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Study on succession of insect pest complex and their natural enemies in mango

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Abstract
Investigations on succession of insect pest complex and their natural enemies in mango were carried out at Horticulture Farm, B. A. College of Agriculture, Anand Agricultural University, Anand during September, 2013 to August, 2014 and September, 2014 to August, 2015. Among 14 species of insect pests that were recorded at various stages of mango crop in an overlapping manner during study period, only five insect pests *viz*., mango hopper (*Amritodus atkinsoni* Lethierry, *Idioscopus* spp.), thrips (*Scirtothrips dorsalis* Hood, *Rhipiphorothrips cruentatus* Hood), leaf gall midge (*Procontarinia matteiana* Kieffer & Cecconi), fruit fly (*Bactrocera dorsalis, B. correcta, B. zonata*) and leaf webber (*Orthaga euadrusalis* Walker) attained major status prevailing in a severe form. Nine insect pests were recorded only as stray/occasional pests during crop growth without causing any severe and perceptible damage to the crop. During the studies, a total of 06 natural enemies (spiders, coccinellids, chrysopids, dragonfly, owlfly and mantid) were found associated with mango tree at different crop growth stages. Among them, spider and coccinellids remained active throughout the year. All the insect pests were either significant or non-significant but positively associated with each other except leaf webber found negatively correlated with thrips, fruit fly, termite, spiders and coccinellids. There was highly significant positive association was established between the natural enemies *viz*., spiders and coccinellids in the mango crop ecosystem.

Keywords: Mango, insect pests**,** natural enemies**,** succession, correlation

Introduction
Mango (*Mangifera indica* L.) is an economically important fruit crop, popularly known as king of fruits. Uttar Pradesh, Andhra Pradesh, Bihar, Karnataka, Himachal Pradesh, Maharashtra, Orissa, Tamil Nadu, Gujarat and West Bengal are the major mango producing states of India and in Gujarat; Valsad, Kheda, Junagadh, Surat and Banaskantha are the known districts for cultivation of this fruit crop (Zala and Bharpoda, 2022) [13]. The popular varieties grown in Gujarat are Kesar, Rajapuri, Langra and Alphonso. In recent years, mango is gaining more and more importance in the national as well as international markets. There is a great demand for fresh fruits as well as processed products prepared from mangoes. This has created the demand for increasing the yield as well as quality of the mango fruits.

The crop is attacked by about 492 species of insects, 17 species of mites and 26 species of nematodes at the world level. Of these, 188 species of insects have been reported from India (Tandon and Verghese, 1985) [12]. Srivastava (1997) [9] reported various insect-pests *viz*., hoppers, mealybugs, gall midges, shoot gall psylla, fruit flies, fruit-sucking moth, thrips, ant, termites, grey weevil, flea weevil, leaf-cutting weevil, whiteflies, stone weevil, bark-eating caterpillar, shoot borers, stem borer, scale insects, leaf webbers and leaf miner on mango. In mango crop ecosystem, number of insect pests simultaneously occur and cause enormous damage to crop. Pest succession is very useful in identifying appropriate crop stage when ecologically sound and economically viable "Integrated Pest Management" programme may be undertaken. Such studies in crop ecosystem are important in detecting incidence of insects with regard to the crop and environment. Succession in general refers to the act of repeated occurrence of one pest by another in fixed order of cyclicity or overlapping pattern. Information on succession of different pests of a crop helps in understanding the order of occurrence of various pests and the critical period during which pest management measures are to be initiated. Studies of pest succession also provide an idea of simultaneous occurrence of insect-pests causing identical damage during particular period of crop growth so that it may be helpful in devising "Integrated Pest Management". Considering the above points in view, investigations on on succession of insect pest complex and their natural enemies in mango was carried out.

Materials and Methods

To study the on succession of insect pest complex and their natural enemies in mango, investigations were carried out at Horticulture Farm, B. A. College of Agriculture, AAU, and Anand during September, 2013 to August, 2014 and September, 2014 to August, 2015 on Kesar variety. The experiment was laid out by selecting more or less equal age (15 years) trees having similar size and canopy. The observations of different pests were recorded from three randomly selected trees from orchard at weekly interval (Standard Meteorological Week wise) from 1st week of September, 2013 (36th SMW) to 4th week of August, 2014 (35th SMW) and 1st week of September, 2014 (36th SMW) to 4th week of August, 2015 (35th SMW) (Zala and Bharpoda, 2022) [13]. The experimental trees were kept free from any insecticidal applications during the course of investigations.

Method of recording observations of different insect pests

Mango hopper

Number of nymphs and adults on a single panicle (10 cm)/inflorescence from each direction (East, West, South and North) of selected tree were visually counted during season. During off season, standard sweep net (4 sweeps /tree, one sweep in each direction) was used to sample the adult hoppers resting on tree trunk after disturbance by using net. Sweeps were made across the zone of flight of hoppers. The net was emptied after each sweep and hoppers were counted (Anon., 2012) [2].

Thrips

Ten terminal twigs from lower canopy of each of experimental tree were selected randomly for counting thrips population.

Leaf webber

The number of webs/tents formed by the pest was counted from each direction by covering the whole tree.

Leaf gall midge

On each selected and tagged trees, four leaves from terminal twig were selected randomly from each direction. On visual observations, galling index (0-5) was given by Zala and Bharpoda, 2022 [13]. To standardize the scale, 100 leaves were randomly selected and brought to the laboratory. Collected leaves were categorized into the following index looking to the per cent leaf area covered based on number of galls counted.

Galling Index

Index	Leaf area covered (%)	Average number of gall (s)	Standard deviation (±)
0	No galls (completely free)	0	0
1	20% leaf area covered	6.9	2.02
2	40% leaf area covered	16.6	1.17
3	60% leaf area covered	26.8	3.19
4	80% leaf area covered	47.9	4.38
5	More than 80% leaf area covered	129.6	5.58

Fruit fly

For recording the observations of mango fruit fly, five methyl eugenol traps were placed in mango orchard after initiation of inflorescence. From each trap, numbers of male fruit flies were recorded at weekly interval from flowering to end of mango season.

Termite

A total of five spots on ten trees of each (all four corners and at centre of orchard) were examined for termite infestation in the orchard. Number of trees with symptoms of termite out of ten trees in each spot was noted.

Natural enemies

The population of predatory spiders and coccinellids were recorded from four twigs of each selected tree at weekly interval.

Correlation Analysis

In order to determine the succession of insect pests and their natural enemies, the periodic mean incidence of the major insect pests and their natural enemies were worked out. The mean values of individual year were pooled and used for discussing pest succession. Simple correlation was worked out between various pests and their natural enemies using their weekly mean population by adopting a standard statistical procedure (Steel and Torrie, 1980) [10].

Result and Discussion

Succession of major insect pests and their natural enemies in mango

Fourteen insect pests were recorded on mango crop at Horticulture farm, BACA, AAU, Anand during study period (September, 2013 to August, 2015). Diversity and status of major as well as stray/occasional insect pests of mango are given in Table 1 and Table 2, respectively. Mango hoppers were observed mostly during September to May. Present findings are in close agreement with findings of Bana *et al.* 2018 [4] who reported that mostly, hopper population associated with new flush and flowering stage of the tree and attained peak activity during flowering cum fruit setting stage of the crop and thereafter, population started declining gradually. The incidence of thrips was observed throughout year and attained major pest status which was also reported by Bana *et al.* (2015) [3]. The findings of present investigations are more or less in close agreement of findings of Bana *et. al.* 2018 [4] who reported that thrips remained more active during vegetative (new flush) and flowering cum fruit setting stages. Leaf gall midge was observed almost throughout the year and attained major pest status by forming galls in new flush leading to defoliation of the leaf biomass and reduction of the photosynthetic activities which was also reported by Bana *et al.* 2018 [4] and Patel *et al.* 2011 [7]. Fruit flies were observed as major pest and recorded throughout the investigation period, wherein maximum catches were observed during April-July using methyl eugenol impregnated fruit fly trap which coincided with fruiting and harvesting stages of the crop. Similar findings were reported by Bana *et al.* 2018 [4] and Bana *et al.* 2017 [5]. Mango leaf webber remained active during July to December month and attained major pest status by lowering productivity due to severe webbed and dried leaves. The present findings are more or less in close agreement with findings of Kannan and Rao (2006) [6] who reported peak incidence during first fortnight of November.

Other than major pests recorded on mango crop, ash weevil, blackfly, scale insect, red ant, mealybug, stem borer, bark eating caterpillar, termite and fruit borer were observed as stray/occasional pests during crop growth without causing any severe and perceptible damage to the crop. Of these recorded

insect pests, ash weevil, blackfly and scale insect were found attacking on leaf; red ant and mealybug were found attacking on twig and fruit; stem borer, bark eating caterpillar and termite were found attacking on tree trunk/branches whereas fruit borer, *Conogethes punctiferalis* Guenée, *Deanolis* spp. were found attacking on inflorescence and fruit. More or less present findings are in close agreement with findings of Bana *et al* (2018) [4].

During the studies, a total of 06 natural enemies (spiders, coccinellids, chrysopids, dragonfly, owlfly and mantid) were found associated with mango tree at different crop growth stages (Table 3). Spider and coccinellids remained perceptible throughout crop growth and appeared as major natural enemies of insect pests of mango whereas chrysopids, dragonfly, owlfly and mantid associated with mango tree occasionally (Table 3).

Table 1: Diversity and status of major insect pests of mango at Horticulture farm, BACA, AAU, Anand during September, 2013 to August, 2015

Sr. No.	Insect pests	Order and Family	Period of major activity	Plant parts mostly damaged
1	Mango hopper (*Amritodus atkinsoni* Lethierry, *Idioscopus* spp.)	Hemiptera Cicadellidae	Sep-May	New flush/inflorescence
2	Thrips (*Scirtothrips dorsalis* Hood, *Rhipiphorothrips cruentatus* Hood)	Thysanoptera Thripidae	Throughout year	Leaf
3	Leaf gall midge (*Procontarinia matteiana* Kieffer & Cecconi)	Diptera Cecidomyiidae	Throughout year	Leaf
4	Fruit fly (*Bactrocera dorsalis, B. correcta, B. zonata*)	Diptera Tephritidae	April-July	Fruits
5	Leaf webber (*Orthaga euadrusalis* Walker)	Lepidoptera Pyralidae	July-Dec	Leaf

Table 2: Diversity and status of stray/occasional insect pests of mango at Horticulture farm, BACA, AAU, Anand during September, 2013 to August, 2015

Sr. No.	Insect pests	Order and Family	Plant parts mostly damaged
1	Ash weevil, *Myllocerus* spp.	Coleoptera Curculionidae	Leaf
2	Blackfly, *Aleurocanthus woglumi* Ashby	Hemiptera Aleyrodidae	
3	Scale insect, *Aspidiotus destructor* Signoret	Hemiptera Diaspididae	
4	Red ant, *Oecophylla smaragdina* Fabricius	Hymenoptera Formicidae	Twig and fruit
5	Mealy bug, *Drosicha mangiferae* Green	Homoptera Margarodidae	
6	Stem borer, Batocera rufomaculata DeGeer	Coleoptera Cerambycidae	Tree trunk/branches
7	Bark eating caterpillar *Inderbela* spp.	Lepidoptera Cossidae	
8	Termite, *Odontotermes* spp.	Isoptera Termitidae	
9	Fruit borer, *Conogethes punctiferalis* Guenée, *Deanolis* spp.	Lepidoptera Crambidae	Inflorescence and fruit

Table 3: Diversity and status of natural enemies of insect pests of mango at Horticulture farm, BACA, AAU, Anand during September, 2013 to August, 2015

Sr. No.	Natural enemies	Status/occurrence
1	Spiders	Throughout year
2	Coccinellids	
3	Chrysopids	Stray/occasional
4	Dragonfly	
5	Owlfly	
6	Mantid	

The results presented in Table 4 revealed that there was a significant positive or negative relationship between various insect pests and their natural enemies in mango ecosystem. Hoppers showed coexistence with termite, spiders and coccinellids as it was highly significantly associated with the activity of these insects (r = 0.801**, 0.899**, and 0.804**, respectively). Similarly, hopper showed positive association with thrips, gall midge and fruit fly whereas it showed highly significant negative association with leaf webber (r = -0.592**). In case of thrips, highly significant positive association was established with fruit fly (r = 461**) and termite (r = 0.404**). The positive companionship was also established between thrips and gall midge, spiders as well as coccinellids whereas negative with leaf webber. Leaf webber showed significant positive association with gall midge (r = 0.324*). The same pest, leaf webber, showed highly significant negative association with fruit fly, termite, spiders and coccinellids (r = -0.415**, -0.595**, -0.567** and 0.515**, respectively). Gall midge was significantly and positively correlated with fruit fly as it was shown from the correlation coefficient (r = 0.335*). Gall midge and fruit fly exhibited non-significant correlation with termite, spiders and coccinellids. Termite showed highly significant positive association with spiders (r = 0.816**) and coccinellids (r = 0.738**) which revealed the simultaneous occurrence and multiplication of these insect pests in mango crop. There was highly significant positive association (r = 0.894**) was established between natural enemies *viz*., spiders and coccinellids in the mango crop ecosystem [Table 4].

Bana *et al*. (2018) [4] recorded hoppers, thrips, leaf webber, gall midge, scale insects, mealybug and fruit fly as major pests of mango whereas shoot borer, stem borer, ash weevil, leaf miner, mite, red ant, semilooper, fruit borer and hairy caterpillar as minor/ sporadic levels in South Gujarat. Anant (2016) [1] studied the pest succession in mango and opined that the first major groups of insects to attack in the vegetative stage were mango leaf hoppers, leaf webber, mealy bug, leaf gall midge, leaf eating caterpillar, scale insect, black fly, slug caterpillar, gundhi bug and natural enemies recorded were- red ant, black ant, *Cotesia* spp. mantid, dragon fly, damselfly, ladybird beetle, green lace wing, predatory sting bug and spiders. However, mango leaf hoppers, leaf webber, scale insect, leaf gall midge, black fly, spider and red ant were available till the fruiting stage. The second major groups of insect pests to attack during the new shoot emergence stage were- thrips, shoot gall psylla, plant hopper, crane fly, green sting bug and leaf miner and natural enemies were recorded- platigastrid, predatory sting bug, horse fly, ichneumonid wasp and assassin bug however thrips, mealy bug and leaf miner

were observed till the fruiting stage. The third major insect attacked during the flowering stage was- tussock caterpillar, available till the flowering stage. The fourth major group of insect pests visited only in fruiting stage was- tiger moth. No much information on the association between/ among various insect pests as well as their natural enemies was available in the past literatures and therefore, present findings could not be compared and discussed in light of earlier reports. However, seasonal synchrony of coccinellids with mango sucking pests may represent an important cause of mortality of hoppers and thrips (Prabhakar and Roy, 2010) [8]. Sushil Kumar (2006) [11] reported simultaneous occurrence of the hopper, spiders and coccinellids. These findings are more or less in agreement with the present results.

Table 4: Correlation coefficient (r) between major insect pests and their natural enemies on mango (Pooled: 1st and 2nd year)

Insect pests	Insect pests						Natural enemies	
	Mango hopper	Thrips	Leaf webber	Gall midge	Fruit fly	Termite	Spiders	Coccinellids (adult)
Mango hopper	-	-	-	-	-	-	-	-
Thrips	0.119	-	-	-	-	-	-	-
Leaf webber	-0.592**	-0.208	-	-	-	-	-	-
Gall midge	0.085	0.033	0.324*	-	-	-	-	-
Fruit fly	0.167	0.461**	-0.415**	0.335*	-	-	-	-
Termite	0.801**	0.404**	-0.595**	0.048	0.262	-	-	-
Natural enemies								
Spiders	0.899**	0.213	-0.567**	0.086	0.082	0.816**	-	-
Coccinellids (adults)	0.804**	0.199	-0.515**	-0.004	-0.076	0.738**	0.894**	-

Note: * Correlation is significant at 0.05 level; ** Correlation is significant at 0.01 level

Conclusion

In nutshell, among 14 species of insects that were recorded at various stages of mango crop in an overlapping manner during study period, only five insect pests *viz*., mango hopper (*Amritodus atkinsoni* Lethierry, *Idioscopus* spp.), thrips (*Scirtothrips dorsalis* Hood, *Rhipiphorothrips cruentatus* Hood), leaf gall midge (*Procontarinia matteiana* Kieffer & Cecconi), fruit fly (*Bactrocera dorsalis, B. correcta, B. zonata*) and leaf webber (*Orthaga euadrusalis* Walker) attained major status prevailing in a severe form. Nine insect pests were recorded only as stray/occasional pests during crop growth without causing any severe and perceptible damage to the crop. During the studies, a total of 06 natural enemies (spiders, coccinellids, chrysopids, dragonfly, owlfly and mantid) were found associated with mango tree at different crop growth stages. Among them, spider and coccinellids remained active throughout the year. All the insect pests were either significant or non-significant but positively associated with each other except leaf webber found negatively correlated with thrips, fruit fly, termite, spiders and coccinellids. There was highly significant positive association was established between the natural enemies *viz*., spiders and coccinellids in the mango crop ecosystem. Thus, the strategy for the management of insect pests becomes sound and economical by incorporating the information on occurrence and pest succession.

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