



Seasonal abundance of mealybug *Phenacoccus solenopsis* (Tinsley), natural enemies on cotton and its correlation with weather factors in Jalna (Maharashtra)

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Abstract

The Cotton Mealybug *Phenacoccus solenopsis* Tinsley is invasive pest which threatening cotton cultivation. Field surveys conducted on Bt and non Bt cotton fields in eight blocks of Jalna district reveals that maximum population of mealybug observed 82.33 and 68.4 per 10 cm of apical shoot during 3rd week of October in 2013 and 5th week of September in 2014 season respectively. The maximum population of its natural enemies like, predators viz. Coccinellid, Crysoperla and Spider observed 1.77 (1st week of October), 2.11 (5th week of September), 0.68 (1st week of October) per plant during 2013 and 1.94 (4th week of September), 1.76 and 0.29 (3rd week of September) per plant during 2014 season respectively. Incidence of parasitoid (parasitized cocoons) observed to be 31% during 4th week of October (43 SMW) in 2013 and 24% during 2nd week of October (41 SMW) in 2014 season. The correlation studies indicates the population of mealybug $r=0.20$ and $r=0.62$ and parasitoid $r=0.31$ & $r=0.59$ during 2013 and 2014 season shows significant positive correlation with maximum temperature. While significant negative correlation observed between abundance of mealybug population $r=-0.13$ and $r=-0.11$ and parasitized cocoons $r=-0.41$ and $r=-0.34$ with rainfall in both the season. Weather factors particularly maximum temperature and rainfall affects the population of mealybug and its natural enemies. Cotton growers can manage this pest easily by regular close monitoring of mealybug, its natural enemies and local weather conditions.

Keywords: Mealybug, *Phenacoccus solenopsis*, Natural enemies, Bt Cotton, Correlation

1. Introduction

Cotton (*Gossypium* spp.) is one of the important commercial fiber cash crop of India and cultivated on 11.9 million hectares area having production of 398 lakh bales and productivity of 511 kg per hectare. Whereas in Maharashtra state area under cotton cultivation is about 41.92 lakh hectare with production of 84 lakh bales and productivity 341 kg lint/ ha (CCI, 2013) [8]. Cotton crop plays a significant role in sustaining the livelihood of estimated 5.8 million cotton farmers and about 60 million people depend on cotton cultivation, marketing, processing and exports (CCI, 2017) [37]. Cotton production contributes to the national economy and provides employment to large population. India is the largest producer and 2nd largest exporter of cotton in the World. India is also leading consumer of cotton and exported 116.96 lack bales cotton in 2013 to the foreign countries (CAB, 2016) [9]. To serve these demands of cotton it is necessary to increase the cotton production. The cotton production gets affected by several biotic and abiotic components. Insect pest is such one of the important impediments in cotton yield increase. In India, 162 species of insect's attack cotton at various stages of plant growth of which 15 are key pests (Kannan *et al.*, 2004) [26]. During the last decades in India and Pakistan a new pest emerged out called as cotton mealybug and caused significant yield losses.

Cotton mealybug (CMB) *Phenacoccus solenopsis* Tinsley (Hemiptera:Pseudococcidae) is an invasive pest that threatening cotton cultivation among the globe. It is polyphagous insect pest reported damaging more than 200 plants species belongs to different 55 families (Abbas *et al.*, 2005, Arif *et al.*, 2009; Vennila *et al.*, 2011; Harde *et al.*, 2018a) [5, 3, 36, 18] that includes field crops, vegetables,

ornamentals, fruit crops, medicinal and weeds. This pest sucks the plant sap from leaves, apical stems, flowers and fruits of host. *P. solenopsis* cause yield loss by directly infesting leaves, stems, flowers, fruits and also indirectly by secreting honey dew which promotes the development of sooty mold that reduce photosynthesis ultimately deprive of nutrients; honey dew attracts ants as transporting agents of the mealy bugs to different host plants (Vennila S., 2010) [35]. Cotton mealybug caused 30 to 60 per cent yield losses in cotton (Dhawan *et al.*, 2007) [12] in Panjab of Pakistan. Survey at Baroda in Gujrat 20-90% plants were adversely affected causing a reduction of 50% yield in highly infested cotton fields (Jhala *et al.*, 2008, Nagrare *et al.* 2009) [22, 26]. Infestation of *P. solenopsis* on Bt cotton was maximum in Parbhani with 40.95 percent leaf infestations and 35.77 percent green boll damage (Bhosle *et al.* 2009) [7]. Traditionally farmers rely on synthetic insecticide for the management of this pest. But synthetic insecticides constitute a great danger to the environment, health hazards to human and causes of cases of resistance development (Aubertot *et al.* 2005, Nerio *et al.*, 2009) [5, 27]. Biological control is the most important method of controlling mealybugs and under pesticide free conditions several species of predators attack *P. solenopsis* and can effectively regulate mealybug populations (Tanwar *et al.*, 2007; Gautam *et al.*, 2010; Ram and Saini, 2010) [33, 16, 29]. However multiplication of mealybug and associated insects affected with change in weather conditions. Changes in climate profoundly affect the population dynamics and the status of insect pests (Woiwod, 1997) [38]. Weather factors like temperature, relative humidity and rainfall showed positive effect on the insect biology and their incidence in fields (Dhawan *et al.*, 2009) [11]. Temperature is one of the

major environmental factors that influences survival and abundance of mealybugs (Amarasekare *et al.*, 2008; Chong *et al.*, 2008) [2, 10]. Jeyakumar *et al.* (2009) [23] observed humidity favored the multiplication of the mealybug, but the intense rainfall adversely affects the spread and reduces the intensity. Till date no details study on the seasonal incidence/ population dynamics of mealybug and its natural enemies was found in Jalna district. Therefore by keeping this view we conducted this study. This study would be helpful into farmers in formulating the effective management strategies of this pest.

2. Materials and methods

2.1. Study area

Field surveys conducted on Bt and non Bt cotton fields during 2013 and 2014 cotton season in eight blocks (Ambad, Badnapur, Bhokardan, Ghansawangi, Jafrabad, Jalna, Partur and Mantha) of Jalna district (19° 50'N, 75° 53'E) located in the Marathwada region of Maharashtra. These surveys made on farmer's field who generally grown Bt and some desi cotton. All the agronomic practices like land preparation, spacing for sowing, fertilizer application, weeding, hoeing and irrigation etc followed by farmers as per recommendations of SAU.

2.2 Sampling of Mealybug and Natural Enemies:

Two villages were selected from each block of Jalna district in which one fixed and one random plot has been selected

for pest survey. Sampling was initiated on weekly interval from July (one month after cotton sowing) to December (up to harvesting stage) at different stages of crop in each cotton season. Twenty plants randomly selected from each field for the observations of mealybug *P. solenopsis* and counted as number per 10 cm of apical shoot (Hanchinal *et al.*, 2010) [17]. Meanwhile mealybug samples collected and stored in 90% ethyl alcohol and stored in research laboratory for species identification. Population of natural enemies including predator viz. Cocclinelid, cysoperla, spider counted per plant while and parasitoids (parasitized cocoons) recorded on percent incidence. Observations of rainfall, average minimum & maximum temperature, average morning and afternoon relative humidity data recorded from mini weather station located at KVK Jalna. Correlation coefficient worked out to know the relationship between mealybug and natural enemies' population with weather parameters.

3. Results & Discussion

3.1 Incidence of mealybug

The cotton mealybug *P. solenopsis* observed throughout the cotton season in agro-ecosystem of Jalna district. It was recorded on cotton plants at different stages like vegetative, bud/square formation, flowering, boll developing, fruiting, crop harvesting stage and also up to uprooting of cotton stalk (Fig. 2A & 2B).

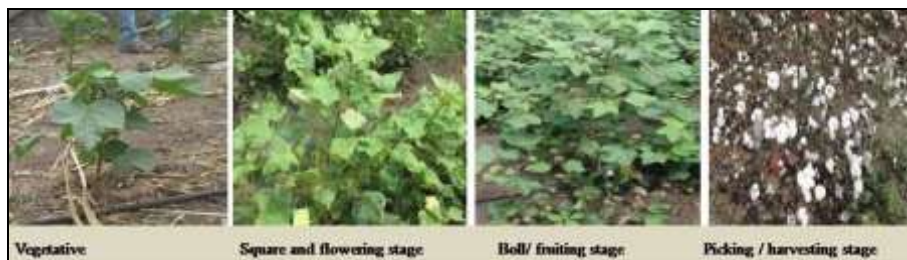


Fig 2A: Different stages of cotton crop



Fig 2B: Infestation of Mealy bug at different stages of cotton crop

The result of present study reveals that Mealybug incidence starts from July and observed up to December month. Incidence of mealybug observed in range of 1.91 to 82.33 and 0.62 to 68.4 mealybugs per 10 cm of apical shoot from July to December in both 2013 and 2014 season respectively (Tab 1). Highest population of mealybug observed 82.33 and 68.4 mealybugs per 10 cm of apical shoot during 3rd week of October in 2013 and 5th week of September in 2014 (Tab 2.) when cotton was in full flowering and boll/ fruit developed stage (Fig 3 & 4). This study shows that CMB appear just after (15-20 days)

Cotton sowing and increased gradually during August when cotton crop was in bud/square formation at fully vegetative stage (Fig. 2A & 2B) and reached to highest peak in September and October when crops was in flowering and boll developed stage. After that its incidence declines slowly up to cotton harvesting during December in both season. The similar results recorded by Singh and Kumar, 2012 [32] who reported the maximum population of mealybug during October month on both cotton and okra. They found around 188 adults/15 cm on apical shoot of cotton during peak season.

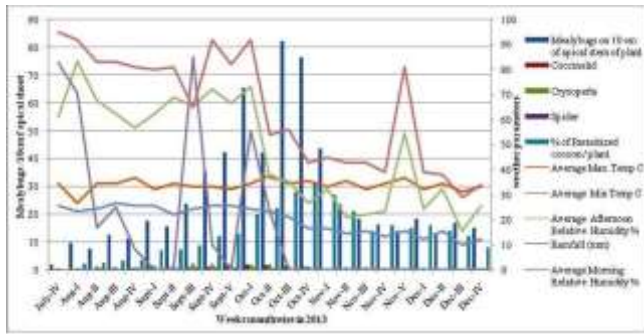


Fig 3: Incidence of Mealy bug and Natural enemies with weather parameters on cotton in 2013

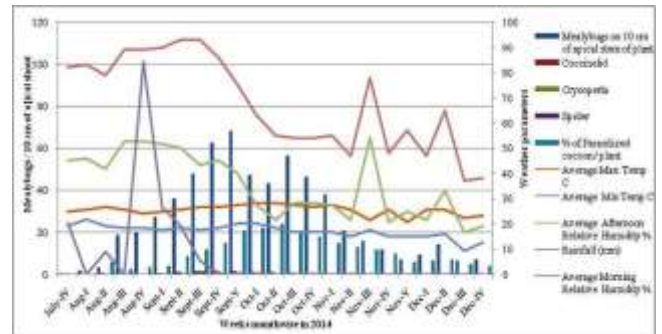


Fig 4: Incidence of Mealy bug and Natural enemies with weather parameters on cotton in 2014

Table 1: Incidence of Mealy bug & Natural enemies on Bt cotton in Jalna district in 2013

SM weeks 2013	Months	No. of Mealybugs per 10 cm apical shoot	Coccinellid	Cryosperla	Spider	% of Parasitized cocoon / plant	Average Max. Temp C	Average Min Temp C	Average Morning Relative Humidity %	Average Afternoon Relative Humidity %	Rainfall in (mm)	Stages of cotton crop
30	July-IV	1.91	0.32	0.5	0.23	0	31	23	95	55	74.6	Vegetative
31	Aug-I	9.66	0.34	0.7	0.29	2	24	21	92	75	63.6	
32	Aug-II	7.5	0.34	1.04	0.39	2.4	31	22	83	61	15	
33	Aug-III	12.5	0.41	0.81	0.32	3.1	31	24	83	56	22.5	
34	Aug-IV	11.25	0.49	0.92	0.37	3.5	33	23	81	51	7.2	Flowering and square stage
35	Sept-I	17.5	0.62	1.32	0.44	7	29	23	80	56	0	
36	Sept-II	15.5	0.79	1.66	0.46	7.4	31	20	81	62	0	
37	Sept-III	23.75	0.66	2.03	0.59	8.6	30	22	65	59	76.6	Flowering & Boll developed stage
38	Sept-IV	35.42	0.83	1.98	0.62	12	30	23	92	65	9.2	
39	Sept-V	42.14	1.32	2.11	0.66	13	29	23	82	60	0	
40	Oct-I	65.42	1.77	1.87	0.68	20	31	22	92	66	49.9	
41	Oct-II	42.14	1.6	1.86	0.46	22	34	21	54	33	21	Picking / harvesting
42	Oct-III	82.33	1.32	1.31	0.56	28	31	19	56	32	0	
43	Oct-IV	76.33	0.98	1.12	0.52	31	32	15	43	24	0	
44	Nov-I	43.5	0.43	0.56	0.32	27	30	15	45	29	0	
45	Nov-II	23.5	0.38	0.89	0.38	21	32	13	43	19	0	
46	Nov-III	18.25	0.3	0.82	0.37	14	29	14	43	20	0	
47	Nov-IV	16.26	0.29	0.69	0.31	16	31	12	39	21	0	
48	Nov-V	13.81	0.28	0.69	0.35	15	33	14	81	49	0	
49	Dec-I	18.2	0.3	0.61	0.3	16	29	11	39	22	0	
50	Dec-II	12.56	0.27	0.56	0.33	14	31	14	38	29	0	
51	Dec-III	16.75	0.3	0.5	0.29	12	28	9	29	14	0	
52	Dec-IV	15.1	0.28	0.63	0.27	8	30	11	34	23	0	
Mean	-	27.45	0.64	1.09	0.41	13.17	30.43	18	63.91	42.65	14.77	

*Mean of 20 plants

The results of present studies are in confirmatory with findings of Sharma *et al.* 2008^[31] in Marathwada region who reported mealybug incidence on cotton starts occurring during last week of July in Kharif and gradually increases up to 2nd week of September before declining during October. He further stated survey of Bt cotton field indicates maximum infestation of 30.1, 8.5 to 27.7, 6.7 to 12.4, 10.3 to 32.8 and 7.1 to 20.2 mealybug/ 2.5 cm apical shoot observed in Parbhani, Nanded, Hingoli, Jalna and Aurangabad district respectively. Hanchnal *et al.* 2010^[17] reported 0.50 and 22.42 mealybugs/10 cm apical shoot in

38th and 52nd SMW and progressively increased throughout the season. The present study shows from November onward population of mealybug declines gradually up to 15.1 and 7.12 mealybugs per 10 cm of apical stem during 4th week of December (52 SMW) in both 2013 and 2014 season respectively; in this period cotton picking mostly completed or in the last stage of harvesting. The similar results recorded on Bt cotton in Jalna by Harde *et al.*, 2018b^[19] that shows highest incidence of mealybug of 10% infested plant during 5th week of September in 2009-10 and 9% incidence during 3rd week of October in 2010-11 season.

Table 2: Incidence of Mealy bug & Natural enemies on Bt cotton in Jalna district in 2014.

SM weeks 2014	Months	No. of Mealybugs per 10 cm apical shoot	Coccinellid	Cryosperla	Spider	% of Parasitized cocoon / plant	Average Max. Temp C	Average Min Temp C	Average Morning Relative Humidity %	Average Afternoon Relative Humidity %	Rainfall in (mm)	Stages of cotton crop
30	July-IV	0.62	0.17	0.52	0.1	0	30	23	82	54	24.5	Vegetative
31	Aug-I	1.84	0.15	0.57	0.11	0	31	26	83	55	0	

32	Aug-II	3.41	0.22	0.27	0.09	6	32	23	79	50	10.8	
33	Aug-III	18.6	0.05	0.36	0.1	2.56	31	22	89	63	0	
34	Aug-IV	20.12	0.17	0.1	0.17	3.41	29	22	89	63	101.3	
35	Sept-I	27.42	0.42	0.26	0.12	4.2	30	21	90	62	32.2	Flowering and square stage
36	Sept-II	36.2	0.94	0.9	0.14	8.6	31	22	93	60	23	
37	Sept-III	48.11	1.39	1.76	1.17	12	32	21	93	52	6.6	Flowering & Boll developed stage
38	Sept-IV	62.7	1.94	1.26	0.82	15	32	22	86	54	0	
39	Sept-V	68.4	1.26	0.92	0.68	21	33	24	75	48	0	Picking / harvest ing
40	Oct-I	47.4	1.09	0.72	0.54	22	34	24	63	33	0	
41	Oct-II	43.2	0.94	0.47	0.31	24	34	22	55	26	0	Picking / harvest ing
42	Oct-III	56.4	0.62	0.78	0.22	21	33	20	54	34	0	
43	Oct-IV	46.4	0.27	0.61	0.2	18	32	20	54	34	0	Picking / harvest ing
44	Nov-I	38	0.22	0.52	0.18	15	33	20	55	33	0	
45	Nov-II	21	0.26	0.57	0.24	13	31	18	47	26	0	Picking / harvest ing
46	Nov-III	16	0.16	0.37	0.15	12	26	21	78	65	0	
47	Nov-IV	12	0.12	0.25	0.29	10	31	18	48	25	0	Picking / harvest ing
48	Nov-V	7.2	0.13	0.28	0.12	6	25	18	57	30	0	
49	Dec-I	9.4	0.13	0.32	0.12	6.4	31	18	47	26	0	Picking / harvest ing
50	Dec-II	14.2	0.13	0.25	0.1	7.2	31	19	65	40	0	
51	Dec-III	6.6	0.1	0.17	0.08	5	27	11	37	20	0	Picking / harvest ing
52	Dec-IV	7.12	0.06	0.18	0.07	4.1	28	15	38	23	0	
Mean	-	26.62	0.48	0.54	0.27	10.28	30.74	20.43	67.70	42.43	8.63	

*Mean of 20 plants

3.2 Incidence of natural enemies

In associated with mealybug some natural enemies observed in cotton crop during both seasons. Population of natural enemies including predator like coccinellids (*Coccinella septempunctata*, *Coccinella speciosa*), chrysoperla (*Chrysoperla carnea*), spiders and parasitoid in the form of parasitized cocoons (*Anaceous bambawalei* and *Promuscudia unfaeiventris*) observed in cotton fields of Jalna district from July to December. Incidence of predator viz. coccinellid, chrysoperla and spider observed in range of 0.28 to 1.77, 0.5 to 2.11 and 0.23 to 0.68 per plant in 2013 while 0.10 to 1.94, 0.17 to 1.76 and 0.07 to 1.17 per plant during 2014 season (Table 1 & 2) respectively. The maximum population of predator viz. coccinellid, chrysoperla and spider observed about 1.77 (1st week of October), 2.11 (5th week of September), 0.68 (1st week of October) per plant during 2013 while 1.94 (4th week of September), 1.76 and 0.29 per plant in 3rd week of September during 2014 when crop was in flowering and fruiting stage (Fig. 3 and 4). Incidence of parasitoid observed about 31% during 4th week of October (43 SMW) in 2013 and 24% during 2nd week of October (41 SMW) in 2014. The similar results obtained by Hanchanal *et al.*, 2010^[17] who found that maximum population of predators coccinellids, chrysoperla and spiders were 0.14, 0.13 and 0.16 per plant while parasitoid cocoons ranged between 0.52 to 20.02 per cent during 2008-09 seasons. The activity of parasitoids started during 44th meteorological week and later on increased gradually achieving its peak during 7th to 9th meteorological weeks. Coccinellids and Chrysopids are major predators of *P. solenopsis* (Gautam *et al.*, 2007; Pala and Saini, 2010; Vennila *et al.*, 2010)^[15, 28, 35]. In Pakistan predatory chrysopids have been found in abundance on mealybug (Muzammil *et al.* 2007)^[25]. The coccinellid larvae feed voraciously preferably on second instar mealybugs than third instar and adult mealybugs; the fecundity of coccinellids numerically affected by the increasing prey density (Fand *et al.*, 2010)^[13]. Tanwar *et al.*, 2007^[33] reported 20-70% mealybug mummies first time in India which formed due to parasitisation caused by parasitoid. Tanwar *et al.*, 2011^[34] reported field survey

conducted in 5 cotton growing blocks of Parabhani in Maharashtra in August, 2008 ranged between traces to 60.6%; the parasitoid samples collected identified as *A. bambawalei* and *P. unfaeiventris* based on their morphological identification. The study of Hanchanal *et al.* 2010^[17] shows highest percentage of parasitoid during 7th SMW which coincides with higher population of mealybug. Shahito *et al.* 2011^[30] reported population of predator and parasitoid positively correlated with mealybug *P. solenopsis*. Report of positive correlation between parasitoids and mealybug population was recorded from South Gujarat by (Arve 2011)^[4]. Hayat (2009)^[20] described parasitoid *Aenasius bambawalei* on *P. solenopsis* from India. Bodlah *et al.* (2010)^[6] recorded *A. bambawalei* naturally occurring on *P. solenopsis* first time on cotton and some weeds in Punjab, Pakistan. Parasitized cocoons ranged between 0.52 to 20.02 per cent. The activity of parasitoids started during 44th meteorological week and later on increased gradually to reach peak during 7th to 9th meteorological weeks. The mealybug parasitoid cocoons were positively correlated with maximum temperature ($r=0.42$) but negatively correlated with other meteorological parameters.

3.3 Correlation studies

The correlation of present studies reveals that weather factors like maximum temperature shows significant positive correlation with mealybug incidence $r=0.20$ during 2013 and $r=0.62$ during 2014 while minimum temperature shows positive correlation $r=0.06$ during 2013 and $r=0.31$ during 2014 season (Table. 3). Average morning and afternoon relative humidity shows negative correlation with population of mealybug incidence during 2013 and positively correlated during 2014. Morning and afternoon relative humidity shows negative correlation with mealybug incidence during 2013 and observed to be positively correlated during 2014. Rainfall shows negative correlation with population of mealybug incidence $r=-0.13$ and $r=-0.11$ in 2013 and 2014 seasons.

Table 3: Correlation of weather parameters with Mealybug and associated natural enemies

Weather parameters	Mealybug /10 cm of apical shoot		Coccinellid/ plant		Crysoperla/ plant		Spiders / plant		% of Parasitized cocoons	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Max Temperature	0.20	0.62	0.27	0.51	0.15	0.46	0.15	0.41	0.31	0.59
Min Temperature	0.06	0.31	0.44	0.38	0.60	0.36	0.47	0.27	-0.41	0.15
Morning R Humidity	-0.12	0.16	0.25	0.36	0.41	0.39	0.33	0.29	-0.53	-0.24
Afternoon R Temperature	-0.12	0.06	0.26	0.18	0.50	0.22	0.39	0.11	-0.55	-0.32
Rainfall	-0.13	-0.11	0.11	-0.10	0.18	-0.21	0.07	-0.13	-0.41	-0.34
Mealybug	1	1	0.78	0.82	0.46	0.70	0.68	0.69	0.81	0.82

Results of present studies are similar with results of the Hanchnal *et al.* 2010^[17] who found mealy bug population was correlated positively significant with maximum temperature (0.77) and negatively correlated with other factors. The similar results also reported by Dhavan *et al.* 2009^[11] who stated that positive correlation among the mealybugs with temperature, whereas negative correlation was observed with relative humidity and rainfall in Punjab. In previous study Harde *et al.*, 2018b^[19] found mealybug incidence shows significant positive correlation with maximum temperature ($r = 0.33$, $r=0.46$), minimum temperature ($r = 0.25$, $r=0.29$) in both season while non-significant negative correlation observed with maximum relative humidity ($r = -0.09$) during 2009-10, minimum relative humidity ($r = -0.19$, $r=-0.05$) and average rainfall ($r = -0.24$, $r=-0.16$) during both the season. The incidence and the intensity of *P. solenopsis* on cotton was found reciprocally related to the temperature conditions (Jeyakumar *et al.*, 2009)^[23] and negatively correlated with the relative humidity and rainfall (Hodgson *et al.*, 2008; Jeyakumar *et al.*, 2009)^[21, 23]. All the meteorological parameters influenced the incidence of mealy bug on cotton in all the districts studied in Faridkot district of Punjab where r-value is 0.71 in percent infestation by mealybug and 0.76 in rows infested by mealybug.

Current study indicates maximum and minimum temperature and morning relative humidity shows positive correlation with incidence of predator populations in both the season. Maximum temperature shows significantly positive correlation with incidence of parasitized cocoons $r=0.31$ & $r=0.59$ during 2013 and 2014 (Tab. 3). Morning relative humidity, afternoon relative humidity and rainfall show negative correlation with incidence of parasitized cocoons in both the seasons. Incidence of Mealybug shows significant positive correlation with population of all natural enemies (coccinellid, crysoperla, spider and parasitoid) in both the season 2013 and 2014. The results of present studies are in confirmatory with findings of Dhavan *et al.* 2009^[11] who mentioned Coccinellid predators and percentage of parasitoids as biotic factor shows strong significant positive correlation with mealybug.

4. Conclusions

This study concludes that incidence of mealybug observed highest during 2013 as compared to 2014 cotton season. Population of mealybug remains more during August to October months because of good vegetative and fruiting stage of crop and thus population of natural enemies (Predators and parasitoids) found more that reduces mealybug naturally. Weather factors particularly maximum temperature and rainfall has significant correlation with population buildup of mealybug and its natural enemies. Thus, Cotton growers can manage this pest easily by regular

monitoring of mealybug, its natural enemies and considering local weather conditions.

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6. Abbreviation

CMB: Cotton mealybug

SMW: Standard meteorological week

SAU: State Agriculture University

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