trial, treatments were as follows:

T_1 = Marshal (Carbosulfan) 20EC @ 2.0 ml/l water
T_2 = Neem oil @ 10.0 ml/l water + 0.5 g detergent powder
T_3 = Plant Revitalization Hormone (PRH) @ 10.0 ml/l water
T_4 = Marshal (Carbosulfan) 20EC + Plant Revitalization Hormone (PRH)
T_5 = Neem oil + Plant Revitalization Hormone (PRH)
T_6 = Marshal (Carbosulfan) 20EC + Neem oil + Plant Revitalization Hormone (PRH)
T_7 = Untreated control (water)

In case of T1, T_2 and T_3 only Marshal, neem oil and PRH were applied at 10 days interval. In case of T_4, T_5 and T_6 Marshal 20EC, neem oil and PRH were sprayed alternatively at 10 days interval.

Treatments application: Fresh neem leaves were collected from SAU campus and weighed by an electric balance then washed thoroughly with running tap water followed by chopping with a knife. About 400 ml water was added with chopped leaves. Then it was blended well by a blender to make it a solution. It was kept undisturbed overnight and filtered through the fine cloth and poured into a volumetric flask and water was added to make 1.0 liter volume. Similarly tobacco leaf extract was prepared by mixing dry leaf powder with water. Neem oil and detergent were mixed with water and solution was prepared. Insecticides were directly mixed with water and solution was made. Plant extracts and insecticides were sprayed with the help of knapsack sprayer having a pressure of 4.5 kg/cm2. Mixture of insecticides or plant extracts in the sprayer was shaken well during spraying. Spraying was done at 11:00 am to avoid drift. Plant Revitalization Hormone (PRH) was collected from Natural BioAgrotech Company, Dhaka mixed with water and sprayed by Knapsack sprayer.

Sampling and data collection: Observation on species of insect pests with their population per plant was recorded from seedling to mature stage of the crop from 10 randomly selected samples of the plants in each plot. The time of appearance of the pests was observed and recorded. The nature of damage and feeding behaviour of the insect pests were carefully observed. The recordings of data were done by visual observations, hand nets, and hand picking of insects from the standing crops during 7:00-10:00 am and 4:00-6:00 pm at weekly intervals. Some insects were also collected by aspirators for laboratory studies. The collected insects were preserved in the insect box and vial having 75% ethyl alcohol for identification. Relative population of insect was calculated as suggested by Biswas *et al*. (2001).

From these data the average number of insect pests was calculated and the percent decrease of population for each treatment was determined by the following formula:

$$\% \text{ Reduction of population over control} = \left[\frac{\text{No. of insects in treatments - No. of insect in control}}{\text{No. of insect in control}}\right] \times 100$$

Yield data: After harvest the plants were sundried and seeds were separated from the pods by beating with bamboo stick. After separation the weight of grain was measured separately from each plot. From these data yield per plot was calculated and percent increase of yield over untreated control plot was determined by the following formula:

$$\% \text{ Increase of yield over control} = \frac{\text{Yield in treatments - Yield in control}}{\text{Yield in control}} \times 100$$

Weather data: The temperature and humidity data were recorded from the field when population of whitefly was counted. The rainfall data was also collected from the weather data of Agargaon Weather Centre, Dhaka.

Statistical analyses: The data were compiled and tabulated in proper form and were subjected to statistical analysis. The percentage data were subjected to ArcSine transformation. Analysis of variance was done following the computer package MSTAT-C program developed by Russel in 1986. The means were separated by using Duncan's Multiple Range Test (DMRT) at 5% level of significance.

RESULTS AND DISCUSSION

Insect Pest Complex: Nineteen species of insect pests belonging to 16 families under six orders were found to infest soybean at SAU experimental field during 2012-13 (Table 1). Most of the insect pests were under three major orders (Lepidoptera, Homoptera and Coleoptera) in which leaf feeding and sucking insect pests were dominant. Of these, five species namely, leaf beetle (*Monolepta signata* Olv.), semilooper (*Plusia orichalcea* [Fab.]), aphid (*Aphis craccivora* [Koch]), jassid (*Amrasca biguttula biguttula* [Ishida]) and whitefly (*Bemisia tabaci* Genn.) caused 90-100%, 40-50%, 85-100%, 70-100% and 90-100% plant infestation, respectively (Table 2). The population density of leaf beetle, semilooper, aphid, jassid and whitefly were 0.60-1.40, 0.40-0.90, 12.40-15.00, 5.40-6.50 and 10.90-13.10 per plant, respectively. Among those insect pests leaf beetle attacked at seedling to pod formation stage of soybean but other four insect pests attacked at vegetative to pod formation stage. Adult leaf beetle and larva of semilooper fed on leaves of soybean but nymph and adult of aphid, jassid and whitefly sucked cell sap from different parts of the plant (Table 1).

Table 1. Insect pests recorded from soybean crop ecosystem during 2012-2013 at SAU experimental field

Sl. No.	Common Name	Scientific name	Order	Family	Feeding behaviour
01.	Hairy caterpillar	*Spilarctia obliqua* (Walker)	Lepidoptera	Arctiidae	Larvae feed on leaves
02.	Tobacco caterpillar	*Spodoptera litura* Fab.	Lepidoptera	Noctuidae	Larvae cut and feed on leaves
03.	Semilooper	*Plusia orichalcea* (Fab.)	Lepidoptera	Noctuidae	Larvae feed on leaves
04.	Pod borer	*Helicoverpa armigera* (Hub.)	Lepidoptera	Noctuidae	Larvae bore pod
05.	Leaf roller	*Lamprosema indicata* F.	Lepidoptera	Pyralidae	Larvae roll and feed on leaves
06.	Leaf miner	*Stomopteryx* spp.	Lepidoptera	Gelechiidae	Larvae mine and feed on leaves
07.	Whitefly	*Bemisia tabaci* Genn.	Homoptera	Aleyrodidae	Nymph and adult suck cell sap
08.	Jassid	*Amrasca biguttula biguttula* (Ishida)	Homoptera	Jassidae	Nymph and adult suck cell sap
09.	Aphid	*Aphis craccivora* (Koch)	Homoptera	Aphididae	Nymph and adult suck cell sap
10.	Mealybug	*Pseudococcus filamentosus*	Homoptera	Pseucoccidae	Nymph and adult suck cell sap
11.	Green stink bug	*Nezara viridula* L.	Hemiptera	Pentatomidae	Nymph and adult suck cell sap
12.	Grey weevil	*Myllocerus discolor* Boh.	Coleoptera	Curculionidae	Adult feed on leaves
13.	Pumpkin beetle	*Aulacophora* spp.	Coleoptera	Chrysomelidae	Adult feed on leaves
14.	Leaf beetle	*Monolepta signata* Olv.	Coleoptera	Chrysomelidae	Adult feed on leaves
15.	Epilachna beetle	*Epilachna* spp.	Coleoptera	Coccinellidae	Larvae and adult feed on leaves
16.	Green grass hopper	*Attractomorpha crenulata* F.	Orthoptera	Acrididae	Nymph and adult feed on leaves
17.	Long horned grass hopper	*Phaneroptera gracilli* Bur.	Orthoptera	Tettigoniidae	Nymph and adult feed on leaves
18.	Stem fly	*Ophiomyia phaseoli* (Tryon.)	Diptera	Agromyzidae	Larvae bore into stem
19.	Flower thrips	*Frankliniella schultzei* Trybom	Thysanoptera	Thripidae	Nymph and adult suck cell sap

The result partially agrees with the findings of Biswas (2013) who recorded 39 species of insect pests in Noakhali region. Biswas (2008) also reported that green stink bug (*Nezara viridula*), semilooper (*Plusia orichalcea*), black cutworm (*Agrotis ipsilon*), leaf miner (*Stomopteryx* spp.), green grasshopper (*Attractomorpha crenulata*), pod bug (*Eusarcocoris* sp.) and aphid (*Aphis craccivora*) became occasionally important and caused serious damage to the soybean crop. The result also contradicts with the findings of Das (1998) who observed two hairy caterpillar and stem fly as most damaging insect pests of soybean. Nevertheless, Ali (1988) observed 47 insect pests from different growth stages of soybean. Moreover, Jayappa (2000) reported 40 and 21 species of insect pests attacking soybean during kharif and summer seasons, respectively in Bangalore. Thus the variation of the insect species attacking soybean varied with location and cultivation season of the year.

Table 2. Incidence of some important soybean insect pests and their infestation level in control plot during 2012-2013 at SAU experimental field

Name of insects	% plant infestation	No. of insect plant-1	Stage of infestation
Leaf beetle	90-100	0.6-1.40	Seedling - Pod formation
Semilooper	40-50	0.40-0.90	Vegetative - Pod formation
Aphid	85-100	12.40-15.00	Vegetative - Pod formation
Jassid	70-100	5.40-6.50	Vegetative - Pod formation
Whitefly	90-100	10.90-13.10	Vegetative - Pod fromation

[1]Data were recorded from 10 soybean plants in each replication.

Incidence of leaf beetle, semilooper, aphid, jassid and whitefly: The population trends of five major insect pests in relation to environmental temperature and relative humidity and age of the crop have been presented in Figure 1 which illustrated that the leaf beetle population increased with temperature, relative humidity and age of the crop. It reached to a peak during 40-50 days after sowing and then declined although temperature was not decreased. Similar trend was observed for semilooper (Figure 2), aphid (Figure 3) and jassid (Figure 4). In case of whitefly, peak population was observed at 40 days after sowing (Figure 5) that then declined with increased age of the crop. Thus temperature, humidity and age of the crop had great influence on the incidence of the insect pests of soybean. The result partially follows the findings of Latif & Akhter (2013) who reported that population of whitefly gradually increased with temperature and humidity up to certain age of the crops and then declined.

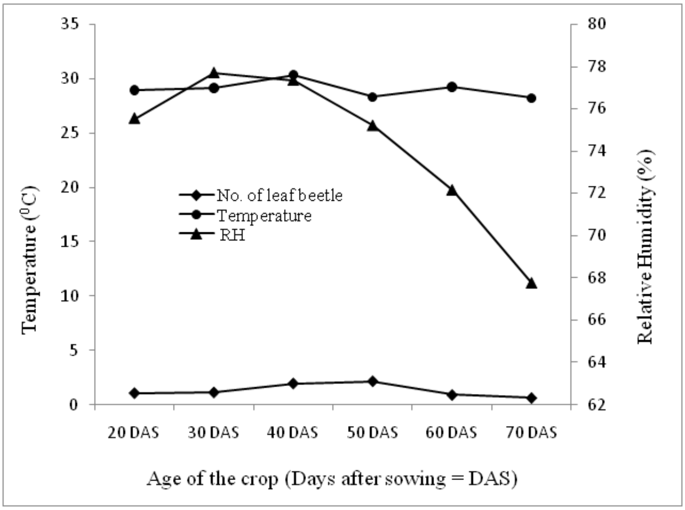

Fig. 1. Population trend of leaf beetle on soybean in relation to temperature, relative humidity and age of the crop.

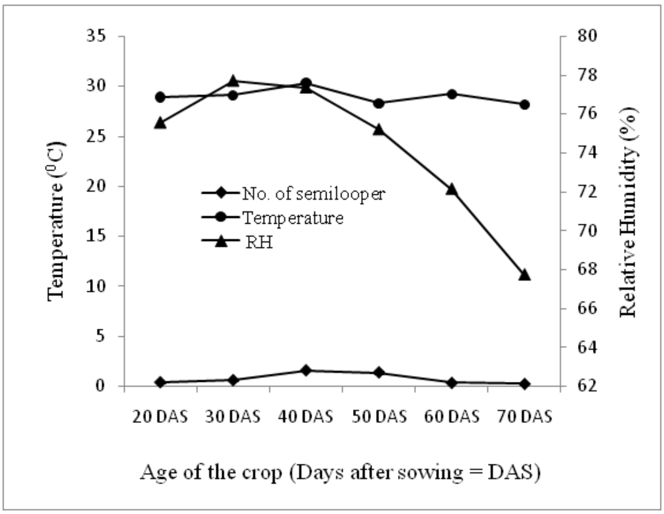

Fig. 2. Population trend of semilooper on soybean in relation to temperature, relative humidity and age of the crop.

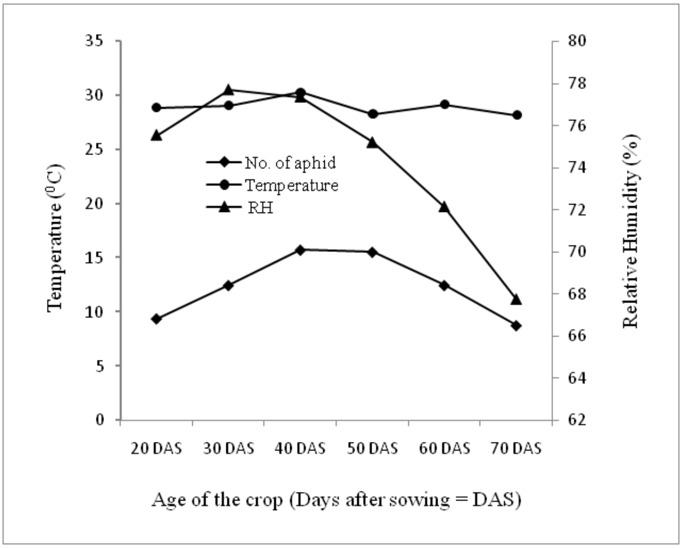

Fig. 3. Population trend of aphid on soybean in relation to temperature, relative humidity and age of the crop.

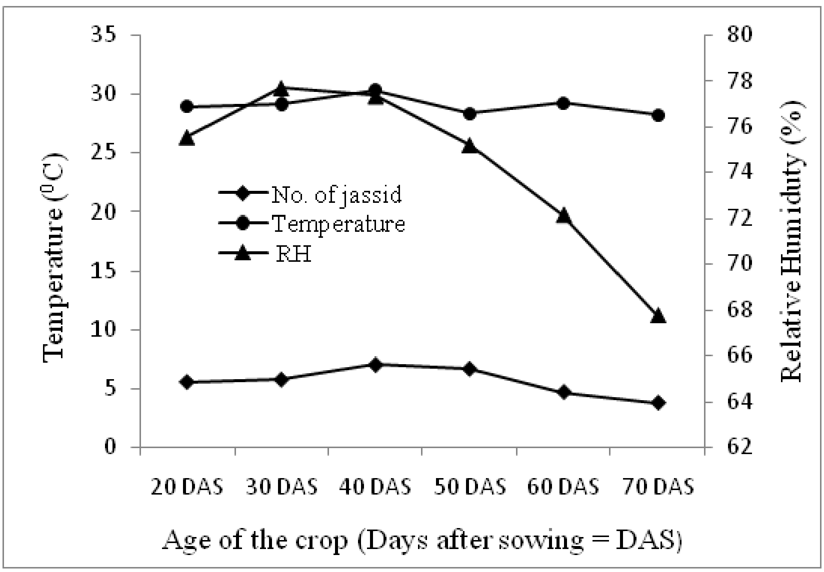

Fig. 4. Population trend of jassid on soybean in relation to temperature, relative humidity and age of the crop.

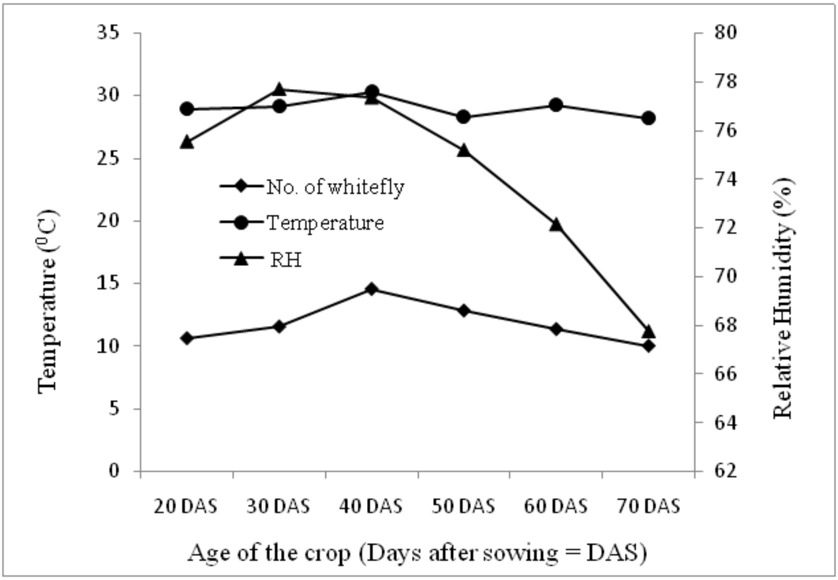

Fig. 5. Population dynamics of whitefly on soybean in relation to temperature, relative humidity and age of the crop.

Effect of some plant extracts and chemical insecticides on insect pests and grain yield of soybean: Spraying of plant extracts and chemical insecticides significantly reduced insect pests incidence and increased grain yield of soybean. The data in Table 3 indicate that the lowest number of leaf beetle (0.60/plant) and semilooper (0.33/plant) was observed in Carbosulfan treated plots having no significant difference with that of Thiamethoxam treated plots. These two insecticides reduced more than 50% population of leaf beetle and semilooper. All the plant extracts reduced more than 30% population of these two insect pests but better result was found in neem oil treated plots which reduced 37.26% leaf beetle and 36.53% semilooper population over control (Table 3). Therefore, spraying of plant extracts and chemical insecticides in the present study significantly reduced the leaf feeding insect pests and neem oil was the best plant material and Carbosulfan was the most effective chemical insecticide against leaf beetle and semilooper of soybean.

Table 3. Incidence of leaf beetle and semilooper in plant extracts and chemical insecticides treated plots

Treatments	No. of leaf beetle/plant	% decrease over control	No. of semilooper/plant	% decrease over control
Neem leaf	0.87 b	31.93 b	0.52 b	31.53 c
Neem oil	0.80 bc	37.26 bc	0.48 b	36.53 bc
Tobacco leaf	0.83 b	34.40 c	0.51 b	32.56 bc
Carbosulfan	0.60 d	52.68 a	0.33 c	54.92 a
Chlorpyriphos	0.73 c	42.35 b	0.45 b	40.91 b
Cypermethrin	0.82 b	35.79 c	0.48 b	36.44 bc
Lambda- cyhalothrin	0.83 b	34.56 c	0.47 b	38.26 bc
Thiamethoxam	0.62 d	51.46 a	0.37 c	50.76 a
Control	1.25 a	--	0.76 a	--
CD (0.05)	0.78	5.73	0.78	8.14
CV	4.85%	8.17%	8.15%	11.56%

In a column means with same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

Plant extracts and chemical insecticides spraying also significantly reduced three major sucking insect pests such as aphid jassid and whitefly. The lowest number of aphid (7.67/plant), jassid (3.79/plant) and whitefly (5.63/plant) was recorded from Carbosulfan treated plots as against the highest in control plot (14.42, 8.22 and 12.22, respectively). But no significant difference was found between Carbosulfan and Thiamethoxam in respect of number of aphid, jassid and whitefly (Table 4). These two insecticides reduced more than 40% aphid and 50% jassid and whitefly population over control. It was also observed that Chlorpyriphos, Cypermethrin and Lambdacyhalothrin reduced more than 40% population of the jassid and whitefly which were significantly lower than Carbosulfan and Thiamethoxam. Among the plant materials, neem oil gave the best result by reducing 35.62% aphid, 37.67% jassid and 41.42% whitefly population over control which was significantly lower than all chemical insecticides treated plots (Table 4). Thus neem oil was the most effective plant material and Carbosulfan was the best chemical insecticide against sucking insect pests of soybean.

Table 4. Incidence of aphid, jassid and whitefly in plant extracts and chemical insecticides treated plots and per cent decrease over control

Treatments	No. of aphid/plant	% decrease over control	No. of jassid/plant	% decrease over control	No. of Whitefly/plant	% decrease over control
Neem leaf	9.92 b	31.27 e	5.64 b	31.52 e	8.65 b	29.07 g
Neem oil	9.30 c	35.62 d	5.13 c	37.67 d	7.15 d	41.42 e
Tobacco leaf	9.78 b	32.28 e	5.63 b	31.76 e	7.95 c	34.95 f
Carbosulfan	7.67 f	46.87 a	3.79 f	54.17 a	5.63 f	53.84 a
Chlorpyriphos	8.40 de	41.85 bc	4.59 e	44.35 b	6.03 ef	50.53 b
Cypermethrin	8.60 d	40.41 c	4.77 de	42.05 c	6.38 e	47.72 c
Lambda- cyhalothrin	8.77 d	39.38 c	4.84 d	41.18 c	6.54 e	46.30 d
Thiamethoxam	8.03 ef	44.43 ab	3.86 f	53.27 a	5.67 f	53.43 a
Control	14.42 a	--	8.22 a	--	12.22 a	--
CD (0.05)	0.42	3.24	0.20	1.41	0.55	1.51
CV	2.56 %	4.75 %	2.31 %	1.91%	4.35 %	1.47%

In a column means with same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

Schedule spraying of plant materials and chemicals also had significant effect on grain yield of soybean. The highest grain yield (1.51 t/ha) was obtained from Carbosulfan treated plots as against the lowest (1.01 t/ha) in untreated control plot. Carbosulfan increased 50.27% yield of soybean over control. But no significant difference was observed among Carbosulfan, Thiamethoxam and Chlorpyriphos in respect of grain yield of soybean (Table 5). Cypermethrin, Lambdacyhalothrin, neem oil and tobacco leaf extract treatments gave statistically similar result in production of soybean. Application of plant extracts and chemical insecticides at 10 days interval reduced population of leaf feeding and sucking insect pests of soybean and increased grain yield. Among the plant extracts neem oil provided the best effectiveness and Carbosulfan showed the best performance in reducing leaf feeding and sucking insect pests of soybean and increasing grain yield over control.

The results partially agree with the report of Latif & Akhter (2013) who observed that Marshal 20EC (Carbosulfan) reduced 50.61% population of whitefly and increased 36.37% yield of soybean. Moreover, the effectiveness of neem oil against insect pests also reported by many researchers which support this results (Muhammad *et al*. 2010, Devaki & Krishnaya 2004). However, the result may vary with the findings of others due to application methods, dose of insecticides, intensity of pest and climatic variations.

Table 5. Effect of plant extracts and chemical insecticides on grain yield of soybean and per cent increase in yield over control

Treatments	Grain yield (t ha^{-1})	% increase of grain yield over control
Neem leaf	1.19 c	17.68 c
Neem oil	1.29 b	28.24 b
Tobacco leaf	1.22 bc	21.27 bc
Carbosulfan	1.51 a	50.27 a
Chlorpyriphos	1.43 a	42.02 a
Cypermethrin	1.29 b	27.91 b
Lambdacyhalothrin	1.25 bc	24.25 bc
Thiamethoxam	1.50 a	48.84 a
Control	1.01 d	--
CD (0.05)	0.08	8.83
CV	3.35%	15.49%

In a column means with same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

Effectiveness of some integrated pest management techniques on insect pest population and grain yield of soybean: Integrated or individual use of neem oil, Carbosulfan and Plant Revitalization Hormone (PRH) reduced leaf feeding and sucking insect pests of soybean and increased yield over control. The data in Table 6 revealed that the lowest number of leaf beetle (0.48/plant) and semilooper (0.13/plant) was recorded from PRH (alone) treated plot which was significantly different from all other treatments. It decreased 62.56% leaf beetle and 82.33% semilooper population over control. However, individual use of neem oil/ Carbosulfan/ PRH gave better result than integrated use of Carbosulfan and PRH or neem oil + PRH or Carbosulfan + neem oil + PRH. Population of sucking insect pest varied significantly in different treatments but lowest number of aphid, jassid and whitefly was recorded from PRH treated plots. No significant difference of jassid incidence was found in Carbosufan, neem oil and PRH treated plots and percent reduction of jassid population over control was higher compared to other treatments (Table 7). For reducing whitefly, PRH and Carbosufan showed similar performance but PRH gave the best result in reducing aphid population over control. Alternate use of neem oil, Carbosulfan and PRH did not give satisfactory results against sucking insect pests of soybean.

Table 6. Effect of integrated pest management techniques on incidence of leaf beetle and semilooper in soybean and per cent decrease over control

Treatments	No. of leaf beetle/plant	% decrease over control	No. of semilooper/plant	% decrease over control
Marshal (Carbosulfan) 20EC @ 2.0 ml/l of water	0.76 c	41.27 b	0.40 d	46.52 b
Neem oil @ 10.0 ml/l of water + 0.5 g detergent powder	0.92 b	29.40 c	0.43 cd	41.71 c
Plant Revitalization Hormone (PRH) @ 10.0 ml/l of water	0.48 d	62.56 a	0.13 e	82.33 a
Marshal (Carbosulfan) 20EC + Plant Revitalization Hormone (PRH)	0.76 c	41.83 b	0.47 c	37.58 c
Neem oil + Plant Revitalization c Hormone (PRH)	0.73	43.46 b	0.58 b	22.08 d
Marshal (Carbosulfan) 20EC + Neem oil + Plant Revitalization Hormone (PRH)	0.91 b	30.00 c	0.45 cd	39.75 c
Control	1.30 a	--	0.75 a	
CD (0.05)	0.10	5.35	0.06	4.56
CV	6.12 %	7.10 %	6.83 %	5.57 %

In a column means with same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

Table 7. Effect of integrated pest management techniques on incidence of aphid, jassid and whitefly in soybean and per cent reduction over control

Treatments	No. of aphid/plant	% decrease over control	No. of jassid/plant	% decrease over control	No. of Whitefly/plant	% decrease over control
Marshal (Carbosulfan) 20EC @ 2.0 ml/l of water	7.47 c	45.54 b	1.82 d	67.66 a	7.43 d	36.99 a
Neem oil @ 10.0 ml/l of water + 0.5 g detergent powder	7.87 c	42.65 b	1.92 cd	65.96 ab	8.13 c	30.99 b
Plant Revitalization Hormone (PRH) @ 10.0 ml/l of water	6.42 d	53.22 a	1.77 d	68.54 a	7.43 d	36.91 a
Marshal (Carbosulfan) 20EC + Plant Revitalization Hormone (PRH)	7.67 c	44.14 b	2.10 bc	62.77 bc	9.25 b	21.66 c
Neem oil + Plant Revitalization Hormone (PRH)	9.28 b	32.36 c	2.37 b	57.98 d	9.40 b	20.16 c
Marshal (Carbosulfan) 20EC + Neem oil + Plant Revitalization Hormone (PRH)	9.00 b	34.41 c	2.20 b	60.78 cd	9.12 b	22.60 c
Control	13.73 a	--	5.62 a	--	11.80 a	--
CD (0.05)	0.54	3.72	0.27	3.96	0.49	3.40
CV	3.47 %	4.86 %	6.01 %	3.40 %	3.06 %	6.62 %

In a column means with same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

Table 8. Effect of integrated pest management techniques on grain yield of soybean and percent increase over control

Treatments	Grain yield (t ha-1)	% increase of grain yield over control
Marshal (Carbosulfan) 20EC @ 2.0 ml/l of water	1.34 b	36.15 b
Neem oil @ 10.0 ml/l of water + 0.5 g detergent powder	1.28 c	30.09 c
Plant Revitalization Hormone (PRH) @ 10.0 ml/l of water	1.41 a	43.75 a
Marshal (Carbosulfan) 20EC + Plant Revitalization Hormone (PRH)	1.20 e	21.62 e
Neem oil + Plant Revitalization Hormone (PRH)	1.18 f	19.82 f
Marshal (Carbosulfan) 20EC + Neem oil + (PRH) Plant Revitalization Hormone	1.22 d	23.68 d
Control	0.98 g	--
CD (0.05)	0.018	1.38
CV (%)	1.10	2.60

In a column means with same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

The result indicates that application of IPM techniques reduced pest population and increased grain yield of soybean (Table 8). The highest yield (1.41 t/ha) was obtained highest from PRH treated plots followed by 1.34 t/ha and 1.28 t/ha from Carbosulfan and neem oil treated plots, respectively having significant difference among them. PRH treatment also increased 43.75% grain yield of soybean over control. Individual use of neem oil/ Carbosulfan/ PRH gave better result than integrated use of Carbosulfan and PRH or neem oil + PRH or Carbosulfan + neem oil + PRH. The effectiveness of PRH alone or in combination with others could not be compared due to lack of references. However, Latif & Akhter (2013) reported that application of Marshal 20EC (Carbosulfan) increased 36.37% yield of soybean which supports this result.

CONCLUSION

The overall results of the present study indicate that nineteen insect pests of 16 families under six Order attacked soybean in the field. Most of them were under the Order Lepidoptera, Homoptera and Coleoptera. Leaf beetle and semilooper were found as major leaf feeder and aphid, jassid and whitefly were major sucking insect pests of soybean. Population of these insect pests increased with temperature, humidity and age of the crop and reached to a peak at 40-50 days after sowing and then declined with age of the crop. Among the plant materials neem oil showed the best performance against all insect pests and produced the highest yield. Carbosulfan gave the best result in reducing insect pests of and increasing yield of soybean over control. Among the IPM techniques, Plant Revitalization Hormone (PRH) alone showed the better performance in reducing insect pests and increasing yield of soybean than Carbosulfan, neem oil and/or combined use of them.

ACKNOWLEDGEMENTS

Authors sincerely acknowledge the financial support of Sher-e-Bangla Agriculutual University Research System (SAURES) and University Grants Commission (UGC).

REFERENCES

ALI, M.I. 1988. A survey of the insect pests of soybean in Northern Bangladesh, their damage and occurrence. *Tropical Pest Mange*. **34**(3):328-330.

ANONYMOUS. 2006. Annual Report, 2005-06. All India Co-ordinated Research Project on Oilseeds, Dharwad Centre. pp. 55-58.

ANONYMOUS. 2014. Krishi Diary-2014. Agricultural Information Service, Khamarbari, Farmgate, Dhaka-1215. pp.13-14.

BISWAS, G.C., HOSSAIN,I M.M. & MAJUMDER, U.K. 2001. Screening of some soybean entries against leaf roller (*Lamprosema indicata* F.). *Bangladesh J. Agril. Res.* **26**(2): 295-300.

BISWAS, G.C. 2008. Insect pests and their management of soybean crop in Bangladesh. In: *Proceedings of the workshop on Prospects and performance of soybean in Bangladesh*. Oilseed Research Center, BARI, Gazipur. 67pp.

BISWAS, G.C. 2013. Insect pests of soybean (*Glycine max* L.), their nature of damage and succession with the crop stages. *J. Asiatic Soc. Bangladesh*. **39**(1): 1-8.

DAS, G.P. 1998. *Major insect and mite pests of important crops and stored products of Bangladesh*. Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. 102pp.

DEVAKI, K. & KRISHNAYA, P.V. 2004. Combination effect of three proprietary formulations of B.t. with neem against *Spodoptera litura* (Fab.). *Indian J. Plant Protec*. **32**(2): 34-36.

DHALIWAL, G.S. & ARORA, R. 1998, *Principles of Insect Pest Management*. Kalyani Pub. New Delhi, India. pp. 57-85.

JAYAPPA, J. 2000. Source plant and seed storage as influencing insecticidal activity of neem *Azadirachta indica (Meliaceae). M.Sc. (Agri.) Thesis*, Uni. Agric. Sci. Bangalore, India.

KUMAR, N.G., HUYEN, N.P.D. NIRMALA, P. & UMADEVI, S.H. 2009. Effect of various methods of application of insecticides on stem fly and termite incidence in soybean. *Karnataka J. Agric. Sci*. **22**(3): 642-643.

KUNDU, G.G. & TRIMOHAN, P. 1992. Preliminary observations on neem products against *Melanagromyza sojae* (Zehnt.). *Pestic. Res. J*. **4**: 65-68.

LAKSHMI, S. & VERMA, S.K. 1998. Traditional pest management practices followed by the farmers of poon-valley. In: *Internl. Conf. Pest Pestic. Mange. Sust. Agric.* 11-13 December, 1998, Kanpur, India.

LATIF, H., SRIVASTAVA, C.P., NATH, S. & SINGH, K.N. 1996. Comparative performance of chemical insecticides against insect pests of pigeonpea. *Pestology*. **20**: 5-7.

LATIF, M.A. & AKHTER, N. 2013. Population dynamics of whitefly on cultivated crops and its management. *Internl. J. Bio-Reso. Stress Manage*. **4**(4): 576-581.

LEATEMIA, J.A. & ISMAN, M.B. 2004. Toxicity and antifeedant activity of crude seed extract of *Annona squamosa. Internl. J. Trop. Insect Sci.* **24** (2): 150-158.

MONDAL M.R.I. & WAHHAB, M.A. 2001. Production Technology of Oilcrops. Oilseed Research Center, BARI, Joydebpur, Gazipur. 111 pp.

MUHAMMAD, N., LATIF, M.A., RAHMAN, M.M. & YASMIN, S. 2010. Comparative effectiveness of neem oil and some chemical insecticides against tobacco caterpillar, Spodoptera litura (Fab.) attacking cabbage. *Bangladesh J. Entomol*. **20**(2): 15-25.

RUSSEL, D.F. 1986. MSTAT-C Package Programme. Dept. of Crop and Soil Science, Michigan State University, USA.

SATTAR, M.A., RAHMAN, M. & ALAM, M.S. 2005. *Krishi Projukti hatboi*. Bangladesh Agricultural Research Institute, Gazipur 1701, Bangladesh. 155p.

SINGH, C.P., GUPTA, S.K. & VISHAL-MITTAL, A.K. 2006, Effects of different plant extracts on growth and development of tobacco caterpillar, *Spodoptera litura* (Fab.). *Environ. Ecol*. **24**(Special 4): 979-982.

SINGH, K.J. & SINGH, O.P. 1998, Residual toxicity of some granular and seed treatment insecticides against blue beetle on soybean. *Pestology*. **22**: 11-13.

(MS received for publication 10 September 2013)

Bangladesh j. entomol. (2013) **23**(2), 83-95 ISSN 1021-1004

MANAGEMENT OF RHIZOME ROT AND RHIZOME FLY COMPLEX IN GINGER UNDER FIELD CONDITION

D. SARKER[1], K. S. ISLAM[2], M. A. ALI[3] & S. N. ALAM[1]

[1]Entomology Division, Bangladesh Agricultural Research Institute, Gazipur; [2&3]Department of Entomology & Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh.

ABSTRACT

Field studies on the management of rhizome rot and rhizome fly complex in ginger were carried out during April 2007 to February 2008 ginger season at Spices Research Centre (SRC), Bangladesh Agricultural Research Institute (BARI), Shibgonj, Bogra, Bangladesh. As it is suspected that both pathogens and insect are responsible for the rhizome damage of ginger, so to find out the appropriate management option(s) of these different pest groups, four trials were carried out with different treatment combinations. The study was conducted in a randomized complete block design (RCBD) with six treatments and three replications in each trial. Only preventive measures were tested in Trial-1, while Trial-2, Trial-3 and Trial-4 were set to test the performance of different treatments both in preventive and curative measures. Results indicated that pre-sowing soil application of neem oil cake @ 400 kg ha^{-1} in combination with Ridomil Gold MZ 68WG @ 7.0 kg ha^{-1} and basal application of the Ridomil Gold @ 3.5 kg ha^{-1} at 4 weeks interval commencing from the first occurrence of plant damage were found as the most effective management options of the pests. On the basis of the calculated BCR pest management effectiveness may be ranked as: pre-sowing application of Ridomil Gold @ 7.0 kg ha^{-1} > Lorsban 15G @ 15.0 kg ha^{-1} with Ridomil Gold @ 7.0 kg ha^{-1} > Neem Oil Cake @ 400 kg ha-1 when the treatments were supplemented with the application of Ridomil Gold @ 3.5 kg ha^{-1} after the first occurrence of plant damage.

Keywords : Rhizome rot, rhizome fly, Ridomil Gold MZ 68 WG, Neem oil cake.

INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) is one of the most important spice crops in Bangladesh. It's cultivation in Bangladesh is concentrated at Rangamati, Rangpur, Nilphamari, Chittagong, Mymensingh, Dinajpur, Tangail, Khagrachari and Bandarban districts (Chowdhury *et al.* 1998a). Bangladesh produces only 43,000 metric tons of ginger from an area of 8,000 hectares as against the requirement of

96,000 metric tons per annum (Akhter *et al*. 2005). The average yield is 5.54 tons ha^{-1} at farmer's level, which is very low as compared to other ginger growing countries of the world. Bangladesh spends considerable amount of foreign exchange by importing ginger each year to meet up the shortfall.

There are several reasons for low yield of ginger in Bangladesh and among them infestation by insect-pest and infection by pathogen are considered as the major ones. Sontakke (2000) reported that the maggots of rhizome fly feed inside the rhizomes by making tunnels. At early infestation no sign of injury was visible on shoots and leaves. In certain cases drying of central shoot (dead hearts) was observed initially when the maggots were entering through less thickened stems. After a week of rhizome infestation by the maggots, yellowing of lower leaves followed by drying of all the leaves including pseudo-stem was observed and such stems were easily detachable from the rhizomes. Under such conditions there was complete damage to rhizomes with bacterial and fungal infestation with foul smell.

Few studies on the management of the pest were undertaken but no effective package has yet been reported. About 8,000 hectares of land in Bangladesh are cultivated for ginger production, the farmers generally fails to harvest healthy crop. Sometimes farmers are using only insecticides or fungicides to overcome the pest problem of ginger but in most of the cases they become unsuccessful except uprooting of the damaged plants and they do not have any other options. The uprooted plants are sometimes piled up at the corner or thrown scattered outside of the field, which may again increases the intensity of plant damage. Considering the above mentioned situation, the present study was undertaken to develop effective management tactic(s) against rhizome pests of ginger.

MATERIALS AND METHODS

The research was conducted at SRC, BARI, Bogra during the ginger season 2007-2008. Since, both pathogens and insect are responsible for the rhizome damage of ginger, so to find out the appropriate management option(s) of these two pest groups, four trials were planned with different treatment combinations. The field was divided into four parts and each into three blocks which was further divided into six plots, each measuring 3m x 1.5m with an inter-plot distance of 1m. The study was conducted in a RCB design with six treatments and three replications in each trial. Only preventive measures were tested in Trial-1, while Trial-2, Trial-3 and Trial-4 were set to test the performance of different treatments both as preventive and curative measures. The details of treatment combination of each trial and their application procedures are as follows:

Trial-1 :

Treatments	Rate of applications	Application procedure
Soil treatment with Lorsban 15G (chlorpyrifos)	15 kg ha^{-1}	Lorsban 15G was mixed with dry sand and applied one day before sowing of seed rhizomes
Soil treatment with Ridomil Gold MZ 68WG (mancozeb + metalaxyl)	7 kg ha^{-1}	Ridomil Gold MZ 68WG was mixed with dry sand and applied one day before sowing of seed rhizomes
Soil treatment with Neem Oil Cake	400 kg ha^{-1}	Neem oil cake was applied in the rows 7 days before sowing of seed rhizomes
Soil treatment with Lorsban 15G and Ridomil Gold MZ 68WG	With same rate used in T_1 and T_2	The mixture of Lorsban 15G and Ridomil Gold MZ 68WG were applied one day before sowing rhizomes as described above
Soil treatment with Neem Oil Cake and Ridomil Gold MZ 68WG	With same rate used in T_3 and T_2	The neem oil cake and Ridomil Gold were applied 7 and 1 day before sowing rhizomes, respectively in the rows
Control	-	No chemical or neem oil cake was applied

After application of chemicals/or plant material in the selected treatments including control. Water was applied up to soil saturation to ensure their proper action in the soil.

Trial-2: In this trial Lorsban 15G @ 15 kg ha^{-1} was applied at 4 weeks interval starting from the time of appearance of plant damage in addition to the all other treatments of Trial-1. The application of Lorsban 15G was done in furrow after appearance of symptom at the base of the plants. Sufficient water was added to ensure enough soil moisture to dissolve the chemical in the soil properly for easy uptake by the plants.

Trial-3: All the treatments of Trial-1 were included and three times application of Ridomil Gold MZ 68WG @ 3.5 kg ha^{-1} at 4 weeks interval starting from the first occurrence of plant damage. The application of Ridomil Gold MZ 68WG after symptom expression was made in furrow at the base of the plants. Sufficient water was added to make the soil moist enough to dissolve the chemical in the soil properly for easy uptake by the plants.

Trial-4: This trial included all the treatments of Trial-1 and three times application of Lorsban 15G @ 15 kg ha^{-1} and Ridomil Gold MZ 68WG @ 3.5 kg ha^{-1} at 4 weeks interval starting from the occurrence of symptom expression. The chemicals were applied in furrow at the base of the plants. The plots were irrigated and the soil was kept moist enough to dissolve the chemical in the soil properly for easy uptake by the plants.

The uniform rhizomes of 40-50g were dipped into Bordeaux mixture solution for 20 minutes, air dried for 30 minutes in shade. The seed rhizomes were sown in row with spacing of 50 cm x 25 cm. The number of healthy and damaged plant was recorded at fortnightly starting from the date of first expression of damage symptom. The yield of healthy rhizomes of each treatment was recorded separately during harvest. The field-collected data were analyzed by using computer-based MSTAT software. LSD value was calculated for comparing treatment means. Benefit-cost ratio (BCR) of each treatment was calculated using standard method (Annon. 2005).

RESULTS AND DISCUSSION

Effect on plant damage : The effects of various treatments on ginger plant damage in different trials are presented in Table 1. In Trial-1, the highest percentage (21.75%) of plant damage was recorded in control treatment, which was significantly different from all other treatments. The second highest (15.04%) percentage of plant damage was observed in Lorsban 15G applied treatments, which differed significantly from rest of the treatments. In contrast, the lowest percentage (5.75%) of plant damage was found in the plots where combination of neem oil cake and Ridomil Gold MZ 68WG were applied. The moderate damage of plant (7.87 to 8.67%) was observed in neem oil cake, combination of Lorsban 15G and Ridomil Gold MZ 68WG and sole application of Ridomil Gold MZ 68WG treatments, which were statistically identical to each other but significantly different from other treatments of the study.

In Trial-2, the plant damage varied significantly among the treatments. The highest percentage of plant damage (16.70%) was found in control treatment and it was significantly different from rest of the treatments (Table 1). The next highest percentage of plant damage (12.48%) was recorded in the plots where the insecticide, Lorsban 15G was applied and this result differed statistically from other treatments. In contrast, the lowest percentage of plant damage (5.05%) was observed in the treatment using neem oil cake with the fungicide, Ridomil Gold MZ 68WG. The moderate damage of plant (6.64 to 7.13%) was found in the treatment of neem oil cake, Lorsban 15G with Ridomil Gold MZ 68WG and Ridomil Gold MZ 68WG alone and these were statistically similar to each other but significantly different from other treatments (Table 1).

Table 1. Effect of various treatments in different trials on plant damage of ginger at SRC, BARI, Bogra during crop season 2007.

Treatments	Plant damage (%)			
	Trial			
	1	2	3	4
Insecticide (Lorsban 15G)	15.04	12.48	3.45	3.40
Fungicide (Ridomil Gold MZ 68WG)	8.67	7.13	1.32	1.28
Neem Oil Cake	7.87	6.64	1.05	1.03
Insecticide + Fungicide	8.07	6.97	1.49	1.47
Neem Oil Cake + Fungicide	5.75	5.05	1.03	1.02
Control	21.75	16.70	5.13	5.00
LSD Value	2.110	1.224	0.540	0.993
Level of significance	0.05	0.05	0.05	0.05
CV (%)	10.37	7.34	13.18	24.81

The mean percentage of plant damage differed significantly among the treatments of Trial-3. The highest percentage of plant damage (5.13%) was recorded in control treatment which is much lower than the control treatments of Trial-1 and Trial-2 and this result was significantly different from rest of the treatments (Table 1). The second highest percentage of plant damage (3.45%) was also obtained in the plots where the insecticide, Lorsban 15G was applied and it was also statistically different from other treatments. On the other hand, the minimum percentage of plant damage (1.03%) was found in the treatment having neem oil cake with Ridomil Gold MZ 68WG applied treatment. The more or less statistically similar damage of plant (1.05 to 1.49%) was recorded in neem oil cake, Ridomil Gold MZ 68WG and Lorsban 15G with Ridomil Gold MZ 68WG applied plots and these were significantly different from other two treatments (Table 1).

In Trial-4, the mean percentage of plant damage varied significantly with the treatments. The highest percentage of plant damage (5.00%) was found in control treatment which is also much lower than those recorded in the control treatments of Trial-1 and Trial-2 but it was significantly different from that of other treatments (Table 1). The next highest percentage of plant damage (3.40%) was obtained in the plots where Lorsban 15G was applied and it was also statistically different from other treatments. On the other hand, the minimum percentage of plant damage (1.02%) was recorded in neem oil cake with Ridomil Gold MZ 68WG treated plot. The statistically identical damage of plant (1.03 to 1.47%) was observed in neem oil cake, Ridomil Gold MZ 68WG and Lorsban 15G with Ridomil Gold MZ 68WG applied plots and these were significantly different from other two treated plots (Table 1).

Effect on rhizome yield : The effects of various treatments on rhizome yield of ginger in different trials are presented in Table 2. The yield of rhizome in different treatments ranged from 2.07 to 4.87 t ha^{-1} in Trial-1. The highest yield (4.87 t ha^{-1}) was found in neem oil cake and Ridomil Gold MZ 68WG applied plot, which was statistically similar to the plots treated with-sole application of Ridomil Gold MZ 68WG and neem oil cake and combine application of Ridomil Gold MZ 68WG with Lorsban 15G. The lowest yield (2.07 t ha^{-1}) was obtained from control plot, which was statistically identical to the Lorsban 15G treated plot (Table-2).

In Trial-2, the yield of rhizome also varied significantly in different treatments. The highest yield of rhizome (5.35 t ha^{-1}) was obtained from neem oil cake with Ridomil Gold MZ 68WG applied plot and it was statistically identical with other three plots treated with Lorsban 15G with Ridomil Gold MZ 68WG, neem oil cake and Ridomil Gold MZ 68WG. The lowest yield of rhizome (2.31 t ha^{-1}) was recorded from control plot and it was statistically similar to the Lorsban 15G treated plot (Table 2).

The rhizome yield also varied significantly in different treatments of Trial-3. The highest yield of rhizome (6.82 t ha^{-1}) was recorded from neem oil cake with Ridomil Gold MZ 68WG applied plot and it was statistically identical to that of Lorsban 15G with Ridomil Gold MZ 68WG, neem oil cake and Ridomil Gold MZ 68WG treated plots. The lowest yield of rhizome (3.40 t ha^{-1}) was harvested from control plot and it was statistically similar to the Lorsban 15G treated plot (Table 2).

Table 2. Effect of various treatments of different trials on yield of rhizome at SRC, BARI, Bogra during ginger season 2007.

Treatments	Yield of rhizome (t ha^{-1})			
	Trial			
	1	2	3	4
Insecticide (Lorsban 15G)	2.29	2.53	3.69	3.78
Fungicide (Ridomil Gold MZ 68WG)	4.42	4.91	6.38	6.51
Neem Oil Cake	4.47	4.96	6.45	6.58
Insecticide + Fungicide	4.51	5.00	6.47	6.62
Neem Oil Cake + Fungicide	4.87	5.35	6.82	6.93
Control	2.07	2.31	3.40	3.44
LSD Value	0.485	1.815	2.948	0.888
Level of significance	0.05	0.05	0.05	0.05
CV (%)	10.20	8.31	5.08	8.64

The yield of rhizome was also varied significantly in different treatments of Trial-4. The highest yield of rhizome (6.93 t ha^{-1}) was recorded from neem oil cake with Ridomil Gold MZ 68WG treated plot and it was statistically identical to that of Lorsban 15G with Ridomil Gold MZ 68WG, neem oil cake and Ridomil Gold MZ 68WG treated plots. The lowest yield of rhizome (3.44 t ha^{-1}) was found from control plot and it was statistically similar to Lorsban 15G treated plot (Table 2). Ramachandran *et al*. (1989), who studied the rhizome rot of ginger caused by *P. aphanidermatum* and found best control of the disease by treating seed and soil with metalaxyl (Ridomil 5G or Apron 35WS).

The combined effect of four trials on per cent plant damage and yield of rhizome is presented in Table 3. The per cent plant damage varied significantly with the trials. A marked reduced percentage of plant damage was found in Trial-3 and Trial-4. The highest percentage of plant damage (11.19%) was recorded in Trial-1 while 9.16% of plant damage was recorded in Trial-2. Although Trial-1 and Trial-2 showed a significant variation in plant damage but the difference is not markedly high. On the other hand, the plant damage was quite low in Trial-3 (2.25%) and Trial-4 (2.20%) indicating that both the trials were equally effective in reducing the plant damage. Trial-1 showed 5 fold higher plant damage than Trial-3 and Trial-4 (Table 3). The yield of rhizome in Trial-1 and Trial-2 differed significantly with the yield of Trial-3 and Trial-4. The highest yield of rhizome (5.64 t ha^{-1}) was obtained from Trial-4, which is statistically identical to the yield of Trial-3. The lowest yield (3.77 t ha^{-1}) was recorded in Trial-1 which was not significantly different from the yield of Trial-2 (4.18 t ha^{-1}).

Table 3. Combined effect of different trials on plant damage and yield of ginger rhizome

Trial	Plant damage (%)	Yield of rhizome (t ha^{-1})
1	11.19 (3.31)	3.77
2	9.16 (3.02)	4.18
3	2.25 (1.60)	5.54
4	2.20 (1.58)	5.64
LSD value	0.17	0.50
Level of significance	0.01	0.01

Figures within parentheses in column are the transformed values, based on Arc Sin $\sqrt{(x/100)}$.

The combined effect of different treatments on per cent plant damage and yield of rhizome over the trials is presented in Table 4. The percentage of plant damage was significantly different among the six treatments. The highest percentage of plant damage (12.14%) was recorded in control plot, which is statistically different from rest of the treated plots. The next highest (8.59%) percentage of plant damage was found in the plots treated with insecticide (Lorsban 15G).

Table 4. Combined effect of different treatments on plant damage and yield of rhizome

Treatments	Plant damage (%)	Yield of rhizome (t ha-1)
Insecticide (Lorsban 15G)	8.59 (2.84)	3.07
Fungicide (Ridomil Gold MZ 68WG)	4.60 (2.12)	5.56
Neem Oil Cake	4.15 (2.01)	5.62
Insecticide + Fungicide	4.50 (2.12)	5.65
Neem Oil Cake + Fungicide	3.21 (1.83)	5.99
Control	12.14 (3.37)	2.81
LSD value	0.144	0.422
Level of significance	0.01	0.01
CV (%)	11.92	8.00

Figures within parentheses in column are the transformed values, based on $\sqrt{(x + 0.5)}$.

The treatments fungicide (Ridomil Gold MZ 68 WG), neem oil cake and combination of Lorsban 15G and Ridomil Gold MZ 68 WG were equally effective and caused 4.60, 4.15 and 4.50% plant damage, respectively. The plant damage was minimum (3.21%) in the plots treated with neem oil cake and Ridomil Gold MZ 68 WG. The plant damage was 3.8 times higher in control treatment than that of neem oil cake and Ridomil Gold MZ 68WG treated one. The data of plant damage indicated that the use of Lorsban 15G alone is not sufficient in reducing the plant damage. The plant damage ranging from 4.15 to 4.60% was found in Ridomil Gold MZ 68 WG, neem oil cake and Lorsban 15G with Ridomil Gold MZ 68 WG treated plots showing moderate efficacy in each case (Table 4). In addition, application of the botanical (neem oil cake) showed an excellent effect resulting in 4.15% plant damage. Although the efficacy of neem oil cake was not statistically superior to the treatments-Ridomil Gold MZ 68 WG, and Lorsban 15G with Ridomil Gold MZ 68 WG but the plant damage was considerably low in the neem oil cake treatment which made it clear that this botanical is very effective in reducing the plant damage. The efficacy of this botanical was also very much comparable to the efficacy of Ridomil Gold MZ 68 WG which indicates that the neem oil cake has a good fungicidal effect. As it is evident from the data that the insecticide, Lorsban 15G alone failed to reduce plant damage and the other four treatments provided a good control in reducing the plant damage, explaining it as a problem more related to fungus.

A significant difference in plant damage between the plots treated with insecticide (Lorsban 15G) and untreated one was evident in the results which could be explained that the insecticide (Lorsban 15G) had effect on the maggot population of rhizome fly. In addition, the maggots of rhizome fly act as a vector of bacteria responsible for rhizome damage as has been highlighted by Arya (2001). The neem oil cake alone and with Ridomil Gold MZ 68WG provided the best result which is probably due to its broad spectrum effect as fungicide as well as insecticide. The application of neem oil cake with Ridomil Gold MZ 68WG resulted in 3.21% plant damage which was the lowest and provided the highest yield of rhizome (5.99 t ha^{-1}). The rhizome yield was 5.62 t ha^{-1} in the plots treated with neem oil cake and was 5.65 t ha^{-1} in Lorsban 15G with Ridomil Gold MZ 68WG treated plot both of which were statistically identical to the treatment of neem oil cake with Ridomil Gold MZ 68WG. The lowest yield (2.81 t ha^{-1}) was found in control plot which was also statistically similar to the yield of Lorsban 15G treated plots.

The diversified effect of neem cake against various groups of pests has been reported by many authors. Korah and Shingre (1968) reported that neem seed cake not only provides nutrition to the plant, but controls soil-borne pests; it also acts as a nitrification inhibitor, helps respiratory activity, increases the population of earthworms and produces organic acids, which help in removing the alkalinity of the soil. Mukherjee *et al*. (1991) observed a lesser number of bacteria, fungi and actinomycetes in neem cake applied soil. Puri (1999) reported that the denitrification property of neem cake may be due to sulfur compounds which have a well-known antibacterial effect, or the lipids associated with the cake may be responsible for inhibition of bacterial growth. Shyam Sunder (2006) reported that azadirachtin is the key insecticidal ingredient found in the neem tree. Azadirachtin is a naturally occurring substance that belongs to an organic molecule class called etranortriterpenoids. It is structurally similar to insect hormones called ecdysones, which control the process of metamorphosis as the insects pass from larva to pupa to adult. Metamorphosis requires the synchrony of many hormones and other physiological changes to be successful, and azadirachtin seems to be an ecdysone blocker. It blocks the insect's production and release of these vital hormones. Insects then will not moult, thus breaking their life cycle.

Kotikal and Kulkarni (1999) determined the efficacy of phorate (Thimet 10G) at 2.5 kg a.i. ha^{-1}, carbofuran (Furadan 3G) at 0.75 kg ha^{-1}, quinalphos (Ekalux 20EC) at 0.67 kg ha^{-1}, neem cake powder at 250 kg ha^{-1}, pongamia cake powder at 250 kg ha^{-1} and vermicompost at 2.5 t ha^{-1} for control of the turmeric pest, *M. coeruleifrons* in Karnataka, India. The application of phorate, carbofuran, neem cake and pongamia cake caused the lowest *M. coeruleifrons* infestation (8 to 10%) compared to 26% in the untreated control.

Reddy and Reddy (2000) reported that the turmeric fields treated with neem cake were free from the rhizome fly (*M. coeruleifrons*) infestation. A soil amendment with neem cake was reported to reduce the soil inoculum of the pathogen causing soft rot in ginger (Sadanandan and Iyer, 1986). Soil and seed treatment with the fungicides of metalaxyl formulations gave the best control of the rhizome rot disease of ginger (Ramchandran *et al*. 1989). The results of the present study reveal that the botanical, neem oil cake can provide a good control of pest complex of ginger rhizome. The efficacy of neem cake has been reflected from the findings of many other workers who agreed upon the similar results. Therefore, from the results of the present study and the reports of various workers it can be considered that the botanical, neem oil cake as one of the good biologically active natural products for the control of pest complex of ginger rhizome.

Economic analysis was made for the two trials (Trial-3 and Trial-4) showing the best performance. The yield of rhizome against different treatments in Trial-3 and Trial-4 and their benefit cost ratios (BCR) calculated following Annonymous (2005a) are presented in Table 5.

Table 5. Economic analysis of different treatments against rhizome damage by pests at SRC, BARI, Bogra during ginger season 2007.

Treatments	Trial	Pest management cost (Tk/ha)	Yield of rhizome (t ha-1)	Gross return (Tk/ha)	Net return (Tk/ha)	Adjusted net return (Tk/ha)	BCR
Insecticide	3	7,650.00	3.69	1,84,500/-	1,76,850/-	9,350.00	1.22
	4	9,900.00	3.78	1,89,000/-	1,79,100/-	11,850.00	1.20
Fungicide	3	10,150.00	6.38	3,19,000/-	3,08,850/-	1,41,350.00	13.93
	4	12,400.00	6.51	3,25,500/-	3,13,100/-	1,45,850.00	11.76
Neem oil cake	3	15,150.00	6.45	3,22,500/-	3,07,350/-	1,39,850.00	9.23
	4	17,400.00	6.58	3,29,000/-	3,11,600/-	1,44,350.00	8.30
Insecticide + Fungicide	3	14,650.00	6.47	3,23,500/-	3,08,850/-	1,41,350.00	9.65
	4	16,900.00	6.62	3,31,000/-	3,14,100/-	1,46,850.00	8.69
Neem oil cake + Fungicide	3	22,150.00	6.82	3,41,000/-	3,18,850/-	1,51,350.00	6.83
	4	24,400.00	6.93	3,46,500/-	3,22,100/-	1,54,850.00	6.35
Control	3	2,500.00	3.40	1,70,000/-	1,67,500/-	0.00	-
	4	4,750.00	3.44	1,72,000/-	1,67,250/-	0.00	-

As per the results, the highest rhizome yield was obtained in the treatment with neem oil cake plus Ridomil Gold MZ 68WG in Trial-4 while the highest BCR of 13.93 was obtained from sole application of Ridomil Gold MZ 68WG in Trial-3 but it was 11.76 in the same treatment of Trial-4. The BCR of Lorsban 15G with Ridomil Gold MZ 68WG treatment was 9.65 calculated from Trial-3 which was 8.69 in Trial-4. The next BCR (9.23) was recorded from the neem oil cake applied treatment in Trial-3 where this was 8.30 of the same treatment in Trial-4. Considering the BCR, the treatments were ranked as: Ridomil Gold MZ 68WG > Ridomil Gold MZ 68WG with Lorsban 15G >Neem Oil Cake.

REFERENCES

ANONYMOUS. 2005a. Annual Report, 2004-2005. Division of Entomology, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. 82p.

ANONYMOUS. 2005b. Yearbook of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics. Planning Division, Ministry of Planning, Government of the People's Republic of Bangladesh. p75.

AKHTER, M. I., RAHIM, M. A. & MIAH, M. A. K. 2005. The Production Technology of Spices Crops. Spices Research Centre, Bangladesh

Agricultural Research Institute, Shibgonj, Bogra, Bangladesh. Publication No. bklt-01. 34p.

ARYA, P. S. 2001. Ginger Production Technology. Kalyani Publishers, New Delhi-110 002. 169p.

CHOWDHURY, A. K., FIROZ, Z. A. & HAQUE, F. M. E. 1998a. Performance of ginger legumes intercropping at different spacing of ginger in hilly region. *Bangladesh J. Agril. Res*. **23**(1) : 135-142.

KORAH, P. A. & SHINGRE, A. K. 1968. On the effect of non-edible oil cakes on the respiratory activity of soil. *Agricultural Research Journal of Kerala, India*. **6** : 95-97.

KOTIKAL, Y. K. & KULKARNI, K. A. 1999. Management of rhizome fly, *Mimegralla coeruleifrons* Macquart (Micropezidae : Diptera), a serious pest of turmeric in Northern Karnataka. *Pest Managt in Hort. Ecosyst*. **5** (1) : 62-66.

MUKHERJEE, D., MITRA, S. & DAS, A. C. 1991. Effect of oil cakes on changes in carbon, nitrogen and microbial population in soil. *J. Indian Soc. Soil Sci*. **39** : 457-462.

PURI, H. S. 1999. NEEM, The Divine Tree, *Azadirachta indica*. Harwood Academic Publishers. Printed in Singapore. 182p.

RAMACHANDRAN, N., DHAKE, G. N. & SHARMA, Y. R. 1989. Evaluation of systemic fungicides for efficacy against rhizome rot of ginger. *Indian Phytopath*. **42** : 530-533.

REDDY, M. R. S. & REDDY, P. V. R. M. 2000. Preliminary observations on neem-cake, against rhizome fly of turmeric (*Curcuma longa*). *Insect Environ*. **6**(2): 62-67.

SADANANDAN, A. K. & IYER, R. 1986. Effect of organic amendments on rhizome rot of ginger. *Indian Cocoa, Arecanut and Spices J*. **9** (4): 94-95.

SHYAM SUNDER, 2006. NEEM - For Organic Farming and Health. J. V. Publishing House, 322-323, Rai Bahadur Bazar, M. G. H. Road, Jodhpur, India. 102p.

SONTAKKE, B. K. 2000. Occurrence, damage and biological observations on rhizome fly, *Mimegralla coeruleifrons* infesting ginger. *Indian J. Entomol*. **62** (2): 146-149.

(MS received for publication 12 September 2013)

Bangladesh j. entomol. (2013) ***23****(2), 97-114* *ISSN 1021-1004*

INSECTICIDAL AND REPELLENT EFFECT OF SOME INDIGENOUS PLANT EXTRACTS AGAINST RICE WEEVIL, *SITOPHILUS ORYZAE* (L.) (COLEOPTERA: CURCULIONIDAE)

M. A. A. BACHCHU*, M. O. GHANI, M. A. HOSSAIN & R. ARA

Department of Entomology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur.

ABSTRACT

Insecticidal and repellent effect of five indigenous plant extracts was evaluated against rice weevil, *Sitophilus oryzae* (L.) during the period from April to December 2012. The petroleum ether extracts of ata (*Annona squamosa*) and castor seed (*Ricinus communis*), leaf of karabi (*Nerium olender*), marigold (*Tagetes erecta*) and nishinda (*Vitex negundo* L.) at 0.5, 1.0 and 1.5 % concentration were evaluated for their repellency, direct toxicity and residual effects. The results showed that all tested plant extracts were effective in reducing insect infestation and had different toxic, residual and repellent effects on *S. oryzae*. Among the five tested plant extracts, ata seed extract showed the highest toxic effect (mortality 64.18 %) while the castor seed extract resulted the lowest toxic effect (21.66 %). Mortality percentages were directly proportional to the level of concentration and hours after treatment. All extracts provided good protection of wheat seeds by reducing insect oviposition, F_1 adult emergence and grain infestation over control. The residual effect of ata seed extract was higher than that of all other plant extracts based on emergence of adults. Ata seed extract also showed the highest repellency effect and castor seed extract showed the lowest repellency effect. The order of toxicity was found ata > karabi > marigold > nishinda > castor considering all the concentration and efficacy.

Keywords: Plant extracts, Petroleum ether, Mortality, Repellency, *Sitophilus oryzae*

INTRODUCTION

The people of Bangladesh store different kinds of grains both for the seed and food purposes to ensure a continuous supply through out the year. In developing countries like Bangladesh, the losses due to insect infestation in storage are the most serious problem, particularly in villages and towns. In fact, huge amount of

*Corresponding author: Email:adnan_hstu@yahoo.com

food grains are either damaged or lost due to lack of proper knowledge of storage methods. Storage losses can be significant in developing countries where more than 70 % of cereal production is stored in farms (Wright 1985). This damage may loss about 5 to 10 % in temperate zone and 20 to 30 % in tropical zone (Haque *et al.* 2000). In Bangladesh, about 10 - 15 % of food products are wasted due to lack of proper post harvest technologies at rural to national godowns (Ali 1999).

More than 600 species of Coleopteran pests attack stored agricultural products which cause quantitative and qualitative losses (Sarker *et al.* 2006, Rajendran & Sriranjini 2008). Among them, rice weevil, *Sitophilus oryzae* (L.) is one of the major pest of grains stored in bulk at farms and has got economic importance (Lucas & Riudavets 2002). Both the adult and grub feed voraciously on a variety of stored cereals viz., rice, wheat, maize and sorghum causing serious losses, particularly in the monsoon (Lee *et al.* 2001). Rice weevil causes substantial damage to stored grain in Bangladesh but its loss estimates are scanty. The *S. oryzae* has a relatively short developmental period and high populations can easily be built up within short time (Aitken 1975). For that reason, heavy infestations may take place unless control measures are taken.

Control of this pest in store mostly relies on the use of various broad spectrum synthetic insecticides and the fumigants like methyl bromide and phosphine. Though they are effective, but solely reliance on chemicals protection has serious drawbacks such as direct toxicity to beneficial insects and human health and increased environmental and social costs (Negahban *et al.* 2006, Cosimi *et al.* 2009). Moreover, *S. oryzae* has been reported to develop resistance to synthetic insecticide (Benhalima *et al.* 2004). Indigenous plant products as natural insecticides may be an alternative of chemicals (Khattach & Hameed 1986, Mahmud *et al.* 2002). The use of locally available indigenous plant materials in the control of pests are an ancient technology and used in many parts of the world (Roy *et al.* 2005). There are about 2000 plants have been reported to possess pest control properties (Ahmed *et al.* 1984). The uses of botanical pesticides are very promising because of several advantages such as they are easily available, less expensive, biodegradable, safe to apply and unique in action. Even though the use of simple crude botanical leaf and seed extracts is important for grain protectant by resource limited farmers in developing countries like Bangladesh. Keeping these in view the present study was therefore, undertaken to assess direct toxicity, residual and repellent effects of five indigenous plants extracts against rice weevil.

MATERIALS AND METHODS

The study on the insecticidal and repellent effect of five indigenous plant extracts against rice weevil, *Sitophilus oryzae* (L.) was carried out in the laboratory of the Department of Entomology, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period from April to December 2012.

Collection and preparation of botanicals: The fresh leaves of karabi (*Nerium olender*), marigold (Tagetes erecta) and nishinda (*Vitex negundo* L.), seeds of ata (*Annona squamosa*), and castor (*Ricinus communis*) were collected from the HSTU campus. They were kept in the laboratory for 7 days for air drying followed by one day sun drying before making powder. After drying they were made powder separately by an electric grinder in the laboratory and passed through a 60-mesh sieve to get fine powder. Later, the powder was stored separately at room temperature in air tight plastic pot for the study.

Collection of wheat grain: Healthy wheat grain Triticum aestivum (L.) was purchased from the local market of Dinajpur town. The grains were thoroughly cleaned, sun dried, cooled and maintained at 10±2 % moisture level and stored at room temperature in big air tight plastic bags for further use.

Culture of test insect: Adult rice weevils were collected from the godown of Dinajpur town and were mass reared in the laboratory at ambient temperature (28±3^{o}C) in glass jars. Approximately 200 adults of the collected weevils were released in each glass jar (47 cm height × 4 cm dia) containing 500 g of wheat seeds and the mouth was closed with nylon organza. The weevils were allowed for free mating and oviposition for a maximum period of 7 days. After oviposition, the weevils were separated from the seeds by sieving and seeds along with eggs were left in the container for further development. They were allowed to emerge as larvae and later into pupae. The newly emerged adults were collected and again allowed for oviposition in newly added fresh seeds in plastic containers (26 cm height x 10 cm dia.) to maintain a stock culture of the test insect. The stock culture of the test insect was maintained throughout the study period. Only 1 to 7 days old adult weevils were used for the subsequent studies.

Preparation of plant extracts: Previously prepared 100 g of different plant powders were dissolved in 300 ml of petroleum ether separately and stirred for 30 minutes in a magnetic stirrer. The mixture was then allowed to stand for 72 hours and shaking several intervals (6 hours). Then, the mixture was filtered through a filter paper (Whatman no. 1) and allowed to evaporate the solvents. The filtrates were taken into round bottom flasks and condensed by evaporation of solvent in a water bath at 70ºC to make it 10 ml which was used as stock solution (Kamruzzaman *et al.* 2004). From this, 1.5 %, 1.0 %, and 0.5 % concentration was prepared for the study. Pilot experiments were done to obtain the appropriate dose.

Toxicity test: Toxicity test of five indigenous plant extracts against *S. oryzae* were conducted according to the method described by Talukder & Howse (1993) with minor modification. Before applying extracts to the thorax of the insect, 10 minutes chilling were done at 4ºC in refrigerator. One µl of prepared solution was applied to the dorsal surface of the thorax of each insect with the help of a micropipette. Ten insects per replication were treated and each treatment was replicated thrice along with control. Insect mortality was recorded at 24, 48 and 72 hours after treatment (HAT). The percentage of the mortality was corrected using Abbott's (1987) formula before analysis.

Residual toxicity effects: For evaluating residual effect of plant extracts on insect mortality, the extracts were mixed with wheat grains separately (1ml / 50 gm wheat) followed by air dried for 10 minutes. Extract treated wheat grain were placed in bottle (10 cm height x 7 cm dia.). Five pairs of one day old adults were released into the bottle containing plant extracts treated wheat grain and bottle was covered with perforated lid. Three replications were maintained for each of the concentration (1.5%, 1.0% and 0.5%) of the individual plant extracts along with control. All treated bottles were kept at ambient temperature (28±3ºC) in the laboratory for oviposition. After 7 days, dead and alive adult weevils were removed from each container and number of eggs on the grain surface were counted. For the determination of oviposition, 100 seeds were collected randomly from each bottle of each treatment and examined under magnifying glass (10x), eggs were counted and returned to respective container for further development. After emergence the F_1 adult, 100 seeds were counted up to the period of 48 days and for calculating inhibition rate (% IR), the number of insects in control and treated ones were counted. Now the IR (%) was calculated by the following formula:

% IR= Cn-Tn/Cn x 100
Where, Cn= Number of insect on control treatment
Tn = Number of insect on treated treatment

Repellency test: The repellent activities of the five indigenous plant extracts were evaluated using the filter paper impregnation method (Talukder & Howse 1994) with a minor modification. The Whatman no. 40 filter papers were cut into two half, and 1ml solution of each concentration was applied to each half uniformly with the help of micro pipette. The treated and control papers (solvent only) then air dried for 20 minutes to evaporate the solvent. The treated half of the paper was placed with the untreated half and kept them at the bottom of petridishes face to face. The treated and control paper were placed in a Petridish (90 mm diameter) face to face and then 5 pairs of adults were released at the centre of the filter paper. Vaseline was applied to the inner vertical side and lid of the petridish to prevent the weevils from climbing onto the side. Then the petridish was covered with its lid and kept in darkness in the laboratory. The number of insects was counted on each half portion at hourly intervals upto the 6th hour along with control. Each treatment was replicated thrice. The data was expressed as percentage of repulsion (PR) using the following formula where: the positive values expressed repellency while the negative showed attractancy. The PR was calculated by using the following formula: PR= (Nc-50) x 2 where, Nc= % of insects present in the control half. The average values were categorized according to the following scale as stated by McDonald *et al.* (1970).

Class	Repellency (%)	Class	Repellency (%)
0	> 0.01 to 0.1	III	40.1 to 60
I	0.1 to 20	IV	60.1 to 80
II	20.1 to 40	V	80.1 to 100

Statistical analysis: The collected data were statistically analyzed by using completely randomized design (CRD). The treatment mean values were separated by Duncan's New Multiple Range Test (DMRT). The observed mortality data was also subjected to probit analysis. All statistical analyses were done through a Mathematical and Statistical (MSTAT) program and graphical works through Microsoft Excel program.

RESULTS

The insecticidal potency of five indigenous plant extracts was evaluated against rice weevil under laboratory conditions. The results of the experiment are described below:

Direct toxicity effects : The average mortality percentages of rice weevil due to plant extracts were differed statistically (P < 0.05) among the treatments (Table 1). Mortality at 24, 48 and 72 hours after treatment (HAT) indicated that ata seed extract possessed the highest (64.18%) toxic effects, whereas castor seed extract the lowest (21.66%)(Table 1). The order of the toxicity of five plant extracts was: ata > karabi > marigold > mishinda > castor. The highest mortality (79.11%) was observed at the highest concentration (1.5%) of plant extract while the lowest mortality (37.34%) was found at the lowest concentration (0.5%) (Table 2). But no mortality was observed in control treatment. The interaction effects of plant, dose and time was found statistically significant (Table 3). Average values indicated that the cent percent mortality was found from ata plant extracts at highest concentration (1.5%).

Table 1: Mean mortality percentage of rice weevil, *Sitophilus oryzae* treated with different plant extracts by tropical application method at different HAT (Interaction of plant extract and time).

Name of the Plant extracts	Mortality percentage at different time intervals			
	24 HAT	48 HAT	72 HAT	Average mortality
Ata	60.83a	65.00a	66.67a	64.18a
Karabi	50.00b	60.00a	62.50a	57.50b
Castor	18.33e	21.67d	25.00c	21.66e
Marigold	37.50c	45.83b	47.50b	43.62c
Nishinda	31.67d	34.17c	47.50b	37.79d
P- value	0.0001	0.0001	0.0001	0.0001
LSD	4.69	5.21	4.48	3.95
CV (%)	4.32	3.91	2.89	2.63
SE	1.64	1.82	1.56	1.38

HAT= Hour after treatment
Within column values followed by different letter(s) are significantly different by DMRT at 5 % level of probability.

Table 2: Effect of doses of different plant extracts on the mortality of rice weevil, *S. oryzae* by tropical application method at different HAT (Interaction of doses and time).

Dose (%)	Mortality percentage at different time intervals			
	24 HAT	48 HAT	72 HAT	Average mortality
0.0 (control)	0.00d	0.00d	0.00d	0.00d
0.5	32.67c	35.33c	44.00c	37.34c
1.0	56.00b	65.33b	68.67b	63.35b
1.5	70.00a	80.67a	86.67a	79.11a
P- value	0.0001	0.0001	0.0001	0.0001
LSD	4.20	4.66	4.01	3.53
CV (%)	4.32	3.91	2.89	2.63
SE	1.46	1.62	1.40	1.23

HAT= Hour after treatment

Within column values followed by different letter(s) are significantly different by DMRT at 5 % level of probability.

Probit analysis for toxicity : The results of the probit analysis for the estimation of LD50 values, 95% feducial limits and chi square values at 24, 48 and 72 HAT for the mortality of rice weevil are presented in Table 4. The LD50 values indicated that ata (0.45 µg) was the most toxic followed by karabi (0.50 µg). Meanwhile castor (2.16 µg) was the least toxic at 24 HAT. Ata also maintained the highest toxicity when the LD50 values were compared at 48 HAT (0.41 µg) and 72 HAT (0.36 µg). Similar trend of results was also observed at 48 and 72 HAT. The chi-square values indicated that mortality of insect at different HAT were insignificant at 5% level of probability and did not show any heterogeneity.

Table 3: Mean mortality percentage of rice weevil, *S. oryzae* treated with different plant extracts by tropical application method at different dose level and HAT (interaction of plant extracts, dose and time).

Name of the Plant extracts	Dose (%)	Percentage of insect mortality at different time intervals			
		24 HAT	48 HAT	72 HAT	Average mortality
Ata	0.0	0.00j	0.00h	0.00h	0.00j
	0.5	56.67e	60.00cd	66.67d	61.13e
	1.0	86.67b	100.0a	100.0a	95.57ab
	1.5	100.0a	100.0a	100.0a	100.0a
Karabi	0.0	0.00j	0.00h	0.00h	0.00j
	0.5	50.00ef	53.33de	63.33d	55.57ef
	1.0	70.00d	86.67b	86.67c	81.10c
	1.5	80.00bc	100.0a	100.0a	93.33ab
Castor	0.0	0.00j	0.00h	0.00h	0.00j
	0.5	10.00i	10.00h	16.67g	12.20i
	1.0	26.67h	33.33fg	36.67f	32.23h
	1.5	36.67g	43.33ef	46.67e	42.20g
Marigold	0.0	0.00j	0.00h	0.00h	0.00j
	0.5	23.33h	30.00g	33.33f	28.90h
	1.0	53.33e	60.00cd	60.00d	57.80ef
	1.5	73.33cd	93.33ab	96.67ab	87.77bc
Nishinda	0.0	0.00j	0.00h	0.00h	0.00j
	0.5	23.33h	23.33g	40.00ef	28.90h
	1.0	43.33fg	46.67e	60.00d	50.03fg
	1.5	60.00e	66.67c	90.00bc	72.23d
	P- value	0.0001	0.0001	0.0001	0.0001
	LSD	9.39	10.42	8.97	7.90
	CV (%)	4.32	3.91	2.89	2.63
	SE	3.28	3.63	3.13	2.75

HAT= Hour after treatment

Within column values followed by different letter(s) are significantly different by DMRT at 5 % level of probability.

Table 4: Relative toxicity (by probit analysis) of different plant extracts treated against rice weevil, *Sitophilus oryzae after* 24, 48 and 72 HAT.

Name of the Plant extracts	No. of insect used	LD_{50} values (µg)	95 % fiducial limits		χ^2 values
			Lower	Upper	
24 HAT					
Ata	90	0.45	0.3264015	0.6316205	0.20743
Karabi	90	0.50	0.2848516	0.9023578	0.00009
Castor	90	2.16	1.055749	4.426739	0.06769
Marigold	90	0.93	0.7455038	1.171104	0.00899
Nishinda	90	1.14	0.8321165	1.562745	0.04704
48 HAT					
Ata	90	0.41	0.2997458	0.5756118	1.09452
Karabi	90	0.48	0.3618938	0.638851	0.06141
Castor	90	1.67	1.069428	2.617227	0.22149
Marigold	90	0.73	0.6048285	0.8881281	2.18805
Nishinda	90	1.03	0.7958676	1.342043	0.07574
72 HAT					
Ata	90	0.36	0.2402006	0.5647698	0.88356
Karabi	90	0.38	0.2434323	0.6143315	0.39381
Castor	90	1.61	0.9496852	2.744131	0.05333
Marigold	90	0.70	0.5814081	0.8563526	3.82381
Nishinda	90	0.66	0.5151702	0.8595201	2.24758

HAT = Hour after treatment

Values were based on four concentrations, three replications of 10 insects each.

χ^2 = Goodness of fit

The tabulated value of χ^2 is 5.99 (d. f = 2 at 5% level)

Probit regression lines : The probit regression lines for the effect of five different plant extracts are shown in figures 1. The insect mortality rate showed positive correlation with doses of the plant extracts in all cases. The probit regression lines

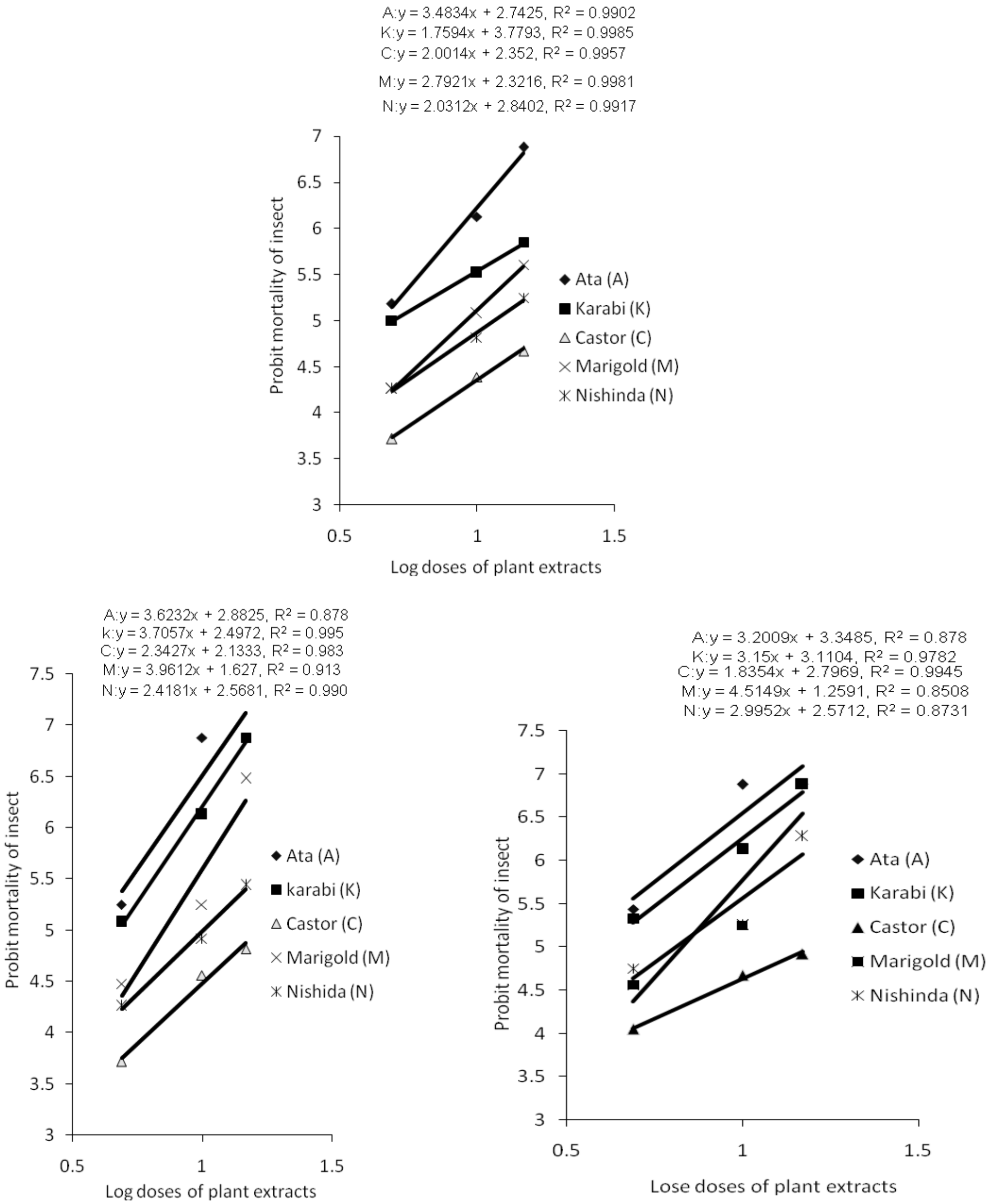

Fig.1. Relationship between probit mortality and log doses of different plant extracts on rice weevil, *Sitophilus oryzae* at 24 HAT (left), 48 HAT (right) and 72 HAT (bottom)

for the effect of five different plant extracts (ata, castor, karabi, marigold and nishinda) on rice weevil showed a clear linear relationship between probit mortality and their doses. The probit regression lines become steeper as doses increased, because the adult insects were exposed to more toxic materials at higher doses. Comparing among five probit lines, ata showed the highest and castor showed the lowest probit mortality at 24, 48 and 72 HAT.

Residual toxicity effects : The number of eggs, holes and F1 adults emerged were statistically different among the plant extracts in all level of concentration (Table 5). Significantly the lowest number of eggs (6.00), holes (3.33) and F1 adult (0.67) were found in ata followed by karabi at the highest concentration (1.5%). On the contrary, the highest number of eggs (18.00), holes (12.00) and F1 adults (10.67) were found in castor at same concentration. The highest inhibition (88.50%) was observed when seeds were treated with ata seed extract followed by karabi leaf (85.89%), marigold leaf (68.00%) nishoinda leaf (64.00%) and castor seed (55.55%) extracts over control. Almost similar trends of results were observed with other doses of extracts.

Table 5. Residual toxicity effect of different plant extracts at different concentrations on *Sitophilus oryzae* after grain treatment.

Name of the plant extracts	Concentrations (%)	No. of eggs /100 seeds	No. of holes /100 seeds	No. of F_1 adults /100 seeds	Inhibition rate (%)
Ata	0.0	29.33 a	28.67 a	27.00 a	0.00j
	0.5	11.00 ghi	9.67 ij	2.33 hij	66.66cd
	1.0	7.67 ij	6.67 jk	1.67 hij	77.01bc
	1.5	6.00 f	3.33 l	0.67 j	88.50a
Karabi	0.0	29.33 a	26.00 abc	23.67 b	0.00j
	0.5	15.67 ef	7.33 jk	3.67 h	75.12bc
	1.0	12.00 gh	5.33 kl	2.33 hij	79.49ab
	1.5	8.00 ij	3.67 l	1.33 ij	85.89ab
Castor	0.0	28.67 a	27.00 ab	27.00 a	0.00j
	0.5	24.67 bc	20.33 d	18.67 c	24.69i
	1.0	21.33 cd	18.33 de	16.00 d	32.09hi
	1.5	18.00 de	12.00 hi	10.67 f	55.55ef
Marigold	0.0	27.67 ab	25.00 bc	25.00 ab	0.00j
	0.5	18.00 de	15.00 fg	13.00 e	40.00gh
	1.0	14.67 efg	12.67 gh	10.00 f	49.33fg
	1.5	11.67 gh	8.00 jk	3.33 hi	68.00cd
Nishinda	0.0	27.67 ab	24.00 c	25.00 ab	0.00j
	0.5	18.00 de	15.67 ef	11.67 ef	37.33h
	1.0	14.00 fgh	12.33 ghi	7.67 g	50.67f
	1.5	10.67 hi	9.00 j	3.33 hi	64.00de
	LSD	3.341	2.712	1.929	10.7
	$\frac{s}{x}$	1.169	0.948	0.675	3.7

Within column values followed by different letter(s) are significantly different by DMRT at 5 % level of probability.

Repellency effect : The repellency effects of ata, castor, karabi, marigold and nishinda leaf and seed extracts on rice weevil showed that all the five plant extracts have good repellent action at all tested level of concentration (Table 6). The repellency effect differed significantly among the plant extracts and different level of concentration ($P < 0.05$). Among the plant extracts, ata showed the highest

(73.33%) repellency at the maximum dose (1.5%) while the lowest (28.89%) repellency was observed in castor seed extract followed by nishinda (32.22) leaf extract at 1.0% level of concentration. The order of repellency class of different plant extracts at various concentrations was found II to V (Table 6).

Table 6. Repellent effect of different plant extracts at different dose level on *Sitophilus oryzae* using treated wheat grain at different HAT (interaction of plant, dose and time).

Name of the Plant extracts	Repellency rate (%)								
	Doses (%)	1 HAT	2 HAT	3 HAT	4 HAT	5 HAT	6 HAT	% Mean repellency	Repel. classes
Ata	0.0	0.00f	0.00d	40.00a-c	0.00c	0.00e	0.00f	6.70gh	I
	0.5	20.00d-f	53.33bc	53.33ab	40.00a-c	66.67a-c	86.67ab	53.33a-d	III
	1.0	33.33c-e	66.67a-c	40.00a-c	60.00ab	93.33a	93.33a	64.43a-c	IV
	1.5	46.67b-d	80.00ab	73.33a	66.67ab	86.67ab	86.67ab	73.33a	IV
Karabi	0.0	0.00f	20.00cd	0.00c	20.00bc	0.00e	0.00f	6.700gh	I
	0.5	40.00b-d	60.00a-c	33.33a-c	20.00bc	20.00de	33.33c-f	34.43d-f	II
	1.0	33.33c-e	60.00a-c	46.67a-c	53.33ab	40.00c-e	53.33a-e	47.80b-e	III
	1.5	46.67b-d	60.00a-c	73.33a	80.00a	66.67a-c	66.67a-d	65.57ab	IV
Castor	0.0	0.00f	0.00d	0.00c	40.00a-c	40.00cde	0.00f	13.30f-h	I
	0.5	53.33bc	33.33b-d	26.67a-c	40.00a-c	40.00c-e	46.67b-e	40.00c-e	II
	1.0	6.66ef	46.67bc	20.00bc	26.67bc	20.00de	53.33a-e	28.89e-g	II
	1.5	33.33c-e	53.33bc	40.00a-c	80.00a	60.00a-d	46.67b-e	52.23a-e	III
Marigold	0.0	0.00f	0.00d	0.00c	0.00c	0.00e	20.00ef	3.30h	I
	0.5	60.00a-c	60.00a-c	53.33ab	66.67ab	60.00a-d	26.67d-f	54.43a-d	III
	1.0	40.00b-d	66.67a-c	46.67a-c	53.33ab	46.67b-d	73.33a-c	54.43a-d	III
	1.5	86.67a	100.0a	33.33a-c	53.33ab	33.33c-e	53.33a-e	60.00a-c	III
Nishinda	0.0	0.00f	0.00d	0.00c	0.00c	0.00e	0.00f	0.00h	0
	0.5	46.67b-d	53.33bc	73.33a	60.00ab	60.00a-d	33.33c-f	54.43a-d	III
	1.0	20.00d-f	40.00b-d	26.67a-c	20.00bc	46.67b-d	40.00c-f	32.22d-f	II
	1.5	66.67ab	46.67bc	73.33a	80.00a	66.67a-c	93.33a	71.13ab	IV
P- value		0.0773	0.0384	0.3184	0.118	0.0263	0.0717	0.117	
LSD		27.41	39.42	40.33	42.73	38.41	36.69	21.21	
CV (%)		2.38	3.00	4.78	4.13	4.89	4.96	3.43	
SE		9.57	13.77	14.09	14.93	13.42	12.81	7.41	

HAT= Hour after treatment
Mean followed by the same letter(s) did not differ significantly at 5% level by DMRT

DISCUSSION

Some promising information was obtained from the present study. The results of the findings revealed that all the tested plant extracts had toxic effects against *S. oryzae*. Among those ata seed extracts had significant toxic effect. Mortality percentage of all the plant extracts were found directly proportional to the doses and time of exposure (Tables 1-3). Adult mortality might attribute owing to insecticidal potency of the extracts. Except ata seed extract, none of the other tested extracts were found effective at maximum dose (1.5%). Although the seed extract of castor and the leaf extracts of karabi, nishinda and marigold performed significant mortalities of rice weevil but failed to provide cent percent mortality. It is indicated that various efficacies of pest controlling properties of different tested plant extracts are not uniformly distributed. Babu *et al.* (1998) reported that the seeds of Custard apple, *Annona squamosa* were found to have insecticidal properties. The mortality per cent recorded by Ali *et al.* (1981) is comparable with present findings. The adult mortality is probably due to the presence of bioactive chemical components in plant products. The biological activity of ata seed extracts might be attributed to its several alkaloids contents such as Anonaine, Squamocins B to N, Annotemoyin-1, Annotemoyin-2, squamocin & cholesterol, glucopyranoside etc. (Pandey & Brave 2011) which might caused mortality to insects.

The chi-square values ($P < 0.05$) of different plant extracts at different HAT did not show any heterogenecity of mortality. Pandey & Brave (2011) opined that the ethanolic *Annana squamosa* extract showed potent activity against *S. oryzae* where cent percent mortality was achieved within 39.6±1.4 and 14.5±1.1min of exposure at 1% and 5% (w/v) concentration, respectively. Siva (2001) reported that custard apple seed powder at 5 per cent applied in rice and wheat grains showed cent per cent mortality in the same insect within 7 days after adult release. The results also revealed that the plant extracts at highest concentration inhibited F1 adults over the control which was directly proportional to the level of concentrations (Table 5). The reduction in adult emergence is probably due to egg mortality or larval mortality or even reduction in eggs from hatching. The egg mortality has been attributed to the toxic compound present in the plant materials (Su 1977), while Singh *et al.* (1978) considered the physical properties cause changes in the surface and oxygen tension in the egg. Disruption of water balance of egg cause lethality in developing embryo as suggested by Messina & Renwick (1983). Similar results were also observed by Srivastava & Mann (2002).

The repellency influenced by plant extracts as compared to control (Table 6). This might be due to the effective adhesion of extracts on adult or either create obstacle in their rupturing or some unknown physiological changes resulting in repulsion. The present study agreed with the previous finding of Mishra *et al.* (1992). They found that wheat grains can be protected from the attack of *S. oryzae* by mixing custard apple seed powder at 5 per cent for 75 days. The custard apple seed extract possess more olfactory repellency property against normal susceptible strain of *S. oryzae* and *T. castanum* (Quadri, 1973).

The present study indicates the insecticidal potency of indigenous plant extracts (ata, castor, karabi, marigold and nishinda) against stored rice weevil. The finding of insecticidal bio-activity is of great economic importance for sustainable grain preservation. The reasons for using natural insecticides are less prone, cheaper, easily available, and processesable. Therefore, plant extracts can be used in suppressing storage pest especially rice weevil.

REFERENCES

ABBOTT, W.S. 1987. A method of computing the effectiveness of an insecticide. *J. American Mosquito Cont. Assoc.* **3**: 302-303.

AHMED, S., GRAINGE, M., HYLIN, J.W., MITEHEL, W.C. & LITSINGER, J.A. 1984. Some promising plant species for use as pest control agents under traditional farming systems. In: Proc. *2nd Int. Neem conf.* R. Halzhousen centre, Germany, pp 565 - 580.

AITKEN, A.D. 1975. Insect travelers I : Coleopteran *Technological Bulletin*. **31**.

ALI, M.M. 1999. National consideration in plans and programmes. In: I.S. Chowdhury (ed.). Observer Magazine. 15 October, 1999. the Bangladesh Observer, Al-Helal Printing and Publishing Co. Ltd., Motijheel C/A. Dhaka-1000.

ALI, S.I., RAVAT, R.R. & SINGH, O.P. 1981. Effectiveness of various form of custard apple seed powder as seed protectant against the pulse beetle, *Callosobruchus chinensis* L. *Bull. Grain Tech.* **19**: 53-55.

BABU, P.B.S., RAO, J.M. & JOY, B. 1998. Effect of crude oils of *Annona squamosa* and *A. reticulata* on feeding and development of *Spodoptera litura* (Fab.) larvae. *J. Insect Sci.* **11**: 184-185.

BENHALIMA, H., CHOUDHARY, M.Q., MILLIS, K.A. & PRICE, N. 2004. Phosphine resistance in stored product insect collected from various grain storage facilities. *J. Stored Prod. Res*. **40**(3): 241 - 249.

COSIMI, S., ROSSI, E., CIONI, P.L. & CANALE, A. 2009. Bioactivity and qualitative analysis of some essential oils from mediteranean plants against stored product pests: evaluation of repellency against *Sitophilus zeamais* Motschulsky, *Crypiolester ferrugineus* (*stephensis*) and *Tenebrio molitor* (L.). *J. Stored Prod. Res*. **45**: 125 - 132.

HAQUE, M.A., NAKAKITA, H., IKENAGA, H. & SOTA, N. 2000. Development inhibiting activity of some tropical plants against *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae). *J. Stored Prod. Res*. **36**: 281 - 286.

KAMRUZZAMAN, M., SHAHJAHAN, M., CHOWDHURY, S. & ISLAM, M.F. 2004. Repellant effect of some indigenous plant extracts against rice weevil, *Sitophilus oryzae* (L.) *Bangladesh J. Environ. Sci*. **10**: 271-275.

KHATTACH, S.U. & HAMEED, M. 1986. Control of pulse beetle, *Callosobruchus chinensis* (L.) by gamma radiation, irradiated as unmated adults. *Bangladesh J. Zool*. **14**(2): 167-169.

LEE, B., CHOI, W., LEE, S. & PARK, B. 2001. Fumigant toxicity of essential oils and their constituent compounds towards the rice weevil, *Sitophilus oryzae*. *Crop Prot*. **20**: 317-320.

LUCAS, E. & RIUDAVETS, J. 2002. Biological and mechanical control of *Sitophilus oryzae* (Coleoptera: Curculionidae) in rice. *J. Stored Prod. Res*. **38**: 293 - 304.

MAHMUD, M.K., KHAN, M.M.H., HUSSAIN, M., ALAM, M.I. & AFRAD, M.S.I. 2002. Toxic effect of different plant oils on pulse beetle, *C. chinensis* L. (Coleoptera: Bruchidae). *J. Asiatic Society Bangladesh*. **28**(1): 11-18.

MCDONALD, L.L., GUY, R.H. & SPEIRS, R.D. 1970. Preliminary evaluation of new candidate materials as toxicants, repellents and attractants against stored product insects. *Marketing Res. Report* No. 882. Agric. Res. Service,U.S. Dept. Agric. Washington. P. 8.

MESSINA, F.J. & RENWICK, J.A.A. 1983. Effectiveness of oils in protecting stored cowpea from the cowpea weevil (Coleoptera: Bruchidae). *J. Econ. Entomol*. **76**(2): 34 - 36.

MISHRA, B.K., MISHRA, P.R. & MOHAPATRA, H.K. 1992. Studies on some plant product mixtures against *Sitophilus oryzae* (L.) infesting wheat seeds. *Indian J Plant Prot*. **26**: 178-182.

NEGAHBAN, M., MOHARRAMIPOUR, S., & SEFIDKON, F. 2006. Chemical composition and insecticidal activity of *Artemisia scoparia* essential oil against three Coleopteran stored-product insects. *J. Asia-Pac. Entomol*. **9**:381-388.

PANDEY, N. & BRAVE, D. 2011. Phytochemical and Pharmacological Review on *Annona squamosa* Linn. *Int. J. Res. Phar. Bio. Sci*. **2**(4): 1404 - 1412.

QUADRI, S.S.S. 1973. Some indigenous repellents for storage pests, Pesticides. 7, 18.

RAJENDRAN, S. & SRIRANJINI, V. 2008. Plant products as fumigants for stored product insect control. *J. Stored. Prod. Res*. **44**: 126 - 135.

ROY, B.B., AMIN, R., UDDIN, M.N., ISLAM, A.T.M.S., ISLAM, M.J. & HALDER, B.C. 2005. Leaf extracts of Shiyalmutra (*Blumea lacera*) as botanical pesticides against lesser grain borer and rice weevil. *J. Biol. Sci*. **5**(2): 201-204.

SARKAR, S., LATIF, Z. & GRAY, A. 2006. Natural products isolation. *Methods in Biotechnol*. **20**: 897-915.

SINGH, S.R., LUSE, R.A., LEUSCHNER, K. & NENGU, D.1978. Groundnut oil treatment for the control of *Callosobruchus chinensis* (L.) during cowpea storage. *J. Stored Prod. Res*. **14**(2): 77 - 80.

SIVA, S. 2001. Evaluation of indigenous products and boric acid against stored grain pests. M. Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad. Karnataka, India. p. 125.

SRIVASTAVA, M. & MANN, A.K. 2002. Screening of pesticidal efficacy of plant, Peganum harmala against pulse beetle, *Callosobruchus chinenesis* (L.). *Indian J. Entomol*. **61**(2): 103 - 114.

SU, H. C.F. 1977. Insecticide properties of black peeper to rice weevils and cowpea weevils. *J. Econ. Entomol*. **70**(1): 18 - 21.

TALUKDER, F.A. & HOWSE, P.E. 1993. Deterrent and insecticidal effects of extracts of pithraj, *Aphanamixis polystachya* (Meliaceae) against *Tribolium castaneum* (Herbst). *J. Chem. Ecol*. **19**: 2463-2471.

TALUKDER, F.A. & HOWSE, P.E. 1994. Laboratory evaluation of toxic and repellent properties of the pithraj tree, *Aphanamixis polystachya* Wall and Parker against *Sitophilus oryzae* (L.) Int. J. Pest Management. **41**(3): 274-279.

WRIGHT V.F. 1985. Use of pesticides for insect control in farm storage. pp 335-341. In: B. R. Champ and E. Highly (eds.). Pesticides and humid tropical grain storage systems. Australian Centre for International Agricultural Research Proceedings 14. Canbera, Australia.

(MS received for publication 15 September 2013)

Bangladesh j. entomol. (2013) ***23****(2), 115-122* *ISSN 1021-1004*

BIO-RATIONAL MANAGEMENT PACKAGES AGAINST POD BORER COMPLEX ATTACKING SUMMER COUNTRY BEAN

S. N. ALAM[1], N. K. DUTTA[1], M. MAHMUDUNNABI[1], M. F. KHATUN[2] & A. K. M. Z. RAHMAN[1]

[1]Entomology Division, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur; [2]Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur-1706, Bangladesh

ABSTRACT

A field experiment was undertaken at research field of Bangladesh Agricultural Research Institute (BARI), Gazipur during Summer 2012 cropping season to evaluate several bio-rational management packages against pod borer complex attacking country bean. There were four treatment packages viz.,: Package 1= Sanitation (Hand picking and destruction of infested flowers, pods and larvae) + release of bio-control agents (*Trichogramma chilonis* and *Bracon hebetor*) + spraying of Bt powder; Package 2= Sanitation + release of bio-control agents (*Trichogramma chilonis* and *Bracon hebetor*) + spraying of Spinosad 45 SC; Package 3= Sanitation + release of bio-control agents (*Trichogramma chilonis* and *Bracon hebetor*); Package 4 = Sanitation + spraying of Voliam flexi 300 SC (Chlorantraniliprole + Thiamethoxam) and an untreated control. Results indicated that, the management package P2 appeared as the best package which provided 75.93% and 90.17% reduction of flower and pod infestation, respectively over control by pod borers. The highest yield increase over control (84.46%) and benefit cost ratio (9.55) was also obtained from this management package.

Keywords: Pod borer complex, bio-rational management, summer country bean.

INTRODUCTION

Country bean, *Lablab purpureus* (L.) is one of the most popular vegetables in Bangladesh. Now- a- days, country bean has become a year round crop instead of growing during winter only (Hossain *et al*. 2009). Due to demand and high price during humid summer season farmers are growing country bean in large scale. So, due to year round availability as host, infestation of different insect pests has also been increased. Among them, pod borers, *Maruca vitrata* and *Helicoverpa armigera* cause both quantitative and qualitative losses (Alam *et al*. 2011). Previously, pod borer, *Maruca vitrata* was considered as the single borer pest of country bean in Bangladesh (Alam 1969). But recently it was observed that Helicovarpa armigera was also infesting pods of country bean (Alam *et al*. 2011). The larvae of the borers feed on flower buds, flowers and young pods of different bean plants, which severely affect pod yield (Chi *et al*. 2003, Rouf 2004).

Current management practices of pod bores in Bangladesh are based almost entirely on insecticides. Farmers are spraying different types of insecticides at a very high frequency and dose on country bean to save the crop from the borer complex. Indiscriminate use of chemical insecticides to control borer pests leads to pest resurgence, secondary pest outbreak and natural enemy destruction. This practice not only increases cost of production but also causes environmental pollution and human health hazard (Rashid *et al*. 2003) and develops the pest resistance (Ekesi 1999, Ulrichs *et al*. 2001). In view of the above situation, it is necessary to develop some management practices which are not only effective, but also safer to human & animal health and congenial to the non target organisms. Therefore, the present study was conducted with a view to develop an environment friendly and bio-rational management package(s) against pod borer complex attacking summer country bean.

MATERIALS AND METHODS

This study was conducted at the research field of Entomology Division, BARI, Gazipur during summer 2012 cropping season. There were three dispersed replications and the experiment was set in RCB design. The country bean variety "IPSA seem 2" was grown following the recommended practices (Zaman 1992). The unit plot size was 4m x 2.5m. There were five treatment packages and these were assigned as follows:

Package 1= Sanitation (weekly hand picking and destruction of infested flowers, pods and larvae) + weekly release of bio-control agents, (*Trichogramma chilonis* @ 1 gm parasitised eggs/ha/week and *Bracon hebetor* @ 1000-1200 adults /ha/week) + spraying of Bt powder @ 0.4g / l of water (4 sprays at 15 days interval starting from the first appearance of pest attack), Package 2= Sanitation +weekly release of bio-control agents as above + spraying of Spinosad 45 SC @ 0.4ml / l of water (4 sprays at 15 days interval starting from the first appearance of pest attack), Package 3= Sanitation +weekly release of bio-control agents as above, Package 4= Sanitation + spraying of voliam flexi 300 SC (Chlorantraniliprole + Thiamethoxam) @ 0.5ml/l of water (at 7 days interval starting from the first appearance of pest attack and continued up to the last harvest) and an untreated control.

The larval parsitoid, *Bracon hebetor* and egg parasitoid, *Trichogramma chilonis* were mass reared at IPM laboratory, BARI and released weekly starting from flowering stage of the crop and continued up to the end of the cropping season. To avoid dispersal of biocontrol agents plots of package 1, 2 & 3 were taken 400 m away from rest of the other plots.

Bracon hebetor adults were kept in a glass jar which was covered with black cloth. One jar contained around 1200 adult parasitoids. These were released directly throughout the field keeping the mouth of the jar open. Newly emerged adults (from 1 g parasitized eggs) of *Trichogramma chilonis* were released in a glass jar having twisted papers and kept 2-3 hrs for dispersal within the twisted papers. These twisted papers were then randomly placed on the canopy of the crop throughout the field.

Numbers of healthy and infested flowers were counted and recorded from randomly selected 50 rachis. At each harvest the number and weight of healthy and infested pods were also recorded. The percent flower and pod infestation by borer was calculated from the recorded data.

The collected data were compiled, coded, tabulated and analyzed statistically using MSTAT-C software. The means were separated for significant difference using DMRT. For understanding the comparative profitability of different treatment packages benefit cost ratios were calculated following Ali *et al.* (1996).

RESULTS AND DISCUSSION

Effectiveness of various management packages on pod borer infestation and yield of country bean: It is revealed from the Table 1 that, percent flower infestation (3.70) and pod infestation (2.08) by borers was significantly lowest in the package 2 comprising of sanitation + biocontrol agents release + spraying Spinosad 45SC and this was followed by package 4 composed of sanitation + spraying Voliam flexi 300 SC treated plots where flower infestation (5.15%) and pod infestation (6.33%) by borers were recorded. While, the highest flower infestation (15.37%) and pod infestation (21.15%) by borers was obtained in untreated control plots. Accordingly, Package 2 resulted the highest reduction of flower and pod infestation

(75.93% and 90.17%, respectively) over control. Consequently, the highest yield increase over control (84.46%) was obtained from Package 2, while the second highest (75.66%) was from Package 4. In contrast, the lowest yield increase over control (12.32 %) as obtained from Package 3 utilizing sanitation + bio-control agents treated plots (Table 2).

Benefit - Cost analysis : Economic analysis of the present study has been presented in Table 3. It may be mentioned here that the expenses incurred in the present study referred to those only on the pest control. It was observed that the highest benefit-cost ratio (BCR) (9.55) was calculated from the plots treated with package 2 comprising sanitation + releasing biocontrol agents + spraying Spinosad 45 SC followed by plots of Package 4 consisting of Sanitation + Voliam flexi 300SC spray (6.10). In contrast, the lowest BCR (3.61) was obtained from Package 3 treated plot comprising sanitation + bio-control agents. So, considering BCR, sanitation along with bio-control agents release and spraying Spinosad 45 SC (Package 2) may be recommended for effective management of pod borers attacking country bean.

In Bangladesh, research attempts to develop management approach(es) of pod borer attacking country bean were mainly concentrated on studying the efficacy of insecticides. A limited efforts have been given for developing IPM approach or bio-rational based management approach. Rahman (2013) advocated the conservation of predatory black ants + hand picking of infested flowers and pods at alternative days+ spraying of Neem oil @ 3ml/l of water or Cymbush 10 EC @ 1ml/l of water at seven days interval or application of Sumialpha at a single flower infestation per inflorescence as an effective IPM package against pod borers of country bean. Rouf & Sarder (2009) reported that hand picking and destruction of infested flowers and pods with pod borer larvae, cutting of older leaves and twisted young twigs along with spraying of Emamectin benzoate (Proclaim 5SG) @ 1g per litre of water at 7 days interval as the best performance in reducing 89.36 % flower and 80.53 % pod damage over control leading to 44.21 % yield increase. However, Alam *et al*.,(2011) obtained satisfactory results through hand picking of infested flowers and pods along with application of neem seed kernel extract. All of the above findings are partially comparable with the results of the present study. In a field study to obtain a suitable management option against pod borers of summer country bean, Mollah *et al*., (2012) reported that application of neem oil (stored) offered the best result compared to other tested chemical insecticides.

Table 1. Treatmentwise percent borer infestation in country bean grown at BARI experimental field, Gazipur during summer 2012 cropping season as influenced by different packages

Treatment packages	Percent borer infestation in country bean			
	% flower infestation	% flower infestation reduction over control	% pod infestation	% pod infestation reduction over control
Package 1 : Sanitation + biocontrol agents + Bt spray	8.47b	44.89	9.73b	54.00
Package 2 : Sanitation + biocontrol agents + Spinosad 45SC spray	3.70d	75.93	2.08d	90.17
Package 3 : Sanitation+ biocontrol agents	9.94b	35.33	8.76b	58.58
Package 4: Sanitation+ Voliam flexi 300SC spray	5.15c	66.49	6.33c	70.07
Untreated control	15.37a	-	21.15a	-

Means followed by the same letter(s) did not differ significantly by DMRT ($p<0.05$)

Table 2. Yield of country bean as influenced by different management packages at Gazipur during summer 2012 cropping season

Treatment packages	Yield (t/ha)	% Yield increase over control
Package 1 : Sanitation + biocontrol agents + Bt spray	12.32b	20.43
Package 2 : Sanitation + biocontrol agents + Spinosad 45SC spray	18.87a	84.46
Package 3 : Sanitation+ biocontrol agents	11.49bc	12.32
Package 4: Sanitation+ Voliam flexi 300SC spray	17.97a	75.66
Untreated control	10.23c	-

Means followed by the same letter(s) did not differ significantly by DMRT ($p<0.05$)

Table 3. Benefit cost analysis after application of different management packages for the control of country bean pod borers

Treatment packages	Marketable yield (t/ha)	[1]Gross return (Tk/ha)	[2]Cost of Treatment (Tk/ha)	Net return (Tk/ha)	Adjusted net return (Tk/ha)	Benefit/ Cost Ratio (BCR)
Package 1 : Sanitation + biocontrol agents + Bt spray	12.32	369600	10840	358760	51860	4.78
Package 2 : Sanitation + biocontrol agents + Spinosad 45SC spray	19.87	596100	27400	568700	261800	9.55
Package 3 : Sanitation+ biocontrol agents	11.49	344700	8200	336500	29600	3.61
Package 4: Sanitation+ Voliam flexi 300SC spray	17.97	539100	32720	506380	199480	6.10
Untreated control	10.23	306900	0	306900	0	-

Cost of relevant materials/activities:

[1]Farmgate price of summer country bean @ Tk. 30.00 per kg,

[2][Cost of Bio-control agents: Bracon @ Tk 150/jar, Trichogramma @ Tk 100/g; Cost of Spinosad 45SC: @ Tk 2400/100ml; Cost of Voliam flexi 300SC : @ Tk 265/50ml; Cost of sanitation: 2 laborers/ha @ Tk 180.00/labour/day; Cost of bicontrol agent release: 2 laborers/ha @ Tk 180.00/labour/day; Cost of spray : Two laborers/spray/ha @ Tk 180.00/labour/day; Spray volume required: 500L /ha.]

CONCLUSION

In Bangladesh, cultivation of summer country bean in getting popularity day by day because farmers are earning much more benefit through cultivating this crop compared to other summer vegetables. The findings of the present study led to assume that biorational based integrated management approach(s) might help our farmers in combating pod borers in a sustainable way without relying on conventional insecticides. However, further studies may be suggested for on-farm validation of the proposed management package.

ACKNOWLEDGEMNT

This research work was done by NATP: Phase-1, SPGR, BARC funded project "Development and up-scaling of integrated pest management technologies in vegetable crops".

REFERENCES

ALAM, M. Z. 1969. Insect pests of vegetables and their control in East Pakistan Published by The Agriculture Information Service. Department of Agriculture. Dhaka-3, East Pakistan. 146 pp.

ALAM, S.N., DUTTA, N. K., SARKAR, M. A., ISLAM, M. I. & CORK, A. 2011 Pest status and management of different borer complex of country bean. *Bangladesh j. entomol*. **22**(1):79-86

ALI, M. I., KHORSHEDUZZAMAN, A. K. M., AHMED, A. & KARIM, M. A. 1996. Effect of intercropping of coriander with brinjal on the incidence of brinjal shoot and fruit borer. *Annual Report* 1995-96. Entomology Division, BARI, Gazipur. pp. 1-6.

CHI, Y, SAKAMAKI, Y., KUSHIGEMACHI, K. & CHI, Y. C. 2003. The seasonal abundance of the legume pod borer, *Maruca vitrata* in Kagoshima, Japan. Memoirs of the Faculty of Agriculture, Kagoshima University. **38**: 41-44.

EKESI, S. 1999. Insecticide resistance in field populations of the legume pod-borer, *Maruca vitrata* Fabricius (Lepidoptera: Pyralidae), on cowpea, *Vigna unguiculata* (L.), Walp in Nigeria. *International J. Pest Management*, **45**(1): 57 - 59.

HOSSAIN, M. S., RAHMAN M. M., ALAM, M. Z., MIAH, M. I. H. & AKHTER, S. 2009. Effect of variety and planting dates on the incidence of pod borer (*Maruca vitrata* F.) in year round country bean. *Bangladesh j. entomol*. **19**(2): 33-44.

MOLLAH, M M I, RAHMAN, M M & ALAM, M Z. 2012. Efficacy of different insecticides against pod borer, *Maruca testulalis* (Geyer) on country bean. *Bangladesh j. entomol*. **22**(2):13-20.

RAHMAN, M. M.2013. Vegetable IPM in Bangladesh, Radcliffe's IPM World Text book (on line)/CFANS/University of Minnesota. http://ipmworkd.umn.edu

RASHID, M. A., ALAM, S. N., ROUF, F. M. A. & TALEKER, N. S. 2003. Socio-economic parameters of eggplant pest control in Jessore District of Bangladesh. *AVRDC Technical Bull*. **29**: 1-54.

ROUF, F. M. A. 2004. Integrated pest management for legume poborer, *Maruca vitrata* in country bean. *Annual Report* 2003-2004, Entomology Division, Regional Agricultural Research Station, Jessore. pp. 7-9.

ROUF, F. M. A. & SARDER M A .2009. Development of suitable IPM packages for the control of legume pod borer (*Maruca vitrata* F.) on country bean. *Bangladesh j. entomol*. **19**(2): 21-32.

ULRICHS, C., MEWIS, I., SCHNITZLER, W. H. & BURLEIGH, J. R. 2001. Effectivity of synthetic insecticides against *Maruca vitrata* F. and the parasitoid *Bassus asper* (Chou and Sharkey) in the Philippines. Vortrage der Entomologentagung in Dusseldorf vom 26.

ZAMAN, S. M. H. 1992. Irrigated crop production manual. Dept. of Agril. Ext., Amader Bangla Press, Azimpur, Dhaka. pp. 7-8.

(MS received for publication 22 September 2013)

Bangladesh j. entomol. (2013) **23**(2), 123-130 ISSN 1021-1004

PREVALENCE AND PARASITISM OF LARVAL PARASITOID *PEDIOBIUS FOVEOLATUS* ON EPILACHNA BEETLE GRUBS

F. KHATUN[1], S. N. ALAM[2], N. K. DUTTA[2], M. Y. MIAN[3] & E. RAJOTTEE[4]

[1]Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur; [2]Entomology Division, Bangladesh Agricultural Research Institute (BARI), Gazipur; [3]IPM CRSP, Horticulture Research Centre, BARI, Gazipur; [4]Penn State University, USA

ABSTRACT

An unknown parasitic wasp (larval parasitoid) was emerged from the reared mummies of epilachna beetle collected from different vegetable fields at Horticultural Research Centre and Entomology Division experimental fields of Bangladesh Agricultural Research Institute (BARI) Joydebpur, Gazipur. The parasitoid was later identified as *Pediobius foveolatus* (Hymenoptera: Eulophidae). Abundance of epilachna grub (host) and its parasitoid *P. foveolatus*, parasitism efficacy and parasitism optimization of this parasitoid were studied during July 2010 - February 2013 period. The highest number of epilachna grubs were recorded during July-September and the parasitism by *P. foveolatus* was also highest during that period. On an average 21.89 *P. foveolatus* were emerged from a single mummy per week in the pesticide free field. On the other hand number of parasitoid released from the bio-pesticide treated plots were also satisfactory (on an average 18.14 *P. foveolatus* were released) in comparison to that of pesticide free fields. Highest numbers (14.4) of parasitoids were emerged when two healthy epilachna grubs were exposed to one pair of parasitoid, *P. foveolatus*. However, total time needed for parasitoid emergence on the number of grubs exposed to the parasitoids did not varied significantly (parasitoid emergence time varied from 8.44 to 8.89 days).

Keywords: Prevalence, parasitism, *Pediobius foveolatus*, epilachna beetle.

INTRODUCTION

Two species of Epilachna beetle, *Epilachna dodecastigma* & *E. vigintoictopunctata* are serious pests of different vegetable crops in Bangladesh (Khan *et al.* 2000). Between them the spotted leaf beetle, *E. vigintioctopunctata* (F.) is an important pest of the solanaceous (brinjal, tobacco, tomato, potato etc.) and cucurbitaceous (gourds, melon, cucumber etc.) crops in India (Krishnamurti 1932, Puttarudriah and Krishnamurti 1954, Sengupta and Panda 1959, Mandal

1971, Mohansundaram and Uthamaswamy 1973, Azam *et al.* 1974). Both adult beetles and grubs feed on the epidermal tissues of the leaves by scrapping, resulting drying and shading of the leaves. Due to its nature of feeding this pest is sometime called as leaf scrapping coccinellid beetle (Imura and Ninomiya 1978). The nature of damage by the larvae is somewhat distinct from that of the adults. The grubs confine their attack to the lower surface and adults usually feed on the upper surface of the leaves (Prodhan *et al.* 1990). The third and fourth instar grubs are more destructive and voracious. Rajgopal and Trivedi (1989) reported that epilachna beetle may cause damage up to 80% of plants depending on place and prevailing environmental conditions. Farmers are generally dependent on toxic chemical pesticides for its control. Sometimes they are applying toxic chemicals indiscriminately to control the pest, that leading to the development of pest resistance, resurgence and health hazard. However, a parasitic wasp, *Pediobius foveolatus* is found to parasitize the larvae of the Mexican bean beetle (MBB) (Lall 1962). *P. foveolatus* has shown the most potential in controlling MBB populations. *P. foveolatus* is a small, 2.0-3.5 mm, gregarious wasp that parasitizes MBB larvae (NJDA 2004). The parasitic wasp *P. foveolatus*, is an effective natural bio-control agent used to combat this pest (NJDA 2004). The damage from Mexican bean beetle has been reduced to tolerable economic levels in new jersey, USA after the first release of this parasitic wasp (Robbins *et al.* 2006). Considering this, it is very much essential to identify the natural enemy (ies) in Bangladesh especially parasitoid of epilachna beetle as well as other alternative tools of chemical pesticides. So, the present study was undertaken to find out the prevalence and parasitism of natural enemies of epilachna beetle in different vegetable crops. Identification of its natural enemies was also considered.

MATERIALS AND METHODS

Three studies were undertaken on host and parasitoid abundance, parasitism efficacy at different eco-system and parasitism optimization of *P. foveolatus* on epilachna beetle. Details of the studies are as follows:

Host and parasitoid abundance study: Abundance of epilachna grub (host) and its natural parasitism by *P. foveolatus* (Hymenoptera: Eulophidae) were studied during July 2010 - February 2013 period. The study was conducted on two vegetable crops, viz., brinjal and bitter gourd at Horticultural Research Fields (HRC) and Entomology Division experimental fields of Bangladesh Agricultural

Research Institute (BARI), Gazipur. Non-sprayed fields of those vegetable crops were inspected at every fifteen days interval. Number of total grubs as well as the number of parsitised grubs /10 leaves /5 plants /crop /plot were counted and recorded. Mean percent parasitism was calculated from the recorded data.

Parasitism efficacy at different eco-system: Natural parasitism of epilachna grubs by *P. foveolatus* at pesticide free as well as bio and chemical pesticide treated plots were observed in the experimental brinjal fields HRC and Entomology Division, BARI, Gazipur during July- October 2012 and 2013 at weekly basis. The plot size was 5x5 m^2 and each plot was considered as one treatment replication. The experiment was laid out in Randomized Complete Block Design with three replications. In the bio-pesticide treated plots, plants were sprayed with Spinosad (Tracer 45 SC @ 0.4 ml/liter of water) and chemical pesticide treated plots were sprayed with Cypermethrin (Ripcord 10EC @ 1 ml/liter of water) at an interval of 10 days after one month of transplanting. Ten parasitised grubs of epilachna beetle were collected from those fields per week (started from last week of July and continued till 1st week of October, total 10 week) and reared them in the laboratory. Parasitised grubs of epilachna beetle were collected from pesticide free, bio-pesticide and chemical pesticide treated plots. Parsitoids adults emerged from the reared grubs were preserved in 80% alcohol for identification and other necessary actions.

Parasitism optimization study: Determination of optimum number of parasitoid to be released for getting higher parasitization rates of epilachna grub is important. This would help sound mass rearing of parasitoid (*P. foveolatus*) on natural host, epilachna grub. For that purpose 1 to 5 healthy grubs on brinjal leaves were released in petridishes separately, where 1 pair of *P. foveolatus* was released before. The petridishes were covered with fine nylon nets. The study was repeated three times with three replications (during each study) following CRD design. This study was done in temperature and humidity controlled greenhouse (temperature 24±2^{o}C & humidity 70±5%) at Entomology Division, BARI, Gazipur.

RESULTS AND DISCUSSION

Host and parasitoid abundance study: A parasitic wasp (larval parasitoid) was emerged from the reared mummies of epilachna beetle collected from brinjal and bitter gourd fields. The parasitoid was identified as *Pediobius foveolatus* (Hymenoptera: Eulophidae). Identification was done with the help of a taxonomist of Pennsylvania State University (PSU), USA. It is revealed from Figure 1 that, natural parasitism of *P. foveolatus* varied according to the availability of the epilachna host grub. The parasitism was as high as 32.8% in September 2012, 38.9% in August 2011 and 52.6% during August 2010. The highest epilachna grubs were recorded during July-September and the parasitism by *P. foveolatus* was also highest during that period. However, the highest parasitism was observed during the month of August and thereafter the population of epilachna grubs declined. Rajgopal and Trivedi (1989) reported that the peak period of infestation varies with regions. Generally the peak is found in July-August in India.

There is a positive correlation between the number of epilachna grub/plant and percent parasitism. Rajendran & Gopalan (1997) observed natural parasitism of *H. vigintioctopunctata* by *P. foveolatus* on eggplant was 47.1%. On the other hand, this was 28.5% on potato and 64.5% on *Solanum nigrum* L. (Sheng and Wang 1992). The parasitoid caused 51.94± 12.20% parasitism in the field collected larvae of *H. vigintioctopunctata*. *Pediobius foveolatus* is known to be a potential parasitoid of various phytophagous coccinellids and caused up to 62% parasitism in *Epilachna ocellata* Redenbacher (Dhingra *et al.* 1986) and 80% in *E. philippinensis* Dieke (Chiu and Moore 1993).

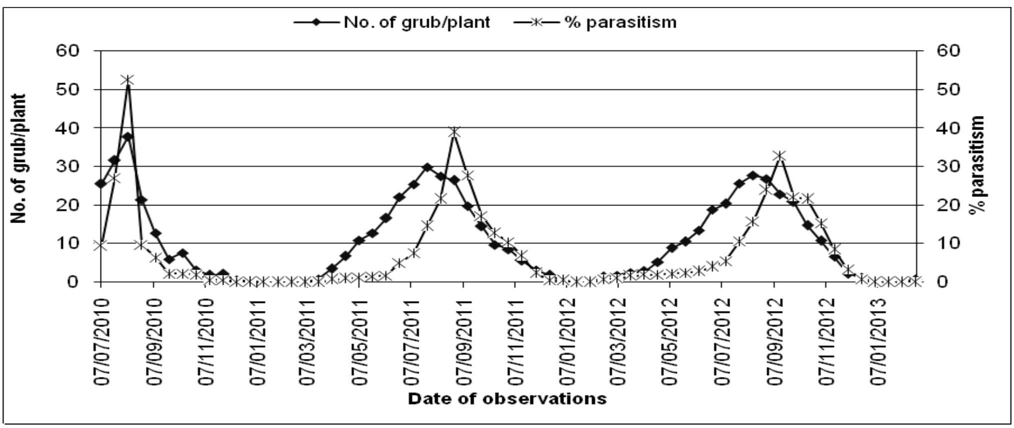

Fig. 1. Natural parasitism of epilachna beetle grubs by *P. foveolatus* on brinjal and bitter gourd leaves at BARI Farm, Gazipur

Parasitism efficacy at different eco-system: No parasitized epilachna grubs were observed in the insecticide treated plots. On the other hand the emergence rates of parasitoids from the mummies in pesticide free fields and bio-pesticide treated fields were not similar during the whole observation period (Table 1). On an average 21.9 (during 2012) and 22.9 (during 2013) *P. foveolatus* were emerged from a single mummy per week (Table 1) in the pesticide free field. On the other hand number of parasitoid emerged from the bio-pesticide treated plots were also satisfactory with a mean of 18.1 during 2012 and 20.2 during 2013 in comparison to that of pesticide free fields. The natural parasitism as well as the number of parasitoid emerge per grub was positive in the pesticide free and bio-pesticide sprayed fields, which can effectively suppress the epilachna beetle population in an area. As no parasitism of epilachna grubs by *P. foveolatus* were observed in the chemical pesticide (Cypermethrin (Ripcord 10EC @ 1 ml/liter of water) treated plots so it can be assumed that cent percent mortality of the larval parasitoid, *P. foveolatus* occurred due to application of synthetic chemical pesticides.

Table 1. Number of parasitoid emerged from parasitised grub of epilachna beetle collected from non-pesticide, bio-pesticide and chemical pesticide applied brinjal plot at BARI farm, Gazipur (July - October 2012 and 2013)

Observational period (week)	No. of parasitized larvae (mummies) reared	Mean No. of emerged parasitoids per epilachna grub					
		Pesticide free field		Bio-pesticide applied field		Chemical pesticide applied fields	
		2012	2013	2012	2013	2012	2013
Week 1	10	6.5	8.4	5.8	7.5	0	0
Week 2	10	7.5	11.5	6.4	9.5	0	0
Week 3	10	18.4	16.5	16.2	13.2	0	0
Week 4	10	24.0	22.4	19.9	19.0	0	0
Week 5	10	29.0	26.8	23.8	24.5	0	0
Week 6	10	30.0	31.0	26.6	28.5	0	0
Week 7	10	30.5	33.5	24.4	29.0	0	0
Week 8	10	32.8	31.4	26.4	27.5	0	0
Week 9	10	22.4	25.5	18.4	22.0	0	0
Week 10	10	17.8	22.4	13.5	19.5	0	0
Mean		21.9	22.9	18.1	20.2	0	0

Parasitism optimization study: It is revealed from Table 2 that the highest number (14.4) of parasitoids were emerged when two healthy epilachna grubs were exposed to one pair of parasitoid, *P. foveolatus*. However, total time needed for parasitoid emergence did not varied so much on the number of grubs exposed to the parasitoids (parasitoid emergence time was 8.44 to 8.89 days).

Table 2. Optimization of the host (epilachna grub) on brinjal leaves for highest parasitism by larval parasitoid, *P. foveolatus* for mass rearing of the parasitoid at IPM greenhouse, Entomology Division, BARI, Gazipur

No. of parasitoid released/petridish	No. of grub released/ petridish	Total time needed for parasitoid release (days)*	No. of parasitoids released/grub*
1 pair	1	8.67 a	7.0 a
1 pair	2	8.44 a	14.4 c
1 pair	3	8.67 a	12.8 c
1 pair	4	8.67 a	14.2 c
1 pair	5	8.89 a	10.5 b

* Mean of three sets of experiment, each having 3 replications; Means having same letter(s) in a column are not significantly different at P> 0.01 followed by LSD.

ACKNOWLEDGEMENT

The research work has been done with the financial assistance of USAID funded IPM - IL (CRSP) project.

REFERENCE

AZAM, K. M., AZIZ, S. A. & ALI, M. H. 1974. A new record of Ugamenonias parasite of *Epilachna vigintioctopunctata* in India. *Curr. Res*. 3: 88.

CHIU, C. H. & MOORE, A. 1993. Biological control of the Philippine lady beetle, *Epilachna philippinensis* (Coleoptera: Coccinellidae), on solanaceous plants by the parasitoid, *Pediobius foveolatus* (Hymenoptera: Eulophidae), on Saipan. pp.79-80, *In Proceedings XIX International Cong. Entomol*.

DHINGRA, M. R., DHAMDHERE, S. V. & RAWAT, R. R. 1986. Natural enemies of *Epilachna ocellata* Redenbacher at Jabalpur (Madhya Pradesh). *Bull. Entomol. Res*. **27**:184-185.

IMURA, 0. & NINOMIYA, S. 1978. Quantitative measurement of leaf area consumption by *Epilachna vigintioctopunctata* (Fabricius) (Coleoptera: Coccinellidae) using image processing. *Appl. Ent. Zool*. **33**(4): 491-495.

KHAN, M. H., ISLAM, B.N., RAHMAN, A.K.M.M. & RAHMAN, M. L. 2000. Life table and the rate of food consumption of epilaclina beetle, *Epilachna deodecastigma* (Wied.) on different host plant species in laboratory condition. *Bangladesh j. entomol*. **10**(1-2): 63-70.

KRISHNAMURTI, B. 1932. The potato epilachna beetle, *E. vigintioctopunctata*. Bull. Dept. Agric., *Mysore (Entomol. Ser.)*, **9**: 1-16

LALL, B.S. 1962. On the biology of *Pediobius foveolatus* (Crawford) [Eulophidae: Hymenoptera]. *Indian J. Entomol.* **23**(4): pp. 268-273

MANDAL, S. C. 1971. A note on the host range of Epilachna beetle, *E. vigintioctopunctata* in Bihar. *Allahabad Farmer* **45**: 187-188.

MOHANSUNDARAM, M. & UTHAMASWAMY, S. 1973. A note on the *Epilachna* spp. commonly found in Tamil Nadu with observation on the host range and distribution. *Sci. culture* **39**: 305-306.

NJDA. 2004. Mexican bean beetle parasitoid *Pediobius foveolatus* (Hymenoptera: Eulophidae). New Jersey Department of Agriculture Beneficial Insectary. Trenton, New Jersey.

PRODHAN, S., JOTWANI, M.G. & PRAKASH, S. 1990. Comparative toxicity of insecticides to the grub and adult of *Epilachna vigintioctopunctata* Fab. (Coleoptera: Coccinellidae). *Indian J. Entomol*. **24**(4): 223-228.

PUTTARUDRIAH, M. & KRISHNAMURTI. B. 1954. Problem of Epilachna control in Mysore. Insecticidal control found inadvisable when natural incidence of parasites is high. *Indian J. Entomol*. **16**: 137-141.

RAJAGOPAL, D. & T.P. TRIVEDI. 1989. Status biology and management of epilachna beetle, *Epilachna vigintioctopunctata* Fab. (Coleoptera: Coccinellidae) on potato in India. *Trop. Pest Management.* **35**(4): 410-413.

RAJENDRAN, B. & M. GOPALAN. 1997. *Pediobius foveolatus* (Crawford) (Eulophidae: Hymenoptera) a potential parasitoid on the grubs of eggplant spotted beetle *Henosepilachna vigintioctopunctata* Fab. *Entomon*: **22**: 147-149.

ROBBINS, G., HUDSON, W., DORSEY, T., SCUDDER, T., & MAYER, M., 2006, Biological Control of the Mexican bean beetle *Epilachna varivestis* (Coleoptera:Coccinellidae) using the parasitic wasp *Pediobius foveolatus* (Hymenoptera: Eulophidae). Unpublished internal document of the New Jersey Department of Agriculture.

SENGUPTA, G. C. & N. PANDA. 1959. Insecticidal control of *Epilachna vigintioctopunctata* (F.). *J. Econ. Entomol*. **51**: 749.

SHENG, J. K. & G. H. WANG. 1992. Studies on the biology of *Pediobius foveolatus* (Hym.: Pteromalidae) in the Nanchang area. *Chinese J. Biol. Control*. **8**: 110-114.

(MS received for publication 05 November 2013)

Bangladesh j. entomol. (2013) **23**(2), 131-138 ISSN 1021-1004

Scientific Note

REPELLENT EFFECTS OF SOME INDIGENOUS PLANT DUSTS AGAINST THE LARVAE OF *RHIZOPERTHA DOMINICA* (F.)

NOOR MAHAL, W. ISLAM*, K. A. M. S. H. MONDAL & S. PARWEEN[1]

Institute of Biological Sciences, University of Rajshahi, Rajshahi 6205;
[1]Department of Zoology, University of Rajshahi, Rajshahi 6205, Bangladesh

The larvae of *Rhyzopertha dominica* (F.) when fed with treated whole wheat grains with leaf and seed dusts repelled ($P<0.001$) under starved and non-starved conditions. The percentage of larvae which repelled the treated wheat increased with the increase of doses. The degree of repellency was arranged in descending order: *Nigella sativa>Vitex negundo>Eucalyptus camaldulensis>Murrya paniculata>Jatropha curcas>Datura metel.*

Keywords: *Rhyzopertha dominica*, plant leaves, dusts.

Plants have been reported to have repellent and antifeedant properties against a number of insect species (Jermy *et al*. 1981). Insects showed avoidance to plant-treated food or even starved to death without eating on minimal feeding of the treated food (Qadri 1973, Munakata 1977). Chemical constituents of some plants inhibit insects' feeding though not killing insects directly and these properties of plants are of great importance in protecting stored grains and cereals from insect infestation (Munakata 1977). For stored product insect management there is a continuous search for repellents and antifeedants that are more effective, more economic and more specific than the traditional synthetic insecticides (Mohiuddin *et al*. 1993). Depending on the antifeedant and repellent properties of plants, suitable food packaging materials are also being screened. A number of such packaging components were found to provide effective protection against the insects like *Tribolium castaneum* and *Rhizopertha dominica* (Highland 1980, Bloszyk *et al*. 1990). Good number of published reports are available on the repellent or antifeedant effects of various plant oils and extracts against the stored product insects, of which the maximum works are with neem.

However, powders of spices like turmeric, garlic, black and red peppers were found to be effective against the stored product insects, and these reports were

*Corresponding author: mwislam2001@yahoo.com

published during 1970-2000. During that time research works were done with Mentha leaf powder (Patel & Valand 1994, Kashyap *et al*. 1974), citrus leaf powder (Singh *et al*. 1996a,b), Akanda leaf powder (Jacob & Sheila 1993). Reports were also published on the efficacy of indigenous plant powders in India and Africa.

The present research was planned to screen the repellent effects of dry leaf dusts of some indigenous plants of Bangladesh viz., *Murraya paniculata* (Linn.) Jack (Kamini), Jatropha curcas Linn. Jamaal Gota), *Vitex negundo* Linn. (Nishinda), *Datura metel* Linn. (Datura), and seed dust of Nigella sativa Linn.(Black cumin), and the leaf dust of the exotic plant Eucalyptus camaldulensis Dehn. (Eucalyptus), against the larvae of the lesser grain borer, *Rhyzopertha dominica* (F.) under starved and non-starved (for 24- and 48 hours) conditions.

The study was undertaken at the Institute of Biological Sciences, University of Rajshahi during 2000-2002. Materials and methods of the study are presented under the following subheadings.

Collection of *Rhyzapertha dominica*: A sub-culture of *R. dominica* was obtained from the stock culture maintained in Bangladesh Council of Scientific and Industrial Research (BCSIR) Laboratories, Rajshahi. Healthy adult beetles of the sub-culture were separated and kept in beakers containing sterilized fresh white wheat grains. For about 400 adults approximately 400 g of wheat was provided. Mouth of the beaker was covered with fine muslin cloth to prevent escape of the beetles. After 24 hours, the wheat with adults were sieved through a 80 and 500 micrometer mesh sieve to collect the eggs. The eggs were then placed in petri dishes and incubated at room temperature ($20 \pm 1^{o}C$) in the laboratory.

The eggs hatched within 5 to 8 days. The newly hatched larvae were collected and kept separately in petri dishes according to the hatching batch. These larvae (10-48h old) were used in this study.

Plants used: Fresh leaves of orange jasmine (*M. paniculata*), Barbado nut (J.curcas), Eucalyptus (E. camaldulensis), datura (*D. metel*) and chaste tree (*V. negundo*) were collected from the wild areas of the Rajshahi University campus. Seeds of Black cumin (N. sativa) were purchased from the local market. The plants, other than Black cumin, were identified by the herbarium staff of the Botany Department, Rajshahi University.

Preparation of dusts: From the collected leaves of each plant, only the mature leaves were chosen. These leaves were then dried in a well-ventilated room from

5-7 days. The dried leaves were again dried in an oven at 35ºC for three hours before grinding. The dry leaves were then powdered using an electric grinder. The leaf dust of each plant was passed through 80 micrometer sieve to discard the coarse particles, and stored in air tight glass bottle. Seeds of Black cumin was oven dried at 35ºC for 2 hours, then ground in an of electric grinder and kept in airtight and glass bottle. Required quantity of dust of each plant was mixed thoroughly with 50g of white wheat grain to prepare doses of 1, 2, 4 and 8% w/w. The doses were kept separately in glass bottles with proper labeling.

Experimentation: The experiment was conducted in choice chambers as described by Mondal (1984). Filter papers of 9 cm diameter were divided into two equal halves by drawing a straight line, and then placed in petri dishes of similar diameter. One half of the petri dish was loaded with 3g of wheat treated with the experimental plant dust, and in the other half untreated fresh wheat grains (3g) were kept. Twenty newly hatched (10-48 h old) larvae were released at the middle of the petri dish thus providing an option for the insects to select either treated or untreated grain. Such separate choice chambers were used for each dose of each plant dust.

The experimental larvae were used in three sets:

i) Non-starved larvae of age 10-12h;
ii) Starved larvae of 24 h, and
iii) Starved larvae of 48 h.

All the experiments were replicated five times and conducted at room temperature of (20±1ºC) in the laboratory.

The distributional differences of number of larvae in the two halves of the choice chambers were analysed by chi-square test. Significant effect of each dose of each plant was tested by ANOVA.

The results revealed that all the plant dusts at doses from 1-8% strongly repelled ($p<0.001$) the larvae of *R. dominica* under starved or non-starved conditions (Table 1). The percentage of larvae that avoided the treated wheat increased with the increase of dose. Moreover, the non-starved larvae were repelled more by the treated wheat than the starved larvae. Again, the repellent effect of the plants was recorded at higher number among the 24-h starved larvae than the 48-h starved larvae (Table 1). The degree of repellency of the plant dusts as found against the larvae (both non-starved and starved) could be arranged in the following order: *N. sativa*>*V. negundo*>*E. camaldulensis*>*M. paniculata*>J. curcas> *D. metel*.

Table 1: Number of *R. dominica* larvae in plant dust treated wheat grain under non-starved and starved conditions (N=100).

Leaf/seed dust of plant	Dose (%)	Distribution of larvae in treated wheat (λ^2- value)		
		Non-starved	Starved (24-h)	Starved (48-h)
N. sativa	1	10 (64.00)	12 (57.76)	14 (51.84)
	2	8 (70.56)	9 (67.24)	12 (57.76)
	4	4 (77.44)	6 (77.44)	8 (70.56)
	8	8 (84.64)	4 (84.64)	5 (81.00)
M. paniculata	1	16 (46.21)	20 (36.00)	22 (31.36
	2	14 (51.84)	18 (40.96)	17 (43.56)
	4	10 (64.00)	14 (51.84)	15 (49.00)
	8	8 (70.56)	10 (64.00)	12 (57.76)
J. curcas	1	20 (36.00)	23 (29.16)	25 (25.0)
	2	18 (40.96)	19 (38.44)	20 (36.0)
	4	14 (51.84)	16 (46.24)	18 (40.96)
	8	12 (57.76)	12 (57.76)	15 (49.0)
E. camaldulensis	1	14 (51.84)	16 (46.24)	18 (40.96)
	2	12 (57.76)	14 (51.84)	15 (49.0)
	4	10 (64.0)	11 (60.84)	13 (54.76)
	8	7 (73.96)	8 (70.56)	10 (64.0)
D. metel	1	25 (25.0)	28 (19.36)	30 (16.0)
	2	20 (36.0)	24 (27.04)	28 (19.36)
	4	16 (46.24)	20 (36.0)	26 (23.04)
	8	12 (57.76)	15 (49.0)	20 (36.0)
V. negundo	1	14 (51.84)	15 (49.0)	18 (40.96)
	2	11 (60.84)	12 (57.76)	16 (46.24)
	4	8 (70.56)	10 (64.0)	12 (57.76)
	8	6 (77.44)	8 (70.56)	10 (64.0)

Note: All λ^2-values were significant at $p<0.001$ level of significance

The present results showed that the leaves and seeds of the tested plants possessed some chemicals that repelled the *R. dominica* larvae significantly. The repellent effect of each plant dust was more in the non-starved larvae, the reason being the non-starved larvae physiologically did not force to feed on the treated grain due to the smell of the leaf/seed dusts. Whereas, the starved larvae were forced to eat both treated and untreated grain because of hunger, which increased with the starving period. Effectivity of the tested plant dusts depended on starved condition of the larvae. These plants might have shown olfactory and gustatory sensitivity to the larvae resulting in significantly avoiding the treated wheat by them. Mahal (2002) observed similar repellent effects of the same plants against both sexes of the adult *R. dominica*.

Powder of African chili fruit, *Clerodendron*, *Eucalyptus* and *Dutura* leaves showed repellent effect against *R. dominica* (El-Lakeah *et al*. 1997). The authors reported that Eucalyptus leaf showed moderate repellency to R. dominica, but in the present experiment strong repellency was observed using Eucalytus leaf dust. The reason behind this might be due to the different doses and different species of Eucalyptus were used in the experiments. Leaf dusts of chaste tree (*V. negundo*), Begonia and Wood apple showed repellent action against a number of stored product insects including *R. dominica* (Prakash *et al*. 1981, 1983, David *et al*. 1988,), and neem leaf dust was at the top of the list of repellents, which also strongly repelled *R. dominica* (Sharma 1995).

Shayesteh & Ashouri (2010) tested the repellent effect of three powdered spices, viz., chili pepper, cinnamon, black pepper against three stored-product insects, *R. dominica*, *Sitophilus granarius* and *T. castaneum*. They reported that all the tested plant powders had repellent activity against the three stored-product insects. Adults of *S. granarius* repelled faster, followed by *T. castaneum* and R. dominica. At higher concentrations and in intervals, wheat grains treated with cinnamon powder showed higher repellency to adults of *S. granarius* (92.5% after 1 h), followed by chili pepper treatment for *T. castaneum* (up to 72.5% after 6 h), and black pepper treatment for *R. dominica* (up to 58.75% after 24 h).

Use of native plant dusts for the control of stored grain insect pests had been suggested by Nukenine *et al* (2007). They found that dry leaf dusts of some indigenous plants of Cameron and one Eucalyptus species, gave complete protection against *Sitophilus zeamais* in grain stores of subsistence agricultural farmers. They concluded that the native plants are easily available, can be used without leaving any hazardous residues, and grain pest management is cost effective.

CONCLUSION

The present results revealed that the dry leaf/seed dusts of the studied indigenous plants possessed repellent activities, either olfactory or gustatory or both against the larvae of *R. dominica*. If the dusts are mixed with wheat, can be easily winnowed or washed out before consumption, thus not affecting the human health and these do not impose hazards to the storage ecosystem. It is suggested that dusts can be used in the small scale grain stores for keeping away *R. dominica*.

REFERENCES

BLOSZYK, E., NAWROT, J., HARMATTHA, J., DROZDZ, B. & CHEMIELEWICZ, Z. 1990. Effectiveness of antifeedants of plant origin in protection of packaging materials against storage inscets. *J. Appl. Ent.* **110**: 96-100

DAVID, B. V., SUKUMARAN, D. & KANDASAMY, C. 1988. The Indian Privet (*Vitex negundo* Linn.) - A plant possessing promising pesticidal activity. *Pesticides* **22**: 27-30

EL-LAKEAH, F. A., KHALED, O. M., KHATTAB, M. M. & ABDEL-RAHMAN, T. A. 1997. Effectiveness of some plant extracts and powders against the lesser grain borer *Rhizopertha dominica* (Fab.). *Ann. Agric. Sci. (Moshtohor)* **35**: 567-578

HIGHLAND, H. A. 1980. Resistant barriers for stored product insects. CRC Handbook of transportation and marketing in agriculture. *Food Commodities* **1**: 41-45

JACOB, S. & SHEILA, M. K. 1993. A note on the protection of stored rice from the lesser grain borer, *Rhyzopertha dominica* Fab. by indigenous plant products. *Indian J. Ent.* **55**: 337-339

JERMY, T., BUTT, B. A. & MCDO NOGH, L. 1981. Antifeedant for the Colorado potato beetle - antifeedant constituent of some plants from the sagebrush community. *Insect Sci. Appl.* **1**: 239-242

KASHYAP, N. P, GUPTA, V. K. & KAUSHAL, A. N. 1974. Mentha spicata Linn.

a promising protectant to stored wheat against *Sitophilus oryzae*. *Bull. Grain Tech*. **12**: 41-44

MAHAL, N. 2002. *Biology and control of Rhizopertha dominica (Fabricius) (Coleoptera: Bostrichidae)*. Ph D Thesis, Institute of Biological Sciences, University of Rajshahi, 329pp.

MOHIUDDIN, S. QURESHI, R. A, AHMED, Z & QURESHI S A 1993. Laboratory evaluation of some vegetable oils as protectants of stored products. *Pak. J. Sci. Res*. **36**: 377-379

MONDAL, K. A. M. S. H. 1984. A method of determining the larval instars of *Tribolium castaneum* Herbst (Coleopetra: Tenebrionidae). *Lab Practice* **33**:120-121

MUNAKATA, K. 1977. Insect feeding deterrents in plants. pp. 93-102 In: *Chemical control of insect behavior: theory and application*. John Wiley & Sons., New York,

NUKENINE, E N., ADLER, C. & REICHMUTH, C. 2007. Efficacy evaluation of plant powders from Cameroon as post-harvest grain protectants against the infestation of *Sitophilus zeamais* Motschulsky (Coleoptera:Curculionidae). *J. Plant Disease & Protection.* **114**: 30-36

PATEL, K. P. & VALAND, V. M. 1994. Bio-efficacy of plant materials against *Rhyzopertha dominica* Fab. infesting stored wheat *Triticum aestivum* Linn. *Gujarat Agric*. *Univ. Res. J.* **20**: 180182

PRAKASH, A., PASALU, I. C. & MATHUR, K. C. 1981. Begonia leaves: a grain protectant in paddy storage. *Bull. Grain Tech*. **19**: 59-61

PRAKASH, A. PASALU, I. C. & MATTHUR, K. C. 1983. Use of bel (*Aegle marmelos)* leaf powder as a protectant against storage pests of paddy. *Agric. Res. J. Kerala* **21**: 79-80

QADRI, S. S. H 1973. Some new indigenous plant repellents for storage pests. *Pesticides* **7**: 8-22

SHARMA, R. K. 1995. Laboratory studies on the efficacy of neem leaf powder and cob ash against *Rhyzopertha dominica* (Fab.) in stored maize. *Indian J. Ent*. **57 (1)**: 15-17

SHAYESTEH, N. & ASHOURI, S. 2010. Effect of four powdered spices as repellents against adults of *Rhizopertha dominica* (Fab.), *Sitophilus* *granarius* (L.) and *Tribolium castaneum* (Herbst). 10th International Working Conference on Stored Product Protection, Iran. 799-804.

SINGH H, MRIG, K. K. & MAHLA, J. C. 1996a. Effect of different plant products on the fecundity and emergence of lesser grain borer, *Rhyzopertha dominica* (Fab.) in wheat grains. *Ann. Biol*. **12**: 96-98

SINGH H, MRIG, K. K. & MAHLA, J. C. 1996b. Efficacy and persistence of plant products against lesser grain borer, *Rhyzopertha dominica* (Fab.) in wheat grain. *Ann. Biol*. **12**: 99-103

(MS received for publication 12 August 2013)

BANGLADESH JOURNAL OF ENTOMOLOGY

Volume 23 **Number 2** **December 2013**

CONTENTS