Arthropod Fauna Associated with Rose and Management of the Pestiferous Species

xqykc ds lEcfU/kr la?kikn tho o ihM+d iztkfr;ksa dk izcU/ku

RAJENDRA SINGH

Thesis

Master of Science in Agriculture

(Entomology)

2021

DEPARTMENT OF ENTOMOLOGY
RAJASTHAN COLLEGE OF AGRICULTURE

MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND TECHNOLOGY UDAIPUR-313001 (RAJASTHAN)

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Thesis

Submitted to

Maharana Pratap University of Agriculture and Technology, Udaipur

In partial fulfillment of the requirement for the degree of

Master of Science in Agriculture

(Entomology)

By

RAJENDRA SINGH

2021

CERTIFICATE-I

CERTIFICATE OF ORIGINALITY

The research work embodied in the thesis titled "**Arthropod Fauna Associated with Rose and Management of the Pestiferous Species**" submitted for the award of degree of **Master of Science in Agriculture** in the subject of **Entomology** to Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan), is original and bonafide record of research work carried out by me under the supervision of **Dr. Narayan Lal Dangi**, Assistant Professor, Department of Entomology, Rajasthan College of Agriculture, Udaipur. The contents of the thesis, either partially or fully, have not been submitted or will not be submitted to any other institute or university for the award of any degree or diploma.

The work embodied in the thesis represents my ideas in my own words and where others' ideas or words have been included. I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the university and can also evoke panel action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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CERTIFICATE-II

Date: /   /2021

This is to certify that the thesis entitled **"Arthropod Fauna associated with Rose and Management of the Pestiferous species"** submitted for the degree of Master of Science in Agriculture in the subject of Entomology, embodies bonafide research work carried out by **Mr. Rajendra Singh** under my guidance and supervision and that no part of this thesis has been submitted for any other degree. The assistance and help received during the course of investigation have been fully acknowledged. The draft of this thesis was also approved by the advisory committee on 06/08/2021.

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This is to certify that **Mr. Rajendra Singh** student of Master of Science in Agriculture, **Department of Entomology** has made all the corrections/modifications in the thesis **"Arthropod Fauna Associated with Rose and Management of the Pestiferous Species"** which were suggested by the external examiner and the advisory committee in the oral examination held on ___/___/2021. The final copies of the thesis duly bound and corrected were submitted on ___/___/2021 are enclosed here with for approval.

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Place: Udaipur
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1. INTRODUCTION

Rose is grown everywhere in India. It is enjoyed by growing roses in gardens, fields, parks, in the courtyards of government and private buildings, even in the beds and pots of the gardens of the houses. The rose blooms profusely throughout northern India, especially in Rajasthan and in Bihar and Madhya Pradesh from January to April. There is a lot of rose cultivation in South India especially in Bangalore and also in Maharashtra and Gujarat.

Indian roses are traditionally well known in world floriculture market and holds first ranks in international market. Rose is the most favored flower in the global market. India has very high probable for export of cut flowers. Its share is approximately 51 per cent of the sum whole of European markets. India has excellent favorable climatic situation for flowers production for trade in winter while the demand in Europe. India is having superior scope for earning precious foreign exchange through flower trade especially through rose cultivated under restricted environment *i.e*. required for flower cultivation.

The trends towards rose cultivation has increased throughout the area include Pushkar (Ajmer), Chittaaurgarh , Udaipur, the cultivation of *chetti* roses in the historic Haldighati area in Rajsamand district of Rajasthan is proving to be a boon for local farmers. Each farmer gets a business of 10 to 15 lakh rupees from one bigha farming during a year. The *cheti* rose is grown in about 20 hectares of land in 8 – 10 villages around khamnor and nathdwara in rajasthan In pushkar 25000 kg rose flowers are produced daily. The importance of rose farming is well known, be it in the type of cut flowers, rose water, rose syrup, essential oil and best *gulkand*; especially, from the *cheti* variety. In the perfume of the rose too, the *cheti* rose is well thought-out the best. The objectives of their study with the arthropod fauna are to the production of rose are high, but marketability and productivity are declining considerably due to damage of insect pest. The pest situation varies from place to place with the difference in agro-climatic conditions of the locality. In this context, information on succession and pest complex in a specific agro-ecosystem is very much necessary in devising pest management strategies, which would not only be economically feasible but also ecologically sound. Such information on ornamental crops is small particularly from the state of Rajasthan.

Rose is an attractive prickly ornamental shrub belonging to the genus, *Rosa* in the family Rosaceae. Rose is symbol of love, innocence and admiration. Rose is a well-liked crop for both domestic and marketable cut flowers. Roses are exclusively used in decorations and ornamentation, without rose gardens are considered incomplete. The by produce of rose include oil, rose water, which are valuable and important base material for a number of industries such as perfume, pharmaceutical and cosmetic (Ayci *et al*., 2005), but the measure use of roses in the cut flower industry and for landscaping.

Rose plant is infested by several insects, mites, diseases, and nematodes posing a serious threat to rose cultivation. Insects and mites attack on rose plants at different growth stages. Commonly found and regular pests are thrips *Frankliniella* sp, aphids (M*acrosiphum rosae* L.), scales (*Lindingaspis rossi, Aonidiella aurantii, Aspidiotus spp*), whiteflies (*Bemisia tabci* Genn.), leafhoppers (*Edwardsiana rosae*), chafers (*Oxycetonia versicolor*), termites (O*dontotermes obesus*), and mites (T*etranychus cinnabarinus*). Several of these pests are found during the year damaging the rose and affecting the flower of rose yield. All these sap sucking pests occur in large numbers in clusters under the surface of leaves, on shoots, flowers and buds in field. Mite and insect pests on rose can cause 28–95 per cent damage individually both in field and polyhouse. (Hegde *et al*., 2020).

Most floricultural crops are infested by thrips, aphid, scale insects, black flies and mites among the sap sucking pests. Defoliating pests include polyphagous Lepidoptera like *Spodoptera* and *Helicoverpa*; besides, the leaf cutter bees of Megachilidae family that are reported as minor pests. Among the beneficial insects are the solitary bees, honeybees and flies that pollinate the flowers for better production. Study of the diversity of beneficial and pestiferous arthropod fauna and their population activities is essential prior to developing a pest management strategy; hence, the present investigation was taken up. Keeping in view the gaps in entomological research on ornamental plants, I took up this research work on the study of arthropods associated with rose for a short period of 6 to 8 months, as expected for Master's degree, and work out suitable pest management strategy.

Looking to these facts as worth exploring the following study on, "Arthropod Fauna associated with Rose and Management of the pestiferous species" was proposed with the following objectives:

The objectives were as follows:

1. To study the qualitative and quantitative abundance of arthropod fauna.
2. To analyse the diversity of insect pollinators.
3. To evaluate the relative bio-efficacy of different pesticides against major pests.

2. REVIEW OF LITERATURE

2.1 Pestiferous arthropod fauna associated with rose

Hole and Salunkhe (1997) studied that the incidence of *Macrosiphum rosae* (L.) was on 30 rose cultivars during winter and summer seasons of 1991 and 1992 at Pune, Maharashtra. The pest builds up started in 3rd week of January and peaked (149.25 aphids/shoot) during the 4th week of February. Maximum temperature, minimum temperature, relative humidity in the morning, relative humidity in the afternoon and bright sunshine hrs were in the from 30.3 to 31.5°C, 9.7 to 11.7°C, 85 to 91%, 28 to 31%, 9.6 to 10.1 h, respectively which prevailed during February month appeared to be congenial for multiplication of aphids. Increase in population of aphid was significantly positive correlated with minimum temperature, maximum temperature, in period first, while a highly significant negative correlation was observed in period second.

Ahmed and Aslam (2000) studied the influence of ecological factors on rose aphid, *Macrosiphum rosaeformis* (Das) (Homaptora, Aphididae) infesting rose (*Rosa indica* var. Iceburg). The population of aphid was found from March to May that peaked in the second week of April, 2000. More aphid densities were recorded on top portions of the plant. High temperature over 30 C associated with rain fall, relative humidity and windstorm substantially reduced the number of aphids on rose. Deformation of flowers and stems leaves resulted in case of strong infestation by the aphid.

Gahukar (2003) observed that the population levels of two species of thrips *Thrips flavus* Schrank and *Scirtothrips dorsalis* Hood were found high during January to March and low in May to July when monitored for three consecutive years. The percentage of infested flowers varied from 14–88% in 1996, 28–95% in 1997 and 37–52% in 1998. Population density different between 9–44, 10–47 and 11–33 thrips/flower in 1996, 1997 and 1998, respectively. Number of thrips collected significantly fluctuated with the level of flower infestation, compactness, flower colour, position and size of petals. Thrips preferred small sized, loose and orange /red colored flowers.

Rajkumar *et al.* (2004) reported the most commonly associated pests with rose to be common blossom thrips, *Frankliniella schultzei* (Pergande) (Thysanoptera: Thripidae); aphids, *Macrosiphum rosae* (Linnaeus) (Hemiptera: Aphididae); greenhouse whiteflies, *Trialeurodes vaporariorum* (Westwood) (Hemiptera: Aleyrodidae); mealy bugs, *Planococcus citri* (Risso) (Hemiptera: Pseudococcidae); foliage feeders and bud borers, *Helicoverpa armigera* (Hubner); *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae) and mites, *Tetranychus urticae* Koch (Acarina: Tetranychidae).

Demirozer (2012) recorded infestations by *Helicoverpa armigera* (Hubner) on flowers of *Rosa damascena* for the first instance in Turkey. During May and June 2010, 53 oil-bearing rose orchards were inspected and four of them were infested with *H. armigera.* Both laboratory and field observations displayed that the pest attacks principally carpels and stamens rather then petals. Furthermore, *H. armigera* larvae were observed feeding on dried rose petals located on drying racks in rose oil factories.

Vashisth *et al.* (2013) carried out a survey on the insect pests of rose in polyhouses and reported eight insect species *viz. Trialeurodes vaporariorum* (Westwood), *Myzus persicae* (sulzer), *Spodoptera litura* (Fabricius)*, Helicoverpa armigera* (Hubner)*, Plutella xylostella* (Linnaeus,1758)*, Liriomyza trifolii* (Burgess)*, Thrips tabaci* (Lindeman) *and Frankliniella* sp. in four districts of Hìmachal Pradesh.

Ali (2013) observed five species of aphid colonizing cultivated and native rose shrubs in Baghdad province, Iraq from wintry weather to early summer of 2012, which were *A. gossypii* Glover, *Aphis fabae* Scopoli, Myzus *persicae* (Sulzer), *Macrosiphum rosae* (L.), and *Rhodobium porosum* (Sanderson). The effects of relative humidity and temperature on the incidence of these aphid species were investigated and it was observed that incidence was affected by these two weather conditions. Statistical analysis showed high significant differences among frequency of species of aphid and different plant parts of rose.

Pizzol *et al.* (2014) observed that the species of thrips and their population densities occurring outside and inside rose greenhouse from 2006 to 2009 years, in France. The predominant species were *Frankliniella occidentalis* (Thripidae) and *Thrips tabaci* (Thripidae). Rose were infested mainly at the end of autumn and in spring. In this study, *Thrips australis* and *Scirtothrips inermis* were identified for the first time in France. Increasing populations of thrips inside the greenhouse were associated to the peak abundances outer surface in the spring, at time of replacement of muslin cloth used to cover the entrance of greenhouse. In autumn, no coefficient correlation was observed between pest populations outside and inside the greenhouse, where individuals of thrips population current in the greenhouse continued reproduction during this period.

Quratulain *et al.* (2015) reported that the incidence population of aphid, *Macrosiphum rosae* (L.) on rose started from November and declined with decrease in temperature in December and increased again by the end of February. Golizadeh *et al*., (2017) evaluated resistance indices, development, survivorship and reproduction of rose aphid on 10 rose cultivars *viz.* Bella Vita, Cool Water, Dolce Vita, Maroussia, Orange Juice, Pink promise, Roulette, Tea, Valentine, and Persian Yellow in laboratory at 25 ± 1°C, 65 ± 5 per cent relative humidity and photoperiod of 16:8 (L/D) h and found that rose aphid survived successfully on all 10 rose cultivars.

Hegde *et al.* (2016) found that rose thrips, *Scirtothrips dorsalis* prevailed throughout the flowering period and attained peak during May. Thrips followed an annual pattern in distribution over time. Cumulative mean numbers of thrips were more in polyhouse than open fields.

Smitha *et al.* (2017) reported the major insect pest on rose to be *Macrosiphum rosae* (L.), *Thrips tabaci*, *Anomala orientalis* (Waterhouse, 1875), *Aonidiella aurantii*, *Achaea janata* (Linnaeus), *Orgyia posticus*, *Megachile anthracina*, *Odonototermes obesus*.

Islam *et al.* (2017) studied the incidence of spider mites on 12 different varieties of roses *viz.* Wild rose, Crazy love bi-color, Yellow star, Missing love, Compassion, Charming lady, Dream bangle, Sleepy moon, Sweet doll, Moon light, Sweet love and Mini moni. Incidence of spider mites showed significant variation due to the effect of varieties. Among the varieties, Sweet Love was tolerant of pests and the lowest number of spider mites was recorded at vegetative and flowering stages. Varieties of rose significantly influenced the incidence of pests as well as growth characteristics of rose indicating lowest number of infested leaves per plant, lowest number of infested branches/plant and lowest number of infested flowers per plant on

Sweet Love variety. Sweet Love variety showed tolerance to spider mites of rose and gave better yield among all varieties evaluated, while sweet doll variety was graded as susceptible to mites due to pest incidence and infestation.

Amin *et al.* (2020) observed that the population of thrips started to increase in the first week of January, gradually increasing and reaching its maximum (2.6 ± 0.2 individuals/flower) in the first week of February, and then declined. The population of aphid started to increase in the second week of November, reached its peak (8.4 ± 0.6 individuals/shoot) in the fourth week of December, and then declined. The mite population started increasing in the second week of December, increased continuously until its peak (8.4 ± 0.4 individuals/shoot) in the first week of March, and then declined. The populations of mites, aphids and thrips persisted until the third week of April, the third week of May, and the first week of April, respectively. The mite population had a significant positive correlation with temperature.

2.2 Insect pollinators visiting rose

Knuth (1908) compiled data on insect visitors to *Rosa* species in Europe. These included sawflies, earwigs, a fossorial wasp, and twenty genera of beetles, seven flies (a Stratiomyidae (*Oxycera*), four Syrphidae (*Helophilus, Syritta, Didea, Eristalis*), two Muscidae (*Anthomyia, Aricia*)), and seven bees (*Andrena, Apis, Bombus, Halictus, Megachile, Osmia, Prosopis*).Species of the genus *Bombus* were the most general visitors to *R. rugosa* in Sweden (three species noted), although species of *Andrenidae, Halictidae, Megachilidae,* and *Apis mellifera* were also observed (Dobson *et al*., 1999).

Kevan *et al*. (1990) found that most insect activity on *Rosa setigera* started around 08.00 am, peaked around 09.30 am with hoverflies and 11.30 am with bees, and then decreased. For hoverflies only, visitation increased again, later in the day. In lowa, the peak of honeybee activity on six *Rosa* species. (*R. blanda, R. carolina, R. rugosa, R. multiflora, R. setigera, and R. xanthinia*) was earlier in the day, between 08.00 am and 09.00 am, with their pollen being available from around 06.30 am, 07.00 am, or 07.30 am until 11.00 am or 12.00 noon, depending on the species (Parker, 1926). In Maine, Melanostoma arrived significantly earlier on *R. carolina* than did either bumble bees or *Toxomerous,* sometimes even before the flowers had opened, and their activity peaked earlier than that of other species, typically declining by 07.00 am (Morse, 1981). The numbers of *Toxomerous* and *Bombus* visits increased to a peak by 09.00 am, declined rapidly in *Toxomerous* and much more slowly in *Bombus* (Morse, 1981). Many bumble bees were found to concentrate their activities on *R. drolina* until the pollen was exhausted at mid-day, and then they switched to other flowers (Morse, 1981). As well, bumblebees in Maine collected pollen from *R. nitida* at approximately 09.00 am (when the flowers first opened) at 12.00 noons (Heinrich, 1976).

Jesse *et al.* (2006) recorded insect pollinators visiting invasive *Rosa multiflora* flowers in Iowa, USA on yellow sticky traps. The common insect orders that were collected on the sticky traps included Coleoptera, Diptera, Hemiptera, Hymenoptera, Mecoptera, and Thysanoptera. Many of the insects recorded on the sticky cards were known to feed on pollen. Syrphid flies were the most generally observed taxa visiting the flowers. In 2003, of the total number of visitors observed, 43% were Syrphidae, 35% other Diptera, 14% honeybees, 4% bumble bees, 2% solitary bees, 1% other Hymenoptera, and in 2004, the total observations included 48% Syrphidae, 12% other Diptera, 12% honeybee, 10% solitary bee, 11% Coleoptera, 4% Halictidae, and 1% other Hymenoptera.

Macphial (2007) found that *Apis mellifera* spent around 5.4/4.2 seconds per male/female *R. setigera* flower (Kevan *et al* 1990). Macphial (2007) had recorded *Apis mellifera* foraging for longer periods of time per visit (8.9 ± 0.73/25.1 8.2 seconds in 2004/2005, respectively) than Kevan *et al.* (1990) had. This difference may be related to the differentne species being observed (particularly the number of anthers each has), and to yearly variation. For example, in 2004, the mean visit duration by honeybees to *R. blanda* was 3.75 + 0.9, *R. canina* was 13.4 ±1.9, and *R. virginiana* was 7.4 + 0.7 seconds. In 2005, the mean visit duration to *R. blanda* was 62.25 18.0, *R. multiflora* was 6.5 + 3.5, and *R. virginiana* was 11.25 + 2.8 seconds (there were no honeybee visits recorded to *R. multiflora* in 2004 or to *R. cinnamomea* in either year, and *R. canina* was only observed in 2004).

Victoria *et al.* (2007) recorded insect visit to be the maximum between 09.00 am and12.00 noon,, and foraging rates peaked sharply at 09.00 am, indicating the probable period when most pollen was available. Identified bee genera included *Andrena, Apis, Augochlorella, Bombus, Hylaeus, Ceratina, Halictus, Lassioglossum, Calliposis,* and *Xylocopa*. Observed insects were fitted into one of the seven groups, with the VIIIth grouping being a place for periods with no recorded insect visitors. When all observations are considered together, the other bees grouping contained the most visits (459), followed by hover flies (268), honeybees (177), bumble bees & large carpenter bees (136), other flies 385 (92), (no visitors) (62), unknown/uncertain insect types (47), other insects (44), and beetles (32).

Negishi *et al.* (2010) recorded insect visitation rates on *Rosa rugosa* and *Rosa hirtula* during May, 2008 that peaked (177) at 8:00 am, and were high between 8:00 am to 12:00 noon. On the contrary, insect visitation rates on *R. multiflora*, *R. yaku-alpina*, *R. 'lavande*' (Floribunda Tea rose), *R. 'WGS'* (Hybrid Tea rose [HT], *R. 'Easy going* (Hargoing) and *R. 'Princess of Wales'* were extremely low. Honeybees (*Apis mellifera* Limaeus and *Apis cerana japonica*), bumble bees (*Bombus hypocrita* Perez, etc.), carpenter bees (*Xylocopa appendiculata circumvolans* Smith), which were important as pollen-gathering insects, were observed solely on *R. rugosa* and *R. hirtula*. Other bees or beetles were observed on other wild roses, such as *R. multiflora* and *R. yaku-alpina*, and all rose species the high rate of visits of pollen-gathering bees to *R. rugosa* and *R. hirtula* might be due to the fact that the pollen produced/flower was superior than that of the *R. multiflora* and other rose species examined. Moreover, it seemed to be easier to collect pollen from single-petaled *R. rugosa* and *R. hirtula* than double-petaled cultivated roses. For this reason, the pollen-gathering bees might have preferentially visited and gathered pollen from *R. rugosa* and *R. hirtula*.

Kevan (2017) observed that the flowers of wild roses attract a great diversity of insect visitors and almost all feed on pollen. The wide variety of bees, of which the most conspicuous were bumblebees (*Bombus* spp.), carpenter bees (*Xylocopa* spp.) and the familiar honeybees (*Apis mellifera*), all forage at rose flowers to collect pollen. Bumblebees are often heard making high-pitched buzzing sounds as they harvest pollen. This sound and vibration serve to release pollen from the anthers. The bees take the pollen back to their nests where it is used for feeding the larvae. Rose pollen, like pollen of many other flowers, is highly nutritious, being rich in proteins, amino acids, carbohydrates, lipids and vitamins. Other insects, including some small bees, eat the pollen while on the flowers. The nutrients in the pollen are converted into yolk in developing eggs of flies, beetles and other insects. Particularly conspicuous on roses are hover flies *(Syrphidae*), many of which are beneficial as their larvae consume aphids.

Khan (2017) studied the biodiversity of aphidophagous syrphid flies in daffodil, chrysanthemum, wild and rose flowers (including fennel, dandelion, and black berry) of floriculture ecosystems of Kashmir during 2013 - 2014. A sum of 21 species were observed and among all, *Eristalis tenax* (11.57% and 9.80%) was the most widely abundant and distributed syrphid species, followed by *Eoseristalis cerealis* (10.49% and 9.00%) and *Eupeodus corolla* (9.12% and 7.63%); while *Syritta* sp. (0.82% and 1.17%) followed by *Palpada* sp. (1.49% and 2.02%) were least distributed and abundant species of syrphid fly in daffodil, chrysanthemum, rose and wild flowers (including fennel, dandelion and black berry) in the respective years. The highest mean species diversity (H!) of syrphid flies was in Harwan of district Srinagar and the highest species richness (Da) was recorded in Mamoosa of district Baramullah and in Shalimar of district Srinagar.

Kachhawa *et al.* (2020) reported that the probability of entomophilous pollination depends ahead the diversity of insects. A total of 18 insect species were observed for *Tagetes erecta* (Mexican Marigold) from 9 families and 2 orders (Hymenoptera and Diptera). Hymenoptera was observed to be the most abundant order followed by Diptera. Apidae was found to be the most abundant family followed by Muscidae, Scoliidae, Megachilidae, Colletidae, Halictidae, Syrphidae, Calliphoridae and Vespidae. *A. dorsata* bee in the learn area was the major pollinator and as the most helpful pollinator carrying loose pollen grains with the highest pollination index (123402.60) sticking to their body (17235). The Simpson index was estimated at 0.2859, indicating high diversity in the study area and the Simpson diversity index was estimated to be at 0.7141, indicating that when randomly selected from a sample; there is a more than 71 per cent probability of the 2 distinct species. The Shannon index was estimated at 1.525, which reflects the dominance of a sample group.

2.3 Evaluation of different pesticides against major insect pests of rose.

Rajkumar *et al.* (2005) revealed that fipronil (0.01%) was the most effective chemical and protected rose against thrips up to 15 days after treatment. Acephate (0.075%) and imidacloprid (0.1%) was least effective against the thrips of rose.

Prabhakar *et al.* (2011) recorded Neem seed kernel extract (NSKE) to be superior to neem oil, pongamia oil and the commercial neem product against rose thrips, *Scirtothrips dorsalis.* NSKE was also found to reduce thrips density to the extent of 64% - 88%. In rose fields where pest suppression measures are hardly practised, farmers can apply NSKE, monocrotophos. Based on the cost of vertimac and spinosad, these can be recommended to be cost-effective for commercial polyhouses growing roses.

Ekantaramayya *et al*. (2012) studied the efficacy of selective botanicals against *Scirtothrips* dorsalis on rose at different stages (bud, half opened flower and full opened flower). The half opened flowering stage of rose was suitable in controlling *Scirtothrips dorsalis*. Among the botanicals, 2 per cent Neem Seed Kernel Extract (NSKE) was suitable, which controlled 69.08 per cent thrips.

Hammed *et al*. (2013) evaluated the botanical extracts from 5 medicinal plants viz., *Azadirachta indica*, *Melia azadirach*, *Eucalyptus cineraceae*, *Momordica charantia*, *Calatropis cineraceae* against the pest complex of *Rosa indica*, and pollinators and predators associated with it. Plant extracts exhibited variable responses to *Thrips tabaci* (L.), *Helicoverpa armigera* (Hub.), syrphid flies, *Apis florea* (F.) and *Maladera castanea* (A.) population. Results unveiled that *A. indica* seed extract caused 77 % mortality in *T. tabaci* population after 72 hrs of the application. *A. indica* seed extract and *M. charantia* extract killed 84.00 and 82.00 percent *H. armigera* population after 72 hours. *M. azadirach* leaf extract and A. *indica* leaf extract proved safer to Syrphid flies. *M. azadirach* and *E. cineraceae* leaf extract proved less effective to *A. florea*. Order of efficacy of botanical extracts of plants used in the experimental period against *M. castanea* was *C. cineraceae* > *A. indica* seed kernel extract> *M. azadirach*>E. *cineraceae*> *A. indica* leaf extract> *M. charantia* fruit extract after 72 hrs of the treatment.

Rafique *et al.* (2015) recorded that the Botanical extracts of tobacco, neem and detergent solution was used as treatment for the management of rose aphids during 2008 to 2009. Botanical products tobacco and neem extract have been found promising and useful for control. Among botanical extracts, the highest percentages of aphids were killed consistently across the time after application by tobacco leaf extracts. Neem was also found to produce appreciable result. Reductions of aphid population increased with increase of the time after treatments were applied. The farmers can also use tobacco and neem extracts at the time of initial infestation of aphid on rose plants.

Khanjani (2016) recorded the efficacy of neem essential oil, Citowett, Super oil, Volk oils and common pesticide compounds against greenhouse whitefly, *Trialeurodes vaporariorum* (Hemiptera: Aleyrodidae) on rose flower. All treatments had significant difference with control (α=5%). The most effective compound was 1 ml/L neem oil mixed to 0.5 ml/L deltamethrin with 91.72 and 90.79 % mortality rate followed by buprofezin with 89.29 and 81.84 % mortality rate for nymphs and adult whiteflies, respectively. In addition, 0.5 ml/L spiromesifen showed 78.22 and 64.02 % MR and 0.5 ml/L pyridaben with 80.32 and 82.84 % MR on the nymphs and adults respectively.

Sathyan *et al.* (2017) revealed that significantly lowest population of thrips, *Scirtothrips dorsalis* per three buds on rose was recorded in fipronil 5 SC @ 0.15 per cent, followed by tolfenpyrad 15 EC @ 0.1 per cent and diafenthiuron 50 WP @ 0.12 per cent. The insecticides dimethoate 30 EC @ 0.15 per cent, acetamiprid 20 SP @ 0.02 per cent and thiacloprid 21.7 SC @ 0.1 per cent also proved to be effective in managing thrips as compared to thiamethoxam 25 WG @ 0.02 per cent, chlorpyriphos 20 EC @ 0.25 per cent.

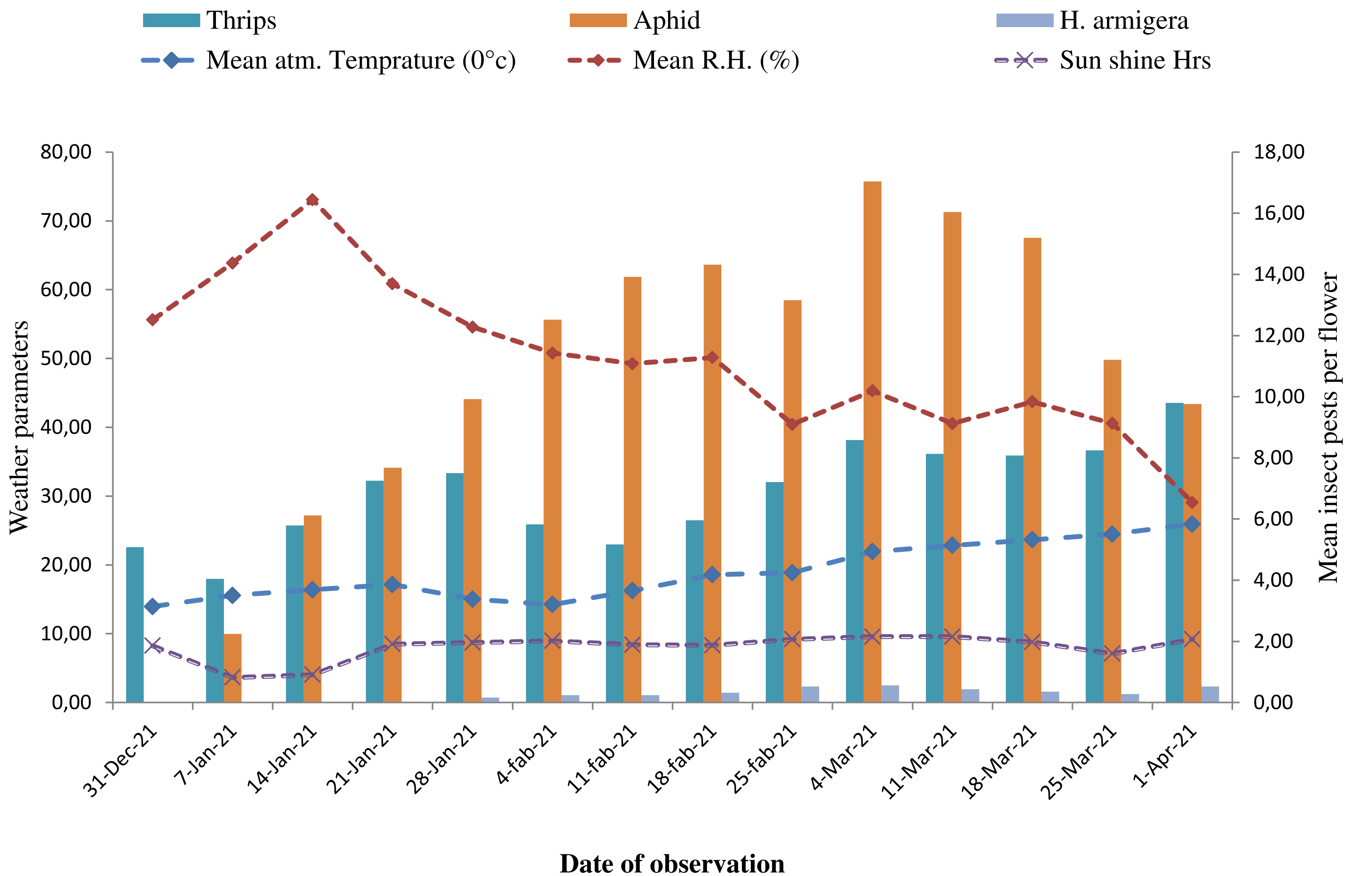
Raghavendra and Chinniah (2018) recorded *Tetranychus urticae* on jasmine and rose crops that was managed using spiromesifen 240 SC @ 0.75 ml/L as foliar application.

Kaur *et al.* (2019) evaluated including spiromesifen and propargite against insects and it was observed that Propargite and Spiromesifen significantly reduced the population of *Tetranychus urticae* with higher mortality in spiromesifen 14 DAS in cucumber, okra and rose respectively. Similarity 100 per cent reduction of mites/leaf was observed in spiromesifen and 50-75 per cent mortality in neem products at seven days after spraying under polyhouse. Similarly neem oil @ 4 per cent caused 58 per cent reduction in mite population three days after spray, but mortality decreased to 46 per cent 7 days after spray.

Table 2: Seasonal incidence of major insect pests infesting rose during *rabi* Season, 2020-21.

Observed date	**SMW**	**Mean Atm. temperature (°C)**	**Mean R.H. (%)**	**Sunshine (Hrs)**	**Mean thrips/flower**	**Mean aphid/bud**	**Mean *H. armigera* larvae/flower**
31/12/20	52	13.95	55.61	8.26	5.08	0.00	-
07/01/21	1	15.55	63.86	3.64	4.04	2.24	-
14/02/21	2	16.39	73.07	4.04	5.79	6.12	-
21/02/21	3	17.13	60.86	8.49	7.25	7.68	0.00
28/02/21	4	15.01	54.57	8.70	7.50	9.92	0.16
04/02/21	5	14.24	50.79	8.96	5.83	12.52	0.24
11/02/21	6	16.25	49.24	8.39	5.17	13.92	0.24
18/02/21	7	18.58	50.14	8.31	5.96	14.32	0.32
25/02/21	8	18.87	40.42	9.19	7.21	13.16	0.52
04/03/21	9	21.92	45.29	9.57	8.58	17.04	0.56
11/03/21	10	22.82	40.54	9.57	8.13	16.04	0.44
18/03/21	11	23.65	43.71	8.79	8.08	15.20	0.36
25/03/21	12	24.46	40.57	7.11	8.25	11.21	0.28
01/04/21	13	25.92	29.07	9.19	9.80	9.76	0.52
Seasonal mean		18.91	49.84	8.02	6.91	10.65	0.33
Coefficient of correlation (r) for population and mean atmospheric temperature					0.832*	0.519	0.607*
Coefficient of correlation (r) for population and mean relative humidity					-0.720*	-0.581*	-0.817*
Coefficient of correlation (r) for population and sunshine					0.583*	0.622*	0.536

* Significant at 5 per cent level of significant; SMW-Standard Meteorological Week



Fig; 1. Seasonal incidence of major insect pests infesting rose during *Rabi* season, 2020-21.

3. MATERIALS AND METHODS

The proposed investigation on, **"Arthropod fauna associated with rose and management of the pestiferous species"** was carried out at Farmers field, New Ashok Nagar, Udaipur, Rajasthan. (NL 24°35'32'' and EL 73°42'30'') during *Rabi season* 2020-21 at the instructional farm, Department of Horticulture, RCA Udaipur. The details of materials used and methodology adopted for the investigation are described in this chapter.

3.1 Experimental site

For the conduct of the field trials, rose plantations of Shri Mohan Lal Mali and Shri Suresh Kumar rose farmers and at the instructional farm, Department of Horticulture, RCA Udaipur were selected. The plantation comprised rose variety "Ganganager rose" in an area of 1000 m^2. New Ashok Nagar, Udaipur. These rose plantations were monitored for the appearance of insect pests at weekly intervals from *Rabi season November*, 2020 to April, 2021. Udaipur is located at 24°35' N latitude and 73°42' E longitude at an elevation of 582.17 MSL (Mean Sea Level) in the state of Rajasthan. The region comes under agro-climatic Zone IV (a) "Sub-humid southern plains and Aravalli hills'' of Rajasthan.

3.2.1 Qualitative and quantitative abundance of arthropod fauna on rose.

Sampling and general observations:

Observations on pestiferous insects/mites were taken on a weekly basis during early morning (07.00 am to 08.00 am) of the day and the pest population data were correlation coefficient majored with prevailing abiotic conditions of the environment including the mean atmospheric temperature, relative humidity and sunshine hours. The metrological data was obtained from Department of Agronomy Rajasthan college of Agriculture, Udaipur and was considered appropriate as the rose plantation was located close to the metrological observatory of the college.

Observations

a) Mite infestation was planned to be recorded from six leaves per plant (two each from upper, middle and lower canopy of the plants). But mite infestation was not observed during the period investigation.

b) Thrips and aphids were recorded from the growing twigs and flower buds on 25 randomly selected plants. Aphids were recorded by visual count method, while for thrips the twigs were gently shaken to collect the thrips on a white paper sheet smeared with a thin layer of white grease.

c) Leaf eating caterpillars were recorded visually from the same 25 flowers and expressed as numbers per plant.

3.2.2 Diversity of insect pollinators visiting rose.

Observations were taken for different groups of pollinators visiting the cultivated rose during flowering at different time intervals: 09:00 to 11:00, 11:00 to 13:00 and 15:00 to 17:00 hours of the day their activity was observed for 1 minute on each flower during flowering period. Such observations were taken from 5 flowers in bloom. The data were later averaged as per time interval and according to insect group to infer the pollinator faunal diversity as well as dominance of particular group during the time intervals being observed. After collecting the representative specimens of the pollinators' fauna they were processed and pinned on cards. Initially, good quality photographs (dorsal & ventral view) of the solitary bees were send for identification to Dr V. V. Belavadi ,Department of Entomology, GKVK, Bangalore, due to covid-19 restrictions.

3.2.3 Statistical analysis

The following statistical analyses were made towards estimating the species richness and abundance:

The following statistical analyses were made:

Mean density

$$\text{Mean density} = \frac{\sum Xi}{N}$$

Where,

Xi = No. of insects or natural enemies in i^{th} sample

N = Total No. of plants sample

Expressing quantitative diversity as a percentage

$$\text{Relative density (R.D.)} = \frac{\text{No. of individuals of the species}}{\text{No. of individuals of all species}} \times 100$$

3.3 Evaluation of relative bio-efficacy of Pesticides against major insect pests of rose

Different insecticides were evaluated for their relative bio-efficacy against the major insect pests of rose. The experiment was laid out in Completely Randomized Design containing seven treatments and three replications.

The treatment schedule comprised two sprayings, the first spray was done on 30 January, 2021 when sufficient build-up of pest population was observed and the second spray was done after 30 days of first spray.

Experimental details:

Location	-	Farmers field, Udaipur, during 2020-21
Crop	-	Rose
Variety	-	Ganganager Rose
Treatments	-	Seven
Replications	-	Three
No of plot-	-	21
Design	-	CRD (completely randomized design)
Time of experiment	-	November 2020 to April 2021

Treatment Details:

The following treatments were evaluated against the sucking pest on rose.

1. Neem seed kernel extract [NSKE] @ 5 percent concentration.
2. Fipronil 0.3 % GR @ 20 kg per ha.
3. Spiromesifen (240 SC) @ 0.8 ml L-1
4. *Dashparni* (DP) @ 10 per cent concentration.
5. *Neemastra* @ 5 per cent concentration.
6. *Teekhasat* (TS) @ 3 per cent concentration.
7. Control (Untreated)

Preparation of Neem (*A. indica*) Seed Kernel Extract

To prepare neem seed kernel extract (NSKE) the kernels of neem were collected and dried in the shade. The kernels were crushed with the help of pastel and mortar (brass make). The powder obtained was passed through 60-mesh sieve and then mixed with Luke-warm distilled water on weight by weight basis taking equal quantities of powder and water. The suspension obtained was considered to be of 100% concentration from which the desired concentration of 5% was prepared by dilution using distilled water.

Preparation of *Dashparni*

To prepare *Dashparni* (10 leaves extract) the following ingredients were taken:

10 liter Cow urine	2 kg Beal leaves
2 kg Cow dung	2 kg Nerium leaves
5 kg Neem leaves	500 g Tobacco leaves
2 kg Karanj leaves	500 g Garlic
2 kg Custard apple leaves	500 g Turmeric
2 kg Dhatura leaves	500 g Green chili
2 kg Basil leaves	200 g Ginger
2 kg Papaya leaves	200 liter Water
2 kg Marigold leaves	

Procedure of Preparation

In a plastic container of 500 liter capacity, 200 liters of water was taken, to which 2 kg cow dung and 10 liter of cow urine were added. After proper mixing, the pastes made from leaves of neem, karanj, custard apple, dhatura, bael, tulsi, papaya, nerium and marigold were added and thoroughly mixed. On the next day (after 24 hours) the pastes of tobacco, chilly, garlic, dry ginger and turmeric was added. The entire mixture was mixed well covered by cotton cloth and kept under shade for 40 days. This mixture was daily stirred using a wooden stick.

Preparation of *Teekhasat*

For preparing *Teekhasat* the following ingredients were taken: green chilies (500 g), garlic (500 g), dhatura leaves (1 kg) and neem leaves (500 g) in cow urine (10 liter), these ingredients were crushed in cow urine. After that the mixture was boiled till the volume was reduced to half. This boiled mixture was considered to be 100 percent concentration from which required dilutions were prepared.

Preparation of *Neemastra*

To prepare *Neemastra* the ingredients required were: *A. indica* leaves (5 kg), neem kernels (5 kg), cow urine (5 liter) and cow dung (1 kg).

Procedure: Neem leaves and neem karnels were ground separately and then mixed in 5 liters of cow urine to which 1 kg cow dung was added. This mixture was put in a large container (plastic) size 10 liter capacity. Was thoroughly mixed with a bamboo stick. Then the mixture was covered with a muslin cloth and allowed to stand for 48 hours with proper mixing at least four times**.**

Observations:

The numbers of major sap sucking insect pests were recorded from 5 randomly selected plants in each replication **one** day before and 1, 3, and 7 days after the insecticidal treatments.

Analysis: The data obtained for number of sap sucking pest before and after treatment were calculated to ANOVA and the results presented as mean number of insect after treatment in all the treatments including control.

Formula for simple correlation (Pearson, 1895):

$$r_{xy} = \frac{\sum XY - \frac{(\sum X)(\sum Y)}{n}}{\sqrt{\left[\sum X^2 - \frac{(\sum X)^2}{n}\right]\left[\sum Y^2 - \frac{(\sum Y)^2}{n}\right]}}$$

Where,

r_{xy} = Simple correlation coefficient

X = Variable *i.e.* a biotic component. (Average temperature and relative humidity rainfall and sunshine hours)

Y = Variable *i.e.* mean number of insect pests

n= Number of paired observations

Table 3: Seasonal activity of insect pollinators on rose during 2020-21.

Date of observation	Mean Atm. Temperature (°C)	Mean R.H. (%)	Sunshine (Hrs)	Wind velocity (kmph)	Mean/ 5 flowers
19/03/21	23.8	32.0	3.6	5.9	6.67
20/03/21	24.4	44.5	7.8	3.9	6.00
21/03/21	24.3	45.5	7.1	2.1	5.00
22/03/21	25.6	44.5	8.2	3.1	5.33
23/03/21	24.3	41.5	6.5	1.3	5.00
24/03/21	24.1	45.0	9.1	4.5	6.33
25/03/21	24.0	35.5	8.9	3.7	6.00
26/03/21	22.5	37.0	9.1	3.3	7.33
27/03/21	24.8	32.0	9.3	2.7	6.67
28/03/21	25.6	34.5	9.0	2.4	8.67
29/03/21	27.9	35.5	9.3	3.5	8.00
30/03/21	28.3	29.0	9.5	5.9	9.00
31/03/21	28.5	35.5	9.2	6.4	7.67
01/04/21	26.0	20.5	9.0	5.9	8.67
02/04/21	25.5	33.0	9.7	2.5	7.67
Seasonal mean	25.3	36.3	8.3	3.8	6..93
Coefficient of correlation (r) for population and mean atmospheric temperature					0.573*
Coefficient of correlation (r) for population and mean relative humidity					-0.769*
Coefficient of correlation (r) for population and total sunshine					0.480
Coefficient of correlation (r) for population and wind velocity					0.490

* Significant at 5 per cent level of significant

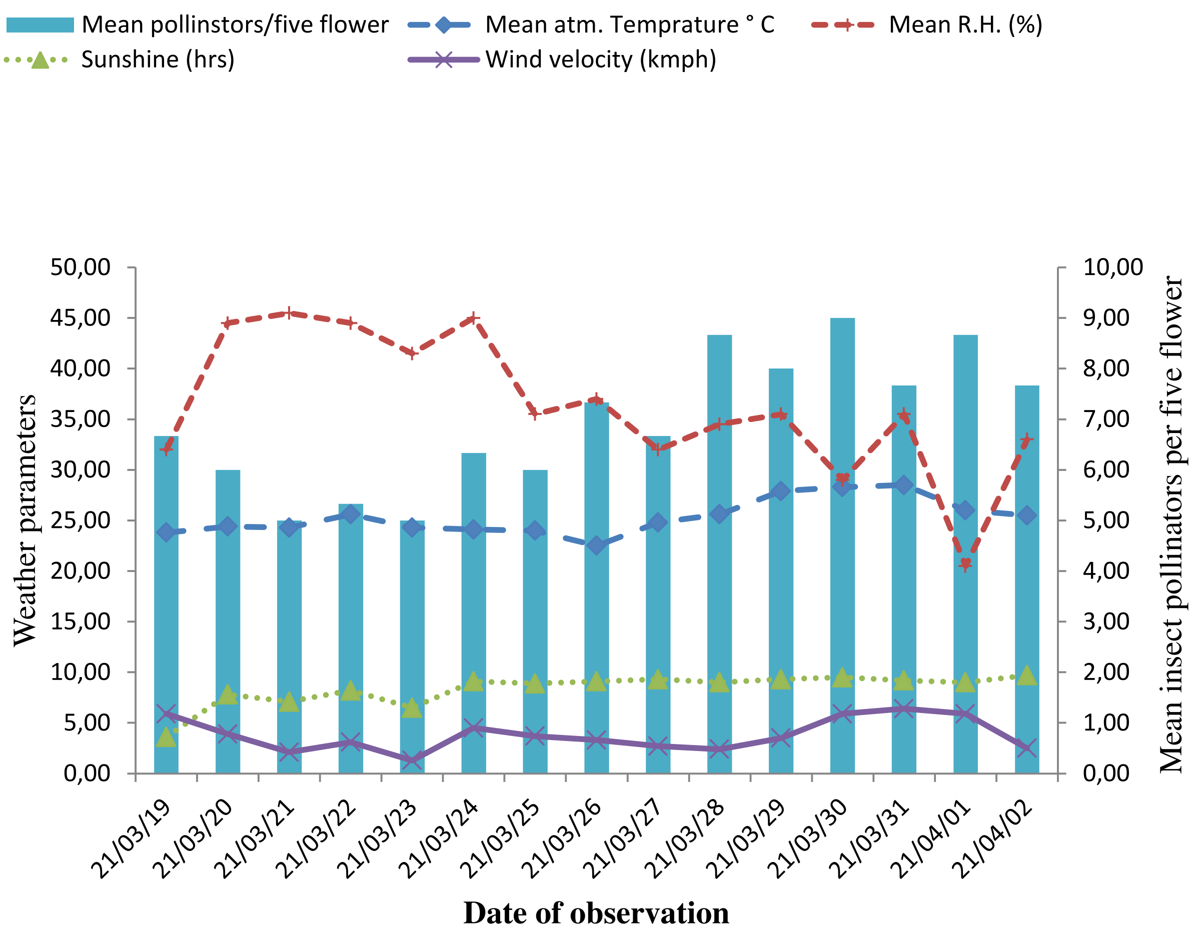


Fig. 2. Seasonal activity of insect pollinators on rose during 2020-21.

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22/03/21	25.6	44.5	8.2	3.1	5.33
23/03/21	24.3	41.5	6.5	1.3	5.00
24/03/21	24.1	45.0	9.1	4.5	6.33
25/03/21	24.0	35.5	8.9	3.7	6.00
26/03/21	22.5	37.0	9.1	3.3	7.33
27/03/21	24.8	32.0	9.3	2.7	6.67
28/03/21	25.6	34.5	9.0	2.4	8.67
29/03/21	27.9	35.5	9.3	3.5	8.00
30/03/21	28.3	29.0	9.5	5.9	9.00
31/03/21	28.5	35.5	9.2	6.4	7.67
01/04/21	26.0	20.5	9.0	5.9	8.67
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Coefficient of correlation (r) for population and wind velocity					0.490

* Significant at 5 per cent level of significant

Table: 4 Diversity of insect pollinators on rose during 2020-21

Hours of visit during day	9:00 to 11:00				11:00 to 13:00				15:00 to 17:00			
	Mean/5 flowers				Mean/5 flowers				Mean/5 flowers			
Dates observed	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
19/03/21	1.00	0.40	0.60	0.40	0.00	0.40	0.20	0.20	0.60	0.00	0.00	0.20
20/03/21	0.60	0.60	0.40	0.20	1.00	0.00	0.00	0.20	0.40	0.00	0.00	0.20
21/03/21	0.80	0.40	0.40	0.20	0.40	0.20	0.00	0.00	0.00	0.40	0.00	0.20
22/03/21	0.60	0.20	0.00	0.60	0.00	1.00	0.00	0.00	0.40	0.40	0.00	0.00
23/03/21	0.80	0.40	0.20	0.20	0.40	0.40	0.40	0.00	0.00	0.00	0.00	0.20
24/03/21	1.40	0.60	0.20	0.40	0.00	0.40	0.00	0.20	0.00	0.20	0.20	0.20
25/03/21	0.60	0.80	0.00	0.20	0.60	0.00	0.20	0.20	0.40	0.20	0.20	0.20
26/03/21	1.00	0.60	0.40	0.60	0.40	0.40	0.00	0.20	0.20	0.20	0.00	0.40
27/03/21	0.80	0.40	0.20	0.40	0.20	0.40	0.20	0.20	0.40	0.60	0.20	0.00
28/03/21	1.20	0.80	0.40	0.40	0.40	0.80	0.20	0.20	0.20	0.40	0.00	0.20
29/03/21	1.20	0.60	0.00	0.20	0.40	0.60	0.20	0.40	0.40	0.20	0.20	0.40
30/03/21	1.20	0.80	0.40	0.20	0.40	0.40	0.20	0.40	0.80	0.40	0.00	0.20
31/03/21	1.00	0.60	0.40	0.60	0.20	0.40	0.00	0.00	0.20	0.40	0.20	0.60
01/04/21	0.80	0.40	0.40	0.20	0.20	0.60	0.20	0.20	0.60	0.40	0.40	0.80
02/04/21	1.20	0.60	0.20	0.60	0.40	0.40	0.20	0.40	0.00	0.40	0.00	0.20
Total	**14.20**	**8.20**	**4.20**	**5.40**	**5.00**	**6.40**	**2.00**	**2.80**	**4.60**	**4.20**	**1.40**	**4.00**
Relative Density (%)	**44.38**	**25.63**	**13.13**	**16.88**	**30.86**	**39.51**	**12.35**	**17.28**	**32.39**	**29.58**	**9.86**	**28.17**
Pollinator status (%)	**51.28**				**25.96**				**22.76**			

A - *Apis florea* (38.14%); B - *Apis dorsata* (30.13%); C - Solitary bees (12.08%); D - Diptera flies (19.55%)

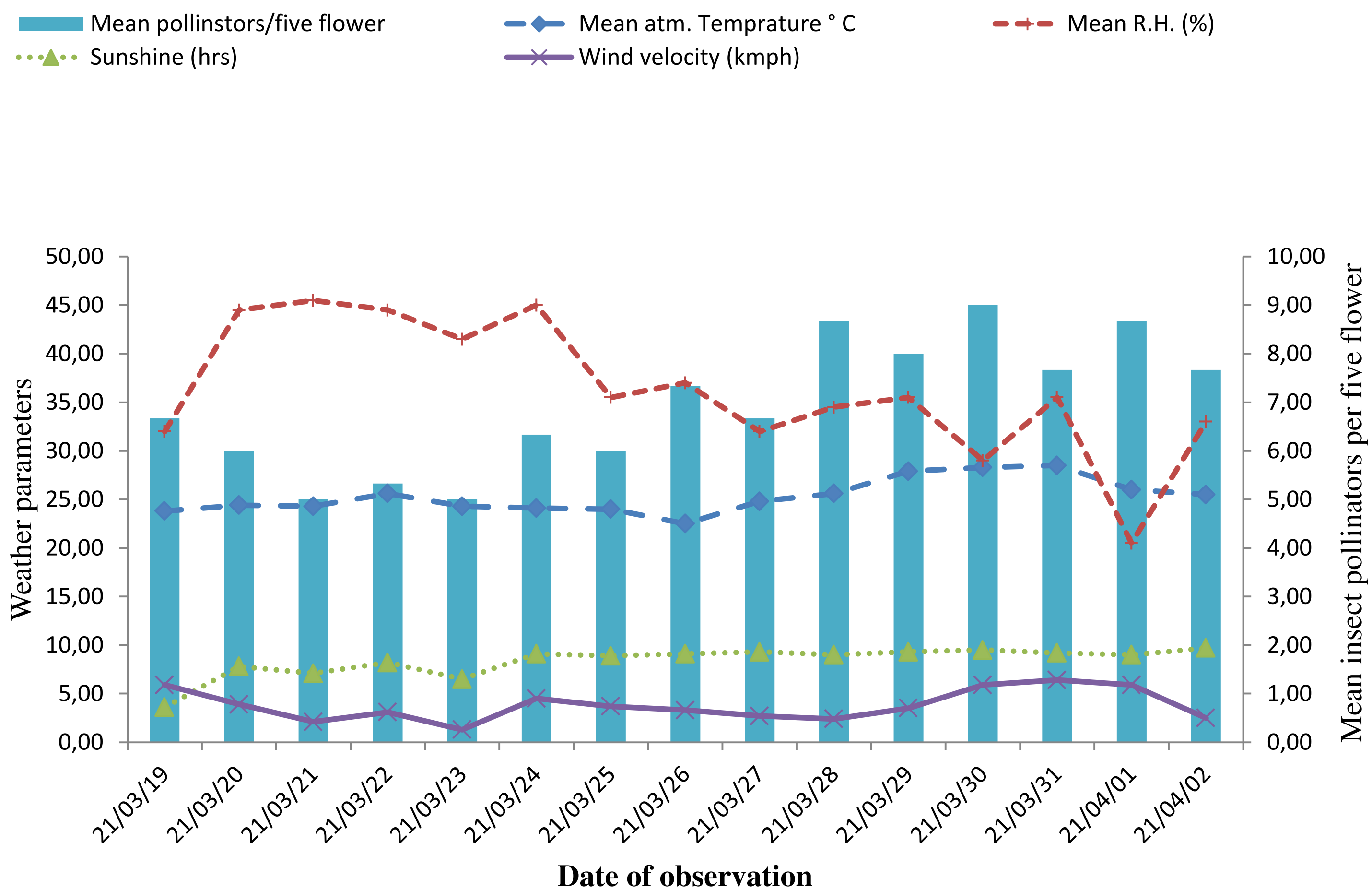


Fig. 2. Seasonal activity of insect pollinators on rose during 2020-21.

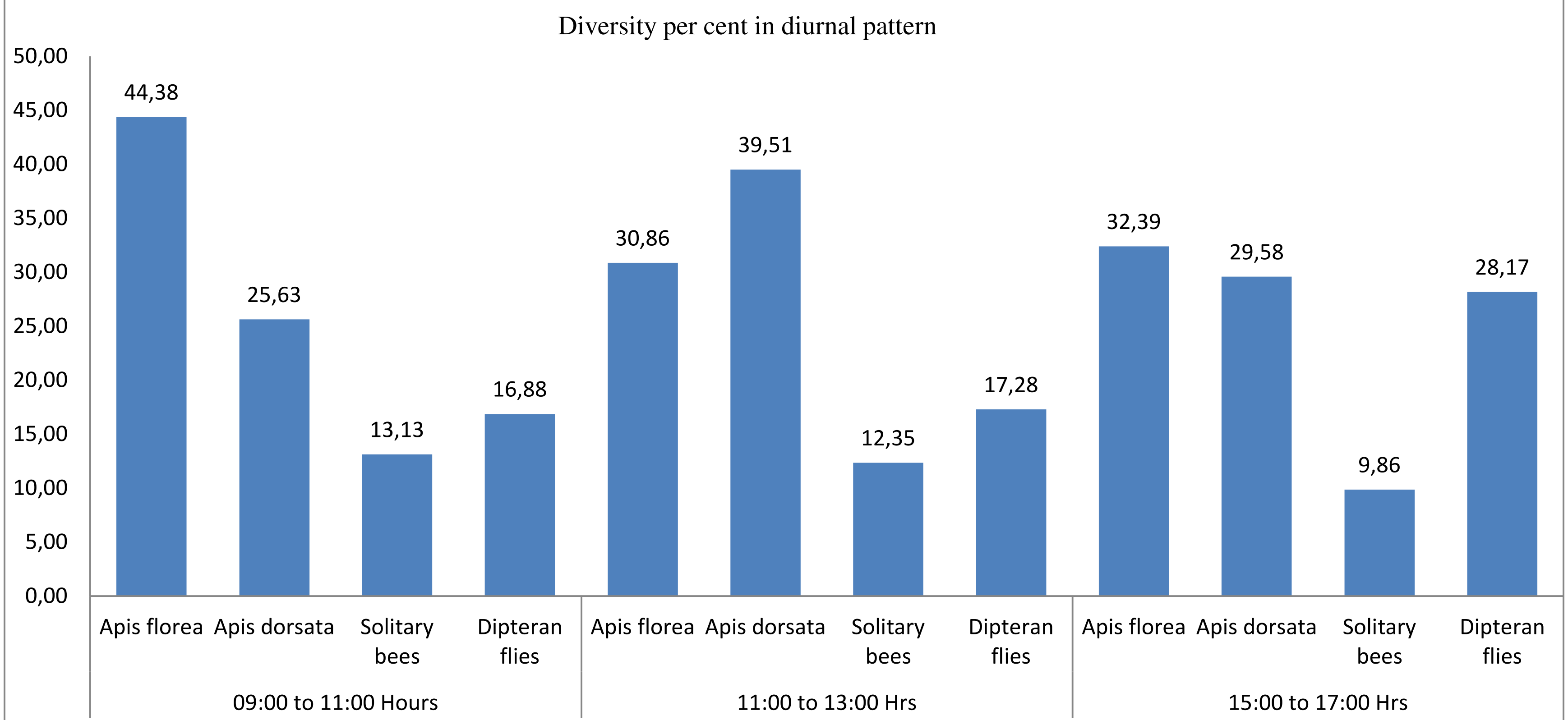


Fig. 3 Diversity of insect pollinators on rose during 2020-21.

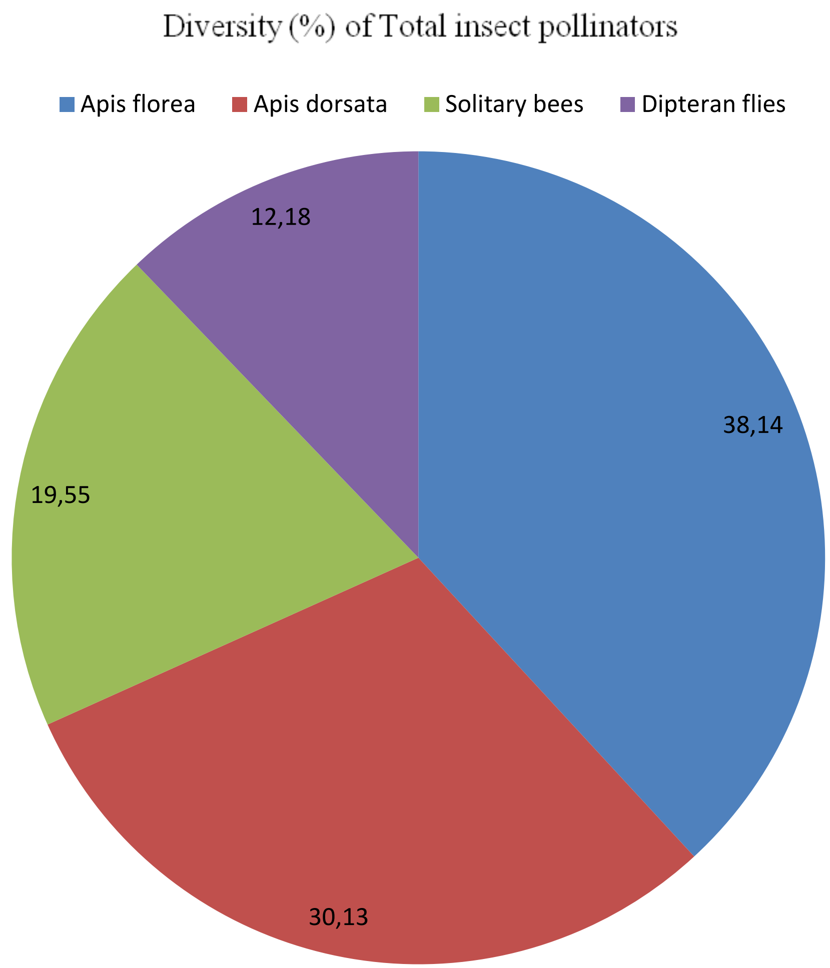


Fig. 4 Diversity of insect pollinators on rose during 2020-21

Table 5: Bioeffacy of pesticides against thrips on rose flower during *Rabi* season 2020-21

Code	Pesticides evaluated	Mean thrips /five flower buds							
		First spray				Second spray			
		PTP	Days after spray (DAS)			PTP	Days after spray (DAS)		
			1	3	7		1	3	7
T_1	NSKE @ 5 %	6.02 (35.7)	3.34a (10.6)	2.92ab (8.02)	3.18ab (9.61)	4.28 (17.8)	2.30a (4.79)	2.11a (3.95)	2.20a (4.34)
T_2	Fipronil 0.3 % GR @ 20 kg/ha.	5.29 (27.4)	2.68a (6.68)	2.21a (4.38)	2.37a (5.11)	4.20 (17.1)	2.15a (4.12)	1.79a (2.70)	1.85a (2.92)
T_3	Spiromesifen (240 SC) @ 0.8 ml/l.	5.03 (24.8)	2.76a (7.11)	2.38a (5.16)	2.43a (5.40)	3.91 (14.7)	2.23a (4.47)	1.94a (3.26)	2.12a (3.99)
T_4	Dashparni (DP) @ 10 %	5.78 (32.9)	3.75a (13.5)	3.50ab (11.7)	3.50ab (11.7)	5.08 (25.3)	2.94a (8.14)	2.85ab (7.62)	2.87ab (7.73)
T_5	Neemastra @ 5 %	5.58 (30.6)	3.74a (13.4)	3.78ab (13.7)	3.81ab (14.0)	5.15 (26.0)	3.36a (10.7)	3.39ab (10.9)	3.52ab (11.8)
T_6	Teekhasat (TS) @ 3 %	5.47 (29.4)	3.77a (13.7)	3.43ab (11.2)	3.70ab (13.1)	5.09 (25.4)	3.14a (9.35)	3.04ab (8.74)	3.19ab (9.67)
T_7	Control (Untreated)	5.36 (28.2)	5.48a (29.5)	5.64b (31.3)	5.83b (33.4)	5.54 (30.1)	5.10a (25.1)	5.12b (25.7)	5.85b (33.72)
S. Em. ±		**0.70**	**1.03**	**0.94**	**0.95**	**0.74**	**1.01**	**0.94**	**0.99**
CD (P=0.05)		**NS**		**2.87**	**2.90**	**NS**		**2.87**	**3.00**

Figures in parentheses are retransformed √X+0.5values; PTP – Pre-treatment populations; Non-significant

Table 6: Evaluation of pesticides against aphids; *Macrosiphumc rosae* on rose during *Rabi* season 2020-21

Code	Pesticides evaluated	Mean aphids /five flower buds							
		First spray				Second spray			
		PTP	Days after spray (DAS)			PTP	Days after spray (DAS)		
			1	3	7		1	3	7
T_1	NSKE @ 5 percent	7.08 (49.6)	4.50 (19.5)	4.24ab (17.4)	4.28ab (17.8)	6.02 (35.7)	3.78a (13.7)	3.35a (10.7)	3.56a (12.1)
T_2	Fipronil 0.3 % GR @ 20 kg/ha.	7.29 (52.6)	3.87 (14.4)	3.62a (12.6)	3.80a (13.94)	5.81 (33.2)	3.14a (9.35)	2.62a (6.36)	2.75a (7.06)
T_3	Spiromesifen (240 SC) @ 0.8 ml/l.	7.24 (51.9)	4.09 (16.2)	3.85a (14.3)	4.00ab (15.5)	5.96 (34.6)	3.23a (9.93)	3.05a (8.80)	3.14a (9.35)
T_4	Dashparni (DP) @ 5 percent	7.18 (51.0)	4.60 (20.6)	4.33ab (18.2)	4.43ab (19.1)	6.34 (39.6)	3.95a (15.1)	3.44a (11.3)	3.79a (13.8)
T_5	Neemastra @ 5 percent	6.97 (48.0)	4.89 (23.4)	4.78ab (22.3)	4.85ab (23.0)	8.10 (65.1)	5.88ab (34.0)	5.83ab (33.4)	5.87ab (33.9)
T_6	Teekhasat (TS) @ 3 percent	7.21 (51.4)	4.77 (22.2)	4.63ab (20.9)	4.84ab (22.9)	8.03 (64.3)	5.42ab (28.8)	5.21ab (26.6)	5.38ab (28.4)
T_7	Control (Untreated)	7.31 (52.9)	6.93 (47.5)	7.13b (50.3)	7.24b (51.9)	8.25 (67.5)	8.00b (63.5)	8.06b (64.4)	7.87b (61.4)
S. Em. ±		**0.89**	**1.19**	**1.00**	**1.10**	**0.71**	**1.07**	**0.96**	**0.99**
CD (P=0.05)		**NS**		**3.03**	**3.33**	**NS**	**3.25**	**2.91**	**3.01**

Figures in parentheses are retransformed √X+0.5values; PTP – Pre-treatment populations; NS-Non-significant

4. RESULTS

The results obtained after analysis of the observed data on different objectives proposed in the research work have been given the below including text, tables and figures.

4.1 Pestiferous arthropod fauna associated with rose

The arthropod fauna associated with rose have been tabulated (Table 1) comprising 17 species of insects (6 pests and 11 pollinators) during 2020-21.

Table 1: Major insect pests and pollinators on rose during *Rabi season* 2020-21.

Insect pests				
Common Name	**S. No.**	**Scientific Name**	**Family**	**Order**
Aphid	1.	*Aphis craccivora* (Koch)	Aphididae	Hemiptera
	2.	*Macrosiphum rosae* (L.)	Aphididae	Hemiptera
Thrips	3.	*Frankliniella* sp.	Thripidae	Thysanoptera
Black fly	4.	*Aleurocanths rosae* (Quaintance)	Aleyrodidae	Hemiptera
Rose bud caterpillar	5.	*Helicoverpa armigera* (Hub.)	Noctuidae	Lepidoptera
Scurfy scale insect	6.	*Aulascaspis* sp.	Diaspididae	Homoptera
Insect pollinators				
Giant honey bee	7.	*Apis dorsata* (Fabricius)	Apidae	Hymenoptera
Dwarf honey bee	8.	*Apis florea* (Fabricius)	Apidae	Hymenoptera
Indian honey bee	9.	*Apis cerana indica* (Fabricius)	Apidae	Hymenoptera
Solitary bees	10.	*Braunsapis* sp. (Michener)	Apidae	Hymenoptera
	11.	*Ceratina* sp. (Latreille)	Apidae	Hymenoptera
	12.	*Ceratina* (pithitis) *binghami* Cockerell	Apidae	Hymenoptera
	13.	*Ceratina* (*Ceratinindia*) sp. 1	Apidae	Hymenoptera
	14.	*Lasioglossum* sp.(Curtis)	Halictidae	Hymenoptera
Leaf cutter bee	15.	*Megchile albifrons* (Smith) Male	Megachilidae	Hymenoptera
Hover fly	16.	Unidentified	Syrphidae	Diptera
Rhiniidae fly	17.	Unidentified	Rhiniidae	Diptera

Syrphidae (Latreille); Rhiniidae (Brauer & Bergenstamm)

4.1.1 Seasonal incidence of major insect pests of rose

Thrips, (Thysanoptera; Thripidae)

During the present investigation, the incidence of thrips commenced from end of December (52th Standard Meteorological Week) during *Rabi* season 2020-21 and continued till the first week of April (13th SMW). The population of thrips ranged from 4.04 to 9.80 per flower throughout the experimental period. The data recorded in Table (2) and Fig. (1) reveal that the population of thrips appeared in the end of December (5.08 per flower); There after population of thrips fluctuated many times and was observed to be the maximum thrice: last week of January, first week of March and first week of April (7.50, 8.58 and 9.80 per flower, respectively) during the crop season; However, the peak population of thrips recorded during first week of April (9.80 /flower), when the mean atmospheric temperature was 25.92°C, mean relative humidity was 29.07 per cent and average sunshine was 9.19 hrs.

The population of thrips indicates significant positive correlation with the mean atmospheric temperature (r=0.832) and sunshine (r=0.583), but with mean relative humidity at showed significant negative correlation (r= -0.720).

Aphid *Macrosiphum rosae* L. (Hemiptera; Aphididae)

In the present investigation that in Table (2) and Fig. (1), the incidence of aphids initiated from first week of January that continued till the first week of April. The mean population of aphids was observed in the range of 2.24 to 17.04 per flower buds during the *Rabi* season, 2020-21. The population increased gradually and reached to its peak in the first week of March with mean population of 17.04 aphids per flower. At the peak period of activity, mean atmospheric temperature, mean relative humidity and sunshine were 21.92 ºC, 45.29 per cent and 9.57 hrs, respectively. The mean aphids population had a negative significant correlation with mean relative humidity (r= -5.81), but with sunshine the coefficient of correlation was significantly positive (r=0.622).

Gram pod borer, *Helicoverpa armigera* Hub. (Lepidoptera: Noctuidae)

The incidence of the larvae of *H. armigera* as given in Table (2) and Fig. (1) reveal that the mean population per flower varied from 0.16 to 0.56. First appearance of the larvae of *H. armigera* was observed in the fourth week of January and was noted upto the first week of April during the *Rabi* season 2020-21. The maximum population of the larvae of *H. armigera* was recorded during first week of March (0.56 larvae per flower), when mean atmospheric temperature was 21.92 °C, mean relative humidity 45.29 per cent and sunshine 9.57 hrs. Correlation studies for the larval population with mean atmospheric temperature showed significant positive correlation (r=0.607) and mean relative humidity showed significant negative correlation (r=-0.817); where with sunshine it was found to be non-significant.

4.2 Seasonal activity and diversity of insect pollinators visiting rose.

Seasonal activity of insect pollinators

The activity of insect pollinators during 19/03/2021 to 02/04/2021 on rose flowers was manifested by honeybees, solitary bees and dipteran flies. As can be observed from Table (3) and Fig (2), honey bees were the primary and dominant pollinators (68.27%). The numbers of bees visiting/flower per minute was recorded at different hours of the day from 09:00 to 17:00 hours. The maximum population of pollinators (9.00 pollinators/five flowers) was observed on 30th March, 2021, as compared to other dates of observation. The minimum population (5.00 pollinators/five flowers) of pollinator's species was recorded on 21st March, 2021. The total pollinators population indicates a positive significant correlation with the mean atmospheric temperature (r=0.573); while a significant negative correlation with relative humidity (r=-0.769).

Diversity of insect pollinators on rose.

Lists of insects pollinators (Table: 4, fig. 3 and 4), includes honey bees and general pollinators on rose during *Rabi* season 2020-21. The pollinators' diversity comprised two species of honey bees (68.24%), five species of solitary bees (12.08%) and two species of dipteran flies (19.55%); besides if you others insects groups were also observed Megachilidae and butterflies but then numerical abundance was less than.

The relative density observed among the pollinators showed the diurnal pattern of visitors on rose flowers revealed that *A. florea* (44.38%) was dominant during morning hours during 09:00 to 11:00 hours, followed by *A. dorsata* (25.63 %), dipteran flies (Syrphidae, Rhiniidae) (16.88 %) and solitary bees (Apidae; Halictidae) (13.13 %). At mid day relative densities during 11:00 to 13:00 hours the maximum pollinators were *A. dorsata* (39.51%), followed by *A. florea* (30.86 %), dipteran flies

(17.28%), and solitary bees (12.35 %). Diversity during 15:00 to 17:00 hours indicated *Apis florea* (32.39 %) to be the maximum followed by *Apis dorsata* (29.58%), dipteran flies (28.17 %) and solitary bees (9.86 %). Total pollinators observed (Table: 4) clearly showed that maximum pollinators occurred during 09:00 to 11:00 (51.28%) as compared to during 11:00 to 13:00 (25.96%) and 15:00 to 17:00 (22.76 %) on rose flowers under natural conditions. The peak activity of honeybees as well as solitary bees was recorded during 09:00 to 11:00 hours.

4.3 Bio-efficacy of pesticides against major sap sucking insect pests of rose

The bio-efficacy of two sprays of six pesticides was evaluated against major sap sucking insect-pests of rose during the experimental period. The first spray was given on 31st January, 2021 during *Rabi* season, while the second spray was taken up 30 days after first spray for the evaluation of the recommended pesticides. The effect of the bio-efficacy of pesticides against thrips and aphids infesting rose has been presented in the Tables (5) and (6).

4.3.1 Bio-efficacy against thrips

First spray

The data in Table (5) shows that the pre-treatment population of thrips ranged from 5.03 to 6.02 thrips/five flower buds and did not vary significantly. Likewise, 1 DAS the population of thrips in the different treatments were not significant with that in the control, ranging from 2.68 to 3.77 thrips/five flower buds. However, the population of thrips in the different treatments three DAS was significantly different among the treatments. Fipronil (0.3% GR) was significantly superior over other treatments in managing the population of thrips as indicated by the mean population of thrips (2.21 thrips/five flowers buds) that was lowest, followed by that in Spiromesifen (240 SC) being the next effective treatment (2.38 thrips/five flowers buds); whereas, in the control the population of thrips was almost more than twice, 5.64 thrips/five flower buds.

Similarly 7 DAS, among the pesticides the minimum population of thrips was recorded in the treatment Fipronil (0.3% GR) with 2.37 thrips/five flower bud and followed by treatment Spiromesifen (240 SC) with 2.43 thrips/five flowers buds). However, the other treatments (NSKE, *Dashparni*) were also found significantly superior to control.

Second spray

The data in Table (5) evinces that the mean population of thrips was not significant among the pre-treatment populations (3.91 to 5.54 thrips/five flowers buds). Likewise, one day after spray the population of thrips in the different treatments were non-significant with that in the control, ranging from 3.91 to 5.54 thrips/five flower buds. It can be observed that 3 and 7 DAS, Fipronil (0.3% GR), Spiromesifen (240 SC) and NSKE (5%) were significantly better than control. Three days after spray, the lowest population of thrips was observed in Fipronil (1.79 thrips/five flower buds) followed by that in Spiromesifen (1.94 thrips/five flower buds) and NSKE (2.11 thrips per five flowers buds) in comparison to the maximum population in control (5.12 thrips/five flowers buds).

Similarly, 7 DAS it could be noted that significantly the minimum population of thrips was in the Fipronil (0.3 GR) treatment (1.85 thrips/five flower buds), followed by that in Spiromesifen (240 SC) treatment (2.12 thrips/five flower buds) and NSKE (5%) application (2.20 thrips/five flower buds). The application of *Dashparni* (10%) treatment (2.87 thrips/flower buds) *Teekhasat* (3%) treatment (3.19 thrips/flower buds) and *Neemastra* (5%) treatment (3.52 thrips/flower buds) were also better than control in managing the thrips population on rose; while, the maximum population of thrips was recorded in control (5.85 thrips/five flower buds).

4.3.2 Bioefficacy against Aphid; *Macroshiphum rosae* (L.)

First spray

The data in Table (6) indicates that the mean population of aphids did not significantly wary among the pre-treatment populations. The mean population of aphids before first spray ranged from 6.97 to 7.31 aphids/five flower buds in the different treatments evaluated. After first spray application, Fipronil (0.3% GR) and Spiromesifen (240 SC) were significantly better than control three days after spray with lowest population of aphids 3.62 and 3.85 aphids/five flower buds compared to that in control with 7.13 aphids/five flower buds. The next effective treatments were NSKE (4.24 aphids/five flower buds), *Dashparni* (4.33 aphids/five flower buds), *Teekhasat* (4.63 aphids/five flower buds) and *Neemastra* (4.78 aphids/five flower buds). After seven days of first spray, Fipronil (3.80 aphids/five flower buds) alone was superior than control (7.24 aphids/five flower buds), but the other treatments were also effective than control though was non-significant.

Second spray

The data as presented in Table (6) shows that the mean population of aphids was non-significant among pre-treatment populations (5.81 to 8.25 aphids/five flowers buds). After the spray, it was observed that Fipronil (0.3% GR), Spiromesifen (240 SC), NSKE (5%) and *Dashparni* (10%) were significantly superior than control 1, 3 and 7 DAS. Three days after spray the population of aphids was recorded the lowest in Fipronil (0.3% GR) with 2.62 aphids/flower buds, followed by that in Spiromesifen (240 SC) with 3.05 aphids/flower buds, NSKE (5%) with 3.35 aphids/flower buds and *Dashparni* (10%) with 3.44 aphids/flower buds. However the next effective treatments were observed for *Teekhasat* (5.21 aphids/flower buds) and *Neemastra* (3%) (5.83 aphids/flower buds) that were better than control (8.06 aphids/flower buds).

Similarly 7 DAS, among the pesticides the minimum population of aphids was recorded in the treatment Fipronil (0.3% GR) with 2.75 thrips/five flower bud and followed by treatment Spiromesifen (240 SC) with 3.14 thrips/five flowers). However, the other treatments (NSKE, *Dashparni*) were also found significantly superior to control.

5. DISCUSSION

The results obtained after research under the different objectives have been discussed in the light of available literature in this chapter.

5.1 Pestiferous arthropod fauna associated with rose.

During the *Rabi* season 2020-21, the arthropod fauna associated with rose included the thrips (*Frankliniella* sp.), aphids (*Aphis craccivora* Koch, *Macrosiphum rosae* L.), rose bud caterpillar (*Helicoverpa armiger* Hub.), black fly (*Aleurocanths rosae*), and the scurfy rose scale (*Aulascaspis* sp).

First appearance of the thrips on rose was observed in last week of December. The thrips population infested the crop upto the first week of April. Thrips attained three peaks: (i) Last week of January, (ii) First week of March and (iii) First week of April with the mean population as 7.50, 8.58 and 9.80 per five flower buds, respectively. The mean atmospheric temperature and sunshine had significant positive correlation with the population of thrips, while relative humidity showed significant negative correlation. The present findings conform to the findings of Deshmukh *et al*. (2017), who reported that thrips were found in large numbers during summer and first fortnight of March. Similar reports were also made by Bukero *et al.* (2015), Hegde *et al.* (2016), Deshmukh *et al*. (2017) and Norboo *et al*. (2017). Most workers reported that the relative humidity showed negative impact on thrips population. Deshmukh *et al*. (2017) observed that maximum temperature showed positive and significant effect on thrips.

Appearance of aphids (2.24 aphids/flower buds) commenced from first week of January. It increased steadily and attained peak (17.04 aphids/flower buds) during first week of March and was recorded on rose up to first week of April. Aphid population showed a significant negative correlation with mean relative humidity, while with sunshine it had a significant positive correlation. The present findings more or less agree with the results of Hole and Salunkhe (1997). They also reported that the *Macrosiphum rosae* build-up started in third week of January and peaked during the fourth week of February. Similarly, Quratulain *et al*. (2015) observed initiation population of aphid in November and a different phase of increase at the end of February. (Miles, 1985) who observed Aphids' population were generally found on buds during periods in early autumn and spring and climatic factors was daily maximum temperatures were above 17 °C and below 30 °C.

First appearance of gram pod borer as the rose bud borer was observed in the last week of January. The pest was noted on the crop upto the first week of April. Gram pod borer larvae attained two peaks: (i) during first week of March (0.56/five flower buds) and (ii) during first week of April (0.52/five flower buds), respectively. The mean atmospheric temperature showed a significant positive correlation with the rose bud caterpillar, *Helicoverpa*; while, the mean relative humidity showed a negative correlation. Earlier, Rajkumar *et al.* (2004) and Vashisht *et al*. (2013) reported *H. armigera* as the most generally associated pest of rose crop with their population however remaining low. Gahukar (2003) reported that humidity had a significant negative relation with affected flowers and larval counts of *Helicoverpa armigera* (Hub.) on rose. Available literature on foliage or flower feeding insect pests of rose is scanty; hence, during the *Rabi* season impact of abiotic factors on *H. armigera* infesting vegetable crops has been consulted. In a field study on tomato during Rabi season, the larval population of *H. armigera* showed significant positive correlation with maximum atmospheric temperature and significant negative correlation with mean relative humidity (Khokhar *et al*., 2019), which is similar to our findings on rose.

5.2 Insect pollinators visiting rose.

The major insect pollinators on rose included members of two insect orders; Hymenoptera and Diptera. Among Hymenoptera, solitary and hive bees were recorded belonging to the families Megachilidae, Halictidae, Apidae. Among Diptera the more common families as pollinators were Syrphidae and Rhiniidae.

The activities of insect pollinators were influenced by the abiotic factors of the environment. Insect pollinator population showed significant positive correlation with mean atmospheric temperature, but with mean relative humidity it showed significant negative correlation. Similar to our observations, the population of *A. florea* and *A. dorsata* was significantly and positively correlated with maximum atmospheric temperature and negatively with relative humidity in the evening but was non-significant with wind speed (Abrol and Bajiya, 2017). In another report, the bee activity increased with temperature, but was not affected by vapour pressure (Nunez, 1977).

In our studies, Hymenoptera were the major group of pollinators that included mainly species of honey bees (68.24%) and solitary bees (12.08%); the next more common group of insect pollinators belonged to Diptera (19.55%). The diurnal pattern of the pollinators on rose flowers was recorded at 09:00 to 11:00 (51.28%), 11:00 to 13:00 (25.96%) and 15:00 to 17:00 (22.76 %) under natural conditions. Kevan *et al*. (1990) found that most insect pollinator activity on *Rosa setigera* started around 08:00 h, peaked around 11:30 h for bees, and then decreased. The peak of honeybee activity on *Rosa* spp. was earlier in the day, from 08:00 hours and 09:00 hours, with their pollen being available from around 06:30, 07:00, or 07:30 hours until 11:00 or 12:00 hours, depending on the species in temperate zones during summer season (Parker, 1926). A great diversity of insects were observed collecting pollen from rose flowers, particularly in the mid-to late mornings. Bees have been reported as the most common visitor, and are probably the best pollinators of *Rosa*, particularly. Besides, honeybees are the most common managed pollinators, and have been shown to have positive effects on many crop species (Free, 1970). Abrol and Bajiya (2017) also recorded Hymenoptera to be the most dominant visitors constituting (87.48, 88.18) per cent of the insect pollinators, followed by other insect pollinators (12.52, 11.82%). Bisht (1975) studied that the rose flowers were mostly visited by pollinating insects such as *A. florea.*

5.3 Evaluation of relative bio-efficacy of Pesticides against major sap sucking insect pests of rose.

The efficacy of two sprays of pesticides was studied against major sap sucking insects on rose during the experimental period. The first spray was given at 31st January, 2021 and the second spray at 30 days after first spray. The overall efficacy of the pesticides evaluated after second spray indicated that Fipronil (0.3% GR) to be significantly the most effective in lowering the population of thrips and aphids 3 and 7 days after the first and second sprays; while, Spiromesifen (240 SC) treatment application was the next in order of efficacy. The treatment with *Neemastra* (5%) was least effective against thrips and aphids on rose 1, 3 and 7 days after each spraying.

Similar studies on rose by many workers such as that of Rajkumar *et al* (2005) revealed that Fipronil (0.01%) was the most effective chemical and protected rose against thrips up to 15 days after treatment. Ekantaramayya *et al*. (2012) studied the efficacy of selective botanicals against *Scirtothrips dorsalis* on rose and found Neem Seed Kernel Extract (NSKE) at 2 per cent as suitable, which controlled 69.08 per cent thrips. Similarly, Prabhakar *et al* (2011) recorded NSKE was most effective in reducing thrips density to the extent of 64 to 88 per cent. Dadmal *et al*. (1999) conducted a field experiment for the management of rose thrips and reported that NSKE (5%) was significantly effective against thrips on rose.

Bio-efficacy against population of aphids, *Macrosiphum rosae* on rose indicated that Fipronil (0.3%) GR, Spiromesifen (240 SC), NSKE (5%), and *Dashparni* (10%) were significantly better than control for the management of aphids. Among these, Fipronil (0.3% GR) was most effective 1, 3, & 7 days after treatment in reducing the numbers of aphids to 2.15, 1.79 &1.85 aphids/ five flower buds; whereas, in the control it was 5.10, 5.12 & 5.85, respectively. Neem seed kernel extract against aphids, *Macrosiphum rosae* at 2 (9.67 aphids/shoot) and 5 per cent (7.67aphids/shoot), respectively (Reddy *et al*. 2002)

6. SUMMARY

The results of the investigations carried out on “Arthropod fauna associated with rose and management of the pestiferous species’’ have been summarized here below:

The collection of arthropods comprising 17 species of insects (6 pests and 11 pollinators) included the thrips (*Frankliniella* sp.), aphids (*Aphis craccivora* Koch, *Macrosiphum rosae* L.), rose bud caterpillar (*Helicoverpa armigera* Hub.), black fly (*Aleurocanths rosae* Q.), and the scurfy rose scale (*Aulascaspis* sp). The major insect pollinators on rose included members of Hymenoptera and Diptera. Solitary and hive bees were recorded belonging to the families, Megachilidae, Halictidae, and Apidae. Among Diptera the more common families as pollinators were Syrphidae and Rhiniidae during *Rabi* season 2020-21.

During the experimental period, incidence of thrips population was severe from end of December to first week of April; thereafter, population of thrips fluctuated many times and was observed to be the maximum thrice: last week of January, first week of March and first week of April, 2021 with 7.50, 8.58 and 9.80 thrips per flower, respectively. It was observed that there was a significant and positive correlation between population of thrips with the mean atmospheric temperature (r=0.832) and sunshine (r=0.583), but with mean relative humidity it showed significant negative correlation (r=-0.720).

The incidence of aphids initiated from first week of January that continued till the first week of April, 2021. Their peak population was noted in the first week of March with mean population of 17.04 aphids per flower buds. The mean population of aphids had a significant negative correlation (r=-0.581) with mean relative humidity, but with sunshine the correlation (r=0.622) was significantly positive.

First appearance of the larvae of *H. armigera* was observed in the last week of January and was noted upto the first week of April, 2021 during the crop season. The maximum population of the larvae of *H. armigera* was recorded during first week of March (0.56 larvae per flower). Correlation studies for the larval population with mean atmospheric temperature showed significant positive correlation (r=0.607); while, mean relative humidity showed significant negative correlation (r=-0.817).

Seasonal activity of insect pollinators visiting rose indicated that the maximum population of pollinators (9.00 pollinators/five flowers) was observed on 30th March, 2021, as compared to other dates of observation. The minimum population (5.00 pollinators/five flowers) of pollinator species was recorded on 21st March, 2021. The total population of pollinators showed a significant positive correlation (r=0.573) with the mean atmospheric temperature; while a significant negative correlation (r=-0.769) with relative humidity. The pollinators' diversity comprised two species of honey bees (68.24%), five species of solitary bees (12.08%) and two species of dipteran flies (19.55%). Total pollinators observed showed that maximum pollinators occurred during 09:00 to 11:00 hours (51.28%) as compared to at 11:00 to 13:00 hours (25.96%) and 15:00 to 17:00 hours (22.76 %) on rose flowers under natural conditions. The peak activity of honeybees as well as solitary bees was recorded during 09:00 to 11:00 hours.

In field testing of pesticides against sap sucking insects of rose, the treatments with Fipronil (0.3% GR) and Spiromesifen (240 SC) were significantly superior over the other treatments against thrips after three and seven days in the first spray, while in the second spray NSKE (5%) was next most effective treatment after three and seven days. Bio-efficacy of aphid population after first spray application showed that Fipronil (0.3% GR) and Spiromesifen (240 SC) were significantly superior than control three days after spray. While after seven days of first spray, Fipronil (0.5% GR) alone was better than control. After the second spray, it was observed that Fipronil (0.3% GR), Spiromesifen (240 SC) NSKE (5%) and *Dashparni* (10%) were significantly better than control 1, 3 and 7 DAS.

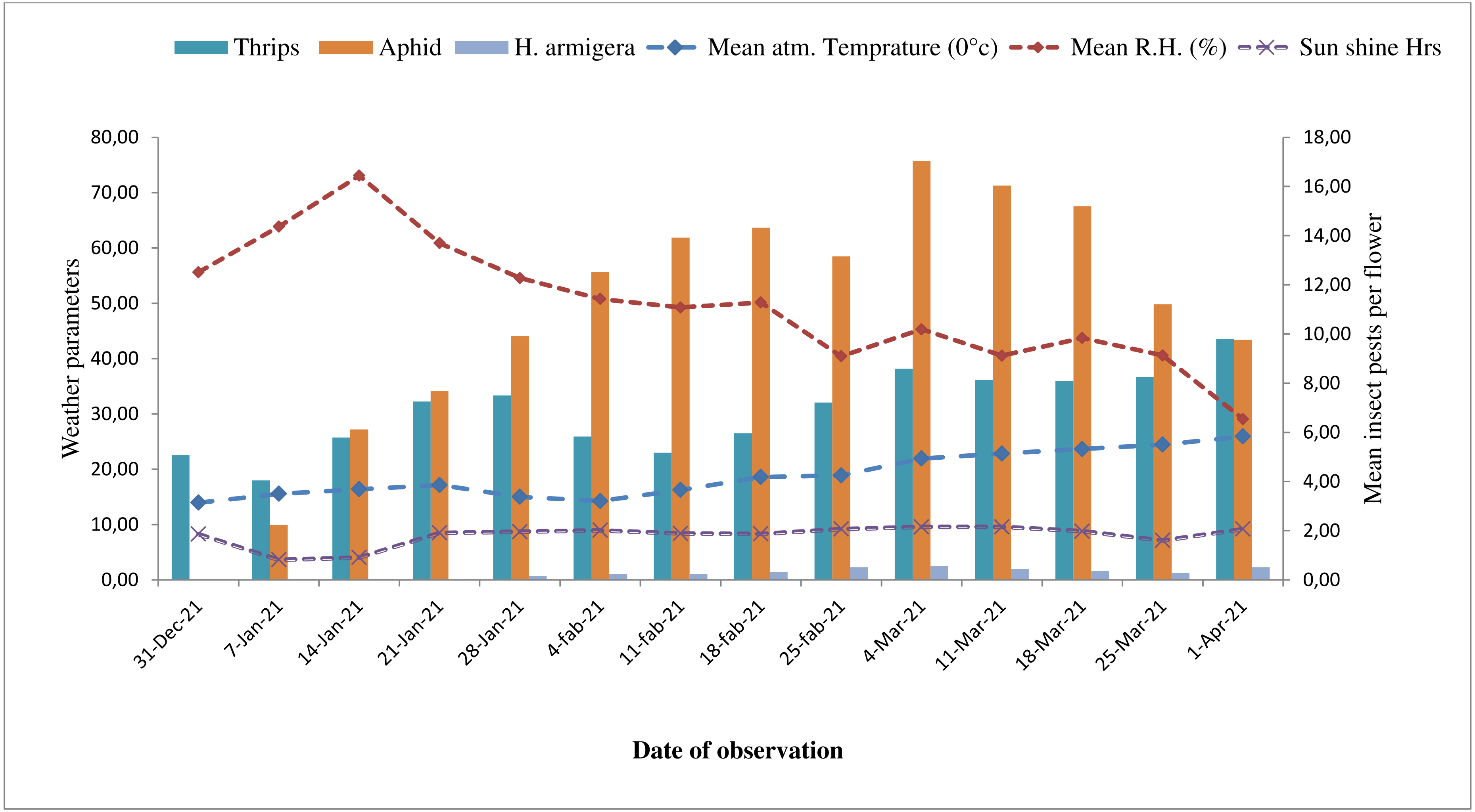


Fig.1: Seasonal incidence of major insect pests infesting rose during *Rabi* season, 2020-21

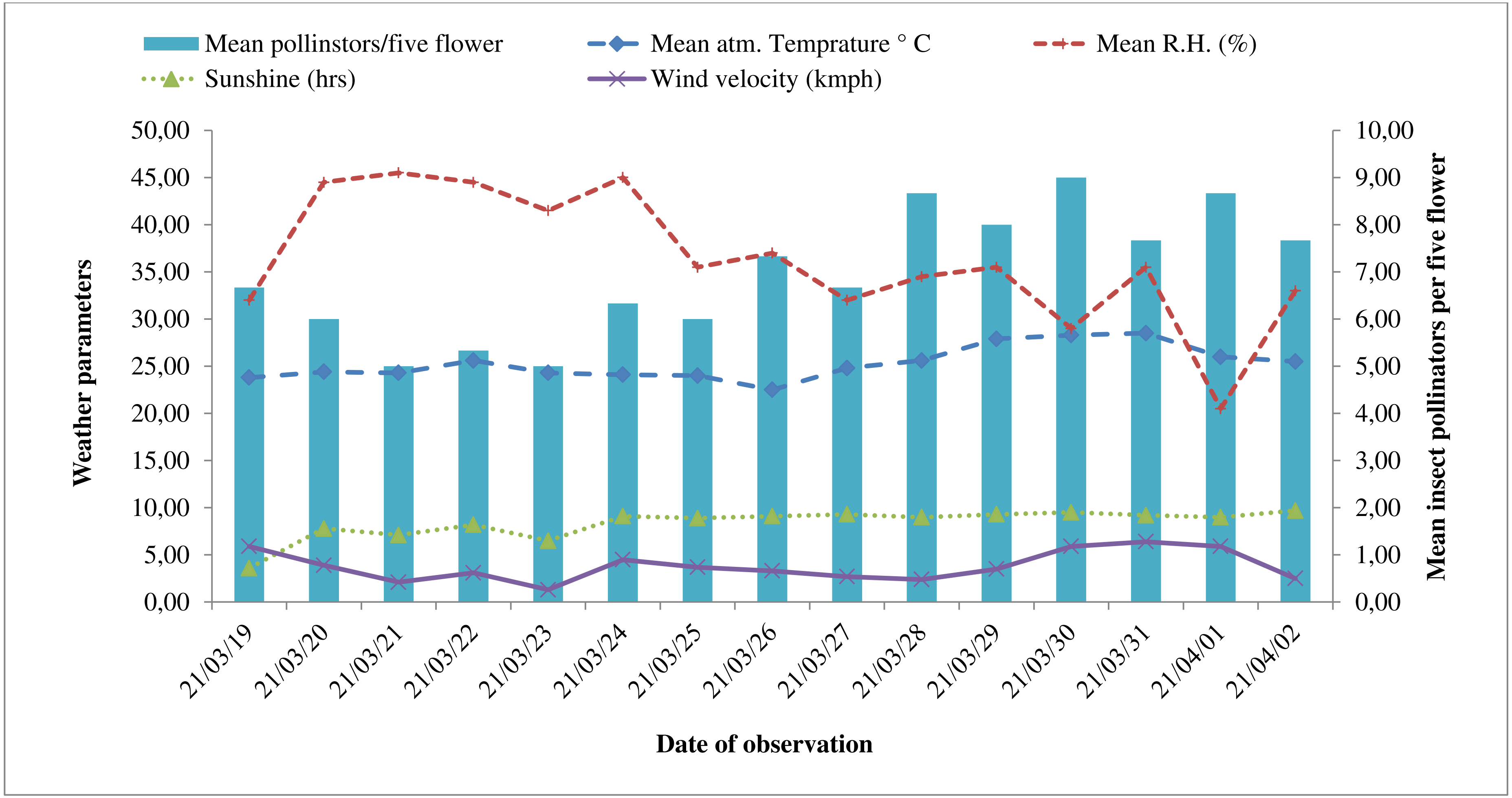


Fig.2: Seasonal activity of insect pollinators on rose during 2020-21

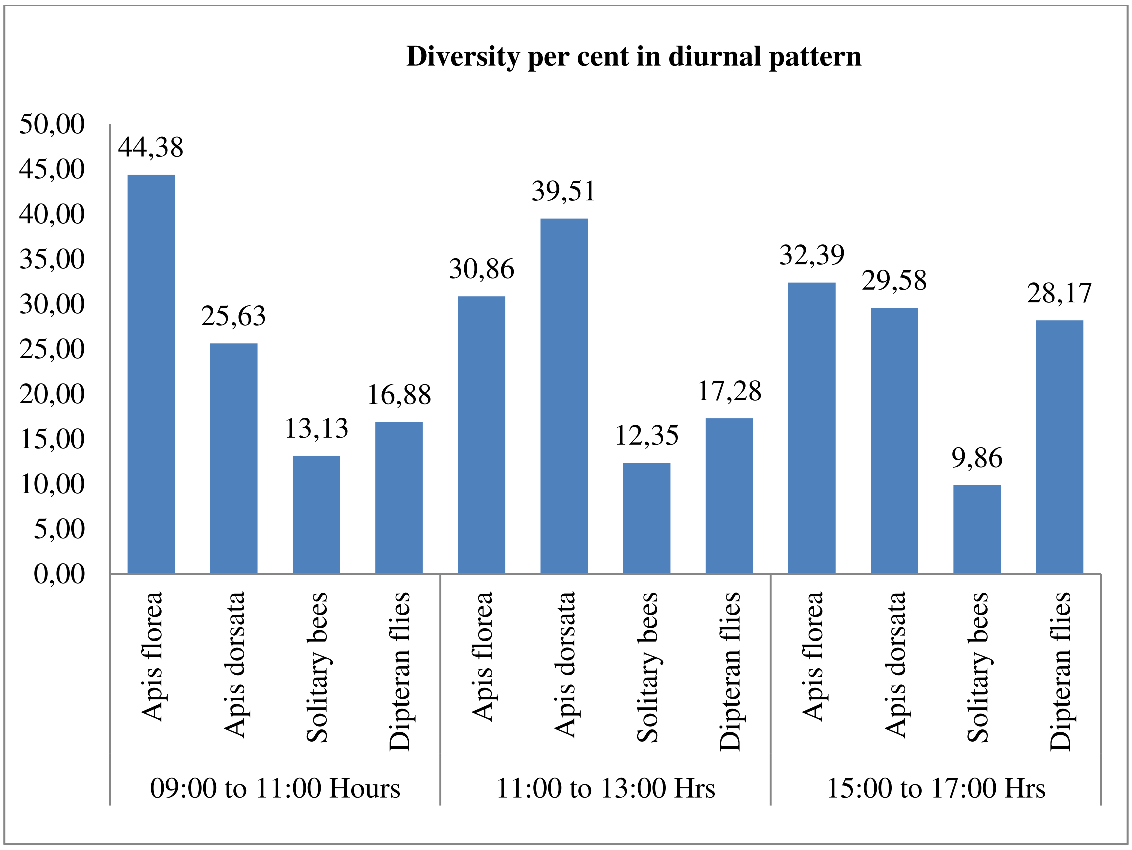


Fig. 3 Diversity of insect pollinators on rose during 2020-21

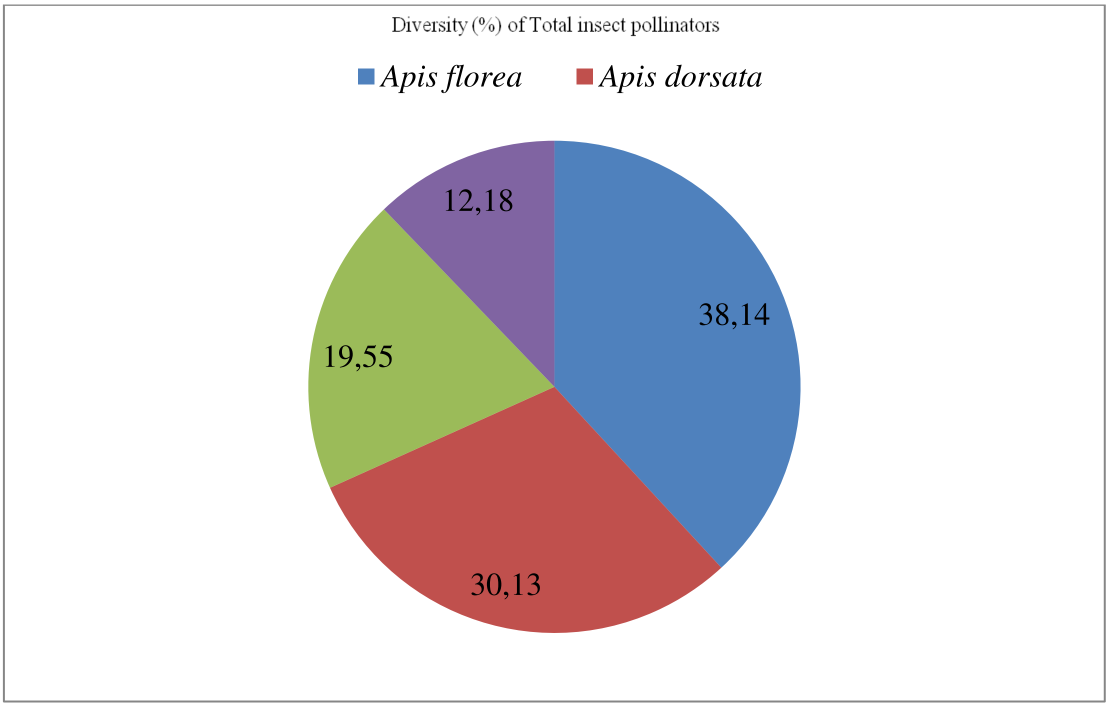


Fig.4: Diversity of insect pollinators on rose during 2020-21

Plate 1: General view of Field Experimental

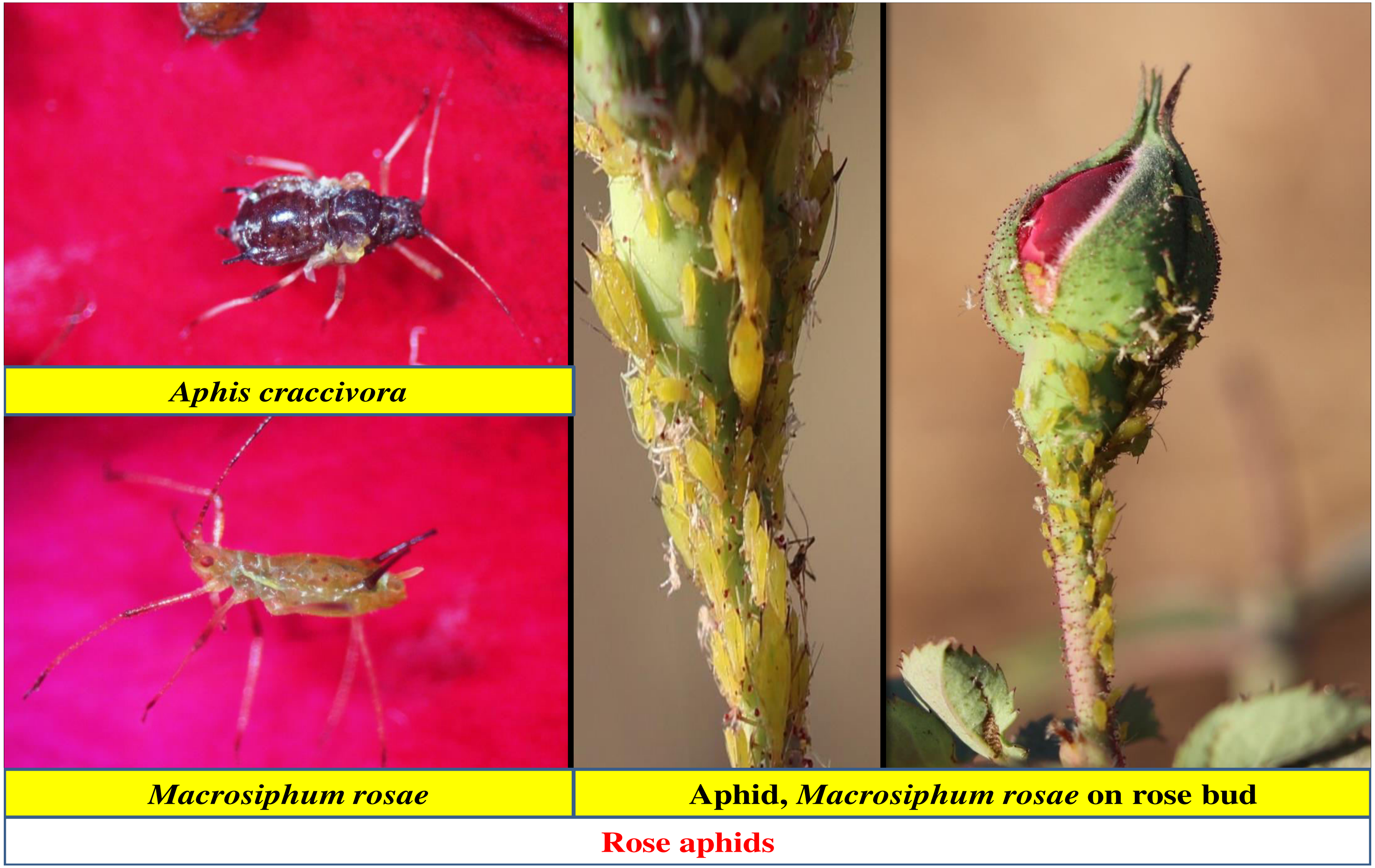
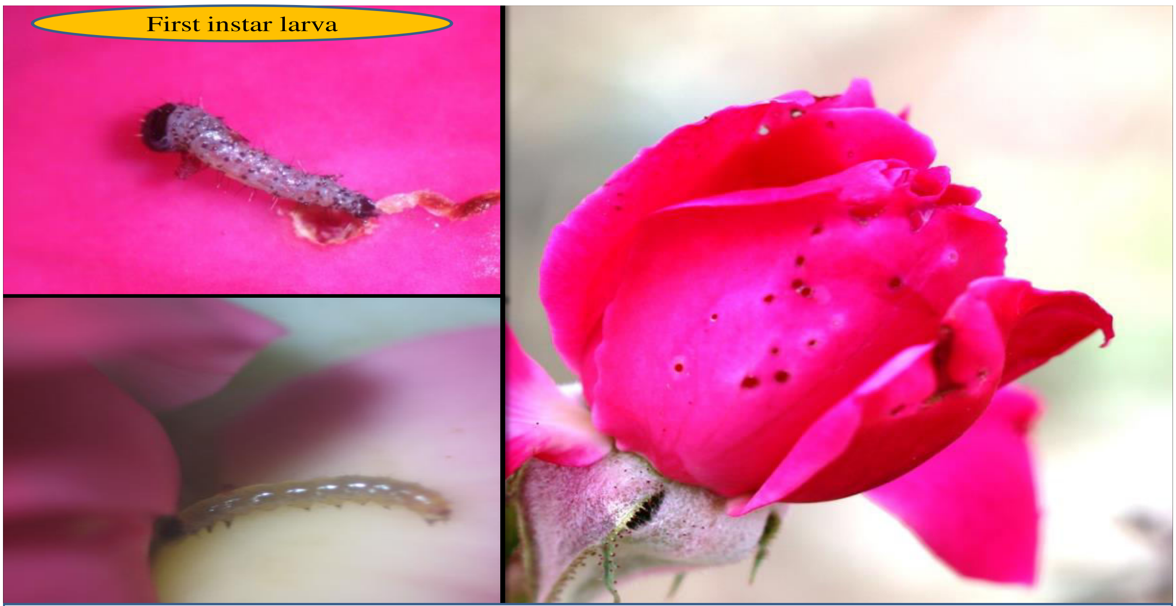


Plate 2: Insect pest of rose

Thrips and their damage flower

Black fly: *Aleurocanths rosae*

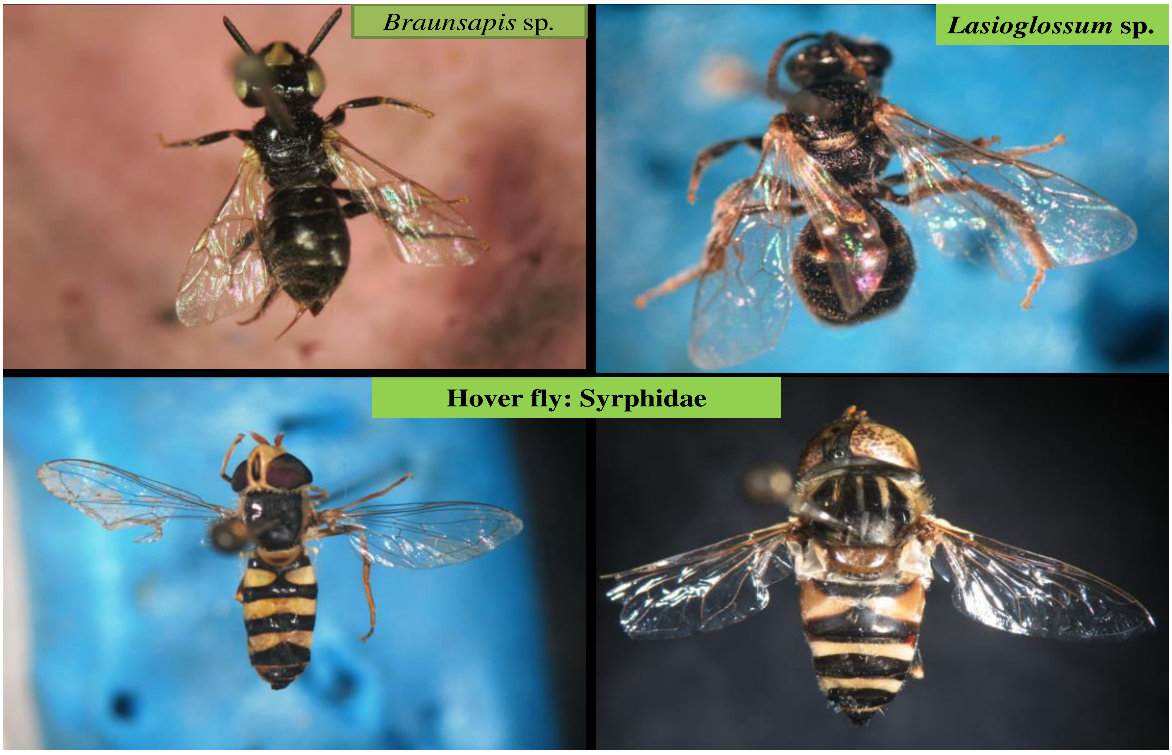
Plate 3: Insect pest of rose



H. Armigera **larvae and damage flower**

Scurfy scale insect, *Aulascaspis* sp.

Plate 4: Insect pest of rose



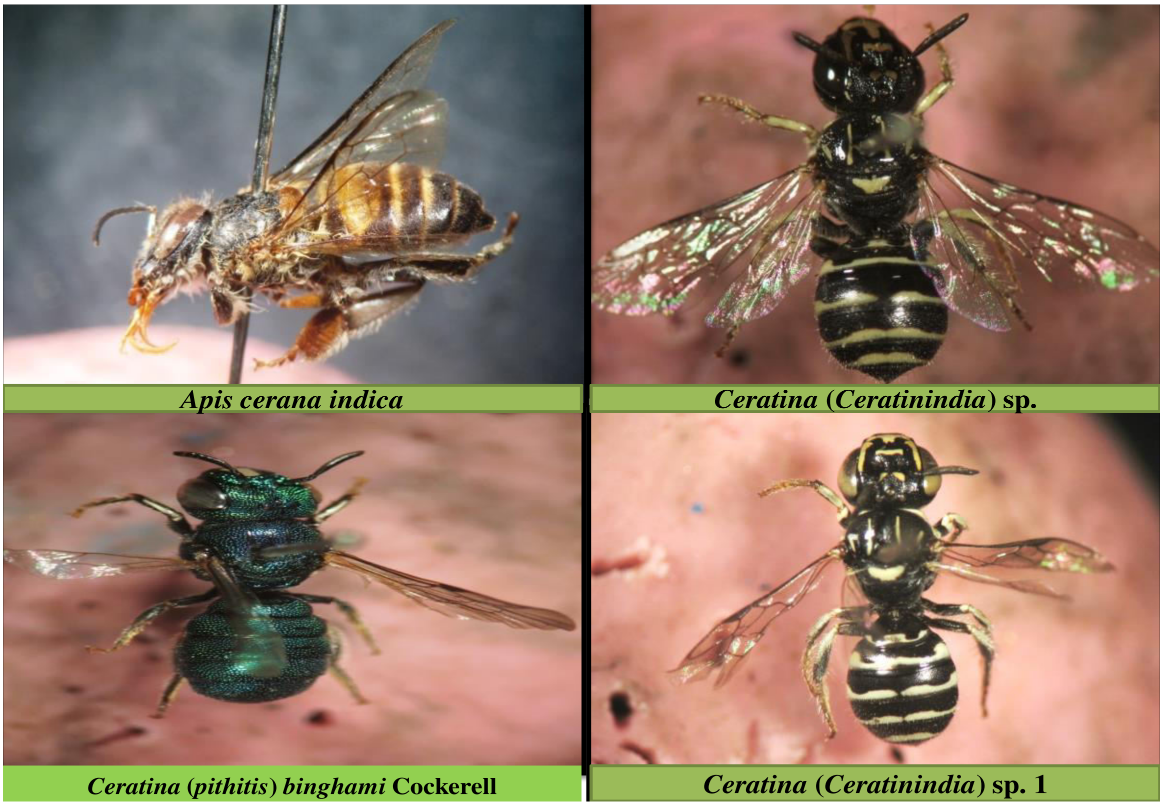
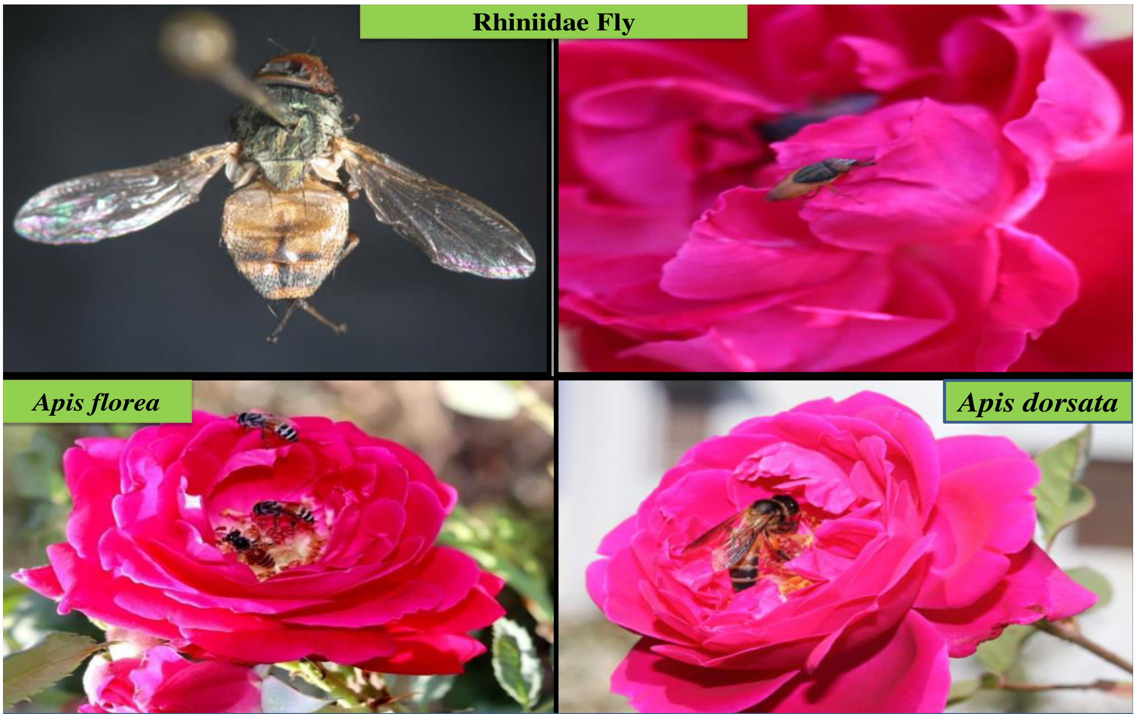


Plate 5: Insect pollinators visiting rose

Leaf cutter bee; *Megchile albifrons* (Smith) Male



Insect pollinators visiting rose

Plate 6: Insect pollinators visiting rose

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Arthropod fauna associated with rose and management of the pestiferous species

Rajendra Singh * **Dr. N. L. Dangi****
Research Scholar **Major Advisor**

ABSTRACT

Investigations on **"Arthropod fauna associated with rose and management of the pestiferous species"** were carried out at Farmer's field, Udaipur, during *Rabi* season 2020-21, with the objectives of recording the pestiferous insect and mite fauna associated with rose; the key pollinators; and evaluating the bio-efficacy of some pesticides.

The arthropod fauna associated with rose comprised 17 species of insects (6 pests and 11 pollinators) that included thrips, aphids, the rose bud caterpillar, blackflies and the scurfy rose scale. The major insect pollinators included members of Hymenoptera and Diptera. During the crop season, the peak populations of thrips, aphids and larvae of *H. armigera* were recorded in the first week of April (9.80 thrips/flower buds), first week of March (17.04 aphids/flower buds) and first week of March (0.56 larvae per flower) 2021, respectively. The mean atmospheric temperature evinced a significant positive correlation with thrips (r = 0.832) and *H. armigera* (r = 0.607); thrips (r = 0.583) and aphids (r=0.622) had a significant positive correlation with sunshine; whereas, the relative humidity indicates significant negative correlation with thrips (r = -0.720), aphids (r = 0.581) and *H. armigera* (r = -0.817), respectively. The pollinators' the total population of pollinators showed a significant positive correlation (r=0.573) with the mean atmospheric temperature; while a significant negative correlation (r=-0.769) with relative humidity. The relative density of pollinators visiting rose comprised: honeybees, *A. florea* & *A. dorsata* with (68.24%); solitary bees (12.08%) and dipteran flies (19.55%). Most pollinators preferred to visit rose flowers during 9 to 11 hours of the day.

The overall efficacy of pesticides against sap sucking insects of rose (thrips and aphids) showed Fipronil (0.3% GR) and Spiromesifen (240 SC) to be significantly superior over all the other treatments, followed by NSKE (5%) and *Dashparni* (10%) that were significantly better than control 1, 3 and 7 DAS.

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xqykc ds jl pwld dhVksa] i.kZthoh vkSj eks;yk ds f[kykQ dhVukf'k;ksa dh tSo&çHkkfork ds ckjs esa vkadyu fd;k x;k ftlesa fQçksfuy ¼0-3 th vkj½ ,oa LikbjksesflQsu ¼240 ,l lh½ dks vU; lHkh ç;qä dhVukf'k;ksa dh rqyuk esa csgn çHkkoh ik;k x;kA bZlh rjg ,u-,l-ds-bZ- ¼5 çfr'kr½ vkSj n'ki.khZ ¼10 çfr'kr½ fNM+dko ds 1] 3 vkSj 7 fnu ij vuqipkfjr D;kfj;ksa dh rqyuk esa çHkkoh ik;k x;kA

APPENDIX - I

ANOVA: Analysis of variance for effect of different treatments against thrips infesting rose in first spray during *Rabi* Season, 2020-21

Source of Variation	D. f.	PTP		
		SS	MSS	F
Treatment	6	1.9	0.3	0.2
Error	14	20.76	1.48	-

Source of Variation	D. f.	ONE DAS		
		SS	MSS	F
Treatment	6	15.6	2.6	0.8
Error	14	44.54	3.18	-

Source of Variation	D. f.	THREE DAS		
		SS	MSS	F
Treatment	6	23.6	3.9	1.5
Error	14	37.78	2.70	-

Source of Variation	D. f.	SEVEN DAS		
		SS	MSS	F
Treatment	6	24.3	4.1	1.5
Error	14	38.49	2.75	-

PTP = Pre-treatment population; DAS = Days after spray

APPENDIX - II

ANOVA: Analysis of variance for effect of different treatments against thrips infesting rose in second spray during *Rabi* Season, 2020-21

Source of Variation	D. f.	PTP		
		SS	MSS	F
Treatment	6	6.7	1.1	0.7
Error	14	22.98	1.64	-

Source of Variation	D. f.	ONE DAS		
		SS	MSS	F
Treatment	6	19.1	3.2	1.0
Error	14	43.31	3.09	-

Source of Variation	D. f.	THREE DAS		
		SS	MSS	F
Treatment	6	24.0	4.0	1.5
Error	14	37.63	2.69	-

Source of Variation	D. f.	SEVEN DAS		
		SS	MSS	F
Treatment	6	33.4	5.6	1.9
Error	14	41.33	2.95	-

PTP = Pre-treatment population; DAS = Days after spray

APPENDIX - III

ANOVA: Analysis of variance for effect of different treatments against aphids infesting rose in first spray during *Rabi* Season, 2020-21

Source of Variation	D. f.	PTP		
		SS	MSS	F
Treatment	6	1.9	0.3	0.2
Error	14	20.76	1.48	-

Source of Variation	D. f.	ONE DAS		
		SS	MSS	F
Treatment	6	15.6	2.6	0.8
Error	14	44.54	3.18	-

Source of Variation	D. f.	THREE DAS		
		SS	MSS	F
Treatment	6	23.6	3.9	1.5
Error	14	37.78	2.70	-

Source of Variation	D. f.	SEVEN DAS		
		SS	MSS	F
Treatment	6	24.3	4.1	1.5
Error	14	38.49	2.75	-

PTP = Pre-treatment population; DAS = Days after spray

APPENDIX - IV

ANOVA: analysis of variance for effect of different treatments against aphids infesting rose in second spray during *Rabi* Season, 2020-21

Source of Variation	D. f.	PTP		
		SS	MSS	F
Treatment	6	6.7	1.1	0.7
Error	14	22.98	1.64	-

Source of Variation	D. f.	ONE DAS		
		SS	MSS	F
Treatment	6	19.1	3.2	1.0
Error	14	43.31	3.09	-

Source of Variation	D. f.	THREE DAS		
		SS	MSS	F
Treatment	6	24.0	4.0	1.5
Error	14	37.63	2.69	-

Source of Variation	D. f.	SEVEN DAS		
		SS	MSS	F
Treatment	6	33.4	5.6	1.9
Error	14	41.33	2.95	-

PTP = Pre-treatment population; DAS = Days after spray

Plagiarism Report

(By Urkund Software)

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Course	:	M.Sc. (Ag.) Entomology
File name (pdf)	:	Rajendra_Singh_Ento_M.Sc._2019_RCA_152_ 2021.pdf
Title of the thesis	:	**Arthropod Fauna Associated with Rose and Management of the Pestiferous Species**
Total pages in the thesis	:	50
Assigned ID by Urkund Software	:	D
Plagiarism Level (%)	:	8%
Date	:	12/08/2021

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