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## ARTICLE DETAILS

## ABSTRACT

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The red pumpkin beetle has been found to be widely distributed throughout all zoogeographic regions of the world except the Neartic and Neotropical regions and all over the South-East Asia, Africa, Mediterranean region towards the west and Australia in the East. It was also found to occur in Bangladesh, India, Pakistan, Afghanistan, Ceylon, Burma, Indo-China, Iraq, Iran, Persia, Palestine, Greece, Turkey, Israel, South Europe, Algeria, Egypt, Cyprus and the Andaman Island. The red pumpkin beetle has been found to be abundant in April and May. The highest incidence of the red pumpkin beetle was found to appear at around 9 am. The highest incidence of red pumpkin beetle was recorded on muskmelon, which was followed by sweet gourd and cucumber at seedling, vegetative and reproductive stages of cucurbit plants. Cucurbits, sweet potato and some legumes were found to be the hosts of this beetle. Among all hosts, sweet gourd and muskmelon were found to be the most preferred hosts followed by cucumber and khira while bitter gourd, snake gourd, sponge gourd and ribbed gourd were found to be least or non-preferred hosts by the red pumpkin beetle. It was found to cause damage up to 35-75% on cotyledons at seedling stage, around 70% on leaves and 60% on flowers by making irregular holes on infested plant parts.

## KEYWORDS

Cucurbits, red pumpkin beetle, host preference, damage.

## 1. INTRODUCTION

Cucurbits are the most widely grown and important crops in the tropical and subtropical countries of the world. A large number of cucurbits such as sweet gourd, bottle gourd, ash gourd, cucumber, sponge gourd, ribbed gourd, snake gourd, khira, muskmelon, bitter gourd etc are grown in different parts of the country. Cucurbits are grown all the year round and it supplies a major portion of the vegetable foods. In Bangladesh cucurbits occupy about 66 % of the vegetable lands producing only 11 % of total vegetable production [1]. In summer, the major vegetables grown in Bangladesh are cucurbits [2]. Pumpkin beetle is the major pest and causes considerable damage to almost all cucurbitaceous crops [3]. Among different species of pumpkin beetles, incidence of adult stage of red pumpkin beetle, *Aulacophora foveicollis* (Lucas) on different cucurbits have been reported by various workers [4-6]. The red coloured (*A. foveicollis*) and the orange coloured (*A. abdominalis*) beetles as two separate species that are equally serious and major pests of cucurbitaceous vegetable crops in Bangladesh [7]. The two species namely red pumpkin beetle, *Raphidopalpa foveicollis* and blue pumpkin beetle, *R. atripennis* are common in north-western India, the former being more important [8]. The pumpkin beetles *Aulacophora atripennis* (blue), *A. cincta* (yellow with black border), *A. intermedia*, and *Raphidopalpa foveicollis* (red) are very common on cucurbitaceous plants [9]. Both the adults and the grubs of red pumpkin beetle cause considerable damage to cucurbits during all stages of plant growth. Adults feed on the leaves, flowers and in some cases on fruits, while grubs attack the roots, underground stem and leaves closely touch with soil, thereby lowering the yield substantially. This attempt was undertaken to review the distribution, incidence, host preference and damage severity of red pumpkin beetle.

## 2. OCCURRENCE AND DISTRIBUTION OF RED PUMPKIN BEETLE

The pest is common in the South East Asia, Africa as well as in Mediterranean region towards west and Australia in the East [10]. The RPB occurs on various cucurbits in Ceylon, in Palestine and is one of the most important pests of melon in Greece [11-13]. The beetles of *A.*

*abdominalis* in East Pakistan (now Bangladesh) become abundant in spring while *Aulacophora foveicollis* (Lucas), is widely distributed throughout all zoogeographic regions of the world except the Neartic and Neotropical regions [14,15]. He also cited that *A. foveicollis* is a serious pest of cucurbits in every district of the then East Pakistan. *Aulacophora foveicollis* (Lucas), is widely distributed throughout Pakistan, India, Afghanistan, Ceylon, Burma, Indo-China, Iraq, Iran, Persia, Palestine, Greece, Turkey, Israel, South Europe, Algeria, Egypt, Cyprus and the Andaman Island. It is widely distributed all over the South-East Asia as well as the Mediterranean region towards the west and Australia in the east, In India, it is found in almost all the states, though it is more abundant in the northern states [16]. This pest is found in the Mediterranean region, Africa and Asia, is widely distributed in Asia, Australia, Southern Europe and Africa [17].

The red pumpkin beetle occurs throughout the year, but they are active from March to October, though the peak period of activity is between April to June and causes severe damage to the crops, especially at the seedling stage. The pest hibernates during the cold season as adult, in November and reappear by the end of April and the broods overlap thereafter with higher mortality among the hibernating adults [18,19]. The maximum population of the beetle during April, May and again between July-August. The infestation on bottle gourd flowers observed from December and reaches its peak by the first week of January and then it declines. He also reported that reproduction is very limited, and mortality is high during winter with five generations in a year. Overlapping of generations of the insect is very common during the period of its incidence. Beetles completely disappeared throughout July at temperature higher than 35°C which seems to be lethal or semi lethal for the beetle while beetles were found capable of surviving wide range of relative humidity [20]. Its generation appears in June and early July as well as in late August and September, the second generation received the favorable condition for the development of the beetles [21]. The red pumpkin beetle appeared on the host leaf from 7:00 am to 6:00 pm. In the early part of the day, insect first appeared at 7:00 am. Its population increased gradually with the progress of the day showing maximum population at around 9:00 am. After 9:00 am

its incidence started to decrease having the lowest population at 2:00 pm.

In the later part of the day, population of RPB started to increase after 2:00 pm and continued up to 6:00 pm, when maximum incidence was recorded. Such trend of diurnal incidence of RPB was observed on three hosts having different levels of susceptibility [22]. Findings of the observation clearly showed that populations of the RPB were low during middle of the day when temperature is maximum. The temperature may be the principal factor for influencing diurnal distribution of RPB on cucurbits. In general, the phytophagous insects always avoid scorching sun to protect themselves from desiccation [23-24]. In this situation, they tried to conceal themselves under soil, leaves and debris. Bright sunlight with high prevailing temperature is always unfavourable for phytophagous insects [25]. Maximum population of the insect is observed during April and May and then it shows a downward trend, the population again exhibits an upward trend in July and August [26].

Hibernating beetle becomes active at an ordinary temperature of 20°C and relative humidity of 89% on musk melon in India. Beetle's population was found to be at an average temperature of 28.8°C. Relationship of pest population with temperature was positive and that with relative humidity was negative [27]. The relative abundance of red pumpkin beetle, *Aulacophora foveicollis* L. during 1998 in the Peshawar valley with different cucurbitaceous vegetables was high from May 7 to June 18, 1998, while from June 25 to August 13, 1998, the population gradually declined [28]. The maximum number of red pumpkin beetle was recorded in muskmelon at seedling stage and population was 3.75 per plant and lowest was in snake gourd, 0.25. Similarly, beetles recorded at vegetative stage were more on muskmelon (4.5/plant) and minimum was 0.00 in snake gourd, whereas the population of beetle recorded at reproductive stage were 8.74 in muskmelon at highest and 0.75 at minimum in bitter gourd, ribbed gourd and snake gourd [29].

The population dynamics of red pumpkin beetle (*A. foveicollis*) in relation to weather parameters by using pumpkin as host crop during kharif 2004 and summer 2005 in Anand, Gujrat, India had the highest attack of the beetle was recorded during August to September in kharif and March to April in summer. Relative humidity and vapour pressure had significant positive relationship with beetle population during kharif, while they were negatively correlated in summer on pumpkin. Increase in temperature had significant positive correlation with the beetle population on pumpkin crop during summer [30].

The population of red pumpkin beetle on three preferable hosts namely muskmelon, cucumber, and sweet gourd was minimal in the month of March. Its population increased gradually with the progress of time up to May and decreased thereafter. The highest population of RPB was recorded in the month of May. The population of blue pumpkin beetle on three preferable hosts namely bitter gourd, ribbed gourd and sponge gourd followed the similar trend. Such increasing and decreasing trends in pumpkin beetle population might be due to changes in food availability. In March, food availability was the lowest because plants were young. In May, plant growth was maximal covering largest canopy. In June, plants were at their senescent stage causing food scarcity. The monthly variations in populations of RPB and BPB on their preferred cucurbit hosts might be due to temperature fluctuation in the months of March, April, May and June. The highest incidence of red pumpkin beetle was recorded on muskmelon, which was followed by sweet gourd and cucumber at seedling, vegetative and reproductive stages of cucurbit plants. The population of red pumpkin beetle was the lowest at 2-leaf stage. Its population increased gradually with the increase of seedling age up to 8-leaf stage and decreased thereafter giving the highest peak at 8-leaf stage. The flowers were more preferable to red pumpkin beetle as compared to leaves of cucurbit at reproductive stage [31].

### 3. HOST PREFERENCE OF RED PUMPKIN BEETLE

Red pumpkin beetle, *Aulacophora foveicollis* Lucas (Coleoptera: Chrysomelidae) is a common and major pest of a wide range of cucurbits. It is a serious pest of cucurbitaceous vegetables such as ash gourd (*Benincasa hispida*), pumpkin (*Cucurbita pepo* L.), tinda (*Citrullus vulgaris* var. *fistulosus*), ghia tori (*Luffa aegyptica*), cucumber and melon. The beetles are very common on cucurbitaceous plants. They also mentioned that *Rhaphidopalpa foveicollis* prefers pumpkin (*Cucurbita maxima*) and *Aulacophora atripennis* prefers sponge gourd (*Luffa cylindrica*) and both the species do not feed on *Momordica charantia*. In general, both the species feed on *Cucurbita maxima*, *C. pepo*, *Cucumis melo* var. *utilissimus*, *C. melo*, *C. sativus*, *Citrullus lanatus*, *C. vulgaris* var. *fistulosus*, *Luffa cylindrica*, *L. acutangula* and *Trichosanthes anguina*. The beetle *R. foveicollis* in addition feeds on *Benincasa hispida* and *Lagenaria vulgaris* also. The RPB is particularly a severe pest of pumpkins, musk melons and bottle gourds,

but it appears to be able to feed on any cucurbits [32].

They have also reported that when cucurbits are absent, it is found feeding on other plant families. This beetle is a polyphagous insect and prefers cucurbit vegetables and melons. However, some leguminous crops are also their main alternate hosts. Red pumpkin beetle is a pest of cucurbits and sweet potato [33]. Bitter gourd, cucumber, white gourd, snake gourd, sweet gourd, bottle gourd and many other plants are found to be seriously damaged by the RPB. He also indicated that melons, ribbed gourd, sponge gourd, snake gourd, cucumber, kakrol (teasel gourd) and kankri (*Cucumis utilissimus*) are also attacked in East Pakistan. This pest also occurred on tomato, maize, lucern besides cucurbits in Greece. In addition, the pest was recorded to attack forest trees like *Dalbergia latifolia*, *Michela champaca* and *Tectona grandis* in India and also on rice plants in Indo-China [34].

Sponge gourd was the least preferred by the red pumpkin beetle among the gourds, while the bottle gourd was most preferred and ridge gourd was intermediate in reaction and preferred sweet gourd followed by cucumber, squash melon, sponge gourd and bottle gourd [35]. Significant varietals differences for resistance to red pumpkin beetle in summer squash both in the field and cage experiments. Plants were screened at cotyledonary-leaf stage, 1 true-leaf stage and 2-4 true-leaf stage by releasing field collected beetles inside the cage through an opening provided in the center of the cage [36]. Sixty (60) beetles per cage at 2-4 true-leaf stage was released on 10 different hosts for feeding preference by the beetle by allowing feeding in two conditions: free feeding and non-free feeding and data was recorded at 24, 48 and 72 hours of feeding. Different cucurbit hosts namely bitter gourd, bottle gourd, little gourd, long melon, musk melon, pumpkin, ridge gourd, sponge gourd, squash, water melon was used in the study. In case of free feeding the long melon (*Cucumis melo* var. *utilissimus*) was most attacked and lowest was bitter gourd (*Momordica charantia*) whereas in no-choice (non-free feeding) leaf area maximum damage was done on musk melon (*Cucumis melo*) and minimum damage was done on water melon (*Citrullus lanatus*).

The RPB has a special preference for the leaves of cucurbit plants except those of the bitter gourd on which they have not been reported to feed to any appreciable extent, attacks cucumber, melon and gourds [37,38]. The number of beetles on 10 plants of each crop was set to be a standard for host preference studies and descending order was *Cucumis melo* var. *flexuosus* (snake cucumber), *C. melo* (melon), *C. sativus* (cucumber) and *Lagenaria siceraria* (bottle gourd) for both 1975 and 1978 seasons. However, *Cucumis melo* var. *flexuosus*, *C. melo*, *C. sativus* did not differ significantly in their preference from each other and, thus collectively regarded as the beetle's first choice. Beetle mostly prefers the mature leaves and flowers as compared to the senseless flowers and leaves of small (young) aged. Similarly, the plant parts especially flowers and leaves having high rate of nitrogen, protein and low proportion of sugars and moderately high phenol contents in them. Melon varieties were most preferred hosts for adult beetle followed by snake cucumber, while cucumber varieties showed less preference during both fall and spring seasons. Whereas, water melon and squash when grown in the spring season, were not preferred to the beetle. The number of generations differs according to host and season of red pumpkin beetle but mostly it has at least 4 generations in the year starting at mid-April to mid-November [39].

Bitter gourd was highly resistant to the RPB while sponge gourd and bottle gourd were considered resistant. The cucumber, muskmelon and water melon were moderately resistant to the pest [40-41]. The preference order of 21 cucurbit vegetables noted that bitter gourd was highly resistant to the beetle, while sponge gourd, bottle gourd was moderately resistant, muskmelon and cucumber were susceptible to the pest while banana squash, muskmelon and bottle gourd were the preferred hosts of the adults while cucumber, white gourd/ash gourd, chinese okra, bitter gourd, snake gourd, watermelon and sponge gourd achieved the second order of preference to the beetles (*Aulacophora foveicollis*).

Host preferences by larval stage of red pumpkin beetle in India causes damage to roots while adult stage harms the plant by feeding on leaves, flowers and stem due to its gregarious feeding behaviour [42]. Bottle gourd (*Lagenaria siceraria*), cucumber (*Cucumis sativus*), water melon (*Citrullus lanatus*), ridge gourd (*Luffa acutangula*), pointed gourd (*Trichosanthes dioica*) and ash gourd (*Benincasa hispida*). In addition to other plants which were recorded as collateral host of the pest are, okra (*Abelmoschus esculentus*), sweet potato (*Ipomoea batatas*) and green gram (*Phaseolus aureus* [Vigna radiata]) [43].

Host preference of red pumpkin beetle and melon fruit fly using different cucurbits during the summer of 1997 in India, reported bitter gourd as least preferred, whereas cucumber, musk melon, bottle gourd and pumpkin as medium in preference, round gourd (*Citrullus lanatus* var.

*fistulosus*) and long melon (*Cucumis utilissimus*) as highly preferred and watermelon as the favorite host by the red pumpkin beetle [44]. Host preference of the red pumpkin beetle with 23 different crops and found that red pumpkin beetle infesting 11 crops namely pumpkin, cucumber, bottle gourd, snake gourd, watermelon, ridge gourd, round gourd, pointed gourd, sponge gourd, brinjal and berseem. Red pumpkin beetle has not been found infesting bitter gourd. He also reported that tomato and sweet potato have reported as host plants by different scientists in various areas [45].

In Bangladesh, among five cucurbits (viz., sweet gourd, ash gourd, sponge gourd, snake gourd and cucumber) sweet gourd is identified as the most susceptible and highly preferred host to RPB and cucumber is recognized as less susceptible and less preferred host to the pest observed that [46]. Leaves of snake gourd plants at their flowering and fruiting stage were found to be severely damaged by a group of even more than 20 beetles per leaf at Bangladesh Agricultural Research Institute (BARI) farm, Joydebpur, Gazipur [47]. It is a serious pest of sweet potato and cucurbits attacking cucumber, melons and gourds.

Screening against red pumpkin beetle using 68 lines of cucumber (*Cucumis sativum*) and observed that beetle cause damage at different stages i. e. cotyledonary, true leaf, flowering and fruiting stages of the crop to all other lines except eight lines, which were PCUC-7, PCUC-36, PCUC-47, PCUC-66, PCU-99, PCUC-102, PCUC-108 and PCUC-110 [48]. Eight cucurbit crops were used to observe host preference against red pumpkin beetle in Islamabad during 2002 and reported that long muskmelon and melon were the most favourable hosts and no plant reached to 5 true leaves stage after germination when they receive beetle's attack. Red pumpkin beetle also prefers cucumber, watermelon, tindagourd and ridge gourd but less damage and medium preference was reported by them to muskmelon, long melon and bottle gourd while sponge gourd was the least preferred host [49].

A study on red pumpkin beetle was conducted to checked out the susceptibility of six pumpkin cultivars and reported that genotype APKL-7 and APKL-2 attacked by less number of beetles and hence less attack. Whereas the cultivars APKL-6 and APKL-4 received more number of red pumpkin beetle and indicating high infestation which was equal to the infestation of the local variety [50]. Ten different cucurbit host plants for their consumption ratio based on chlorophyll contents present in each species and age of leaf and observed that maximum preferences of red pumpkin beetle were given to musk melon (*Cucurbita melo* L.) which was also high in chlorophyll contents [51].

The host preference of RPB to different cucurbit hosts in choice test under net case condition at 1, 6, 12 and 24 hours after release (HAR), observed that the highest population of RPB was found on sweet gourd, which was followed by muskmelon. These two crops may be noted as highly preferred hosts of RPB. At 48 HAR its highest population was found on muskmelon. Bitter gourd was free from infestation of RPB and it was noted as non-preferred host of RPB. The highest percentage of leaf area damage per plant was observed on musk melon leaves followed by sweet gourd and ash gourd. The lowest percentage of leaf area damage per plant was on snake gourd leaves followed by sponge gourd and bottle gourd. Sweet gourd and musk melon were found to be the most preferred host of red pumpkin beetle and bitter gourd was found as non-preferred host of RPB. Non-feeding on bitter gourd or negligible feeding on snake gourd was obtained [52]. A triterpenoid compound from bitter gourd has been found to inhibit feeding of red pumpkin beetle adults completely on cucurbit leaves. However, some authors reported normal feeding on bitter gourd and snake gourd while others found normal feeding of RPB on bitter gourd [53]. An experiment on the *Raphidopalpa atripennis* conducted to estimate the trend of this insect toward three different host plants namely *L. acutangula*, *L. cylindrica* and *M. scabrella* as food source for the pest. *M. scabrella* is a weed plant in which beetle only present in absence of other hosts. Biochemical analysis on rate of composition of different leaf ages was done and showed that beetle's tendency of feeding was more towards plants having more chlorophyll contents and palmitic acid. That is why, damage was proficient to full grown leaves as compared to immature leaves [54].

A field experiment with 10 cucurbits namely sweet gourd (*Cucurbita moschata* L.), bottle gourd (*Lagenaria siceraria* L.), ash gourd (*Benincasa hispida* L.), bitter gourd (*Momordica charantia* L.), sponge gourd (*Luffa cylindrica* L.), ribbed gourd (*Luffa acutangula* L.), snake gourd (*Trichosanthes anguina* L.), cucumber (*Cucumis sativus* L.), khira (*Cucumis sativus* L.) and muskmelon (*Cucurbita melo* L.) was conducted against red pumpkin beetle and reported that muskmelon was the most preferred host by red pumpkin beetle (*Aulacophora foveicollis*) and weekly average number of beetles was almost 14 beetles/plant during the peak infestation

periods. The most preferred host of red pumpkin beetle (RPB) was muskmelon, which was followed by khira, cucumber and sweet gourd and they may be graded as susceptible hosts. Bitter gourd, sponge gourd, ribbed gourd and snake gourd were least or non preference hosts of RPB and they may be graded as resistant hosts. Other two crops bottle gourd and ashgourd were moderately preferred hosts of the insect and they may be graded as moderately susceptible hosts. The order of the most preferred host of blue pumpkin beetle is bitter gourd> ribbed gourd> sponge gourd [55].

A field evaluation with 12 selected lines of musk melon namely CM010, CM039, CM007, CM001, CM004, CM022, CM006, CM002, CM015, CM030, CM005 and CM003 was done against red pumpkin beetle at Bangabandhu Shiekh Mujibur Rahman Agricultural University (BSMRAU), Bangladesh during October to December 2007. The damage was noticed on the cotyledonous leaves and then the abundance of the red pumpkin beetle (RPB) was assessed. It was revealed that none of the 12 musk melon lines either remained free from the attack of RPB or escaped its damage throughout the crop period. In terms of abundance level, CM007 was found to be the most susceptible line followed by CM039 and CM015 showed lower susceptibility followed by CM001. In terms of percent leaf infestation, CM022 was found to be the most susceptible line followed by CM030 and CM001 showed lower susceptibility followed by CM006 [31]. A study on the host preference of red pumpkin beetle against three selected varieties from Cucurbitaceous family in the field and observed that sweet gourd was more preferred as compared of bottle gourd by the beetle and bottle gourd was more preferred in compare of bitter gourd [56].

A study was carried out to find out the morphological characteristics and protein content of leaves of ten cucurbits influencing *Aulacophora foveicollis*. They reported that thickness of mature leaves was much higher than that of young leaves in sweet gourd, ash gourd, sponge gourd, snake gourd, ribbed gourd and muskmelon. In bottle gourd, thickness of young and mature leaves was identical. In cucumber and khira, young leaves were thicker than mature ones. Thickness of young and mature leaves of different cucurbits ranged 0.20-0.48 mm and 0.29-0.48 mm, respectively. Trichome length was higher on young leaves as compared to mature leaves of all cucurbits. Trichome length ranged 0.29-1.05 mm on young leaves and 0.24-0.67 mm on mature leaves of different cucurbits. Young leaves of sweet gourd, bottle gourd, ribbed gourd, cucumber, khira and muskmelon showed higher number of trichomes as compared to mature leaves. Higher number of RPB was found on mature leaf as compared to young leaf of all cucurbit hosts. The highest protein content was found in young leaf (42.42%) of sweet gourd and mature leaf (34.81%) of bottle gourd. The lowest percentage of protein was found in young leaf (22.73%) of bitter gourd and mature leaf (15.77%) of ribbed gourd [57].

Out of four cucurbit species such as bottle gourd, cucumber, sponge gourd and squash, cucumber and squash were found susceptible while bottle gourd was found to be resistant and sponge gourd was found to be moderately resistant in terms of population occurrence of the red pumpkin beetle [58]. Food consumption by the larvae and adult of red pumpkin beetle was highest on sweet gourd followed by bottle gourd [59]. The highest food consumption was recorded on sweet gourd among the crops and the highest leaf area damage was found on local misti kumra (sweet gourd) in net cage experiment among the nine varieties [60].

An experiment was conducted to determine the biochemical composition of cucurbit leaves and their influence on red pumpkin beetle at Bangabandhu Shiekh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh during November 2007 to March 2008 and reported that the highest quantity of moisture was recorded in young leaf of bottle gourd (86.49%) and mature leaf of khira (87.95%) while the lowest moisture content was obtained in young leaf of snake gourd (79.21%) and mature leaf of ribbed gourd (76.43%). The highest nitrogen content was found in young leaf (6.79%) of sweet gourd and in mature leaf (5.57%) of bottle gourd whereas the lowest percentage of nitrogen was found in young leaf (3.64%) of bitter gourd and in mature leaf (2.52%) of ribbed gourd. The highest quantity of total sugar was found in young leaf of bottle gourd (4.90%) and mature leaf of sweet gourd (4.76%). The lowest quantity of total sugar was found in young (2.03%) and mature leaves (2.09%) of bitter gourd. The highest quantity of reducing sugar was estimated from young leaves of musk melon (4.14%) and from mature leaves (4.01%) of sweet gourd. The lowest quantity of reducing sugar was in young (1.85%) and mature (1.83%) leaves of bitter gourd. Relationship of RPB population per leaf with the percent nitrogen, total and reducing sugar content of mature leaves of cucurbits was found positively correlated [61].

Plant parts and plant constituents vary with their developmental stages,

physiologic conditions and plant genotype. These variations have considerable impact on both the behaviour and developmental success of phytophagous insects [62]. The leaves of plants change chemically with age and the quantity of amino-nitrogen present in the phloem sap of plant changes with the progress of growth and maturation of leaves and shoots [63]. Monophagous and oligophagous herbivores often show strong preferences for the more nutritious, younger leaf tissues that are high in toxins, whereas polyphagous herbivores demonstrate a strong preference for the less nutritious, mature leaf tissues [64]. The terminal twigs and leaves appeared as the richest portion in nitrogen content and hair density and decreased with the increase of leaf age of cucumber [65]. Adults of *Raphidopalpa atripennis* were tested for their preference for and utilization of different aged leaves of cucurbit plants (*Luffa acutangula*, *Mukia scabrella* and loofah) and consequent changes in reproductive ability. The flowers of sweet gourd, bottle gourd, ash gourd khira and snake gourd are more preferable to RPB as compared to leaves at reproductive stage [29]. Some workers obtained RPB to feed on leaf, flower bud and flower without indicating the host preference.

#### 4. DAMAGE SEVERITY CAUSED BY RED PUMPKIN BEETLE

The Red Pumpkin Beetle, *Aulacophora foveicophora* Lucas is the most serious pest of the cucurbits. It occurs throughout the year and causes severe damage to the crops, especially at the seedling stage. It is polyphagous and attacks more than 81 plant species including pumpkin, quash, cucumber, bottle gourd, sweet gourd, bitter gourd, snake gourd, wax gourd, watermelon, etc and a wide range of fruit crops [66]. It may cause up to 70 % damage on leaves and 60 % damage on flowers of cucumber. They cause damage most severely on cotyledons and young leaves, but they also feed readily on flowers and mature (not senescent) leaves. The adult beetles feed voraciously on the cucurbit leaf making irregular holes.

They also attack cotyledons and flowers. The beetles may kill seedlings and sometimes the crops have to be resown 3-4 times. The grubs feed on roots and underground portions of host plants as well as fruits touching the soil and thus making such fruits unsuitable for human consumption. The beetles feed on the leaves and young shoots and occasionally attack the stems. The larvae cause most serious damage in an irrigated field, while in a non-irrigated field, the injury is limited to adult feeding on leaves [13]. The beetle feeds on the flowers and young fruits, which ultimately wither and finally fall. Bitter gourd (*Momordica charantia* L.) and other cucurbitaceous vegetables are severely infested by the RPB, *Raphidopalpa foveicollis* Lucas [67]. They attack the crop mainly at the seedling stage. They also cause damage to the leaves during the later period of the crop growth [68].

Both larval and adult stages of red pumpkin beetle are injurious to the crop. The adult beetles feed on leaves, flower buds and flowers. But the larvae feed on root tissue and cause direct damage to the newly developed seedlings [69]. At the advent of spring the beetles defoliate the cucurbit seedlings to such an extent that, sometimes the crop has to be replant for 3-4 times [70, 49]. The adults feed on both surface of leaves, while they feed on the middle of the leaf produce a characteristic, circular ring like injury. Adults feeding on flowers then they feed mainly on petals, but they also attack anthers, pollens, stigma and ovary rendering the flowers incapable of fruiting. The beetles also injure fruit, producing characteristic circular bands of injury which help in rotting and subsequent attach of diseases of the fruits.

It causes severe damage to almost all cucurbits at seedling stage. It causes 35-75% damage to all cucurbits except bitter gourd at seedling stage and the crop needs to be resown. They feed underside the cotyledonous leaves by biting holes into them. Percent damage rating gradually decreases from 70-15% as the leaf canopy increases. Percent losses are quite evident from the percent damage, which may reach up to 35-75 % at seedling stage [71]. Red pumpkin beetle, *Aulacophora foveicollis* Lucas is a serious pest of musk melon (*Cucumis melo* L) particularly in seedling stage [72]. The adults feed voraciously on young leaves which sometimes necessitate resowing. Variation in the infestation of the red pumpkin beetle among different host plants during the different time of the year and ranging from 3-20%.

The beetles feed on whole leaves of young cucurbit plants and kill them while the female red pumpkin beetle lays eggs in soil under plant debris. On hatching, grubs feed on the roots and underground portion of host plants as well as the rind of fruits touching the soil. The adult beetles prefer cotyledons and young leaves and also feed readily on flowers and mature green leaves. The adult beetles feed voraciously on leaf lamina making irregular holes. They prefer young seedlings and tender leaves and the damage at this stage may even kill the seedlings. The adults attack

seedlings, young and tender leaves and flowers [73,74]. The beetles feed on the leaves, flower buds and flowers by making holes on them [3,75].

The RPB (*Raphidopalpa foveicollis* L.) causes considerable damage to cucurbits during all the stages of plant development [76-78]. The adult RPB attack the early growing spring cucurbits at the seedling stage so severely that the crop has to be resown several times, causing great loss of labour, seed and also great delay in crop production. Adult RPB feed on the leaves, flowers and in some cases on fruits, while the grubs attack the roots, underground stems and the leaves closely in touch with the soil. At the advent of the spring, the beetles defoliate the cucurbit seedlings to such an extent that sometimes the crop has to be resown 3 to 4 times. Adults also feed on both surfaces of the leaves, and the adults attack on the middle of the leaf, they produce a characteristics circular ring-like injury. Heavily affected leaves dry up and die. The adults, while feeding on flowers, feed mainly on petals, but they also attack anthers, pollens, stigma and ovary, rendering the flowers incapable of fruiting. He also stated that the beetle was also found to injure fruits, specially kankri (*Cucumis utilisimus*), producing characteristics circular bands of injury which helped in rotting and inviting disease of the fruits. Red pumpkin beetle, *Aulacophora foveicollis* Lucas is also a serious pest of musk melon (*Cucumis melo* L.) particularly at seedling stage. The adults feed voraciously on young leaves which sometimes necessitate resowing. None of the 17 musk melon varieties studied either remained free from the pest population or escaped its damage throughout the crop period [79].

The damage is caused mainly by the adult beetles, which feed, extensively on the leaves, flowers and fruits by making holes and causing death or retardation of growth. He also mentioned that the damage done by the grubs to seedling is also serious. The beetles feed on the leaves, flower buds and flowers by making holes on them. Severe injury is done in young plants right from seedling stage. The beetles are very destructive to cucurbitaceous vegetables, particularly during March-April when the creepers are very young, the grubs damage the plants by boring into the roots, underground stems and sometime into the fruits touching the soil. The beetles injure the cotyledons, flowers and foliage by biting holes into them. The early-sown cucurbits are so severely damaged that they have to be resown. The beetles bite holes on leaves of pumpkin, melons, etc, and also feed on flowers. The grubs remain in the soil and feed on roots, stems and fruits. Red pumpkin beetle is a serious pest of cucurbitaceous vegetables and it feeds on wide range plant species leaves including cucumber, ridge gourd, pumpkin, bottle gourd [80].

A study on different cucurbitaceous crops was conducted against red pumpkin beetle and reported red pumpkin beetle as serious damaging pest of cucurbitaceous vegetables [81]. The pest is most seriously damaging to crops especially to green plant cucurbits [82]. A study on bottle gourd varietal screening was done against red pumpkin beetle with 27 different cultivars and reported that percent damage was fluctuating for different plant species, but the average damage recorded at lowest was 17.45% in VRBG-50 and highest damage was 34.32% in NDBG-56 [83]. The highest leaf infestation was 89.25% in musk melon and 0.00% in bitter gourd in 2010. Red pumpkin beetle is a serious pest of the crops especially cucurbits and cause damage to plants at every stage either is floral, vegetative or reproductive stage. Larval stages cause damage to roots and immature stages of the plant whereas the adult beetle cause damage to plant parts such as leaves, flowers and fruits [84]. The preference order of 21 cucurbit vegetables and noted that bitter gourd was highly resistant to the beetle, while sponge gourd, bottle gourd were moderately resistant, muskmelon and cucumber were susceptible to the pest [85]. In a study of vegetable pests of Ceylon, *Aulacophora steveni* was a common pest of snake gourd causing significant damage to snake gourd [86]. However, normal feeding on bitter gourd and snake gourd was also reported [87].

#### 5. CONCLUSION

The red pumpkin beetle is found to occur in all cucurbits along with some legumes and sweet potato. This beetle is distributed all over the world especially Mediterranean region, Australia, Southern Europe and Africa, South East-Asia. The infestation of the red pumpkin beetle is started in the beginning of April which is gradually increased and reached to the peak in the last week of May and the first week of June, and then the population gradually declined. Out of all cucurbits, bitter gourd, snake gourd, spnoge gourd and ribbed gourd are non-preferred hosts and sweet gourd, muskmelon, cucumber and khira are the most preferred hosts. The severe damage is noticed to cotyledons at seedling stage, leaves and flowers of attacked plants by making irregular holes.

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