Comparison of mechanical control with insecticidal control against Cucurbit Fruit Fly, *Bactrocera Cucurbitae,* (Tephritidae, Diptera) in Bitter gourd at District Swat, Khyber Pakhtunkhwa

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Abstract

Fruit fly is a major threat to fruits and vegetables as it accounts for 30-100% produce loss. Chemical control is being used against it but it is hazardous to human and his environment. Therefore, experimental studies were performed to evaluate the effectiveness of some botanicals and eco-friendly paper bagging against cucurbit fruit fly, *Bactrocera cucurbitae*, (Tephritidae; Diptera) in bitter gourd. The experiment comprised of five treatments, Neem oil (2%), Garlic extract (5%), Newspaper bagging, Trichlorfon (Metallic) 80% SP and control. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replicates. The results indicated that the botanicals and paper bagging significantly reduced infestation of cucurbit fruit fly. Minimum infestation was recorded in paper bagging (7.25%), followed by Garlic extract (36.38%). The maximum infestation was observed in Control (75.55%), followed by Trichlorfon (Metallic) 80% SP (48.06%). Minimum values for larval density fruit^{-1} (5.71), pupae formation (4.60) and adult emergence (3.86) were obtained from paper bagging, followed by Neem oil (8.13, 6.83 and 5.75 respectively). Maximum larval density fruit^{-1} (14.58), pupae formation (13.14) and adult emergence (11.05) were obtained from Control, followed by Trichlorfon (Metallic) 80% SP (12.55, 10.70 and 8.72 respectively). Paper bagging resulted in highest yield (11891.14 kgha^{-1}) with highest cost-benefit ratio (CBR = 4.75), followed by Garlic extract (9625 kgha^{-1}), Neem oil (8479.75 kgha^{-1}), Trichlorfon (Metallic) 80% SP (7190.73 kgha^{-1}) and control (5182.1 kgha^{-1}). It was concluded that paper bagging and botanical extracts (Neem oil and Garlic extract) reduced *B. cucurbitae* infestation as compared to control and also improved crop quality and yield of bitter gourd and are recommended for the Eco-friendly management of *B. cucurbitae.*

Key words: Fruit fly, Mechanical control, Plant extracts, Bitter gourd

Introduction

Bitter gourd (*Momordica charantia L.)*; is an essential cucurbitaceous vegetable grown all over the world (Kubola *et al.*, 2008). Bitter gourd is a nutritious and restorative vegetable and is of great importance to human (Dhillon *et al.*, 2005). It is being used in folkloric medicine for the treatment of diabetes, various ulcers and other infections (Beloin *et al.*, 2005). Bitter gourd plants are subject to different insect pests.

Fruit flies and Red Pumpkin beetle (*Aulacophora foveicollis*) are the major insect pests of bitter gourd (Singh *et al.,* 2006). Tephritid fruit flies (Diptera: Tephritidae) are the devastating insect pests having a foremost influence on global agricultural products, affecting yield losses and dropping the value and marketability of horticultural crops. These fruit flies are amongst the persistent insect pest species of vegetables and fruits in the world which cause direct and indirect economic losses due to injury (Sarwar, 2006). Cucurbit fruit fly; *Bactrocera cucurbitae* (Diptera: Tephritidae) is one of the main tropical fruit flies causing considerable damage in cucurbits. *Bactrocera cucurbitae* has been observed to infest a wide range of crops in the cucurbitacae family (Raguvanshi *et al.,* 2012). Yield losses vary from 30-100% (Nath and Bhusan 2006) depending upon the cucurbit species and the season (Sapkota *et al.,* 2010). The damage is caused by the larvae being hatched from banana like eggs laid in fruits and soft tissues of vegetative parts of the plant and usually consists of breakdown of tissues and internal rotting associated with maggot infestation. The tunnels made by the larvae provide entry points for bacteria and fungi that cause the rotting of fruit (Muhammad *et al.,* 2007). Fruit flies are managed and controlled by different chemicals and attractants to attract and kill the adults of fruit flies (Muhammad *et al.,* 2007). Since the maggots feed inside fruits, chemical control is ineffective also it is inappropriate as insecticides leave toxic residues in fruits (Dhillon *et al.,* 2005). Bio-extracts may be useful against fruit flies. Different local plants like balcher, harmal, kuch and neem have been identified which have repellent and anti-feedant properties (Jilani *et al.,* 1989). Many plants have been used directly or as templates of synthetic pesticides as they contain toxic compounds and virtually act as pesticides (Singh and Sehgal, 2001). Commercially formulated Neem and decoction of Neem leaves block ovarian development of different fruit fly species and minimize the damage and population of these insect pests (Mahfuza *et al.,* 2007). Various management options for cucurbit fruit fly include field sanitation, use of hydrolyzed protein and sugar spray, pheromone traps, botanicals and insecticides spray and bagging and wrapping of fruits (Waseem *et al.,* 2009) but among these management techniques, wrapping or bagging of fruits is more practicable (Mitra *et al.,* 2008). Due to efficacy and zero pesticidal residues in the fruit, bagging is a more superior practice to control and manage fruit flies over chemical treatment. Biodegradable poly-films bagged fruits, 6 to 9 weeks prior to harvesting is being found to control fruit fly effectively (Bilck *et al.,* 2011). Bagging and wrapping improves the texture, color and quality of the fruits and also keeps the female flies away from the fruits (Singh *et al.,* 2007; Mitra *et al.,* 2008). In view of combating the seriousness of cucurbit fruit fly, this study was conducted to investigate the effectiveness of eco-friendly techniques like botanical spray and bagging of fruits with paper to minimize its population and keep environment safe.

Methodology

Experiment location and layout

The experiment entitled as "Comparison of mechanical control with insecticidal control against cucurbit fruit fly, *Bactrocera cucurbitae,* (Tephritidae: Diptera) in bitter gourd at district Swat Khyber Pakhtunkhwa" was conducted at Agricultural Research Institute, (ARI) Mingora Swat-Pakistan, during 2019. Green leaf (Jaunpuri long) variety of bitter gourd was sown in raised beds at recommended seed rate of 500 gkanal^{-1}. Row to row and plant to plant distances were kept as 1.4 m and 30 cm respectively. Bed width was 1 m and a buffer zone of 1.5 m was left between each treatment. The experiment was conducted in Randomized Complete Block Design (RCBD) with three replicates.

For the vines to grow in vertical manner, trellising was done to enhance vigorous growth and to prevent the fruits from contact with soil. Bamboo poles of 3-4 m height were installed at the start of each experimental unit and a net over the bamboo poles was spread along the furrows of the channels.

The following treatments were applied at their respective concentration along with paper bagging and control.

- T1 = Neem oil 2 %
- T2 = Garlic extract 5 %
- T3 = Synthetic insecticide (Trichlorfon (Metallic) 80 % SP)
- T4 = Newspaper bagging
- T5 = Control

Treatments application and data collection

Botanicals (Garlic extract and Neem oil) and synthetic insecticide were prepared according to their concentrations mentioned and sprayed after infestation had started. A total of seven sprays were done at weekly intervals after each picking. Percent infestation at each picking was recorded from randomly selected five plants and then mean % infestation was calculated. For paper bagging the fruits were bagged before maturity with newspaper. Fruits were picked on weekly basis from randomly selected five plants and paper bags were renewed.

Rearing of *B. cucurbitae* and parameters studied

Infested fruits from each experimental unit were brought to laboratory and caged in wooden cages (30*30*60 cm) containing a layer of soil at the bottom for pupation. Larval density was recorded by counting the number of (fruits being cut) larvae feeding inside the fruits of five randomly selected fruits from each experimental unit and then mean was calculated. After 7-12 days of larval duration, the soil of the cages was sieved (with 16 mesh size) to obtain pupae. The pupae were counted, weighed and then transferred to Petri-dishes to be kept in oven for adult emergence. Adults emerged were counted and % adult emergence was calculated. Finally yield and cost-benefit ratio were calculated.

Statistical analysis

The data were subjected to Statistix 8.1 for statistical analysis. The data were tested for significance at significance level of 5% using ANOVA. LSD test was applied to highlight the significance of variance among the treatments.

Results and discussion

Biological parameters of *B. cucurbitae*

The biological parameters of *B. cucurbitae* as significantly affected by treatment application are presented in Table 1. Application of paper bagging resulted in lowest larval density$fruit^{-1}$ (5.71 larvae $fruit^{-1}$), followed by application of neem oil where the larval density$fruit^{-1}$ was 8.13, while the highest larval density was recorded in control (14.58 larvae$fruit^{-1}$) which was found at par with larval density recorded

in Trichlorfon (Metallic) treated plot (12.55 larvaefruit^{-1}). Larval density recorded in Trichlorfon (Metallic) and garlic treated plot was also non-significant. Results also revealed that minimum number of pupae was formed in paper bagged fruits (4.60), followed by neem oil, garlic extract and Trichlorfon (Metallic) with 6.83, 9 and 10.70 pupae respectively, whereas number of pupae was highest in control (13.14). Similarly, the lowest number of *B. curcubitae* adults (3.86) was emerged from paper bagging, followed by neem oil (5.75), whereas highest no. of adults was emerged from control which was 11.05. Likewise, lowest percent adult emergence of *B. cucurbitae* (18.67%) was recorded in paper bagging followed by garlic extract, Trichlorfon (Metallic) and neem oil 37.99 %, 41.40 %, 50.77%, respectively, which were non-significant from each other but significantly higher than paper bagging while the highest adult emergence was recorded in control (96.33%). Like other parameters, pupal weight was also significantly affected by different treatments. However, minimum pupal weight was recorded in paper bagging (4.62 mg) while the maximum pupal weight was recorded in control (4.92 mg).

Table 1. Effect of different treatments application on the biological parameters of *B. cucurbitae* in bitter gourd

Treatments	Larval densityfruit^{-1}	No. of Pupae formed	No. of adults emerged	% Adult emergence	Pupae weight (mg)
Neem Oil 2%	8.13c	6.83d	5.75d	50.77b	4.89ab
Garlic Extract 5%	10.99b	9.00c	6.96c	37.99b	4.82bc
Trichlorfon (Metallic) 80% SP	12.55ab	10.70b	8.72b	41.40b	4.78c
Paper bagging	5.71d	4.60e	3.86e	18.67c	4.62d
Control	14.58a	13.14a	11.05a	96.33a	4.92a
LSD $_{(0.05)}$	2.17	1.11	12	19.31	0.09
CV %	11.10	6.66	7.45	20.91	0.98

Mean values followed by different letters are significantly different at 5% significance using LSD test

Infestation level of *B. cucurbitae* in bitter gourd and yield of bitter gourd

The infestation level of *B. cucurbitae* and yield of bitter gourd as affected significantly by treatments application is given in Table 2. Statistical analysis of variance showed significant variation in fruit fly infestation and yield. Fruits bagged with newspaper was found the most effective treatment having minimum number of infested fruits (1.55), followed by neem oil and garlic extract with 6.30 and 6.67 infested fruits respectively, while the maximum number of infested fruits was recorded in Trichlorfon (Metallic) and control plot 8.33 and 8.81 respectively. Similarly, the lowest fruit fly infestation (7.25%) was recorded where fruits were covered with newspaper bags followed by garlic extract with an infestation level of 36.38%. Infestation recorded in neem oil and Trichlorfon (Metallic) with an infestation level of 45.08% and 48.06% respectively, these being non significantly different from each other but significantly lower than control where the fruit infestation level was 75.55%. Results regarding % decrease in fruit infestation over control, paper bagging showed maximum reduction 90.39% in fruit infestation. Plot where plants were treated with garlic extract was the next most effective treatment having 51.85% reduction over control followed by neem oil and Trichlorfon (Metallic) with 40.33 and 36.38% reduction in fruit infestation respectively. Furthermore, paper bagging yielded the maximum yield of 11891.14 kg ha^{-1} with 129.46 % increase over control followed by garlic and neem extract that yielded

9625 and 7190.73 kg ha^{-1} with 85.73 and 38.76% increase over control, while control yielded the minimum yield of 5182.1 kg ha^{-1}.

Table 2. Effect of different treatments application on the infestation level of *B. cucurbitae* in bitter gourd and yield of bitter gourd

Treatments	No. of infested fruitsplant^{-1}	% Infestation	% Decrease over control	Yield (Kgha^{-1})	% Increase over control
Neem Oil 2%	6.30b	45.08b	40.33	8479.75b	63.635
Garlic Extract 5%	6.67b	36.38c	51.85	9625b	85.73
Trichlorfon (Metallic) 80% SP	8.33a	48.06b	36.38	7190.73c	38.76
Paper bagging	1.55c	7.25d	90.39	11891.14a	129.46
Control	8.81a	75.55a		5182d	
LSD $_{(0.05)}$	1.03	1.11		1.28	
CV %	8.65	6.66		8.04	

Mean values followed by different letters are significantly different at 5% significance using LSD test

Cost-benefit ratio

Results pertaining CBR of different tested treatments against fruit fly in bitter gourd is presented in Table 3. CBR shows positive outcomes as all the tested treatments bear CBR value >1. However, fruits bagging with newspaper bearing highest cost-benefit value 4.75 are most profitable among the tested treatments. Garlic extract is the next most profitable treatment having CBR value of 1.55 followed by Trichlorfon (Metallic) (1.44), while neem oil is least profitable treatment in terms of lowest CBR value 1.25.

Table 3. Cost benefit ratio of different control options of *B. cucrbitae* in bitter gourd

Treatments	Yield kgha^{-1}	Total income (PKR)	Total Cost (PKR)	Net Income	Additional cost of treatment	BCR
Neem Oil 2%	7190	251675	117263	134412	107263	1.25
Garlic Extract 5%	9625	336875	138315	198559	128315	1.55
Trichlorfon (Metallic) 80% SP	8479	381588	162368	219220	152368	1.44
Paper bagging	11891	594556	111736	482820	101736	4.75
Control	5182	155463	10000	145463		

Discussion

Table 1 clearly showed that biological parameters of *B. cucurbitae* were significantly affected by treatments application. Results revealed that among tested treatments, application of paper bagging drastically reduced larval density fruit^{-1}(5.71), pupae formed (4.60), with lowest adult emergence (18.67) and pupal weight (4.62 mg). Present findings are supported by Mukherjee *et al.,* (2007). They found that

bagging of fruits reduces the fruit fly infestation substantially. Biswas (2005) reported that bagging of fruits shows significantly lowest infestation compared to control. Similarly, Amin (1995) also recorded significantly lowest fruit fly infestation (4.61%) in bagged cucumber compared to other chemical and botanical control measures. They elaborated that infestation reduction in fruits bagging was due to the fact that the bagged fruits might have escaped the deposition of eggs by the female fruit fly. Uddin (1996) observed reduced fruit fly infestation in fruits of barrier + yellow pan trap + bagged fruits. Decreased rate of fruit infestation is observed after the fruits had been bagged at the initial stage (Amin, 1995; Kapoor, 1993). They also claimed that bagging might be the successful method of prevention by female fly oviposition. After evaluating seven treatments against the fruit fly on cucumber, Akhtaruzzaman *et al.*, (2003) opined that the treatment Cypermethrin sprayed at 15 days intervals + bagging of fruits at 3 Day after Anthesis (DAA) and left for 5 days + bait trap might be considered as a superior method. Kapoor (1993) revealed fruit bagging as an effective control measure where a smaller number of fruits is there to be bagged but is a deadly task for commercial use in large orchards. Similarly (Fang, 1989) further claimed that bagging of the fruits against *B. cucurbitae* greatly promotes the quality of fruits, yield and a net income increase of 45 and 58% respectively in bitter gourd and 40 and 45% in sponge gourd.

Apart from paper bagging, neem oil and garlic extract were also found the next effective treatments affecting the biological parameters of B. *cucurbitae*. In the present studies, the 2nd best performance of neem oil gets support from reports of various researchers. Chen *et al.,* (1996), Ranganath *et al.,* (1997), Gupta and Dikshit (2010) advocated safety and use of neem products for fruit fly management. Similarly, Sapkota *et al.,* (2010) have documented neem leaf extract as the most effective to manage fruit fly in summer squash with qualitative and quantitative increase in yield attributes. Our results to advocate use of Nimbecidine (Neem) in organic agriculture are also in conformity with Ragumoorthi *et al.,* (1998) who reported Nimbecidene (Neem) the most effective against Moringa fruit fly, *Gotina distigima*. Neem oil and neem-based products might have offered deterrence to oviposition and feeding, which could be the cause. Our results are in conformity with the results of Thakur and Divender (2013) who reported that *Azadiracta indica* plant extract was more effective and also found it to be effective in terms of less egg hatching than other botanicals. Similarly, Singh and Srivastava, (1985), Khattak *et al.,* (2009) and Rehman *et al.,* (2009) also observed deterrence offered by neem seed oil treated bitter gourd fruit to *B. cucurbitae* female fly oviposition. Singh (1998) evaluated neem extract at 1.25-20% and pure azadirachtin at 1.25-10 ppm as oviposition deterrents to *B. cucurbitae* on pumpkin and they reported that neem seed kernal extract deterred oviposition by *B. cucurbitae* at all the concentrations.

In the present study, Trichlorfon (Metallic) was found the least effective treatment that had highest larval density and highest adult emergence with lowest pupal weight. The present findings are in contradiction with the finding of (Nasiruddin and Karim, 1992). They found (8.56%) fruit fly infestation in snake gourd treated with Trichlorfon (Metallic) 80% SP which was comparatively less than that of untreated plot (22.48%). Resistance of *B. cucurbitae* to Dipterx might be one of the reasons for least effectiveness. It needs further lab study to confirm resistance in *B. curcurbitae* to Dipeterx.

As presented in Table 2 infestation level of *B. cucurbitae* is affected significantly by different treatments application. Paper bagging again proved to be the most effective management method to minimize *B. cucurbitae* infestation as it accounts the least % fruit infestation (7.25%) and least no. of infested fruits plant^{-1} (1.5) by *B. cucurbitae*. Neem oil and garlic extract also proved to be best against *B. cucurbitae* infestation but Trichlorfon (Metallic) insecticide was not effective as others. Since, Trichlorfon

(Metallic) has repeatedly been used against fruit flies in Swat region; *B. cucurbitae* might have developed resistance against it. Mondel *et al.,* (2015) from diverse trials of treatments concluded that covering or wrapping of fruit (guava) with propylene bag ranging from transparent to blue and black proved best for fruit fly management as bagging offered 1.43% infestation. The efficiency of neem oil against fruit fly on cucumber is also been reported by (Ranganathan *et al.,* 1997; Mahfuza *et al.,* 2007). Table 2 shows that yield was positively increased with the application of the treatments compared to control. Paper bagging being increased yield by 129.46% over control yielded maximum of all treatments (11891.14 kg ha^{-1}) followed by garlic extract (9625 kg ha^{-1}) which increased yield by 85.76%. Neem oil was found also effective in enhancing yield. Khatun *et al.,* (2016) observed an increase in the yield of bitter gourd plants treated with ambush @ 3 mL/L (more than twice) while in Jubas @ 2 mL/L (1.87 times), Suspend @ 1.5 g/L (1.55 times) and Haron @ 2mL/L (1.52 times) respectively.

Cost-benefit ratio (CBR) values show that all the tested treatments had positive CBR value. The paper bagging increased income 4.75 times for a unit cost. Garlic extract and Trichlorfon (Metallic) treated plots also pertained CBR value more than one. This could be due to the look and glossiness of the produce which raised their market price. Fruits that were obtained from control might have poor appearance due to which their price would have been lowered. Sharma *et al.,* (2013) obtained similar results when they observed attractive red color in apple fruits bagged with yellow colored spun-bound fabric bags which non bagged fruits were lacking. When pears were bagged before harvest, they got more attraction due to their color and eventually got more market prices (Amarante *et al.,* 2002). Sawai *et al.,* (2014) found out the CBR values of different treatments against control while studying fruit fly infestation in ridge gourd. They obtained the highest ICBR (1:47.38) from deltamethrin which followed DDVP (1:45.40) and Malathion (1:26.51) respectively. Our findings cannot be strictly compared with findings of earlier researchers as the cost of control shows a discrepancy with time and region to region.

Conflict of interests

The author declared no conflict of interests.

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References

Akhtaruzzaman, M., M.Z. Alam and M. A. Sardar. 2003. Effectiveness of some IPM packages for economic management of fruit fly on cucumber. J. Asiat. Soc. Bangladesh Sci. 29 (1): 1-10.

Amin, M.R. 1995. Effect of some indigenous materials and pesticides in controlling fruit fly *Bactrocera cncurbitae* Coquillet on cucumber. M. S. Thesis. Department of Entomology, Institute of Postgraduate Studies in Agriculture, Gazipur, Bangladesh. p. 56.

Beloin, N., M. Cbeassor, K. Akpagna, J. Hudson, K. Sousse, K. Koumaglo and J. T. Amason. 2005. Ethnomodiciflal uses of *Memordica charantia* in Toga and relation to its phytochemistry and biological activity. J. Ethnopharmac. 96(1): 49-55.

Bilck, P. A., S. R. Roberto, V. E. G. Maria and F. Yamashita. 2011. Efficacy of some bio-degradable films as pre-harvest covering material for guava. *Scientia Horticulturae*. 130: 341-343.

Biswas, S. K. 2005. Studies on the bionornics and management approaches of cucurbitfruit fly, *B. cucurbitac* on bitter gourd. M. S. Thesis. Department of Entomology, Bangladesh Agricultural University. Mymcnsingh. p 48.

Chen, C.C., Dong, W.J., Cheng, L.L. and Hou, R.F. 1996. Deterrent effect of neem seed kernel extract on oviposition of the oriental fruit fly (Diptera: Tephritidae) in guava. J. Econ. Entomol. 89 (2): 462- 466.

Dhillon, M. K., R. Singh, J. S. Naresh and N. K. Sharma. 2005. Influence of physio-chemical traits of bitter gourd; *Momordica charantia* on larval density and resistance to melon fruit fly; *Bactrocera cucurbitae.* J. Appl. Entomol. 129(7): 393-399.

Gupta, S. and A.K. Dikshit. 2010. Biopesticides: An ecofriendly approach for pest control. J. Biopest. 3(1): 186-188.

Jilani, G., N. Ullah and Ghiasuddin. 1989. Repellency of some plant extracts against *T. casteneum* (Herbst), (Coleoptera: Tembrionidae). Pak. J. Entomol. 11: 18-22

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

Khattak, MK., MM. Rashid, M. Abdullah. 2009. Effect of neem derivatives on infestation, settling and oviposition of melon fruit fly (Bactrocera Cucurbitae Coq.) (Tephritidae: Dipetra). Pak. Entomologist. 31(1):11-15.

Kubola, J., and S. Siriamornpun. 2008. Phenolic contents and antioxidant activities of bitter gourd *(Momordica charantia L.)* leaf stem and fruit fraction extracts in vitro. Food Chem.; 110:881-890.

Mahfuza, K., M.H. Aftab and M.I. Saidul. 2007. Effect of Neem leaf dust and commercial formulation of a Neem compound on the longevity, fecundity and ovarian development of melon fly, *Bactrocera cucurbitae* (Coquillett) and oriental fruit fly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae). Pak. J. Bio. Sci. 10(20): 3656-3661

Mitra, S. K., M. R. Gurung and P. K. Pathak. 2008. Sustainable guava production in West Bengal, India. Acta Horticulturae. 773: 179-182.

Mondal, C. K., P. K. Garain, N. J. Maitra, and A. M. Ramakrishna. 2015. Bio-friently management of Guava fruit fly (*Bactrocera correcta)* through wrapping technique. J. Appl. and Nat. Sci. 7(1): 358-363.

Mukherjee, S., D. A. Tithi, A. A. Bachchu, R. Ara and M. R. Amin. 2007. Life history and management of cucurbit fruit fly *Bactrocera cucurbitae* on sweet gourd. J. Sci. Technol. 5: 17-27.

Nasiruddin, M., and M. A. Karim. 1992. Evaluation of potential control measures for fruit fly, *Bactrocera (Dacus) cucurbitae* in snake gourd. Bangladesh J. Entomol. 2**(**2**)**: 31-34.

Khatoon, N., M. T. Hossain, T. Islam and G. Das. 2016. Comparative efficacy of some biopesticides and a pyrethroid against cucurbit fruit fly, *Bactrocera cucurbitae (Coquillett)* on Bitter gourd. Intl. J. Entomol. Res. 1(2): 23-28.

Raghuvanshi, A. k., S. Satpathy and D. S. Mishra. 2012. Role of abiotic factors on seasonal abundance and infestation of fruit fly, *Bactrocera cucurbitae* (Coq.) on bitter gourd. J. Plant Prot. Res. 52(2): 264-267

Ragumoorthi, K.N., P. V. S. Rao and A. K. Dhawan. 1998. Neem products and plant extracts for managing Moringa fruit fly, *Gitona distigma* (Meigon). Intl. Conference on Ecol. And Sustainable Agric. 2: 38.

Ranganath, H.R., M. A. Suryanearayana and K. Vennakumari. 1997. Management of melon fly, *Bactrocera cucurbitae* Coquillett in cucurbits in South Andaman. Insect Environ. 3(2): 32-33.

Rehman, JU., G. Jilani, A. K. Khan, R. Masih, S. Kanvil. 2009. Repellent and oviposition deterrent effects of indigenous plant extracts to peach fruit fly, *Bactrocera zonata* Saunders (Diptera: Tephritidae). Pak. J. Zool. 41(2):101-108.

Sawai, H. R., S. K. Godse, A. L. Narangalkar, P. M. Haldankar and A. P. Sanas. 2014. Bio-efficacy of some insecticides against Fruit Flies infesting Ridge Gourd. J. Soils and Crops. 24(1): 174-180.

Sapkota, R., K. C. Dahal and R. B. Thapa. 2010. Damage assessment and management of cucurbit fruit flies in spring-summer squash. J. Entomol. and Nematol. 2(1): 007-012.

Singh, R. P., and B. G. Srivastava. 1985. Alcohol extract of neem (*Azadirachta indica* Juss) seed oil as oviposition deterrent for *Dacus cucurbitae* (Coq.). Indian. J. Entomol. 45(1): 497-498.

Singh, S. and S.S. Sehgal. 2001. Investigations on constituents of *Acorus calamus* root oil as attractants to melon fly, *Bactrocera cucurbitae* and Oriental fruit fly, *Bactrocera dorsalis*. I. J. Entomol. 63: 340-344.

Thakur, M., and D. Divender. 2013. Plant extracts as oviposition deterrents against fruit flies, *bactrocera* spp. infesting vegetable crops. Pesticide. Res. J. 25(1): 24-28.

Uddin, M. J. 1996. Development of suitable package(s) of IPM components for the management of selected insect pests of cucumber. M.S. Thesis Institute of Postgraduate Studies in Agriculture, Gazipur, Bangladesh. 72 p.

Waseem, M.A., A. Nagangoud, B. V. Patil, A. Prabhuraj and A. Hussain. 2009. Efficacy of some insecticides against melon fly, *Bactrocera cucurbitae* (Coquillett) on cucumber. Karnataka J. Agric. Sci. 22(3): 701-702.