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First record of *Acythopeus curvirostris citrulli* (Marshall) (Coleoptera: Curculionidae) on sponge gourd, *Luffa cylindrica* (Linn.), its bionomics, diurnal activity and ecofriendly management

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Abstract

The present study reports the first record of melon weevil, *Acythopeus curvirostris citrulli* as a serious pest of sponge gourd from India. Studies were conducted during *Kharif* seasons of 2013-14 and 2014-15 at IIVR, Varanasi and observed that about 70-80 per cent fruits and 30 per cent shoots were damaged by this weevil. Gravid females lay eggs in small batches on the tender fruits just beneath the skin and on hatching grubs start feeding on the soft, tender fruit pulp and continue till pupation. Due to its feeding, the affected fruits rot and there was no seed formation. Pupation occurs inside the fruits. Cocoons are hard blackish in colour made up of fibrous materials of the fruits and larval excreta. Adults emerge from the dry fruits by making small emerging holes. Affected fruits exhibit characteristic brown gummy encrustations on the fruits which significantly reduce its market value.

Keywords: *Acythopeus curvirostris citrulli,* sponge gourd, bionomics, host preference, varietal screening, entomopathogens, insecticides

Introduction

Luffa, *Luffa cylindrica* (Linn.), known as a vegetable sponge or sponge gourd, is a subtropical vegetable cultivated throughout India, but more widely in the Indo-Gangetic plains of Uttar Pradesh, Bihar and Jharkhand. India ranks first in sponge gourd production in the world. Apart from its wide use as a vegetable in various ways as curry, chutney, sambhar or eaten raw like cucumber, its fruit is also used in traditional medicine as an anthelmintic, carminative, laxative, depurative, emollient, expectorant, diuretic and lactagogue. It is also useful in treatment of fever, syphilis, tumours, bronchitis, splenopathy and leprosy (Yoganandam *et al*. 2010). There is a huge demand of this crop almost thorough out the year in this region.

Although insect and mites are major biotic constraints in sponge gourd production in India not much information is available on their economic importance. Recently, Halder *et al*., 2016, reviewed the insect and acarine fauna associated with sponge gourd in the Indo-Gangetic plains of India. During the last couple of years, a new emerging borer pest infesting sponge gourd in Varanasi region of Uttar Pradesh during *Kharif* season was observed. The breeder crop grown at the experimental farm of the institute suffered heavily to a tune of 70-80 per cent fruit damage. The tender fruits had several brown puncture spots with yellowish white secretions followed by brown gummy encrustations causing drying and rotting. Weevils also punctured on vines leading to gradual drying of the sponge gourd vines bearing flowers and fruits also accentuated the problem further. As many farmers of this region experienced the problem and lack of information of the pest on sponge gourd a detailed study was planned.

Materials and Methods

The detailed studies on its taxonomy and morphology, seasonal incidence, host preference, diurnal activity, biology, varietal preference along with search for suitable bioagents, if any, and also chemical insecticides were carried out in the laboratory and research farm during the *Kharif* seasons of 2013-14 and 2014-15 at ICAR-Indian Institute of Vegetable Research (I.I.V.R.), Varanasi (82°52' E longitude and 25°12' N latitude), Uttar Pradesh.

Biosystematics and molecular characterization of melon weevil: The specimens of adult weevils (preserved in 80% alcohol) were sent to National Pusa Collection, Division of Entomology, ICAR-Indian

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Agricultural Research Institute, New Delhi, India and Department of Entomology, Kerala Agricultural University, Thrissur, Kerala, India for taxonomic identification. Morphological study of the weevil was done under stereomicroscope (Nikon SMZ-10A) at Biocontrol Laboratory, I.I.V.R., Varanasi, Uttar Pradesh.

Molecular studies were carried out from the field collected sample of the weevil. A single leg was detached from the specimen and cut into two pieces. The pieces were then cleaned thoroughly with molecular water and genomic DNA was isolated. Genomic DNA was extracted from the leg sample using DNA Sure Tissue Mini Kit (Nucleo- pore, Genetix brand) as per manufacturer's protocol. The mtCO1 region was amplified using forward primer CI-J-2195 (3''!TTGATTTTTTGGTCATCCAGAAGT'!5') in combination with reverse primer TL2-N-3014 (3''!TCCAATGCACTAATCTGCCATATTA'!5') (Frohlich *et al*., 1999; Simon *et al*., 2003). The PCR reactions mixture (25 µl) consisted of 1µl (10 pmol) each primer, 2.5 µl of 10x buffer, 2 mM $MgCl_2$, 2 mM dNTPs and 1 µl of Taq DNA polymerase. PCR mixture were heated at 94°C for 5 min followed by 35 cycles of denaturation at 94°C for 30 sec, annealing for 40 sec at 54°C and extension of 40 sec at 72°C and followed by final extension at 72°C for 5 min in a thermal cycler (Biorad, Germany). The amplified products were resolved by electrophoresis using 1% agarose gel with 1x TAE electrophoresis buffer in a submerged electrophoresis system (Biorad, Germany) at 75 volt; stained with ethidium bromide (1ug/ml) and visualized in a gel documentation system (UVP, UK). The PCR products were purified and sequencing was outsourced to Scigenomics (Cochin, India). The sequences have been deposited in the Bankit at NCBI. The weevil sample was deposited in the National Pusa collection, Division of Entomology, ICAR-IARI, New Delhi– 110012.

Biology of the pest: Biology of the pest was studied under laboratory condition at 28±2°C temperature, 75±5 % relative humidity and a photoperiod of 13:11 (L:D) hour. Initial culture of this weevil was maintained in the lab by collecting the infested fruits of sponge gourd from the field containing different developmental stages of the weevil. Infested fruits were placed in the plastic jars (15 cm diameter and 19.2 cm height) and rearing was done on their natural host (*i.e.,* sponge gourd) for further multiplication. Observation on oviposition were made by keeping twenty pairs of adults in wire screen cages (36 cm x 30 cm x 40 cm) with healthy sponge gourd vines containing tender fruits placed in conical flasks with Hogland solution to maintain their freshness. The grubs were reared on tender fruits. All the biological parameters were recorded and statistically analyzed using statistical package software SPSS version 16.

Diurnal activity: To study the diurnal activity of the melon weevil, the number of adult weevil present on 50 randomly selected tender fruits (up to 10 days from fertilization) were counted once in a week at hourly intervals from early morning (6.00 am) to late evening (6.00 pm) coinciding with sunrise and sunset during the months of September and October. Thus, a total of 650 fruits were sampled per day once in a week. The data so obtained on number of weevil(s) sitting on fruits at a specific time of the day were pooled together for different weeks and months and expressed as average weevil(s) per fruit.

Host preference: Occurrence of the weevil was recorded at weekly intervals in the field throughout the year during 2013-15 on several cucurbitaceous vegetables *viz*., sponge gourd (*Luffa cylindrica* (Linn.)), ridge gourd (*Luffa acutangula* (L.) Roxb.), cucumber (*Cucumis sativus* Linn.), pumpkin (*Cucurbita pepo* Linn.), bottle gourd (*Lagenaria siceraria* (Molina) Standl.) and bitter gourd (*Momordica charantia* Linn.) grown in *Kharif* season at the research farm of the institute. Observations were undertaken to record the relative abundance of the pest. The sampling procedure etc. remained essentially the same as described above for both sponge and ridge gourd.

Screening of sponge and ridge gourds accessions against melon weevil: Studies on infestation of melon weevil, *A. c. citrulli* was undertaken on fifteen promising genotypes of sponge gourd, *viz*. VRSG-12, VRSG-1/12, VRSG-2/12, VRSG-49-1, VRSG-57, VRSG-61, VRSG-77, VRSG-91, VRSG-136, VRSG-154, VRSG-171, VRSG-194, VRSG-195, VRSG-214 and Kashi Divya and two genotypes of ridge gourd *i.e.,* VRRG-26 and VRRG-27 grown in trailing system at the experimental farm of the institute. Two rows of 40 hills for each genotype of respective crops were sown at a spacing of 0.6 x 1.5 mt. The crops were raised following standard agronomic practices except for plant protection measures. The observations on shoot and fruit damage pertaining to each genotype of respective crops were recorded during both the years. The weekly and overall per cent damage was computed by the following formula–

$$\text{Per cent shoot / fruit damage} = \frac{\text{Total number of damaged shoot / fruit}}{\text{Total number of shoots /fruits}} \times 100$$

The observation pest damage taken periodically on respective germplasm were pooled together and presented as extent of damage week wise (irrespective of accessions) during the observational period.

Influence of cultivation technique on incidence of melon weevil: Raised bed and trailing systems of cultivation are followed for sponge and ridge gourd in this region. In raised bed system, ridges of 5x1 m were made and sponge and ridge gourds were grown with a spacing of 0.6 x 1.5 m. In case of trailing system, bamboo based temporary netting system was made and gourd crops were grown. All the recommended agronomic practices were followed in both the cases. Infestation of *A. c. citrulli* were recorded weekly on shoots and fruits of sponge and ridge gourds in both systems of cultivation for their suitability in terms of pest incidence.

Bioefficacy of entomopathogens, botanicals and insecticidse: Talc based formulations of three promising entomopathogenic fungus *viz*., *Beauveria bassiana* IIVR strain (1 X10^{10} cfu/g), *Metarhizium anisopliae* IIVR strain (1 X 10^{10} cfu/g) and *Lecanicillium* (=*Verticillium*) *lecanii* (2 X 10^8 cfu/g) and entomopathogenic bacteria *Bacillus thuringiensis* var Kurstaki (18000 IU/mg) and *Bacillus subtilis*-2 (2.5 x 10^{11} cfu/g) were tested in the experiments. Neem oil (1%) was prepared by dissolving in emulsifying water containing Triton-X-100 as an emulsifier. All the entomopathogenic fungi (5 g/l of water) and entomopathogenic bacteria (each @ 2 g/lit of water) were sprayed alone under Potter's tower at 340 g/cm^2 pressure. In addition, these entomopathogens and neem oil (1%) were also mixed at 1:1 ratio and 1 ml of such mixtures was sprayed under Potter's tower. Fresh uninfested and untreated plant materials were given to treated insects as food and kept at 27±1°C and 70 ± 5% RH. Twenty adult insects (0-24 hour old) in each set and three replications were taken for each treatment.

Twenty insecticides including conventional and newer molecules of different group and mode of actions, as per Insecticide Resistance Action Committee (IRAC, 2014), were evaluated for their relative efficacy against the adult weevil at their recommended doses. These include Quinalphos 25 EC (2 ml/lit), Chlorpyriphos 20 EC (2 ml/lit), Dimethoate 30 EC (2 ml/lit), DDVP 76 EC (0.75 ml/lit), Cypermethrin 25 EC (0.75 ml/lit), Deltamethrin 2.8 EC (0.75 ml/lit), Imidacloprid 17.8 SL (0.35 ml/lit), Thiamethoxam 25 WG (0.35 g/lit), Acetamiprid 20 SP (0.2 g/lit), Emamectin Benzoate 5 SG (0.4 g/lit), Spinosad 45 SC (1 ml/3 lit), Indoxacarb 14.5 SC (0.75 ml/lit), Thiodicarb 75 WP (2 ml/lit), Fipronil 5 SC (1.75 ml/lit), Spiromesifen 22.9 SC (1 ml/lit), Diafenthurion 50 WP (1.2 g/lit), Flonicamid 50 WG (0.33 ml/lit), Chlorantraniliprole *i.e.,* Rynaxpyr 18.5 SC (0.4 ml/lit), Flubendamide 39.35 m/m SC (0.33 ml/lit), Cyantraniliprole *i.e.,* Cyzapyr 10.26 OD (1.6 ml/lit). Newly emerged adults (0-24 hr old) from mature sponge gourd fruits were used for bioassay tests. Twenty such adults were kept in each Petri dish (diameter 9.4 cm and height 4.3 cm) and sprayed separately with 1 ml solution of respective insecticides at their indicated doses under Potter's tower at 340 g/cm^2 pressure. Mortalities were counted 24, 48 and 72 hours after the treatment and corrected per cent mortalities were computed for each treatment. Three replications were taken for each treatment including untreated control. The sprayed petri dishes containing adult weevils were fan dried. For the assessment of toxicity, mortality counts were taken 24, 48 and 72 hours after treatments for insecticides. However, in view of slow action of biopesticides, the observations were continued till eight days *i.e.,* till 192 hour after treatments. The median lethal time (LT_{50}) for entomopathogenic fungi and botanical alone and in combination were calculated to understand compatibility and synergistic action, if any. The control mortality in all the cases was below 10%.

Data analysis: The mortality data was corrected by Abbott's formula (Abbott, 1925) and analysed by Probit analysis (Finney, 1971) with SAS program (version 9.2) for calculating LT_{50}. Any two values of median lethal times (LT_{50}) determined were considered significantly different if their respective 90% confidence limits (CL) did not overlap.

Results and Discussion

Biosystematics and molecular characterization of melon weevil: The identity of the weevil encountered in the present study was confirmed as *Acythopeus curvirostris citrulli* (Marshall) (Coleoptera: Curculionidae: Baridinae) by the taxonomists of Division of Entomology, ICAR-Indian Agricultural Research Institute, New Delhi as well as Department of Entomology, Kerala Agricultural University, Thrissur, Kerala, India. This is the first submission of the sequence of *Acythopeus curvirostris citrulli*. Blast analysis shows it to share 85% identity with *Curculio sikkimensis*, which belongs to the same subfamily, *i.e.*, Curculionidae.

The member of the Baridine weevil genus *Acythopeus* belonging to the family Curculionidae and order Coleoptera are cosmopolitan in occurrence. Its zoogeographical distribution indicate that it is predominantly Afrotropical (with 33 species), followed by Oriental (30), Palearctic (9), Australasian (6), and Neotropical (2); of these eight species occur in the Indian subcontinent (Ramesha, 2015). *Acythopeus burkhartorum* O'Brien and Pakaluk and Acythopeus coccineae O'Brien and Pakaluk are stem gall makers and leaf miners, used as biocontrol agents against *Coccinea grandis*, a weed in Kenya (O'Brien and Pakaluk, 1998). The melon-weevil, *Acythopeus curvirostris* Boh. is one of the most important pests on watermelon fruits and flowers in Saudi Arabia. The highest mean percentage of infested flowers was 93% and 76% during the years of 1999 and 2000, respectively. The adult seasonal distribution were fluctuated in both seasons with the highest number (3.92 insects per branch) of adults was recorded during the third week of June, 1999 (Azzam., 2010). Thompson, 1973 reported that melon weevil, *Acythopeus curvirostris* (Boheman) occurred across the Sudan Belt, in the Middle East, Iran and South India and was generally a minor and transient pest of cucurbit fruits. In another study Boroumand, 1984 documented the present distribution of this weevil, which is one of the serious pests of Cucurbitaceae, extends from Sudan belt to Israel, Syria, Jordan, Turkey, India and Iran. Chandra *et al.*, 1987 recorded that melon weevil, *Acythopeus* (*Carporaris* [*Carpobaris*]) *curvirostris* Marshel infesting watermelon, *Citrullus vulgaris* in Rajasthan. Recently, Jhala and Sisodiya, 2003 reported that *Acythopeus curvirostris citrulli* Boheman is a pest of ivy gourd (*Coccinea grandis*) from Gujarat, India. In the literature, there has been no report of *A. c. citrulli* as a pest of sponge and ridge gourd in the world.Thus present study forms the first report of *A. c. citrulli* as a major pest of sponge and ridge gourd from Varanasi, Uttar Pradesh.

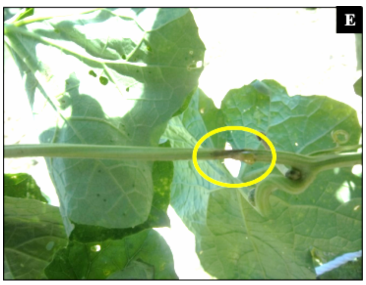
Nature of damage and periodical damage severity: Critical observations on nature of feeding made under field as well as laboratory conditions revealed the weevil to be an internal feeder on fruits of sponge gourd and ridge gourd. Adult weevils bore in to the tender fruits thorough its snout (Fig. A). It makes about 13 – 124 puncture spots on a single fruit with an average of 42.36 spots per fruit. Infestation resulted in oozing out of whitish secretions which later turned to brown gummy encrustation on the fruits (Fig. B). Affected fruits lost their market value. Close observation revealed that gravid females lay eggs singly on the tender fruits just beneath the skin. On hatching, grubs start feeding on soft, tender fruit pulp and continue till pupation (Fig. C). Due to feeding, the affected fruits rot with practically no seed

A. Adult weevils laying eggs on tender sponge

B. Brownish gummy encrusta-

C. Grub feeds inside the fruit

D. Exarate pupae inside the fruit

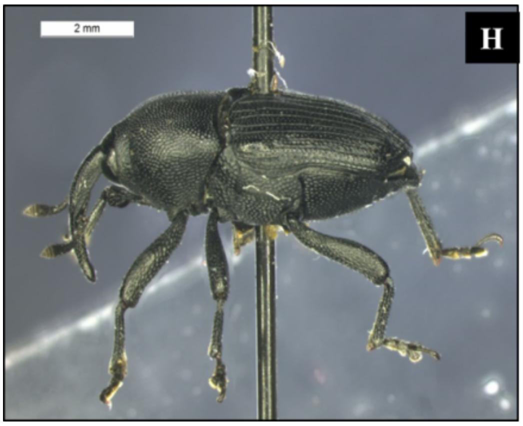


E. Vine injured due to melon weevil

F. Gradual drying of the vines

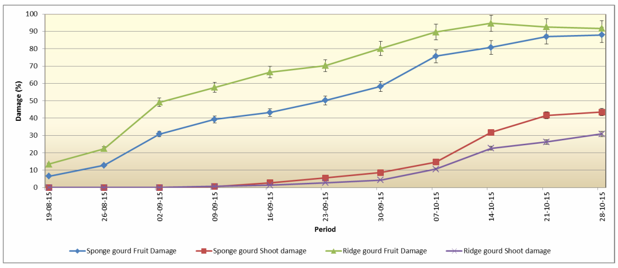
formation. Pupation took place inside hard blackish cocoon made up of fibrous materials of the fruits and larval excreta (Fig. D). Adults emerged from the dry fruits after making small emergence holes. The weevil also bores into the vines (Fig. E) resulting the gradual drying of the vines bearing tender fruits, flowers and flower buds (Fig. F) resulting irreparable loss to the farmers.

G. Adult weevil (dorsal view)



H. Adult weevil (lateral view)

Periodical damage severity of melon weevil on sponge and ridge gourds were worked out from third week of August to last week of October coinciding with their reproductive stages. In sponge and rigde gourds, fruit damage started from third week of August with highest fruit damage 87.93 and 91.67%, respectively, by last of week of October. However, with respect to shoot damages were initiated during second week of September. Highest shoot damages in sponge (43.51%) and ridge gourd (30.87%) were recorded during last week of October when the both the crops were at their physiologically matured stages. Interestingly, maximum fruit damage (91.67%) was recorded on ridge gourd whereas highest shoot damage was noted on sponge



gourd (43.51%). From November onwards the incidence of this weevil was not observed as both the gourds crops were physiologically matured and synchronized with onset of winter in Varanasi.

Biology of melon weevil: Eggs were singly laid under the rind of the tender fruits of sponge gourd. A single gravid female laid eggs 23-59 during her life time. Incubation period varied from 4-17 days depending upon the weather conditions. Grubs were apodous, creamy white in colour and feed inside the fruit till pupation. Full grown grubs were 9.93±0.87 mm in length and 3.47±0.41 mm in width. Pupae were exarate, creamy white in colour with 18.27±1.87 mg body weight and measuring 6.55±1.03 mm in length and 2.74±0.46 mm body width. Adult females were bigger in size than the male.

Morphological observations were done at the Biocontrol laboratory, Indian Institute of Vegetable Research, Varanasi under stereoscopic microscope. The adult weevils of *Acythopeus curvirostris citrulli* are dark brown in colour with metallic luster and striated elytra (Fig. G,H). Antenna inserted at base of the rostrum; scape slender; funicle club shaped. Adult females: length: 6.45±0.31 mm (without rostrum), width: 3.25±0.18 mm, with 9 longitudinal regular, deep striae on each elytron. Adult males: length: 5.33±0.29 mm long (without rostrum), width: 1.85±0.11 mm with 9 numbers of longitudinal striae on each elytron. Rostrum length varied in the sexes, *viz*., 1.89±0.09 mm in female and 1.73±0.13 mm in male. Elytra are shiny, elongated and weakly convex, sides sharply cut and rounded at apex in both sexes. Larvae are apodous, white in colour with a brown head. Full grown grubs measured on an average 9.95±0.16 mm in length and 3.44±0.07 mm in width. Eggs are small oval-shaped, translucent white in colour with chorion smooth. Incubation period lasted for 6 days.

Diurnal activity: *A. c. citrulli* exhibited a strong diurnal activity (Fig. 1). Its incidence gradually increased during day time, from 11 am onwards, with peak activity at 2 pm (an average of 1.57 adults/fruit) thereafter decreasing 3 pm onwards (1.16 adults/fruit). However, it again increased around 4 pm (1.31 adults/fruit). Late evening *i.e.,* 4 pm onwards its abundance gradually declined and at 6 pm only a few weevils could be recorded (0.47 adults/fruit). This information so generated on active period of the pest during the day will help schedule the time for taking up control measures. Earlier, Mohammadpour *et al*., 2013 from Iran reported that both males and females of melon weevil, *Acythopeus curvirostris persicus* had distinct daily activity with two peak active periods during 7:00-9:00 am and 17:00-19:00 pm whereas maximum flight activity was observed during afternoon (14:00 hours) under field condition.

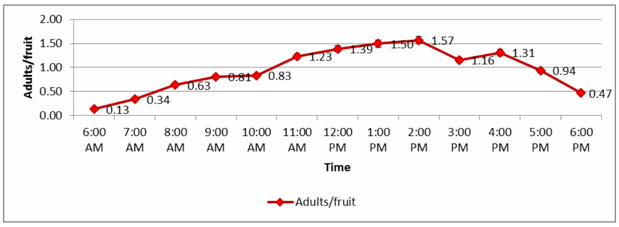


Fig. 1 Diurnal activity of melon weevil, *A. c. citrulli* on sponge gourd

Host preference: Studies on host preference of this weevil to identify the most preferred crop indicated that ridge gourd fruits were more preferred than other cucurbitaceous vegetables including sponge gourd. From the present study it is evident that melon weevil has become a serious threat to sponge and ridge gourd under Varanasi conditions. Paradoxically, as per literature it is said that other cucurbits like little gourd (*Coccinia indica*), cucumber and watermelon are alternate host crops of this weevil (Jhala and Sisodiya, 2003; Mohammadpour *et al*., 2013). In the present study, though the cucurbits crops like cucumber, bottle gourd, pumpkin and bitter gourd were simultaneously available at the same experimental farm at the same period, occurrence of this weevil were only observed in the crops like ridge gourd and sponge gourd during the months of September - October indicating preference of *A. c. citrulli* to these gourd crops over the other cucurbitaceous crops. Nair, 1995 reported that *A. citrulli* is a small dark weevil boring into ripening melon fruits in south India but has not assumed a pest status.

Screening of sponge and ridge gourds accessions against melon weevil: Maximum fruit damage (96.42%) was recorded in the ridge gourd genotype VRRG-26 which was also highest amongst all the test genotypes of sponge gourd and ridge gourd. In contrast, the duo ridge gourd genotypes (VRRG-26 and VRRG-27) suffered least shoot damage compared to other sponge gourd genotypes. Fruits of ridge gourd might be fulfilling more nutritional requirements than sponge gourd to *A. c. citrulli* causing its higher preference. Amongst the sponge gourd genotypes, the cultivars VRSG-61 and VRSG-77 suffered maximum shoot damage of 40.13 and 37.78 per cent, respectively, whereas lowest was in VRSG-57 (24.42%). In case of fruit damage, 96.16 per cent fruit damage was recorded in VRSG-171 followed by VRSG-136 (92.65%). The genotype VRSG-171 was most preferred by melon weevil as it had highest fruit damage and comparatively higher shoot damage (34.81%).

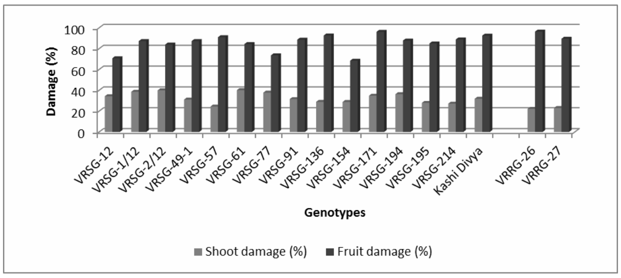


Fig.2 Varietal screening of sponge gourd and ridge gourd against *A. c. citrulli*

Influence of cultivation techniques on incidence of melon weevil: Comparison of the two popular systems of cultivations *viz*., raised bed and trailing systems indicated that trailing system of cultivation harboured more weevil infestation. Significantly highest fruit damage (80.73%) was recorded in the sponge gourd when grown in trailing system than the raised bed system (43.48%). Similar trend was also observed in ridge gourd. In case of shoot damage, both sponge and ridge gourds recorded highest shoot infestation when grown in trail based cultivation followed by raised bed cultivation. Fruits in trail based cultivation might be prone as they were exposed more to the weevil than the raised bed cultivation where some or whole parts of the fruits were always hidden under the spreading leaves.

Bioefficacy of entomopathogens, botanicals and insecticides: Amongst the different biopesticides tested, neem oil (1%) was found most promising and registered lowest median lethal time (64.94 h). In case of three entomopathogenic fungi (EPF), *L. lecanii* at recommended dose was most effective (87.84 h) followed by *M. anisopliae* IIVR strain (101.08 h). When, these three EPF were mixed with neem oil at 1:1 ratio and sprayed at half of their recommended doses, *L. lecanii* and neem oil showed their compatibility and synergistic activity against adults of melon weevil as evidenced by their lowest median lethal time of 63.78 h amongst all the treatments. However, other two EPF *i.e., M. anisopliae* and *B. bassiana* recorded only moderate activity against this weevil. From our present investigation, it is evident that white halo fungus, *L.*

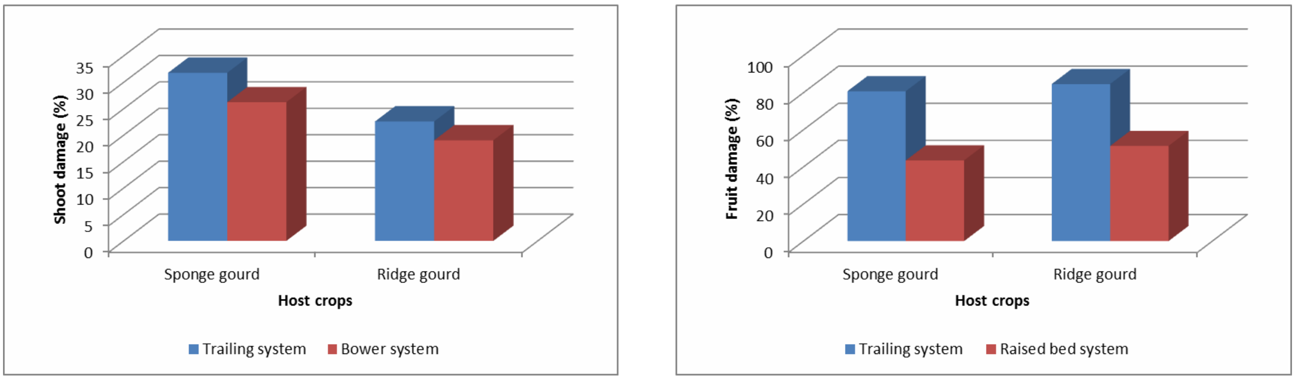


Fig.3 Different methods of cultivation of sponge gourd and ridge gourd on incidence of *A. c. citrulli*

Table 1. Bioefficacy of different entomopathogens alone and in combination with neem oil (1:1) against adults of *A. c. citrulli*

Biopesticides	Heterogenity		Regression Equation (Y=)	LT_{50} (hr)	Fiducial Limit
	df	χ^2			
Metarhizium anisopliae IIVR strain	7	3.155	3.878X – 2.774	101.08	111.31 – 91.80
Beauveria bassiana IIVR strain	8	8.064	4.102X – 3.700	132.05	148.30 – 117.58
Lecanicillium lecanii	6	9.563	5.720X – 6.112	87.84	94.36 – 81.76
Neem oil (1%)	6	8.952	2.444X + 0.569	64.94	77.35 – 54.53
Metarhizium anisopliae IIVR strain + Neem oil	7	3.157	4.949X – 5.133	111.55	125.51 – 99.14
Beauveria bassiana IIVR strain + Neem oil	6	3.033	8.043X – 11.342	107.60	116.11 – 99.71
Lecanicillium lecanii + Neem oil	6	3.736	3.308X – 0.969	63.78	76.30 – 53.31

lecanii apart from controlling different sucking insect pests, is also able to control coleopteran pests like melon weevil. More-over they are also compatible with plant origin insecticides like neem oil. The duo bacteria *viz*., *B. thuringiensis* and *B. subtilis*-2 were not found promising against this pest.

Amongst the twenty insecticides tested against newly emerged adults of melon weevil, only three insecticides namely Quinalphos, Deltamethrin and Thiodicarb caused 100% mortality within 24 hours under laboratory conditions while Chlorpyriphos and Cypermethrin were found promising with 93.33 and 90 per cent mortality, respectively at 24 hour after the treatments and 100 per cent mortality at 48 hours of treatment. It is evident that conventional group of insecticides like Quinalphos (organophosphate), Deltamethrin (synthetic pyrethriods) and Thiodicarb (carbamate) were more effective than the other tested newer molecules (Fig.3). These three insecticides affected the nervous system acting as Acetylcholinesterase (AChE) inhibitors in reversible and irreversible manner, respectively, whereas synthetic pyrethroids group of insecticides act on sodium channel modulators resulting ultimately organism mortality.

From the Present study it is evident that melon weevil, *A. c. citrulli* has become a serious pest of kharif sponge

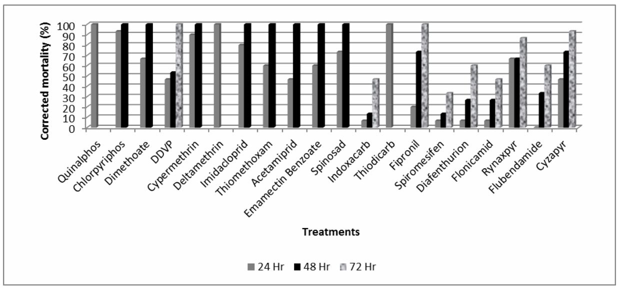


Fig.4 Toxicity of different insecticides against melon weevil

and ridge gourds amounting maximum fruit damage 87.93 and 91.67%, respectively in the region. Damage is more accentuated when vine damage was observed. Weevils punctured on vines leading to gradual drying of the gourd vines bearing flowers and fruits. Highest vine damages in sponge (43.51%) and ridge gourd (30.87%) were recorded during last week of October. The pest was most active during August to October coinciding with autumn season. Diurnal study revealed that afternoon period (1-2 pm) was the most active period for the pest indicating management practices should be adopted during this period. Amongst the biopesticides, neem oil (1%) and/or combination of *L.lecanii* and neem oil at half-of their recommended dose was found promising against this adult weevil. Synthetic insecticides namely Quinalphos, Deltamethrin and Thiodicarb at their recommended doses, as a last resort, caused 100% mortality within 24 hours under laboratory conditions.

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सारांश

भारतवर्ष में चिकनी तोरई में मेलन वीविल के भयंकर प्रकोप का पहली बार सूचना वर्तमान अध्ययन में दिया गया है। अध्ययन भाकृअनुप–भारतीय सब्जी अनुसंधान संस्थान वाराणसी में वर्ष 2013–14 व 2014–15 के खरीफ मौसम में किया गया तथा परिणाम से स्पष्ट हुआ कि लगभग 70–80 प्रतिशत फल इस वीविल से ग्रसित हुए एवं 30 प्रतिशत परोक्ष नुकसान हुआ। सभी मादा छोटे जत्थे में कोमल फलों के छिलके के ठीक नीचे देती है। अण्डे से निकल कर इल्ली मुलायम फलों के गूदे को खाती है तथा ऐसी प्रक्रिया कोकुन बनाने तक होती है। खाने से प्रकोपित फल सड़ जाते हैं तथा उनमें बीज विकसीत नहीं होता है। कोकुन बनने की प्रक्रिया फल के अंदर होती है। कोकुन कठोर काले रंग के होते हैं। जो फल के रेशेदार पदार्थ व इल्ली के मल मूत्र से बने होते हैं। प्रौढ़ सूखे फलों से छोटे छिद्र बनाकर बाहर निकलते हैं। संक्रमित फल चिपचिपा भूरा पपड़ी जैसा स्राव प्रदर्शित करता है जिससे बाजार योग्य फलों का मूल्य घट जाता है।

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