IMPACT OF AUGMENTATION OF PARASITOID *ACEROPHAGUS PAPAYAE* NOYES AND SCHAUFF (HYMENOPTERA: BRACONIDAE) ON PAPAYA MEALY BUG *PARACOCCUSMARGINATUS* WILLIAM GRANARA DE WILLINK (HEMIPTERA: PSEUDOCOCCIDAE) AT KARACHI– SINDH

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خلاصہ

یہ مطالعہ دو سیٹوں کے تجربوں میں شروع کی گئے تھیں، پر ایزیٹائڈ اسیر وفگس پیپیسوائس اور شیفکے ملی بگ پر اکوکس مار جنٹس ولیمیناراڈیولنک کے آبادی پر اضافہ کے اثر کو جاننے کے لئے. انوکلیوٹ (ایک وقت) کی ایکبارہ مارچ میں تقریبا ایک ایکڑ کے پپیہ باغ میں چھوڑے گیے تھے جس میں 1000 ممیوں (پارامیٹائڈ ملی بگ کیڑے) فی 5؛10 اور 20 پودوں؛ ہر ایک کی تیز سپلکیشر کھی گئی. تجربے کے دوسرے سیٹ میں، پیر سائڈائڈ کے فی ایکڑ 10،000 ممیان کو ہر تین ماہ میں چھوڑا گیا اور مارچ سے فی ایکڑ شروع کیا گیا تھا. اضافے کے اثرات ملی بگ کو کنٹرول کرنے میں بہت مؤثر نہیں پایا گیا تھا، اس کے مقابلے میں موجودہ باغات کے قریب موجود جہاں قدرتی دشمن فیلڈ ذخائر (این ایفای آر) کو برقرار رکھا گیا تھا. تاہم ہر پانچ پلانٹس پر پریزیٹائڈ@ 1000 ممیوں کیا نوکلیوٹ (ایک وقت) ریلیز میں کچھ نقصان کار کیڑوں کو کنٹرول میں حیاتیاتیکنٹرول بہتر لگ رہا تھا. جب موسم بہار کے آغاز میں ایک وقت کی ریلیز کرنے پر، پر ایزیٹائڈ اسیر وفگس کی ضروری مقدار کو تیزی سے پالنے کے لئے ملی بگ کی آبادی شروع ہونے سے پہلے کرنا زیادہ ہفائید مند ہے. یہ پیپیا ملی بگ کے حیاتیاتی کنٹرول کے لئے بڑے پیمانے پہ کنٹرول کرنے کی سفارش کی جاسکتی ہے. اس تجربون کا اثر دیکھنے کے لئے ملی بگ کی کالونیاں، جھان پر ایزیٹائڈ اسیر وفگس کو باغاتوں میں چھوڑا گیا اور زرعی دوایوں سے ملی بگ کو کنٹرول کرنے والے باغاتوں کا موازنہ کیا گیا تھا.

Abstract

Studies were initiated in two sets of experiments, to know the impact of augmentation of parasitoid *Acerophaguspapayae*Noyes &Schauffon mealy bug *Paracoccusmarginatus*William Granara de Willinkpopulations. In one set of experimentinoculative (one time)release was made in March in papaya orchard of about one acre area at the rate of 1000 mummies (parasitized mealy bugs)per 5; 10 and 20 plants; each in three replicates. In the other set of experiment 10,000 mummies of the parasitoid were released every month per acre from March onwards in three replicates. Impact of augmentation was found not very effective in controlling mealy bug as compared with orchards existing nearer to where natural enemies field reservoir (NEFR)was maintained. Howeverinocoultive release of the parasitoid @ 1000 mummies per five plants seemed better for biological management of the pest. More observations are needed to standardize the required doze of the parasitoid quantum for one time release atbeginning of spring season when the mealy bug started breeding at faster rate. This could be recommended to cover a wide area for biological control of the papaya mealy bug. Pest densities measured in biologically managed orchards indicated significant decrease in mealy bug densities compared with pesticides managed orchards.

Introduction

The mealy bug *Paracoccusmarginatus*William Granara de Willink,originally known from Mexico was recorded in Asia during 2008–09 (Tanwar *et al.*, 2010;Muniappan *et al.*, 2006),In Pakistan it was recorded in 2008 in Karachi (Sindh) and at Vinder (Balochistan). Daily Ibrat of 24 October 2009, reported that more than 3000 acres (about 1224 ha) of coastal areas of Sindh (DarsanoChanno, Memon Goth, Kathore, DehDimloty and other places were completely destroyed by this insect and about 400,000 trees were uprooted by the farmers. In the current survey in 2014 it was found most common on papaya and other economic plants (banana, guava, vegetables, ornamental plants such as *Plumeria*, rose of China, weeds *Abutilon*, etc.) at altitude between 1-8m in Karachi up to Thatta. (Baber *et a*l., 2015).

Successful introductionsin the near past were made of three Encyrtid parasitoids namely Anagyrus*loecki*Noyes, *Pseudleptomastixmexicana* Noyes & Schauffand *Acerophaguspapayae* Noyes & Schauffin Guam, Palau, Florida, Hawaii, India and Sri Lanka (Muniappan 2010; Muniappan *et al*., 2006 and Meyerdirk *et al*., 2004). Prior to decide for introductions of above mentioned parasitoids in Pakistan survey was conducted in 2014 in Karachi to know the the status of natural enemies already associated with this mealy bug in the area. In this survey a parasitoid *Acerophaguspapayae*and coccinellid predators*Scymnus*sp and

Brumoidessuturalis(Fabricius),were found associated with this mealy bug species. So instead of takingattempts for classical biological control decision was made to study the possibility of maximizing biological control of the mealy bug through conservation and augmentation of already existing natural enemies in the environment (Baber *et a*l., 2015). The experiments were conducted to know the impact of inoculative(one time at beginning of seasonal activity of the pest) and inundative(periodic)releases of parasitoid *A.papayae*on mealy bug densities. Results of these studies are reported here.

Acerophaguspapayae Noyes and Schauff, Anagyrus loecki Noyes and Pseudleptomastixmexicana Noyes and Schauff

Acerophaguspapayae Noyes and Schauff, Anagyrus loecki Noyes and Pseudleptomastixmexicana Noyes and Schauff

Materials and Methods

Survival of *Acerophaguspapayae*in mummies exposed in field in different months

The study on survival of *Acerophaguspapayae* in mummies exposed in field was conducted at three locations in Karachi atMemon Goth, DarsanoChanno and Landhi during 2016. Once a month at each locality fresh formed 100 mummies were pasted on filmy layer of glue on cards of size 3.81x6.35 cm. Three such cards were tied under leaf of papaya ineachlocality. After 10 days of field exposure, the cards were removed and the condition of mummieswere observed. The mummies recovered on each card were counted and examined if they were dry, or had the holes indicating emergence of the parasitoid. Percentage survival was calculated on the basis of mummies recovered with emergence holes.

Impact of inoculate release of *A. papayae to*controlmealy bug

The parasitized host mummies produced in the laboratory on potato sprouts were pasted on cards and releasedin March by tying cards under papaya leaves in papaya orchardsof aboutone acre area @ 1000 mummies per 5 plants (total 200,000) in three replicates at DarsanoChanno;per 10 plants (total 100,000) in three replicatesatKathoreand per 20 plants (50,000) in three replicates at Landhi. Monthly observations for mealy bug dense colonies were counted per 50 papaya leaves at random.To determine parasitismmealy bug developmental stages (2^{nd} –3^{rd}instar nymphs), were counted on 5 infested leaves and then they were kept in jars for a week at room temperature (25-26 degree Centigrade). Mummies formed were separated and counted to calculate parasitism percent.

Impact of inundative release of *A. papayae* in controlling mealy bug

From March onwards monthly release of 10,000 mummies (total 100,000)of the parasitoid was made on one acre papaya orchard in three replicates at Kathore. Populations of mealy bug dense colonies and parasitism was determined as stated above.

Comparison of population trends of parasitoid and the mealy bug at unsprayed orchard 1 km from NEFR and pesticides managed orchard at distance of about 30 km from NEFR

Observations were made from March to December on population trends of parasitoid and the mealy bug colonies in pesticides free orchard at natural enemies field reservoir (NEFR)at Memon Goth and pesticides sprayed orchard at 30 km at Saakran to know the behavior and status of mealy bug in pesticides managed orchard and biologically managed papaya orchard.

Results

Known natural enemies associated with papaya mealy bug

At NEFR not only the parasitoid *A. papayae* was produced from the farm debris the general predators namely *Chrysopacarnea* Stephens, *Brumoidessuturalis*(Fabricius),*Menochilussexmaculatus*(Fabricius),*Scymnuscoccivora*Ayyar, *Stethorusgilvifrons*(Mulsant),*Stethoruspauperucul*sWeise *and Coccinellaseptempunctata*(L.) also developed in thousandsthat were dispersing from here in the environment. So all these became abundant and were seen feeding on mealy bug colonies in papaya orchards nearer to NEFR.

Survival of *Acerophaguspapayae*in mummies exposed in field in different months

Method of releasing mummies pasted on cards worked good. Survival of the parasitoid in mummies exposed in field was above 90% for most of the year (Table 1) at all the places in Karachi. The survival was relatively lesser in April –May when day temperatures were comparatively high.

Table 1 Survival of *A.papayae* in 300 mummies exposed for 10 days in field in different monthsat Karachi

Month	Memon Goth		Darsano		Landhi	
	Mummies recovered on cards after field exposure	Percentage survival	Mummies recovered on cards after field exposure	Percentage survival	Mummies recovered on cards after field exposure	Percentage survival
Jan	136	96.32	148	93.91	129	96.67
Feb	151	92.71	138	93.47	98	96.93
Mar	138	94.92	100	94.00	129	96.89
Apr	123	80.48	129	79.84	156	76.28
May	119	82.35	154	80.51	128	82.81
Jun	167	97.60	177	95.48	138	94.92
Jul	144	95.13	126	93.65	148	95.94
Aug	118	98.3	125	95.2	104	97.1
Sep	124	96.7	99	96.9	98	95.9
Oct	141	94.32	147	91.83	123	92.68
Nov	114	93.80	129	87.50	118	82.20
Dec	159	89.30	103	88.34	194	86.59

Impact of inoculative release of *A. papayae* on mealy bug populations

At DarsanoChanno parasitoid was found active at all population levels of the host mealy bug in orchards where parasitoid release was based per 5 plants. Two peaks of parasitism were observed one in June and second in September (Fig.1). Maximum parasitism recorded was 25.68% in September(Fig. 1). This rate of parasitism was almost two times higher than what was observed in pesticides managed orchard (Fig.4). Dense mealy bug colonies recorded remained low but were relatively more between March and Julywith slight increase in May and then after their numbers got down with increase in parasitism afterward (Fig. 1).The population trends of mealy bug and the parasitoid were almost the same at the orchards where 1000 mummies were released per 10 plants at Kathoreand 20 plants at Landhi.

Impact of inundative release of *A. papayae* in controlling mealy bug

Monthly inundative release of the parasitoid had comparatively better impact than inoculative release of the parasitoid. Parasitism was comparatively higher maximum being above 42 % compared with 25 % where only one release of the parasitoid was made (see figures 1 & 2).

Parasitoid started building up its population in March through April along with the developing population of the host mealy bug reaching its peak in May. For one or the other reason the mealy bug population reached its peak in June and the after that parasitoid seemed to catch mealy bug population as the parasitism level remained high between 20-30%. This indicates that though the parasitoid had its population regulating role the generalists had the role as well in determining population levels of the mealy bug. Comparing this with population trends of the parasitoid and the mealy bug at NEFR the parasitism remained high between 40 and 74 % throughout the year (Fig. 3) whereas the mealy bug populations were extremely low. Dense colonies of the mealy bug had almost completely disappeared and mostly scattered individuals were found (Fig.3)

Comparison of population trends of parasitoid and the mealy bug at NEFR orchard andin orchards with pesticides cover sprays

The role of NEFR was very clear in controlling mealy bug. *A. papayae*population behavior at Memon Goth looked density dependent. Parasitism was high right from the beginning of March. It kept fluctuating throughout from March to December. Two peaks of its populations were observed first being highest in July and second in October (Fig. 3). Because of high parasitism the numbers of mealy bug colonies remained extremely low. In contrast at pesticides sprayed orchard at Saakranthe parasitism was extremely low and (Fig 4) its impact in controlling mealy bug was negligible in this environment. Under weak natural control the mealy bug population remained high almost throughout the year (Fig. 4). By seeing conditions non profitable in pesticides sprayed orchard the farmer uprooted the plants (see plate 1 and 2)

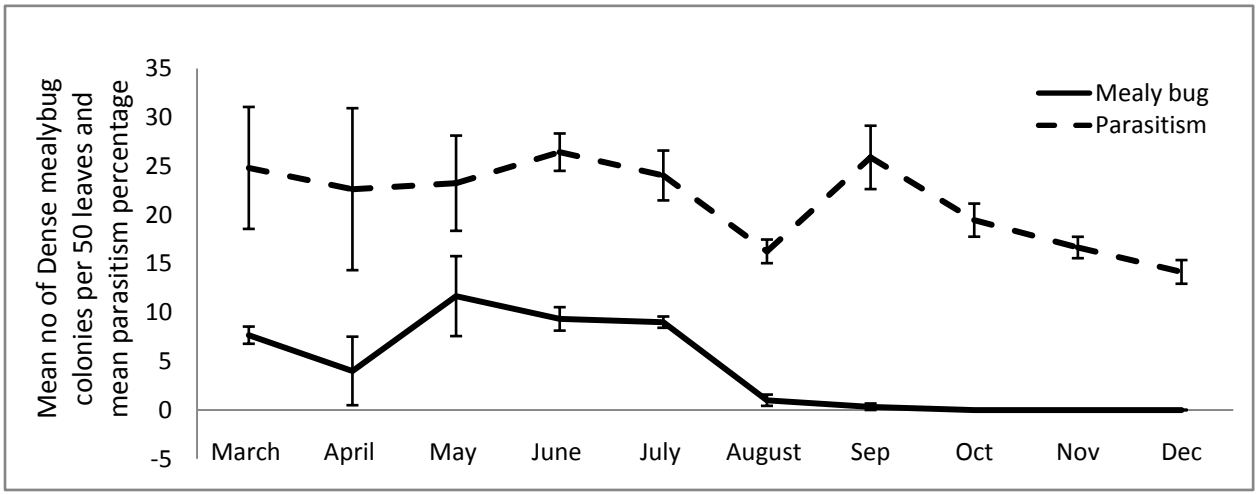

Fig.1. Population trends of parasitoid and mealy bug where a release of 1000 mummies was made per 5 papaya plant in an acre of the orchard at DarsanoChanoo

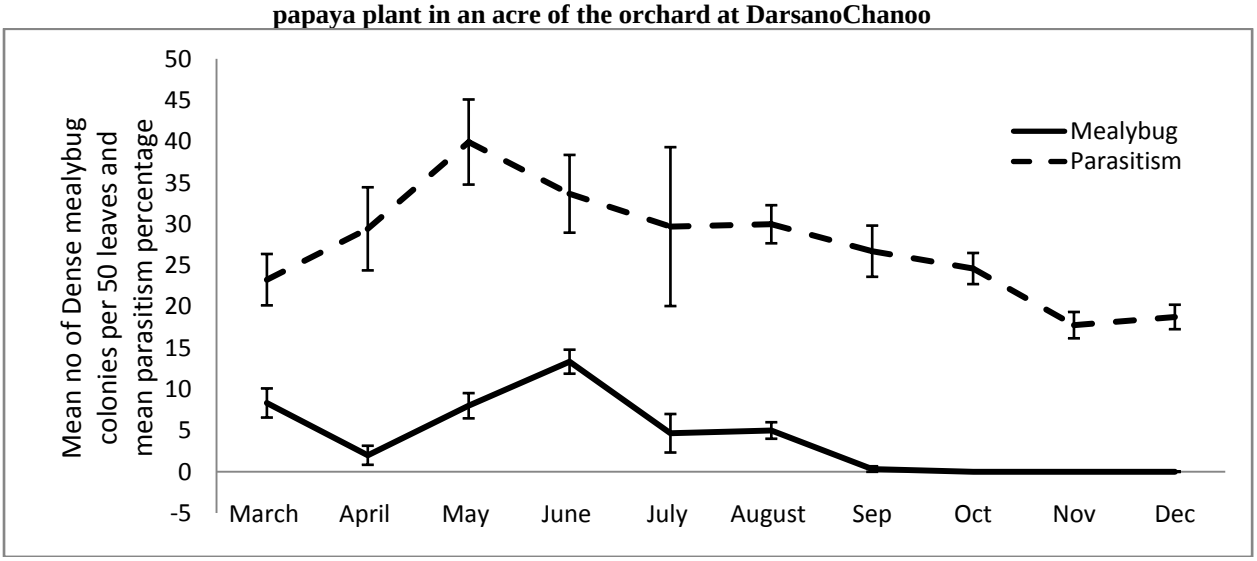

Fig.2. Population trends of parasitoid and mealy bug where release of 10,000 mummies was made per acre of the papaya orchard monthly at DarsanoChanoo

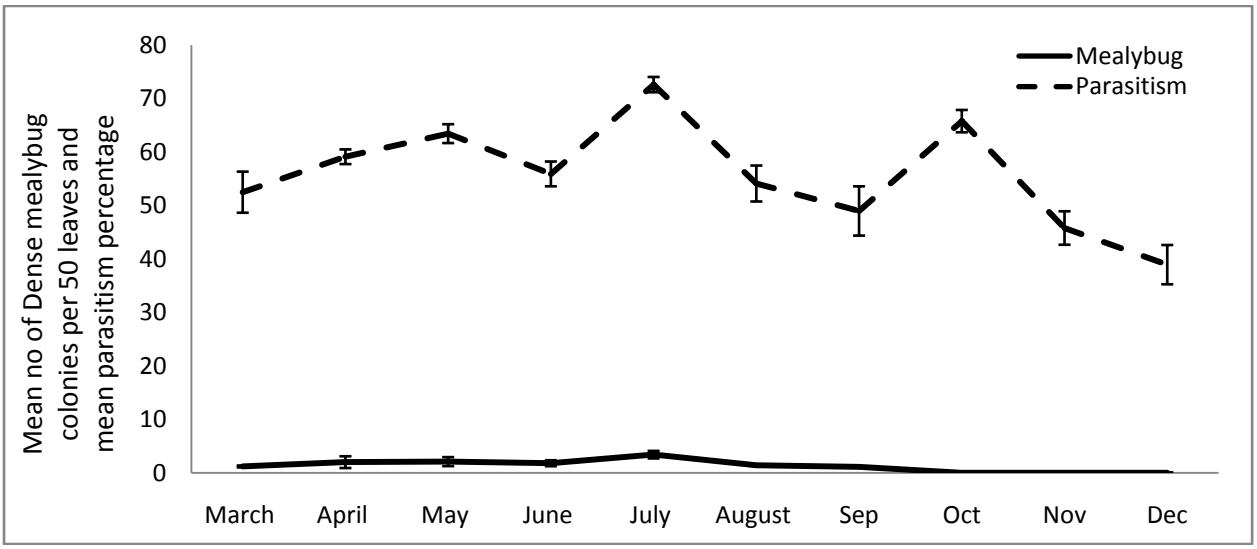

Fig.3. Population trends of parasitoid and mealy bug in NEFR orchard at Memon Goth where parasitoid and predators produced at NEFR shelter were dispersing in surrounding areas almost throughout the year

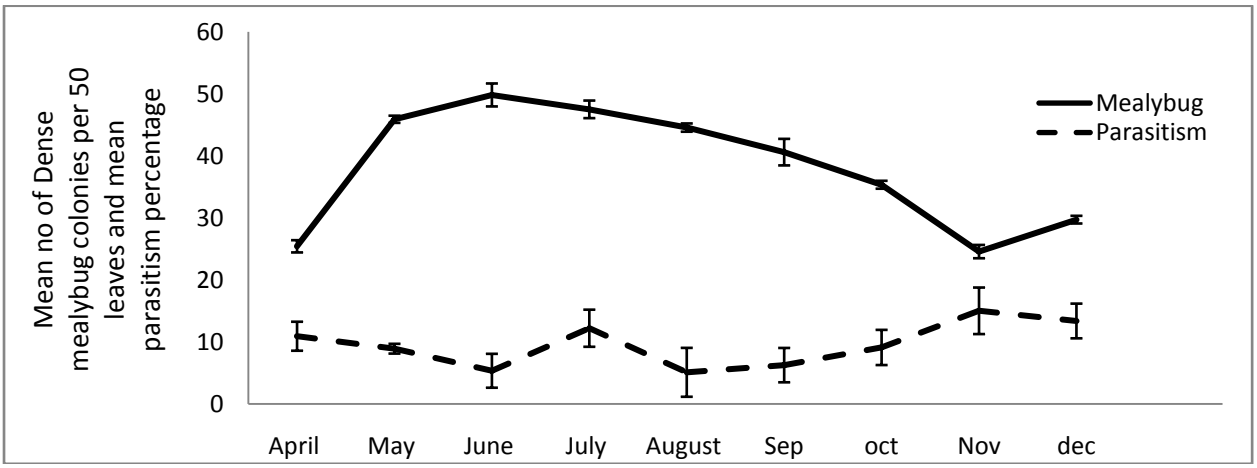

Fig 4. Population trends of parasitoid and mealy bug at pesticide sprayed farmer managed orchard at Saakran

Plate 1. Biologically managed papaya orchard at Memon Goth

Plate2. View of pesticides sprayed papaya field heavily infested with mealy bug at Saakran

Discussions

The experiment result showed that NEFR technique (Fig 3) had more effectively controlled mealy bug population and parasitism as compared to pesticide sprays (control orchards; Fig 4) is more effective results, however due to high used of pesticides sprays on farmers' field. Parasitoid population directly affected with pesticides and mealybug increased with the advantage of wax on the body of mealybug, so sprays directly not kill to mealybug. The results are in agreement with a previous study conducted by Mahmood *et al.*, (2018). In

this study NEFR technology significantly controlled the insect pests as compared to the control treatment (pesticide sprays). In NEFR, millions of natural enemies included different predators were dispersed in surrounding field and controlled associated host within a month. The better control offered by NEFR is due to production of the parasitoid, *Acerophaguspapayae,* as well as many predators are also rearing and dispersing in surrounding fields. Besides parasitoid more effective as compared predators, because parasitoid only specific against associated host.

Exercise of establishing NEFRs on farmers' fields laid down strong foundation to promote conservation biological control of pests leading to less dependence on pesticides. The farm debris carries millions of developmental stages of natural enemies therefore instead of burning, burying or putting insecticides on them or feeding them to livestock part of it can be utilized for onsite mass production of natural enemies of pests. This innovation is based on the concept of conversion of refuse into resources. There are some costs involved in construction of sheds and pots but these are only one time cost with more advantages of saving on pesticides spraying, environment protection and sustainability of pest management on area wide basis. This new idea towards pest management can be made applicable, with modifications, for a number of agricultural pests.

Experiments on impact of inoculative or inundative release of parasitoid *Acerophaguspapayae*were not very conclusive regarding its role regulating population of the host mealy bug. Inocoultive release of the parasitoid @ 1000 mummies per five plants seemed workable and at least this standard can be practiced for area wide control of the mealy bug as support to maintaining natural enemies field reservoirs for maximizing biological control of the pest.

Unilateral pesticides based protection of papaya crop needs review as was evidential on complete failure of pesticides in controlling mealy bug in papaya orchards at Saakran. The approach of safe use of pesticides or lone dependence on biological interventions is advisable at least in case of mealy bugs management. Same approach can be considered for other agricultural pests where possible.

For augmentation of the parasitoid for controlling mealy bug may supportive. Method of parasitoid release in the form of mummies pasted on cards was sufficiently good as the exposed mummies had high survival almost throughout the year in Karachi environment.

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