Indian Journal of Entomology 86(2): 409-413 (2024) DoI. No.: 10.55446/IJE.2024.1707

TOLERANCE IN *BRASSICA JUNCEA* CULTIVARS VIS-A-VIS POPULATION BUILDUP OF MUSTARD APHID *LIPAPHIS ERYSIMI* (KALT.)

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ABSTRACT

Current investigation deciphered the differential level of tolerance in diverse *Brassica juncea* cultivars, and variations in the preference and population buildup of Mustard aphid, *Lipaphis erysimi.* Cultivars RLC 3, NRCHB 101 and Pusa Mustard 27 were least preferred by *L. erysimi.* Further, total number of aphids and aphid resistance index under natural infestation condition were significantly lower on RLC 3, NRCHB 101, RH 725 and Pusa Mustard 27. However, under artificial conditions, total number of aphids, aphid resistance index and multiplication rates were significantly lower on DRMR 150-35, RH 0406, NRCHB 101, Pusa Mustard 27 and RLC 3. The cultivars DRMR 150-35, RH 0406, NRCHB 101, RLC 3, RH 725 and Pusa Mustard 27 were found with least preference, lower aphid resistance index, establishment, population buildup of *L. erysimi* under natural and/or artificial infestation conditions, thus can be used in *Brassica* improvement program.

Key words: Mustard aphid, preference, tolerance, screening, Brassica, artificial screening, susceptible, population buildup, resistance index, multichoice test

In India, the production and productivity of rapeseed and mustard are highly variable due to various biotic and abiotic stresses experienced across crop-growing agroecologies of India. Among the biotic stresses, mustard aphid, *Lipaphis erysimi* (Kaltenbach) is the major yield reducing factor in rapeseed and mustard, causing up to 90% yield loss under severe infestation conditions (Ahuja et al., 2010). Both adults and nymphs suck sap at vegetative, flowering and pod formation stages, which inhibits plant growth resulting in poor pod formation, less seed set, low oil content, and reduced seed yield (Dhillon et al., 2018). Among the various control methods, varietal resistance has received priority in integrated pest management program (Hobner, 1972). In the absence of resistant cultivars, the aphids are currently being managed by insecticidal sprays. Moreover, the insecticides are lipophilic in nature and may have hazardous residues in the oil (Bajpai et al., 2007). Therefore, it becomes imperative that available pest management tactics should be such that provide effective and economical control of the pest without any adverse effect on the environment.

The insect-resistant plants have the unique advantage of providing inherent insect control in the crop, and could be the best alternative for the management of aphids. Further, an insect-resistant cultivar fits well in integrated pest management (IPM) modules as it provides the farmers with ecologically sound, effective and economical option for pest management. Even the varieties with moderate level of resistance can be integrated with other management options to reduce the pesticide application on a crop. The first step in the development of an insect-resistant cultivar is to generate precise knowledge on sources of insect resistance (Stoner and Shelton, 1988). Earlier studies indicate that the resistance to aphids in the primary gene pool are rare bearing very low levels of tolerance to *L. erysimi* (Singh, 2014). Extensive screening efforts of *Brassica* germplasm have failed to identify any effective source of resistance for mustard aphids in India (Dhillon et al., 1993). An artificial infestation screening technique under field conditions has also been developed for evaluation of mustard genotypes for resistance against *L. erysimi* (Dhillon et al., 2018). A thorough understanding of host-plant interactions is of great significance in developing aphid-resistant genotypes (Kumar et al., 2017). Further, these studies emphasize the existence of varied defensive responses to impact the survival of aphids feeding on host plant. Thus, the present studies were intended to understand the differential level of tolerance in diverse *B. juncea* cultivars, and preference and population build-up of *L. erysimi*.

MATERIALS AND METHODS

The test cultivars were grown in 5 row plots of 5 m length, with 30 cm row to row and 15 cm plant to plant spacing in experimental plots of Division of Entomology, Indian Agricultural Research Institute, New Delhi (28.08°N and 77.12°E) during 2021-22 and 2022-23 cropping seasons. All recommended agronomic practices, except insecticide use were followed to raise the *B. juncea* cultivars. In the host preference study, buds and siliquae from the main branch of each *B. juncea* cultivar were cut with scissors from 15 randomly selected plants, thus making 15 replications in a completely randomised design. One bud and one siliquae of each cultivar were placed on a blotting paper at equidistant (2 cm apart) in a circular fashion (perimeter 150 cm), 230 aphids were released in the middle, and covered with mosquito net. After 24 hr, the numbers of aphids settled on each cultivar were counted, and expressed as percent nymphs recovered on respective cultivar.

Under natural infestation conditions, the test *B. juncea* cultivars were monitored daily to track the *L. erysimi* infestation, and population reaching economic threshold level (ETL: 20-25/ 10 cm). Five randomly selected plants of each test cultivar were tagged for recording the observations, thus making five replications in a completely randomized design. At 21 days after *L. erysimi* population reached ETL, the number of aphids on the apical 10 cm main shoot of each selected plant of the test mustard genotypes was recorded and expressed as aphids/plant. However, under artificial conditions, five randomly selected plants of each cultivar were tagged and the third branch from the top of the plant was inoculated with around 20 mixed-stage aphids at the bud initiation stage and covered with specially designed muslin cloth cages. The observations were recorded on the total number of aphids and damaging symptoms at 21 days after *L. erysimi* inoculation. The aphid multiplication rate and the daily multiplication rate of aphid were calculated as per Dhillon et al. (2018). Further, the aphid population index, aphid damage index and aphid resistance index were calculated for all the cultivars under both the conditions as described by Dhillon et al. (2018). The data on host preference, population build-up, different indices and multiplication rates were subjected to analysis of variance using completely randomized design. The significance of differences in the test cultivars were tested by F-test, and the treatment means were compared by least significant differences at p=0.05 using the statistical software SPSS version 16.0.

RESULTS AND DISCUSSION

Plant resistance, in most cases, is governed by several morphological and biochemical plant traits resulting in non-preference, antibiosis, and tolerance to insects (Kher and Rataul, 1991), which also varies across genotypes and seasons. In current study, significant differences in host preference by *L. erysimi* among the test *B. juncea* cultivars was observed, and the % nymphs recovered on diverse *B. juncea* cultivars was ranged from 2.7 to 5.3% (Fig. 1). However, cultivars RLC 3, NRCHB 101 and Pusa Mustard 27 were least preferred (2.7, 3.4 and 3.4% nymphs recovered, respectively), while Pusa Mustard 25, Pusa Double Zero Mustard 31 and Pusa Mustard 32 (5.3, 5.2 and 5.2% nymphs recovered, respectively) were more preferred for their establishment as compared to other *B. juncea* cultivars (Fig. 1). The least preference of a particular cultivars signifies their unsuitability for the establishment of *L. erysimi*. Similarly, Samal et al. (2022) also reported significant differences in the host preference by the *L. erysimi* on diverse *B. juncea* genotypes, and genotypes RBJ 11, RBJ 49, RBJ 77, NPJ 161, PDZ 6, PM 30 and GP 454 were least preferred as compared to other cultivars.

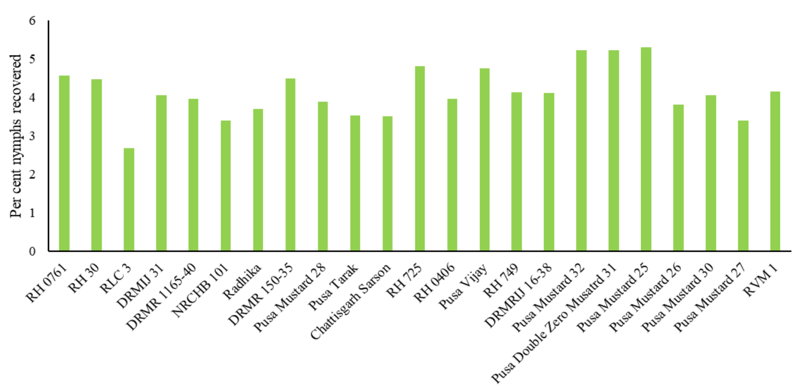

Fig. 1. Host preference of *L. erysimi* on diverse *Brassica juncea* cultivars

Intraspecific genetic variation among plant genotypes has a significant impact on herbivore acceptance and suitability (Barker et al., 2018), which can be judged by the population buildup of test insect over a period of time. In current investigation, the total number of aphids on the test *B. juncea* cultivars varied significantly under natural infestation conditions during 2021-22 and 2022-23 cropping season. Total number of aphids ranged from 90.0 to 248.0 during 2021-22 and 94.2 to 274.8 during 2022-23 cropping season, and significantly lower on RH 0406, RLC 3, Pusa Mustard 25, Pusa Mustard 26 and Pusa Mustard 27, except in a few cases, indicating higher tolerance to *L. erysimi*, while, significantly higher population build-up of aphids was found on DRMRIJ 16-38, DRMIJ 31, RH 749, Pusa Mustard 30 and Pusa Tarak. Furthermore, the aphid population index also varied significantly among the test *B. juncea* cultivars, which ranged from 2.2 to 3.6 during 2021-22 and 2.2 to 3.6 during 2022-23 cropping season. The aphid resistance index on the test *B. juncea* cultivars varied significantly, and ranged from 1.9 to 2.8 during 2022-23 cropping season. Aphid resistance index was significantly lower on RLC 3, NRCHB 101, RH 725 and Pusa Mustard 27 across the test *B. juncea* cultivars, indicating tolerance towards *L. erysimi* (Table 1). Similarly, Ingle et al. (2020) also reported variation in the aphid population index and aphid resistance index among the mutant varieties of mustards. Dwivedi et al. (2019) also found differences in the number of aphids on diverse mustard varieties, and overall maximum mean population of mustard aphid found on variety Varuna and minimum found on variety Rohini. However, under natural condition, there was non-significant difference in aphid resistance index during 2022, while significant difference during 2023, signifying the discrepancies in the selection pressure imposed by aphid population on different cultivars.

There were significant differences in total aphid population after 21 days of inoculation, aphid multiplication rate, and daily aphid multiplication rate of *L. erysimi* on the test *B. juncea* cultivars during 2021-22 and 2022-23 cropping season (Table 2). The total aphid population, aphid multiplication rate and daily aphid multiplication rate were significantly higher on DRMRIJ 16-38 and Pusa Mustard 32, while lower on DRMR 150-35, RH 0406, NRCHB 101, Pusa Mustard

Table 1. Evaluation of *Brassica juncea* cultivars for resistance against *L. erysimi* under natural infestation (rabi 2021-2022 and 2022-2023)

Cultivars	No. of aphids/ 10 cm		Aphid population index		Aphid damage index		Aphid resistance index	
	2022	2023	2022	2023	2022	2023	2022	2023
RH 0761	111.6± 12.5	98.0± 3.6	2.4± 0.2	2.4± 0.2	1.8± 0.2	1.6± 0.2	2.1± 0.2	2.0± 0.2
RH 30	120.8± 13.0	135.4± 12.3	2.6± 0.2	2.8± 0.2	1.8± 0.4	2.0± 0.0	2.2± 0.3	2.4± 0.1
RLC 3	94.2± 7.6	146.0± 26.9	2.4± 0.2	2.4± 0.2	1.8± 0.2	1.4± 0.2	2.1± 0.2	1.9± 0.2
DRMIJ 31	238.8± 20.4	201.0± 6.8	3.6± 0.2	2.6± 0.2	1.6± 0.2	1.6± 0.2	2.6± 0.1	2.1± 0.2
DRMR 1165-40	113.8± 10.2	117.4± 10.1	2.6± 0.2	2.6± 0.2	2.0± 0.0	1.8± 0.2	2.3± 0.1	2.2± 0.1
NRCHB 101	110.6± 7.3	119.6± 9.3	2.4± 0.2	2.6± 0.2	1.6± 0.2	1.2± 0.2	2.0± 0.2	1.9± 0.2
Radhika	148.2± 15.0	130.6± 9.0	2.8± 0.2	2.8± 0.2	2.0± 0.0	1.6± 0.2	2.4± 0.1	2.2± 0.1
DRMR 150-35	122.4± 15.4	106.0± 5.3	2.6± 0.2	2.4± 0.2	1.8± 0.2	1.8± 0.2	2.2± 0.1	2.1± 0.2
Pusa Mustard 28	165.6± 12.1	131.8± 8.0	3.0± 0.0	3.0± 0.0	1.8± 0.2	1.8± 0.2	2.4± 0.1	2.4± 0.1
Pusa Tarak	179.6± 21.5	132.4± 14.9	2.6± 0.2	2.6± 0.2	1.6± 0.2	2.0± 0.0	2.1± 0.2	2.3± 0.1
Chattisgarh Sarson	109.8± 8.8	106.6± 5.1	2.6± 0.2	2.4± 0.2	2.0± 0.0	1.6± 0.2	2.3± 0.1	2.0± 0.2
RH 725	142.4± 16.3	97.6± 4.4	2.8± 0.2	2.2± 0.2	1.2± 0.2	1.6± 0.2	2.0± 0.2	1.9± 0.2
RH 0406	90.0± 10.6	101.4± 5.3	2.2± 0.2	2.4± 0.2	1.6± 0.2	1.6± 0.2	1.9± 0.2	2.0± 0.2
Pusa Vijay	121.2± 10.0	110.0± 5.0	2.6± 0.2	2.6± 0.2	1.8± 0.2	1.6± 0.2	2.2± 0.2	2.1± 0.2
RH 749	220.6± 22.5	191.0± 2.9	3.4± 0.2	3.0± 0.0	1.4± 0.2	2.0± 0.0	2.4± 0.2	2.5± 0.0
DRMRIJ 16-38	248.0± 22.6	274.8± 20.1	3.6± 0.2	3.6± 0.2	1.8± 0.2	2.0± 0.3	2.7± 0.2	2.8± 0.2
Pusa Mustard 32	174.2± 20.9	173.0± 21.5	2.8± 0.2	3.2± 0.2	1.6± 0.2	1.6± 0.2	2.2± 0.1	2.4± 0.1
Pusa Double Zero Mustard 31	114.6± 6.6	106.6± 5.3	2.6± 0.2	2.4± 0.2	1.6± 0.2	1.8± 0.2	2.1± 0.2	2.1± 0.1
Pusa Mustard 25	102.0± 6.2	99.8± 0.7	2.4± 0.2	2.2± 0.2	2.0± 0.0	2.0± 0.0	2.2± 0.1	2.1± 0.1
Pusa Mustard 26	104.8± 6.5	106.0± 6.5	2.4± 0.2	2.4± 0.2	2.0± 0.0	1.6± 0.2	2.2± 0.1	2.0± 0.2
Pusa Mustard 30	204.6± 14.3	223.0± 9.7	3.2± 0.2	3.2± 0.2	1.2± 0.2	1.6± 0.2	2.2± 0.1	2.4± 0.1
Pusa Mustard 27	108.4± 5.6	94.2± 3.0	2.4± 0.2	2.2± 0.2	1.6± 0.2	1.6± 0.2	2.0± 0.2	1.9± 0.2
RVM 1	120.0± 8.2	145.4± 8.5	2.8± 0.2	3.0± 0.0	1.8± 0.2	2.0± 0.0	2.3± 0.1	2.5± 0.0
F- Probability	<0.001	<0.001	<0.001	<0.001	0.22	0.41	0.12	<0.001
LSD (p= 0.05)	39.20	30.70	0.64	0.60	NS	NS	NS	0.42

Table 2. Evaluation of *Brassica juncea* cultivars for resistance against *L. erysimi* under artificial infestation conditions (rabi 2021-2022 and 2022-2023)

Cultivars	No. of aphids		Aphid population index		Aphid damage index		Aphid resistance index		Aphid multiplication rate		Daily multiplication rate	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
RH 0761	684.8± 85.7	717.4± 63.9	4.8± 0.2	5.0± 0.0	1.6± 0.2	1.6± 0.2	3.3± 0.2	3.2± 0.2	34.2± 4.3	35.9± 3.2	1.6± 0.2	1.7± 0.2
RH 30	619.2± 50.8	701.8± 80.5	4.8± 0.2	4.7± 0.3	2.0± 0.0	2.0± 0.0	3.2± 0.2	3.4± 0.1	31.0± 2.5	35.1± 4.0	1.5± 0.1	1.7± 0.2
RLC 3	315.0± 34.9	325.8± 52.7	3.6± 0.2	5.0± 0.0	1.6± 0.2	1.6± 0.2	3.3± 0.2	2.5± 0.2	15.8± 1.7	16.3± 2.6	0.7± 0.1	0.8± 0.1
DRMIJ 31	386.0± 25.0	337.6± 49.4	4.0± 0.0	3.3± 0.3	1.6± 0.2	1.6± 0.2	2.7± 0.4	2.7± 0.3	19.3± 1.3	16.9± 2.5	0.9± 0.1	0.8± 0.1
DRMR 1165-40	688.2± 88.2	674.4± 122.3	4.6± 0.2	3.7± 0.3	1.6± 0.2	1.6± 0.2	2.8± 0.2	3.1± 0.2	34.4± 4.4	33.7± 6.1	1.6± 0.2	1.6± 0.3
NRCHB 101	222.0± 32.9	297.0± 52.3	3.0± 0.4	4.0± 0.6	1.2± 0.2	1.2± 0.2	2.8± 0.2	2.4± 0.3	11.1± 1.6	14.9± 2.6	0.5± 0.1	0.7± 0.1
Radhika	447.2± 21.4	401.6± 84.5	4.2± 0.2	4.0± 0.6	1.4± 0.2	1.4± 0.2	3.0± 0.3	2.9± 0.2	22.4± 1.1	20.1± 4.2	1.1± 0.1	1.0± 0.2
DRMR 150-35	161.0± 24.5	214.2± 11.7	2.8± 0.2	4.7± 0.3	1.2± 0.2	1.2± 0.2	3.2± 0.3	2.2± 0.2	8.1± 1.2	10.7± 0.6	0.4± 0.1	0.5± 0.0
Pusa Mustard 28	338.0± 14.7	369.4± 21.3	4.0± 0.0	3.7± 0.3	1.4± 0.2	1.4± 0.2	2.2± 0.3	2.7± 0.1	16.9± 0.7	18.5± 1.1	0.8± 0.0	0.9± 0.1
Pusa Tarak	364.2± 34.8	401.2± 53.3	3.8± 0.2	3.7± 0.7	2.0± 0.0	2.0± 0.0	2.2± 0.2	3.1± 0.2	18.2± 1.7	20.1± 2.7	0.9± 0.1	1.0± 0.1
Chattisgarh Sarson	380.0± 21.7	427.2± 26.9	4.0± 0.0	4.0± 0.0	1.8± 0.2	1.8± 0.2	2.7± 0.2	3.0± 0.2	19.0± 1.1	21.4± 1.3	0.9± 0.1	1.0± 0.1
RH 725	324.4± 28.5	407.8± 42.1	3.8± 0.2	4.3± 0.7	1.6± 0.2	1.6± 0.2	2.5± 0.5	3.0± 0.2	16.2± 1.4	20.4± 2.1	0.8± 0.1	1.0± 0.1
RH 0406	212.0± 12.8	242.6± 16.2	3.2± 0.2	3.3± 0.3	1.4± 0.2	1.4± 0.2	2.2± 0.2	2.3± 0.2	10.6± 0.6	12.1± 0.8	0.5± 0.0	0.6± 0.0
Pusa Vijay	630.0± 35.4	593.8± 45.5	5.0± 0.0	3.7± 0.3	2.0± 0.0	2.0± 0.0	2.5± 0.3	3.4± 0.1	31.5± 1.8	29.7± 2.3	1.5± 0.1	1.4± 0.1
RH 749	576.8± 44.3	587.2± 37.0	4.8± 0.2	4.0± 0.0	2.0± 0.0	2.0± 0.0	2.7± 0.2	3.4± 0.1	28.8± 2.2	29.4± 1.9	1.4± 0.1	1.4± 0.1
DRMRIJ 16-38	905.2± 116.6	1032.6± 26.1	4.8± 0.2	4.3± 0.3	2.2± 0.2	2.2± 0.2	2.8± 0.2	3.6± 0.1	45.3± 5.8	51.6± 1.3	2.2± 0.3	2.5± 0.1
Pusa Mustard 32	799.8± 41.6	836.2± 97.8	5.0± 0.0	4.0± 0.6	2.0± 0.0	2.0± 0.0	3.0± 0.0	3.4± 0.1	40.0± 2.1	41.8± 4.9	1.9± 0.1	2.0± 0.2
Pusa Double Zero Mustard 31	612.8± 66.1	653.0± 57.2	4.8± 0.2	4.0± 0.0	1.8± 0.2	1.8± 0.2	2.8± 0.2	3.3± 0.2	30.6± 3.3	32.7± 2.9	1.5± 0.2	1.6± 0.1
Pusa Mustard 25	428.0± 45.8	452.0± 57.0	4.2± 0.2	4.7± 0.3	1.8± 0.2	1.8± 0.2	2.8± 0.2	3.0± 0.3	21.4± 2.3	22.6± 2.8	1.0± 0.1	1.1± 0.1
Pusa Mustard 26	595.0± 55.0	549.2± 50.8	4.8± 0.2	4.3± 0.3	2.0± 0.0	2.0± 0.0	2.7± 0.3	3.2± 0.1	29.8± 2.7	27.5± 2.5	1.4± 0.1	1.3± 0.1
Pusa Mustard 30	568.8± 24.9	516.6± 71.2	4.8± 0.2	3.0± 0.0	1.8± 0.2	1.8± 0.2	2.3± 0.2	3.1± 0.3	28.4± 1.2	25.8± 3.6	1.4± 0.1	1.2± 0.2
Pusa Mustard 27	275.6± 14.7	296.2± 37.2	3.8± 0.2	4.0± 0.6	1.4± 0.2	1.4± 0.2	2.7± 0.4	2.4± 0.2	13.8± 0.7	14.8± 1.9	0.7± 0.0	0.7± 0.1
RVM 1	512.2± 8.3	480.4± 23.1	4.8± 0.2	4.7± 0.3	2.0± 0.0	2.0± 0.0	3.5± 0.0	3.3± 0.1	25.6± 0.4	24.0± 1.2	1.2± 0.0	1.1± 0.1
F-probability	<0.001	<0.001	<0.001	0.033	0.003	0.003	0.014	<0.001	<0.001	<0.001	<0.001	<0.001
LSD (p = 0.05)	135.69	162.36	0.56	1.11	0.53	0.53	0.73	0.57	6.78	8.12	0.32	0.39

27 and RLC 3, except in a few cases across the seasons (Table 2). Further, aphid resistance index also varied significantly among the cultivars during 2021-22 and 2022-23 cropping seasons, and significantly lower on DRMR 150-35, RH 0406, NRCHB 101, Pusa Mustard 27 and RLC 3, Pusa Mustard 28, Pusa Tarak and Pusa Mustard 30 (Table 2). Lower aphid population and aphid resistance index indicate that these cultivars have some detrimental effects on the development and survival of *L. erysimi*, which could be due to the influence of pheno-morphological and biochemical traits on the fitness of *L. erysimi*. Samal et al. (2022) also reported the least preference, lower aphid multiplication, and daily multiplication rate of *L. erysimi* on the mustard genotypes RBJ 11, RBJ 49, RBJ 77, NPJ 161, PDZ 6, PM 30 and GP 454. It could be due to certain plant chemicals like constitutive and induced compounds that regulate the plant-herbivore interaction (Holopainen and Blande, 2013), thus negatively affecting the preference, development, and survival resulting in increased plant fitness.

The genetic makeup and/ or biochemical and physical attributes of the host plant impacts the development and survival of the herbivore insect, and same is reflected in the population build-up of that herbivore insect. In the current investigation, the cultivars RH 0406, RLC 3, DRMR 150-35, Pusa Mustard 25, Pusa Mustard 26, NRCHB 101 and Pusa Mustard 27 were least preferred, and harboured a lower number of aphids, lower aphid population index, aphid resistance index and multiplication rates of *L. erysimi*. These cultivars have detrimental effects on the host selection, development, and survival of *L. erysimi*, thus can be exploited in *Brassica* improvement program for sustainable crop production.

ACKNOWLEDGMENTS

The authors thank ICAR-IARI, New Delhi for research facilities, and CSIR-HRDG, New Delhi for providing fellowship to the first author during PhD degree programme.

AUTHOR CONTRIBUTION STATEMENT

KC performed the experiment, captured and analysed the data, and prepared the original manuscript. MKD conceptualised the research and reviewed and corrected the manuscript. NS provided the plant material, review and corrected the manuscript.

CONFLICT OF INTEREST

No conflict of interest.

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(Manuscript Received: October, 2023; Revised: January, 2024;
Accepted: January, 2024; Online Published: February, 2024)
Online First in www.entosocindia.org and indianentomology.org Ref. No. e24707