INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
10–333/WIB/2011/13–1–125–129
http://www.fspublishers.org

Full Length Article

Influence of different Plant Genotypes on some Biological Parameters of Cotton Mealybug, *Phenacoccus solenopsis* and its Predator, *Coccinella septempunctata* under Laboratory Conditions

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ABSTRACT

The response of different plant species on some biological parameters of cotton mealybug and of its predator *Coccinella septempunctata* was investigated. All the tested plant species affected the studied biological parameters of cotton mealybug and *C. septempunctata* significantly. Maximum mortality in 1st instar nymphs (70-90%) was induced by rose (*Rosa indica*), jatropha (*Jatropha curcus*), mango (*Mangifera indica*), ashoke plant (*Saraca indica*), niazboo (*Ocimum basilicum*) and bouginvilla (*Bougainvillea spp*); in 2nd instar nymphs (50 to 70%), by rose, jatropha, mango, niazboo and *Ficus* sp., and in 3rd instar nymphs (40-50%) by ficus, rose, jatropha and bakain. The nymphal duration was prolonged by 20-23 days, when nymphs were fed on rose, jatropha, mango, ashoke plant, niazboo, Ficus and bakain, the same was shortened (16-17 days), when nymphs were fed on peeple, gardenia, shesham, Janem, vincarosa, cotton, shoeflower and silvery. The least fecundity in cotton mealybug was recorded for rose and jatropha (100-200 eggs/ovisac/female), while it was the maximum in case of shoeflower (> 400 eggs/ovisac/female). Sterculia, niazboo, mango, ficus, rose, ashok, bakain, bouginvilla and jatropha caused maximum mortality (61-80%) in the adults of *C. septempunctata*. Life duration of *C. septempunctata* shortened (7-12 days) in case of sterculia, niazboo, mango, *Ficus* sp., rose, ashok, bakain, and bouginvilla; whereas the same was prolonged the most (16-18 days) in case of lantana, itsit, shoeflower and cotton. Sterculia, niazboo and mango, ficus, rose, ashok and bakain badly affected the consumption of *C. septempunctata* (approximately 50-70% reduction in consumption). The consumption by *C. septempunctata* increased by 81-90% of the offered nymphs (10-20% reduction in consumption) in case of lantana, itsit, shoe-flower and cotton as host plants of the prey insect. It was concluded that the host plants influenced the biology of insect pest and its predator. However, the biochemical factors influence the biology of both prey and its host need to be explored.

Key Words: Plant species; Mealybug host; Tritrophic effects; Pest; Predator

INTRODUCTION

Recently, severe infestation of the mealy bug was recorded on cotton in almost 11 out of 18 cotton growing districts of the Punjab, the main cotton growing province of Pakistan (Anonymous, 2006). The heavily infested crop dried altogether just like sprayed with a defoliator (Arif *et al.*, 2007). The attacked shoots and leaves are malformed, due to sticky honey dews produced by the pest, predisposing them to moldy growth. Heavily infested branches shrivel and drop. Damage can be as much as 90%, but occasionally (Meyerdirk *et al.*, 2001) and the attacked plants produce fewer smaller bolls. Boll opening is adversely affected and yield reduction ranges from 58–73% (Dhawan, 1980).

The only method, which is being practiced for the control of cotton mealybug in Pakistan is the chemical control (Arif *et al.*, 2007). This method not only creates health hazards and environmental pollution but is also increasing the resistance in the insects; thus disturbing the balance between the forces of destruction (predators, parasitoids & pathogens) and forces of creation (Biotic potential of pests) in agro-ecosystem (Ahmad & Khan, 1991; Hamburg & Guest, 1997; Sorejani, 1998). These well known hazards of insecticides stimulated to evaluate the alternatives of which biological control is pivotal.

In agro-ecosystem, predators or parasitoids come in contact with preys or hosts, which develop after feeding on different plant genotypes. During feeding, preys or hosts get different phytochemicals, which may affect different biological parameters of both pest and their natural enemies

To cite this paper: Sana-Ullah, M., M.J. Arif, M.D. Gogi, M.R. Shahid, A.M. Adid, A. Raza and A. Ali, 2011. Influence of different plant genotypes on some biological parameters of cotton mealybug, *Phenacoccus solenopsis* and its predator, *Coccinella septempunctata* under laboratory conditions. *Int. J. Agric. Biol.*, 12: 125–129

(Sarfraz *et al.,* 2007). Cotton mealybug is attacked by many predators in agro-ecosystem and *Coccinella septempunctata* is one of the potential predators of soft bodied insects like mealybugs. This study was carried out to evaluate the tritrophic effects of host plants on the biological parameters of cotton mealybug and its predator, C. septempunctata.

MATERIALS AND METHODS

Rearing of pest: *Phenonacoccus solenopsis* was collected from the cotton field and brought into the IPM laboratory, where its colony was cultured on stems of cotton plants with leaves in glass cages (20×30×30 cm). For this purpose, fresh stems with leaves of cotton was washed, cleaned and added to glass cages on daily basis, whereas dried stems with leaves were removed from the glass cages. The colony was maintained under control condition i.e., 25±1°C and 65±5% R.H in the rearing chamber.

Host plant: Twenty different host plants, viz, peepal (*Ficus religiosa*), jatropha (*Jatropha curcus*), silvery plant (*Alnus cordata*), niazbo (*Ocimum basilicum*), mango (*Mangifera indica*), sterculia (*Sterculia khasiana*), itsit (*Trianthema decandra*), bakain (*Melia azedarach*), shisham (*Dilbergia sisso*), shoe flower (*Hibiscus rosasinensis*), gardenia (*Grandiflora Sieb*), rose (*Rosa indica*), ashoke plant (*Saraca indica*), ficus plant (*Ficus* sp.), lantana (*Lantana camara*), vincarosa (*Catharanthus roseus*), bouginvillea (*Bougainvillea spp.*), mulberry (*Morus alba*), jaman (*Syzygium Cumini*) and cotton (*Gossypium hirsutum*) was collected from various places at the campus of University of Agriculture, Faisalabad, Pakistan and brought into laboratory, where they were washed, dried and were directly used in the experiments.

Rearing of *Coccinella septempunctata*: Adults of *C. septempunctata* were collected from wheat field and brought into Integrated Pest Management (IPM) laboratory, Department of Agri. Entomology, University of Agriculture Faisalabad, Pakistan. The collected adults of *C. septempunctata* were cultured on mealybug in glass cages. These glass cages were kept in incubator maintained at 25±1°C and 65±5% R.H. Cotton leaves along with stem infested with mealy bug were taken from the laboratory culture and were offered to adult of *C. septempunctata* in the glass cages to maintain the culture and study the tritrophic interactions.

Experimentation: The experiment was consisted of twenty treatments replicated thrice in Completely Randomized Design. Twenty 1st instar nymphs of *P. solenopsis* were taken from the culture and released in the petridishes (6 cm diameter) having three stems along with leaves (13 cm long), each of 20 collected plants. Twenty nymphs were reared on these plants up to 2nd generation and data regarding different biological parameter of *P. solenopsis*, i.e., nymphal duration of each instar, % mortality of male and female adults and fecundity was recorded. Similarly, a culture of *P. solenopsis* was maintained on twenty plants in separate jars (10×15 cm) to study the performance of *C. septempunctata*. Ten adult females, survived on each plant, were offered to male adults of *C. septempunctata* in petridish, which were, then put in a incubator maintained at 25±1°C and 65±5% R.H.

Statistical analysis: The data regarding life duration, percentage mortality and consumption of *C. septempunctata* adults and total nymphal duration, mortality of instars and fecundity of cotton mealybug were analyzed for variance (ANOVA), technique by using Statistica Package Computer software and means were compared through Tukey's HSD (Honestly Significant Difference) test after Steel and Torrie (1981).

RESULTS

Mortality in different instars of mealybug when fed on different plant genotypes: All the plants induced significant variation in the mortality of 1st, 2nd and 3rd instar of cotton mealybug. Rose, jatropha, mango, ashoke plant, niazboo and bouginvilla induced mortality in the range of 70-90%, whereas, Ficus, peeple and bakain induced mortality in the range of 50-69% in the 1st instar of cotton mealybug. However, rest of the plant genotypes induced 20-49% mortality in 1st instar of cotton mealybug (Table I).

The 2nd instar exhibited 50-70% mortality ranging from, when fed on rose, jatropha, mango, niazboo and Ficus sp., whereas, lesser than 50% mortality was observed, when 2nd instar was fed on rest of the tested plant genotypes. Similarly, Ficus caused 50% mortality in 3rd instar. Rose, jatropha and bakain caused 40-45% mortality in the 3rd instar, whereas rest of the plant species caused lesser than 40% mortality in the 3rd instar. The 1st instar was found comparatively more susceptible and 3rd instar more resistant to the plant chemicals of all tested plant genotypes (Table I).

Total nymphal duration and eggs/ovisac/female of mealybug when fed on different plant genotypes: Significant variation was observed in the nymphal duration and number of eggs per ovisac per female, when mealybugs were fed on different plant sources. The nymphal duration was prolonged by 20-23 days, when nymphs were fed on rose, jatropha, mango, ashok, niazboo, Ficus and bakain, but shortened by 16-17 days, when nymphs were fed on peeple, gardenia, shesham, Janem, vincarosa, cotton, shoeflower and silvery plant. The least fecundity in cotton mealybug was recorded in the adults females, developed from the nymphs fed on rose and jatropha (~100-200 eggs/ovisac/female). Maximum fecundity was recorded from the females, developed from the nymphs, which were fed on shoeflower (> 400 eggs/ovisac/female). The females deposited eggs in the range of 200-300 eggs/ovisac/female, when nymphs were fed on mango, ashok, niazboo and bouginvilla; whereas, 301-400 eggs/ovisac/female, when nymphs were fed on rest of the plant species (Table I).

Table I: Mortality in instar, total nymphal duration and eggs/ovisac/female of cotton mealybug, when fed on different plant genotyps

Host plants	Mortality in 1st instar (%)	Mortality in 2nd instar (%)	Mortality in 3rd instar (%)	Nymphal duration (days)	Eggs/ovisac/female
Rose	88.89± 9.62$_{a}$	63.3±5.8$_{a}$	40±1.2$_{bc}$	20±0.7$_{b}$	150±15.8$_{f}$
Jatropha	86.67± 11.5$_{a}$	55.8±2.2$_{b}$	43.4±2.9$_{b}$	21.7±0.45$_{ab}$	160±12.1$_{f}$
Mango	76.67±8.5$_{b}$	66.7± 4.4$_{a}$	35±2.3$_{d}$	23.3±1.02$_{a}$	213.3±10.8$_{e}$
Ultashok	76.38± 7.5$_{b}$	47.6± 4.1$_{cd}$	36.7±5.8$_{cd}$	21.7±1.0$_{ab}$	216.7±14.3$_{e}$
Niazboo	72.22± 9.62$_{bc}$	55.6±2.2$_{b}$	36.7±2.9$_{cd}$	21.3±0.9$_{ab}$	240±15.2$_{e}$
Bouginvilla	70.93± 7.64$_{c}$	41.1± 3.4$_{e}$	23.3± 2.9$_{ef}$	18±1.01$_{cd}$	300±20.1$_{d}$
Ficus spp	66.67±23.1$_{c}$	50±1.3$_{c}$	50± 4.2$_{a}$	20.6±0.9$_{bc}$	308.9±17.3$_{cd}$
Peeple	60 ±10$_{d}$	33.3 ±0.9$_{ig}$	25 ±2.4$_{e}$	17±0.6$_{d}$	313.3±16.7$_{cd}$
Bakain	50±12.5$_{e}$	33.3±1.1$_{g}$	40±1.8$_{bc}$	21.3±1.1$_{ab}$	337.3±14.7$_{bcd}$
Gardenia	45.83±18.2$_{ef}$	42.2±3.8$_{e}$	25±5.7$_{e}$	17.3±0.8$_{d}$	342.3±16.5$_{bcd}$
Shesham	43.88±5.36$_{fg}$	25.4±9.9$_{h}$	28.3±2.9$_{e}$	17.3±0.9$_{d}$	345±14.8$_{bcd}$
Mulbery	41.66±8.33$_{fgh}$	18.1±3.3$_{i}$	26.7± 2.9$_{e}$	18.7±0.12$_{cd}$	345.7±20.3$_{bcd}$
Sterculia	38.88± 9.62$_{ghi}$	25± 3.5$_{h}$	20± 3.6$_{f}$	19.3±0.7$_{c}$	345.3±16.7$_{bcd}$
Lantana	37.40± 14.1$_{hi}$	39.6± 3.6$_{ef}$	20± 4.3$_{f}$	18.3±1.2$_{cd}$	348.4±18.2$_{bc}$
Jamen	34.07±14.3$_{ij}$	35.5± 3.8$_{fg}$	25±2.8$_{e}$	17.3±0.4$_{d}$	350.5±22.3$_{bc}$
Vincarosa	29.70± 4.27$_{jk}$	27. 5±3.4$_{h}$	15±1.9$_{gh}$	16.7±0.8$_{d}$	360.8±19.5$_{b}$
Cotton	25±3.57$_{kl}$	17. 5±4.8$_{i}$	15 ±45$_{gh}$	17.3±0.6$_{d}$	376.6±18.7$_{b}$
Shoeflower	25± 4.21$_{kl}$	20± 1.3$_{i}$	11.1±4.8$_{h}$	17±1.01$_{d}$	424.3±20.9$_{a}$
Itsit	24±4.31$_{kl}$	44.4±10.2$_{de}$	25± 3.7$_{e}$	18.3±1.2$_{cd}$	360±23.4$_{b}$
Silvery	23.66± 12.8$_{l}$	27.5±8.9$_{h}$	15 ±3.5$_{gh}$	17.6±0.9$_{d}$	370±18.6$_{b}$

Table II: Life span, mortality and consumption of adult *C. septempunctata* fed on different plant genotypes

Plants	Life duration (Days)	Mortality (%)	Consumption (%)
Sterculia	7.67±0.42$_{i}$ (7-9)	86.6±10.3$_{a}$ (61-80)	34±2.1$_{h}$ (30-40)
Niazboo	10±0.45$_{h}$ (10-12)	84±11.3$_{ab}$ (61-80)	39±3.2$_{gh}$ (30-40)
Mango	11±0.65$_{g}$ (10-12)	82.3±10.6$_{bc}$ (61-80)	40±3.5$_{gh}$ (30-40)
Ficus sp	11.3±0.75$_{g}$ (10-12)	81.3±9.78$_{bc}$ (61-80)	40.6±4.2$_{gh}$ (41-50)
Rose	12±0.62$_{f}$ (10-12)	79.3±8.75$_{c}$ (61-80)	46±3.4$_{fgh}$ (41-50)
Ultashok	12±0.49$_{f}$ (10-12)	71.6±11.5$_{d}$ (61-80)	46.6±2.4$_{fg}$ (41-50)
Bakain	12.3±0.41$_{fh}$ (10-12)	74.6±9.12$_{d}$ (61-80)	47.3±5.1f$_{g}$ (41-50)
Bouginvi	12.7±0.75$_{f}$ (10-12)	68±8.97$_{e}$ (61-80)	54±4.3$_{ef}$ (51-60)
Jatropha	13.3±0.67$_{e}$ (13-15)	64.3±10$_{e}$ (61-80)	55.3±5.1$_{def}$ (51-60)
Silvery	14.3±0.87$_{d}$ (13-15)	55±7.58$_{f}$ (41-60)	63.6±4.7$_{cde}$ (61-70)
Gardenia	14.3±0.75$_{d}$ (13-15)	55.6±8.12$_{f}$ (41-60)	66.6±3.6$_{cd}$ (61-70)
Peeple	14.3±0.74$_{d}$ (13-15)	51.3±9.1$_{f}$ (41-60)	68.3±2.9$_{bc}$ (61-70)
Shesham	14.3±0.38$_{d}$ (13-15)	52.3±10.6$_{f}$ (41-60)	70.6±4.5$_{bc}$ (61-70)
Vincaros	15±0.58$_{c}$ (13-15)	46.6±7.5$_{g}$ (41-60)	72.6±3.9$_{bc}$ (71-80)
Mulbery	15.3±0.71$_{c}$ (13-15)	44.6±6.57$_{gh}$ (41-60)	73.3±5.1$_{bc}$ (71-80)
Jamen	15.7±0.46$_{c}$ (13-15)	41.3±7.25$_{h}$ (41-60)	74.6±2.7$_{bc}$ (71-80)
Lantana	16±0.61$_{b}$ (16-18)	36.6±6.81$_{i}$ (20-40)	80.6±3.7$_{ab}$ (81-90)
Itsit	16±0.55$_{b}$ (16-18)	37.6±8.25$_{i}$ (20-40)	80.6±4.0$_{ab}$ (81-90)
Shoeflower	17±0.34$_{a}$ (16-18)	26±6.25$_{j}$ (20-40)	80.6±3.2$_{ab}$ (81-90)
Cotton	17.3±0.45$_{a}$ (16-18)	29±7.21$_{j}$ (20-40)	87.3±4.5$_{a}$ (81-90)

The means with same letters column wise do not differ significantly

Mortality in the adults of *C. septempunctata*: Plant species showed significant variation in the mortality percentage of adults of *C. septempunctata*. A 61-80% mortality was recorded in the adults of *C. septempunctata*, when they were offered those mealybug nymphs, which were fed on sterculia, niazboo, mango, ficus sp., rose, ashok, bakain, bouginvilla and jatropha. Similarly, silvery plant, gardenia, peeple, shesham, vincarosa, mulberry and jamen caused 41-60% mortality in the adults of tertiary consumer *C. septempunctata* passively i.e., through its feeding on mealybug nymphs as fed on tertiary host plants. However, the minimum mortality (20-40%) was recorded when *C. septempunctata* adults fed on those nymphs offered with lantana, itsit, shoeflower and cotton as plant host (Table II).

Life duration and consumption of the adults of *C. septempunctata*: All the tested plant species affected the life span and consumption of adults of *C. septempunctata* passively through pest species. Life span of *C. septempunctata* was shortened by 7-9 days in case of sterculia as host plant of its prey insect (mealybug nymphs). Similarly, life duration of *C. septempunctata* was 10-12 days in case of niazboo, mango, ficus sp., rose, ashok, bakain and bouginvilla as host plants of its prey insect. Life duration of *C. septempunctata* was prolonged by 13-15 days in case of jatropha, silvery plant, gardenia, peeple, shesham, vincarosa, mulberry and jamen; whereas the same was prolonged to the most (in the range of 16-18 days) in case of lantana, itsit, shoeflower and cotton as host plants of its prey

insect (Table II).

The adults of *C. septempunctata* consumed 30-40% of the offered nymphs fed on sterculia, niazboo and mango and 41-50% of the offered nymphs, which were fed on Ficus, rose, ashoke plant and bakain. The afore-mentioned plant genotypes badly affected the predator consumption (by 50-70% reduction). However, 51-60% of the offered mealybug nymphs were consumed in case of bouginvilla and jatropha as host plant of prey insect, whereas, 61-70% of the offered nymphs were consumed in case of silvery, gardenia, peeple, and shesham by the adults of *C. septempunctata*. Therefore, these plant genotypes caused 30-40% reduction in the consumption of adults of *C. septempunctata* on mealybug nymphs. The consumption by *C. septempunctata* increased to 71-80% of the offered mealybug nymphs (20-30% reduction in consumption) in case of vicarosa, mulberry and jamen, whereas the same increased to 81-90% of the offered nymphs (10-20% reduction in consumption) in case of lantana, itsit, shoeflower and cotton as host plants of the prey insect (Table II).

DISCUSSION

In these experiments, all the tested plant species significantly affected the total nymphal duration, mortality in nymphal instars and fecundity of cotton mealybug as well as the life duration, mortality and consumption of its predators, *C. septempunctata*. These finding were highly consistent with Sarfraz *et al.* (2006, 2007) and Dhillon *et al.* (2005). The mortality of the all the instars of cotton mealybug varied significantly on all the plant species. Rose, jatropha, mango, ashok, niazboo and bouginvilla induced maximum mortality, whereas, ficus, peeple and bakain induced intermediate and rest of the tested plant species induced minimum mortality in 1st, 2nd and 3rd instar of cotton mealybug. These variations in the evaluated biological parameters of cotton mealybug may be attributed to the variations in the chemical constituents of tested plants species. Earlier reporters (Korndorfer, 2004; Goussain *et al.*, 2005; Chau & Heinz, 2006; Sarfraz *et al*., 2009) also reported the same reason for variable influences of plant species on the biological parameters of different insects.

The influence of different plant species is not limited to the second trophic level; rather it extends to the tritrophic level via prey/host insect species. The developmental and reproductive parameters of the predators/parasitoids are affected depending on the prey/host type and host plant (Vanhaelen *et al.*, 2002). The finding of these studies also depicted the same conclusion. All the evaluated plant species significantly affected the life duration, mortality and consumption of *C. septempunctata* via mealybug nymphs. The mortality in the range of 61-80% was recorded in the adults of *C. septempunctata*, in case of sterculia, niazboo, mango, ficus, rose, ashok, bakain, bouginvilla and jatropha, 41-60% in case of silvery plant, gardenia, peeple, shesham, vincarosa, mulberry and jamen and 20-40% in case of lantana, itsit, shoeflower and cotton. Life duration of *C. septempunctata* ranged from 7-9 days in case of sterculia, from 10-12 days in case of niazboo, mango, Ficus, rose, ashok, bakain and bouginvilla, from 13-15 days in case of jatropha, silvery, gardenia, peeple, shesham, vincarosa, mulberry and jamen and 16-18 days in case of lantana, itsit, shoeflower and cotton. Vanhaelen *et al*. (2002) reported that host plants (*Brassica napus* L. & *Sinapis alba* L.) had no affect on the development duration of the larvae *E. balteatus*. The variation in the results is due the fact that they have used prey species, host plant and predator species different to ours. Some prey species have the ability to degrade plant secondary metabolites and thus life of the tritrophic level is not affected; while the other prey species do not, thus the tritrophic level is affected. Similarly, the predator species respond differently to allelochemicals of plants genotypes. The adults of *C. septempunctata* consumed 30-40% of the offered nymphs, which were fed on sterculia, niazboo and mango and 41-50% of the offered nymphs, which were fed on ficus sp., rose, ashok, and bakain, 51-60% of the offered nymphs, which were fed on bouginvilla and jatropha and 61-70% of the offered nymphs which were fed on silvery, gardenia, peeple and shesham. The consumption by *C. septempunctata* increased to 71-80% of the offered mealybug nymphs in case of vicarosa, mulberry and jamen, whereas, the same increased to 81-90% of the offered nymphs in case of lantana, itsit, shoeflower and cotton as host plants of the prey insect. Hamdan and Abu-Awad (2007) reported that the average daily consumption of adult *Orius laevigatus* (Fiber) [Hemiptera: Anthocoridae] *was* higher on *B. tabaci* infesting tomato (30.44 eggs & 3.2 larvae) but lower on *B. tabaci* infesting eggplant (27.6 eggs & 2.45 larvae). These results also confirm our findings.

In conclusion, the adults of C. septempunctata were least affected by lantana, itsit, shoeflower and cotton, when were offered to nymphs of cotton mealybug as its host plants.

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(Received 29 June 2010; Accepted 23 August 2010)