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Assessment of yield losses due to mealybug (*Phenacoccus solenopsis* Tinsley) infestation in the cotton farmers' field of south Gujarat

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Abstract

Investigation on incidence and estimation of yield losses due to mealybug (*Phenacoccus solenopsis* Tinsley) was carried out on cotton farmers' fields of South Gujarat during 2015-16 to 2017-18. Total of 21 villages of two districts were surveyed for assessment of losses due to mealybug infestation during the harvesting seasons (October to December). The average intensity of mealy bug was 9.32 and 19.93 per cent within 8.50 and 16.56% infested plants in villages of Umarpada and Olpad taluka of Surat district, respectively. Whereas it was 13.84, 16.50, 21.02 and 21.15 per cent within 12.13, 14.11, 17.33 and 17.44% infested plants in villages of Hansot, Amod, Valia and Bharuch taluka of Bharuch district, respectively. The management practices followed by farmers and the data on natural parasitism of mealybug by *Aenasius bambawalei* Hayat was also recorded in the surveyed villages which indicated per cent parasitism in the range of 6.56 to 9.21 in Olpad and 4.73 to 7.08 per cent in Umarpada taluka whereas it was 4.90 to 11.07 in Hansot, 6.79 to 13.14 in Amod, 10.53 to 14.60 in Valia and 8.00 to 12.61 per cent in Bharuch taluka. The yield loss due to mealybug was assessed based on prevalence of plants having four grade injuries and was estimated to be 0.69 to 1.49% in villages of Olpad taluka whereas it was nil in villages of Umarpada taluka. In Bharuch district, it was 0 to 0.74, 0.68 to 2.63, 1.07 to 2.44 and 1.87 to 2.97% in villages of Hansot, Amod, Bharuch and Valia taluka, respectively. Under farmers' practices, the overall loss estimated was 1.07% worth of Rs. 4800/-per ha comprising of Rs. 2800/-for seed cotton yield and Rs. 1987 for mealybug management.

Keywords: Mealybug, yield loss, parasitism, intensity, infestation

1. Introduction

Cotton is a major fibre crop of global significance useful in producing five basic products *i.e.* lint, oil, seed meal, hulls and linters. India stands first in the world cotton area and it contributes 21 per cent of global cotton produce (Patil and Tiwari, 2014) ^[11]. In Gujarat, cotton is grown in 27.08 lakh ha with production of 103 lakh bales and 661 kg/ha productivity (Anonymus 2019) ^[2]. The paradigm shift in cotton cultivation, production and protection since the advent of Bt cotton in India has changed the pest spectrum and several minor and new species of insects were emerged in the decade. The introduced species of mealybug, *Phenacoccus solenopsis* Tinsley showed predominance than the earlier known species of mealybug on cotton, *Mecaloniccocus hirsutus* which established almost in all cotton growing regions of India onwards 2007-08 and attained the regular key pest status especially in the irrigated regions. With this introduced pests also, the natural parasitoid, *Aenasius bambawalei* Hayat is established well in the region. However, the monocropping and insecticides use for sucking pests management lead to the buildup of mealybug population in the mid-season after cessation of the rain in absence of parasitoid population (Nagrare *et al.*, 2009, Desai *et al.*, 2011) ^[9, 3]. The avoidable loss in seed cotton yield due to this mealybug infestation was estimated to be 25.02 per cent (Pawar *et al.*, 2011) ^[12]. Further, to have clearer picture on loss assessment by different pests on cotton crops on farmers' fields, it has been decided to take up the systematic loss assessment study for mealybug in cotton crops. Hence, to have data on loss assessment due to mealybug infestation, three year studies were conducted through survey on farmers' fields. To ascertain the incidence and assessment of loss under farmers' interventions aided in development of the further management strategies and formulating the integrated management package emphasizing the resistance management and biodiversity conservation. Hence, investigation on incidence and estimation of yield losses due to mealybug (*P.*

solenopsis Tinsley) was carried out in harvesting seasons (September-February) on cotton farmers' fields of South Gujarat during 2015-16 to 2017-18.

2. Materials and Methods

Field visits and extensive surveys were carried out on selected farmers' fields of 21 villages in the South Gujarat comprising of six talukas of two districts (Olpad and Umarpada talukas of Surat and Amod, Valia and Hansot taluka of Bharuch district) from September to February months at fortnightly interval during 2015-16 to 2017-18 (Table 1). Preliminary information along with the plant protection measures adopted by the farmers was also collected simultaneously. For assessment of the losses due to mealybug on farmers' fields, the number of infested plant and intensity of mealybug was recorded from 100 plants by observing twenty plants from five spots of the each field. For the purpose, the selected plants were also subjected to assess the severity of infestation as under: 0: Healthy (No mealybug on any of the plant part); 1: Initiation of crawlers in any part of the plant; 2: Half stem and few branches infested; 3: More than 50 per cent of the branches infested; 4: Whole plant infested

Per cent severity of mealybug damage within tagged plants was calculated by dividing the average grade (Mean grade of twenty tagged plants) with maximum grade (4 grade) multiplied by hundred during each fortnight interval. The number of open and green bolls was counted from 5 plants from 4-grade infested plants and five healthy plants. The seed cotton yield was estimated based on weight of open and green bolls (20 each) on selected plants and converted on hectare basis and interpreted. The actual loss was worked out by comparing anticipated yield if all open and green bolls are intact and healthy and actual damage in the fields. Overall crop loss due to mealybug was estimated by weighted mean method considering cost of management, seed cotton yield and infestation level in different field.

3. Results and Discussion

Representative Fields of 21 villages comprising of 6 talukas of two districts were surveyed for studying incidence, interventions followed by the farmers and loss assessment due to mealybug damage.

3.1 Incidence of mealybug and interventions followed

The primary information collected from the cotton farmers revealed that the majority of cotton farmers sown BG II cotton hybrids with onset of rainfall at all villages except at villages of Hansot and Valia where sowing was carried out early in the month of May on account of irrigation facilities. The information collected during the survey (farmers/labourers) revealed the poor adoption of refuge, use of mixture of insecticides, over dose than recommended doses, early sowing than recommended, ignorance in identification and less prevalent of natural parasitoid and injudicious of use of recommended insecticide by less than 25 per cent respondents whereas knowledge, awareness, identification of natural enemies and use of safer insecticides and spot applications against stationary pest were followed by >35 per cent respondents.

3.2 Mealy bug infestation and parasitism

Survey visits were made during the harvesting season on the cotton farmers' fields (October-November) of Olpad and Umarpada taluka of Surat district and Bharuch, Amod, Valia

and Hansot taluka of Bharuch districts. Total of 21 villages comprising of 6 taluka of two districts were surveyed for assessment of losses due to mealybug infestation/damage.

During 2015-16, in Surat district, the intensity of mealy bug infestation was 8.70 to 13.64 (Av. 11.17) per cent within 8 to 12 (av. 10.0) per cent infested plants in Umarpada taluka whereas it was 17.65 to 28.21 (av. 23.10) per cent within 15 to 22 (av. 18.67) per cent infested plants in Olpad taluka (Table 2). Out of five fields in Surat district, the mealybug infested plants of 4 grades was noticed in three surveyed villages of Olpad taluka whereas it was nil in both the fields of Umarpada taluka. Similarly, in Bharuch districts the mealybug infested plants of 4-grades was noticed in 11 fields out of 16 surveyed fields. The average number of grade-4 plants was 2.33 per 100 plants observed in villages of Olpad taluka whereas it was nil in villages of Umarpada taluka. In Bharuch district, average intensity of mealybug infestation was 15.33, 19.32, 21.34 and 25.09 per cent within 13.00, 15.67, 17.33 and 20.00 per cent infested plants in villages of Hansot, Amod, Bharuch and Valia taluka. The average number of grade-4 plants was 0.60, 2.00, 2.00 and 3.20 plants per 100 plants in respective talukas. The parasitism of mealybug was observed to be 5.18 to 8.24 and 2.68 to 6.84 per cent in villages of Olpad and Umarpada talukas where as it was 2.0 to 16.60, 2.26 to 14.22, 5.20 to 12.33 and 4.80 to 18.80 per cent in villages of Hansot, Amod, Bharuch and Valia talukas of Bharuch district.

During 2016-17, in Surat district, the intensity of mealy bug infestation was 8.70 to 11.11 (av. 9.90) per cent within 8 to 10 (av. 9.00) per cent infested plants in Umarpada taluka whereas it was 17.65 to 26.58 (av.23.08) per cent within 15 to 21 (av. 18.67) per cent infested plants in Olpad taluka (Table 3). Out of five fields in Surat district, the mealybug infested plants of 4 grades was noticed in two surveyed villages of Olpad taluka whereas it was nil in both the fields of Umarpada taluka. Similarly, in Bharuch districts the mealybug infested plants of 4-grades was noticed in 10 fields out of 16 surveyed fields. The average number of grade-4 plants was 1.00 per 100 plants observed in villages of Olpad taluka whereas it was nil in villages of Umarpada taluka. In Bharuch district, average intensity of mealybug infestation was 10.76, 11.15, 22.14 and 22.67 per cent within 9.60, 10.00, 18.00 and 18.33 per cent infested plants in villages of Hansot, Amod, Valia and Bharuch taluka, respectively. The proportion of grade-4 plants was 0.20, 0.33, 1.67 and 2.40 plants per 100 plants in Hansot, Amod, Bharuch and Valia talukas, respectively. The parasitism of mealybug was observed to be 8.20 to 10.30 and 5.20 to 7.60 per cent in villages of Olpad and Umarpada talukas where as it was 3.20 to 10.00, 4.50 to 10.20, 8.60 to 13.20 and 9.20 to 20.00 per cent in villages of Hansot, Amod, Bharuch and Valia taluka.

During 2017-18, in Surat district, the intensity of mealy bug infestation was 5.26 to 8.70 (av. 6.98) per cent within 5 to 8 (av. 6.50) per cent infested plants in Umarpada taluka whereas it was 11.11 to 19.05 (av. 14.07) per cent within 10 to 16 (av. 12.33) per cent infested plants in Olpad taluka (Table 4). Out of five fields in Surat district, the mealybug infested plants of 4 grades was nil in Olpad and Umarpada taluka surveyed fields. Similarly, in Bharuch districts the mealybug infested plants of 4-grades was noticed in 6 fields out of 16 surveyed fields. The average number of grade-4 plants was nil in villages of Olpad and Umarpada taluka. In Bharuch district, average intensity of mealybug infestation was 16.30, 16.59, 20.07 and 20.74 per cent within 13.80,

14.00, 16.67 and 16.67 per cent infested plants in villages of Hansot, Valia, Bharuch and Amod Taluka, respectively. The proportion of grade-4 plants was 0.00, 1.00, 1.33 and 1.33 plants per 100 plants in Hansot, Valia, Bharuch and Amod talukas, respectively. The parasitism of mealybug was observed to be 6.30 to 10.20 and 6.30 to 6.80 per cent in villages of Olpad and Umarpada talukas where as it was 6.90 to 11.20, 9.20 to 20.60, 10.20 to 16.80 and 8.20 to 15.00 per cent in villages of Hansot, Valia, Bharuch and Amod talukas of Bharuch district.

The mean data of three year revealed that in Surat district, the average intensity of mealy bug infestation was 9.32 and 19.93 per cent within 8.50 and 16.56 per cent infested plants in villages of Umarpada and Olpad taluka, respectively. Whereas it was 13.84, 16.50, 21.02 and 21.15 per cent within 12.13, 14.11, 17.33 and 17.44 per cent infested plants in villages of Hansot, Amod, Valia and Bharuch taluka (Table 5). The proportion of grade-4 plants was 1.11 out of 100 plants observed in villages of Olpad taluka whereas it was nil in villages of Umarpada taluka. Out of five cotton fields surveyed in Surat district, the mealybug infested plants of 4 grades was noticed in three surveyed villages of Olpad taluka whereas it was nil in two cotton fields of Umarpada taluka. Similarly, in Bharuch districts the mealybug infested plants of 4-grades was noticed in 13 fields out of 16 surveyed fields. The average number of grade-4 plants was 0.00 and 1.11 plants per 100 plants in villages of Umarpada and Olpad talukas, respectively whereas it was 0.27, 1.22, 1.67 and 2.20 plants per 100 plants in villages of Hansot, Amod, Bharuch and Valia talukas, respectively. During the cotton season, mealy bug was noticed on alternate hosts *viz.*, wild okra, kanski, Parthenium or Hibiscus at few villages (4 out of 21 surveyed villages). Several workers studied the occurrence or dynamics of the mealybug at different locations and varieties. Dhawan and Sarika (2009) [5] recorded highest field infestation in the 30th meteorological week in Bathinda, Muktsar and Ferozepur districts and in 34th metrological week in Faridkot district. Mealybug incidence with peak activity was observed from August to November in Andhra Pradesh (Saroja *et al.*, 2009) [14]. Suresh and Kavitha (2007) [15] reported that the population density of *P. solenopsis* on cotton varied from 0 to 20 per 5cm twig, with peak population between April and May in Tamil Nadu. Dharajothi *et al.* (2010) [4] recorded mean mealybug population ranged from 6.0 to 11.8 per plant during 2008-09. Hanchinal *et al.* (2010) [7] studied the dynamics of *P. solenopsis* and reported it to be initiated from September and gradually increased as crop growth advances showing peak in the 7th meteorological week (180.42 per 10cm apical shoot).

The parasitism of mealybug (Table 5) was observed to be 6.56 to 9.21 and 4.73 to 7.08 per cent in villages of Olpad and Umarpada talukas, respectively where as it was 4.90 to 11.07, 6.79 to 13.14, 10.53 to 14.60 and 8.00 to 12.61 per cent in villages of Hansot, Amod, Valia and Bharuch talukas, respectively. The parasitism of *P. solenopsis* infesting cotton was 15.88 to 40.08 per cent during October-November, 2008 in Vadodara district of Gujarat (Jhala *et al.*, (2009) [8]. Patel *et al.* (2010) [10] recorded 17.16 to 48.82 per cent parasitism of *A. bambawalei* in farmer's field in Anand and Baroda districts during *Kharif* 2009 with peak activity during mid-August to mid-September. Prey consumption rate per day of larval and adult stage of *C. sexmaculata* were varied from 35.00 to 44.00 (Av. 38.80±2.18) and 25.58 to 27.03 (Av. 26.38±0.35) eggs, 13.00 to 18.33 (Av. 14.97±1.47) and 15.52 (Av. 14.83±0.45)

nymphs, and 9.67 to 14.00 (Av. 11.58±1.14) and 10.95 to 12.79 (Av. 12.02±0.40) adults of mealybug, respectively (Sanghani *et al.*, 2017) [13].

3.3 Assessment of loss

During 2015-16, seed cotton yield loss due to mealybug was estimated based on average seed cotton yield of healthy and 4-grade infested plants of surveyed fields. Average seed cotton yield loss due to mealybug infestation was worked out to be 0.00 and 3.00 per cent in Umarpada and Olpad taluka of Surat district, respectively whereas in Bharuch district, it was 2.25, 2.27, 3.76 and 0.72 per cent in villages of Bharuch, Amod, Valia and Hansot talukas of Bharuch districts, respectively (Table 2). During 2016-17, average seed cotton yield loss due to mealybug infestation was worked out to be 0.00 and 1.27 per cent in Umarpada and Olpad taluka of Surat district, respectively whereas in Bharuch district, it was 1.87, 0.33, 3.23 and 0.25 per cent in villages of Bharuch, Amod, Valia and Hansot talukas of Bharuch districts, respectively (Table 3). During 2017-18, average seed cotton yield loss due to mealybug infestation was nil in Umarpada and Olpad taluka of Surat district, respectively whereas in Bharuch district, it was 1.71, 1.61, 1.24 and 0.00 per cent in villages of Bharuch, Amod, Valia and Hansot talukas of Bharuch districts, respectively (Table 4). Overall loss due to mealybug infestation was worked out to be 0.69 to 1.49 (av. 1.22) in villages of Olpad taluka whereas it was nil in villages of Umarpada taluka (no 4-grade plants). In Bharuch district, it was 0 to 0.74 (av. 0.28), 0.68 to 2.63 (av. 1.33), 1.07 to 2.44 (av. 1.87) and 1.87 to 2.97 (av. 2.60) per cent in villages of Hansot, Amod, Bharuch and Valia taluka, respectively (Table 5). The overall loss appeared to be 1.07 in surveyed region which comprised of 0.61 per cent loss in Surat district and 1.52 per cent in Bharuch district. The present finding confirmed with Dhawan *et al.* (2007) [6] who reported that the seed cotton yield loss of 14.82 to 20.61, 17.27 to 21.88 and 41.97 to 45.44 per cent in field infestations of low, medium and high, respectively mealybug infested cotton fields (Ferozepur and Muktsar districts of Punjab) and Anonymus (2009) [1] they reported that the yield losses due to *P. solenopsis* was reported to be 2.4 per cent at grade-1, 31.5 per cent at grade-2, 39.9 per cent at grade-3 and 43.9 per cent at grade-4 at Nagpur.

3.4 Monetary loss (Projected/estimated)

In 2015-16, cotton farmers of different villages of Surat and Bharuch district incurred the expenditure of Rs. 712 to 3200/ha for management of mealybug. The overall loss due to mealybug infestation (in surveyed villages) was estimated to be 1.88 per cent worth of Rs. 2841/ha in addition to Rs. 1988/ha average expenditure incurred for management of mealybug (Table 2). During 2016-17, farmers of different villages of Surat and Bharuch district incurred the expenditure of Rs. 1200 to Rs. 3500/ha for management of mealybug. The overall loss due to mealybug infestation (in surveyed villages) was estimated to be 1.03 per cent worth of Rs. 1488/ha in addition to Rs. 1827/ha average expenditure incurred for management of mealybug (Table 3). In 2017-18, farmers of different villages of Surat and Bharuch district incurred the expenditure of Rs. 780 to Rs. 1690/ha for management of mealybug. The overall loss due to mealybug infestation (in surveyed villages) was estimated to be 0.57 per cent worth of Rs. 927/ha in addition to Rs. 1212/ha average expenditure incurred for management of mealybug (Table 4). Overall,

Based on the practices followed by the cotton farmers of surveyed villages of Surat and Bharuch district, the expenditure of Rs. 1203 to 2453/ha (av. incurred for management of mealybug. The overall loss due to mealybug

infestation (in surveyed villages) was estimated to be 1.07 per cent worth of Rs. 1633.78/ha in spite of management expenditure of Rs. 1675.58/ha against mealy bug infestation in surveyed region (Table 5).

Table 1: Field surveys for assessment of losses due to mealybug infestation at farmers' fields during 2015-16 to 2017-18

Sr. No.	Districts	Taluka	Villages	GPS	No. of farmer survey
1	Surat	Olpad	Bhadol	21.417239°	5
				72.822564°	
			Takarama	21.381075°	5
				72.790132°	
		Delad	21.256934°	5	
			73.091180°		
		Umarpada	Kadvali	21.392181°	5
				73.366682°	
Umarda	21.505178°		5		
	73.354217°				
2	Bharuch	Bharuch	Dabhali	21.799714°	5
				73.102425°	
			Bori	21.810246°	5
				73.014115°	
			Nikora	21.775953°	5
				73.133670°	
		Amod	Shamlod	21.841272°	5
				73.090888°	
			Kelod	21.850033°	5
				72.928628°	
			Kesalu	21.893502°	5
				72.938092°	
		Valia	Daheli	21.561241°	5
				73.214423°	
			Jabugam	21.549063°	5
				73.254172°	
			Vandariya	21.559131°	5
				73.225483°	
			Luna	21.170714°	5
				72.800448°	
			Tuna	21.554255°	5
				73.198657°	
		Hansot	Katasayan	21.545033°	5
				73.806909°	
			Kudadara	21.525874°	5
				72.866350°	
			Valner	21.537248°	5
				72.839664°	
			Katpore	21.520818°	5
				72.717248°	
Dantrai	21.537059°		5		
	72.767426°				

Table 2: Survey for assessment of losses due to mealybug infestation at farmers' fields during 2015-16

Sr. No.	Districts	Taluka	Villages	% infested plants	% intensity (within infested plants)	No. of plants in 4-grade (Based on 100 plants)	Parasitism (%) (5 twigs)	Seed cotton yield (kg/ha)		Yield loss (%)	Projected monetary loss based on 4-grade infested plants (Rs./ha)		
								Healthy	Infested		Yield loss	Management	Total
1	Surat	Olpad	Bhadol	22	28.21	2	5.18	2453	2390	2.59	3173	1550	4723
			Takarama	19	23.46	3	6.33	2658	2553	3.94	5232	1550	6782
			Delad	15	17.65	2	8.24	3306	3224	2.49	4111	1124	5235
			Av.	18.67	23.10	2.33	6.58	2805.72	2722.28	3.00	4172.17	1408.00	5580.17
		Umarpada	Kadvali	12	13.64	0	2.68	3067	3067	0.00	0.00	3200	3200
			Umarda	8	8.70	0	6.84	2716	2716	0.00	0.00	2800	2800
			Av.	10.00	11.17	0.00	4.76	2891.62	2891.62	0.00	0.00	3000.00	3000.00
		Overall (S)		14.33	17.13	1.17	5.67	2848.67	2806.95	1.50	2086.08	2204.00	4290.08
2	Bharuch	Bharuch	Dabhali	19	23.46	5	12.33	2920	2759	5.53	8071	1550	9621
			Bori	22	28.21	1	5.20	2915	2880	1.22	1784	1609	3393
			Nikora	11	12.36	0	5.42	3673	3673	0.00	0.00	2780	2780

	Amod	Av.	17.33	21.34	2.00	7.65	3169.66	3103.97	2.25	3284.88	1979.67	5264.54
		Shamlod	6	6.38	0	2.26	4185	4185	0.00	0.00	2321	2321
		Kelod	20	25.00	2	6.40	3396	3310	2.52	4282	1124	5406
		Kesalu	21	26.58	4	14.22	2788	2668	4.30	5991	1154	7145
	Valia	Av.	15.67	19.32	2.00	7.63	3456.05	3387.55	2.27	3424.53	1533.00	4957.53
		Daheli	22	28.21	2	10.50	3141	3065	2.44	3830	1154	4984
		Jabugam	20	25.00	3	13.80	2978	2861	3.91	5827	2100	7927
		Vandariya	22	28.21	5	18.80	3582	3389	5.39	9648	712	10360
		Luna	16	19.05	3	12.60	3192	3085	3.36	5370	1000	6370
		Tuna	20	25.00	3	4.80	3686	3549	3.72	6851	1154	8005
		Av.	20.00	25.09	3.20	12.10	3316.00	3189.90	3.76	6305.22	1224.00	7529.22
	Hansot	Katasayan	14	16.28	2	16.60	3787	3697	2.37	4480	2000	6480
		Kudadara	14	16.28	0	4.60	3852	3852	0.00	0.00	2500	2500
		Valner	10	11.11	0	6.00	4296	4296	0.00	0.00	2500	2500
		Katpore	6	6.38	0	8.60	4365	4365	0.00	0.00	3200	3200
		Dantrai	21	26.58	1	2.60	3798	3751	1.24	2354	1549	3903
		Av.	13.00	15.33	0.60	7.68	4019.35	3992.01	0.72	1366.79	2349.80	3716.59
	Overall (B)		16.50	20.27	1.95	8.76	3490.26	3418.36	2.25	3595.35	1771.62	5366.97
	Overall		15.42	18.70	1.56	7.22	3169.47	3112.65	1.88	2840.72	1987.81	4828.53

Table 3: Survey for assessment of losses due to mealybug infestation at farmers' fields during 2016-17

Sr. No.	Districts	Taluka	Villages	% infested plants	% intensity (within infested plants)	No. of plants in 4-grade (Based on 100 plants)	Parasitism (%) (5 twigs)	Seed cotton yield (kg/ha)		Yield loss (%)	Projected monetary loss based on 4-grade infested plants (Rs./ha)		
								Healthy	Infested		Yield loss	Management	Total
1	Surat	Olpad	Bhadol	20	25.00	0	8.20	1926	1926	0.00	0.00	1200	1200
			Takarama	21	26.58	1	10.30	2720	2687	1.22	1659	1850	3509
			Delad	15	17.65	2	9.20	2747	2675	2.59	3555	2000	5555
			Av.	18.67	23.08	1.00	9.23	2464.13	2429.36	1.27	1738.25	1683.33	3421.59
		Umarpada	Kadvali	10	11.11	0	5.20	3200	3200	0.00	0.00	1300	1300
			Umarda	8	8.70	0	7.60	3124	3124	0.00	0.00	1500	1500
		Overall (S)			13.83	16.49	0.50	7.82	2813.13	2795.75	0.63	869.13	1541.67
2	Bharuch	Bharuch	Dabhali	17	20.48	2	13.20	3009	2942	2.22	3342	2200	5542
			Bori	15	17.65	2	8.60	2985	2916	2.31	3447	1900	5347
			Nikora	23	29.87	1	10.40	2590	2561	1.09	1407.55	2400	3808
			Av.	18.33	22.67	1.67	10.73	2861.09	2806.45	1.87	2732.27	2166.67	4898.94
		Amod	Shamlod	10	11.11	0	4.50	3111	3111	0.00	0.00	1600	1600
			Kelod	8	8.70	0	6.20	2910	2910	0.00	0.00	1700	1700
			Kesalu	12	13.64	1	10.20	2840	2812	1.00	1419.96	1500	2920
			Av.	10.00	11.15	0.33	6.97	2953.81	2944.34	0.33	473.32	1600.00	2073.32
		Valia	Daheli	19	23.46	3	15.60	3578	3437	3.93	7033	2200	9233
			Jabugam	23	29.87	4	20.00	3002	2842	5.33	8002	3500	11502
			Vandariya	15	17.65	2	13.80	2800	2720	2.87	4021	2000	6021
			Luna	19	23.46	2	11.60	2542	2476	2.62	3331	2100	5431
			Tuna	14	16.28	1	9.20	2726	2688	1.40	1907	2500	4407
			Av.	18.00	22.14	2.40	14.04	2929.55	2832.37	3.23	4858.83	2460.00	7318.83
			Hansot	Katasayan	10	11.11	0	8.60	2744	2744	0.00	0.00	2400
		Kudadara		12	13.64	0	3.20	2660	2660	0.00	0.00	1800	1800
		Valner		7	7.53	0	10.00	3074	3074	0.00	0.00	1800	1800
		Katpore		5	5.26	0	8.20	3333	3333	0.00	0.00	2500	2500
		Dantrai		14	16.28	1	6.30	2899	2863	1.24	1796	2600	4396
		Av.		9.60	10.76	0.20	7.26	2942.07	2934.88	0.25	359.25	2220.00	2579.25
		Overall (B)			13.98	16.68	1.15	9.75	2921.63	2879.51	1.42	2105.92	2111.67
Overall			13.91	16.58	0.83	8.78	2867.38	2837.63	1.03	1487.52	1826.67	3314.19	

Table 4: Survey for assessment of losses due to mealybug infestation at farmers' fields during 2017-18

Sr. No.	Districts	Taluka	Villages	% infested plants	% intensity (within infested plants)	No. of plants in 4-grade (Based on 100 plants)	Parasitism (%) (5 twigs)	Seed cotton yield (kg/ha)		Yield loss (%)	Projected monetary loss based on 4-grade infested plants (Rs./ ha)			
								Healthy	Infested		Yield loss	Management	Total	
1	Surat	Olpad	Bhadol	16	19.05	0	6.30	3240	3240	0.00	0.00	860	860	
			Takarama	10	11.11	0	8.30	3508	3508	0.00	0.00	1200	1200	
			Delad	11	12.36	0	10.20	2933	2933	0.00	0.00	1060	1060	
			Av.	12.33	14.17	0.00	8.27	3226.95	3226.95	0.00	0.00	1040.00	1040.00	
		Umarpada	Kadvali	8	8.70	0	6.30	2815	2815	0.00	0.00	860	860	
			Umarda	5	5.26	0	6.80	3439	3439	0.00	0.00	780	780	
		Av.	6.50	6.98	0.00	6.55	3127.04	3127.04	0.00	0.00	820.00	820.00		
Overall(S)			9.42	10.58	0.00	7.41	3176.99	3176.99	0.00	0.00	930.00	930.00		
2	Bharuch	Bharuch	Dabhali	17	20.48	0	12.30	3671	3671	0.00	0.00	1690	1690	
			Bori	19	23.46	2	10.20	2820	2745	2.67	3765	1020	4785	
			Nikora	14	16.28	2	16.80	3387	3303	2.47	4185	1590	5775	
			Av.	16.67	20.07	1.33	13.10	3292.53	3239.53	1.71	2650.08	1433.33	4083.41	
		Amod	Shamlod	24	31.58	2	13.60	3084	3009	2.42	3736	1560	5296	
			Kelod	8	8.70	0	8.20	3000	3000	0.00	0.00	1320	1320	
			Kesalu	18	21.95	2	15.00	2975	2903	2.41	3586	2100	5686	
			Av.	16.67	20.74	1.33	12.27	3019.55	2970.73	1.61	2440.55	1660.00	4100.55	
		Valia	Daheli	10	11.11	0	13.20	3267	3267	0.00	0.00	1500	1500	
			Jabugam	17	20.48	0	10.00	2716	2716	0.00	0.00	1620	1620	
			Vandariya	8	8.70	0	9.20	3799	3799	0.00	0.00	1450	1450	
			Luna	20	25.00	2	20.60	3067	2987	2.58	3962	1600	5562	
			Tuna	15	17.65	3	17.60	4247	4094	3.61	7663	1140	8803	
			Av.	14.00	16.59	1.00	14.12	3419.16	3372.66	1.24	2324.93	1462.00	3786.93	
		Hansot	Katasayan	14	16.28	0	8.00	3392	3392	0.00	0.00	1124	1124	
			Kudalara	10	11.11	0	6.90	3002	3002	0.00	0.00	1420	1420	
			Valner	19	23.46	0	11.20	2927	2927	0.00	0.00	1320	1320	
			Katpore	18	21.95	0	7.20	3244	3244	0.00	0.00	1660	1660	
			Dantrai	8	8.70	0	7.00	3683	3683	0.00	0.00	1590	1590	
		Av.	13.80	16.30	0.00	8.06	3249.69	3249.69	0.00	0.00	1422.80	1422.80		
		Overall(B)			15.28	18.43	0.92	11.89	3245.23	3208.15	1.14	1853.89	1494.53	3348.42
		Overall			12.35	14.50	0.46	9.65	3211.11	3192.57	0.57	926.95	1212.27	2139.21

Table 5: Survey for assessment of losses due to mealybug infestation at farmers' fields (Pooled 2015-16 to 2017-18)

Sr. No.	Districts	Taluka	Villages	% infested plants	% intensity (within infested plants)	No. of plants in 4-grade (Based on 100 plants)	Parasitism (%) (5 twigs)	Seed cotton yield (kg/ha)		Yield loss (%)	Projected monetary loss based on 4-grade infested plants (Rs./ ha)		
								Healthy	Infested		Yield loss	Management	Total
1	Surat	Olpad	Bhadol	19.33	23.97	0.67	6.56	2523	2506	0.69	867.63	1203	2071
			Takarama	16.67	20.00	1.33	8.31	2950	2907	1.48	2177.22	1533	3711
			Delad	13.67	15.83	1.33	9.21	2994	2950	1.49	2238.00	1395	3633
			Av.	16.56	19.93	1.11	8.03	2822.46	2787.24	1.22	1760.95	1377.11	3138.06
		Umarpada	Kadvali	10.00	11.11	0.00	4.73	3025	3025	0.00	0.00	1787	1787
			Umarda	7.00	7.53	0.00	7.08	3091	3091	0.00	0.00	1693	1693
		Av.	8.50	9.32	0.00	5.90	3058.15	3058.15	0.00	0.00	1740.00	1740.00	
Overall(S)			12.53	14.63	0.56	6.97	2940.31	2922.70	0.61	880.48	1558.56	2439.03	
2	Bharuch	Bharuch	Dabhali	17.67	21.46	2.33	12.61	3198	3120	2.44	3899.53	1813	5713
			Bori	18.67	22.95	1.67	8.00	2913	2852	2.09	3043	1510	4553
			Nikora	16.00	19.05	1.00	10.87	3215	3181	1.07	1728	2257	3984
			Av.	17.44	21.15	1.67	10.49	3108.76	3050.96	1.87	2890.11	1859.89	4750.00
		Amod	Shamlod	13.33	15.38	0.67	6.79	3445	3421	0.68	1172	1827	2999
			Kelod	12.00	13.64	0.67	6.93	3114	3093	0.69	1070.86	1381	2452
			Kesalu	17.00	20.48	2.33	13.14	2877	2801	2.63	3790	1585	5375
			Av.	14.11	16.50	1.22	8.95	3145.08	3104.86	1.33	2011.05	1597.67	3608.71
		Valia	Daheli	17.00	20.48	1.67	13.10	3327	3265	1.87	3117.11	1618	4735
			Jabugam	20.00	25.00	2.33	14.60	2899	2821	2.68	3878.19	2407	6285
			Vandariya	15.00	17.65	2.33	13.93	3384	3298	2.56	4338.64	1387	5726
			Luna	18.33	22.45	2.33	14.93	2941	2856	2.90	4258	1567	5824
			Tuna	16.33	19.52	2.33	10.53	3530	3425	2.97	5242	1598	6840
			Av.	17.33	21.02	2.20	13.42	3216.37	3133.03	2.60	4166.73	1715.33	5882.06
		Hansot	Katasayan	12.67	14.50	0.67	11.07	3312	3289	0.68	1129.57	1841	2971
			Kudalara	12.00	13.64	0.00	4.90	3184	3184	0.00	0.00	1907	1907

		Valner	12.00	13.64	0.00	9.07	3424	3424	0.00	0.00	1873	1873
		Katpore	9.67	10.70	0.00	8.00	3637	3637	0.00	0.00	2453	2453
		Dantrai	14.33	16.73	0.67	5.30	3450	3425	0.74	1272.71	1913	3186
		Av.	12.13	13.84	0.27	7.67	3401.29	3391.68	0.28	480.45	1997.53	2477.99
	Overall(B)		15.26	18.13	1.34	10.13	3217.87	3170.13	1.52	2387.09	1792.61	4179.69
	Overall		13.89	16.38	0.95	8.55	3079.09	3046.41	1.07	1633.78	1675.58	3309.36

4. Conclusion

The cotton sown in the surveyed villages was comprised of approved BG II hybrids. Farmers were aware about identity and management strategies as they used collection and destruction of infested shoot/twigs, interspersing of maize, sowing of non-host pigeon pea on border and application of insecticides viz., Groneem, Buprofezin, Profenofos, Chlorpyrifos and Monocrotophos and Acephate as spot application or full field cover at slightly higher than label claim doses in the region (near recommended strategies). The overall intensity of mealy bug infestation was 16.38 per cent within 13.89 per cent infested plants. Out of 21 surveyed villages, the grade-4 plants were noticed in 16 villages and the average number of grade-4 plants was 0.95 per 100 plants. During the cotton season, mealy bug was noticed on alternate hosts viz., wild okra, kanski, Parthenium or Hibiscus at few villages (4 out of 21 surveyed villages). The presence of parasitoid of mealy bug revealed the well establishment of parasitoid under nature (overall 8.55 percent parasitism) needs to be conserved. The overall loss due to mealybug infestation was estimated to be 1.07 per cent worth of Rs. 1633.78/ha in spite of average management expenditure of Rs. 1675.58/ha incurred by the farmers of 21 surveyed villages.

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