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High density planting with insecticide resistance management approach for sustainable and profitable cotton production in rain fed region

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Abstract
High density planting demonstrations (50) on farmers' fields at varied close spacings (75x10 and 90x10cm) with available compact genotypes (Suraj and G.Cot.16) were compared to normal spacing (120x45 cm) under Insecticide Resistance Management (IRM) umbrella in rain fed regions of Bharuch district under the project "NFSM:HDPS-IRM" during the year 2015-16. Aphid, thrips and leafhopper were found above ETL whereas whitefly and mealybug were found below ETL. The mean larval population of pink bollworm was 4.41 and 3.14 larvae/20 green bolls in Suraj and G.Cot.16 spaced at closed spacings, respectively. The pink bollworm population was 2.51 and 2.68 larvae/20 green bolls in Bt-IRM and non IRM plots, respectively. Suraj variety spaced at 75x10 and 90x10 cm required 4.21 and 3.33 sprays and G.Cot.16 spaced at 75x10 and 90x10 cm required 4.40 and 3.60 sprays against sucking pests and 2.37 and 2.38 and 3.20 and 2.40 sprays against bollworms, respectively as against 5.00 and 5.60 sprays against sucking pests and 2.00 and 3.80 sprays against bollworms in Bt-IRM and Bt-Non IRM cotton, respectively. The net return was found higher in G.Cot.16 HDPS at both the spacing (Rs. 22966 and 17456/acre) than the Suraj HDPS (Rs. 16461 and 8235/acre). The net return for Bt-IRM farmers was higher (Rs.21527/acre) than non IRM-Bt farmers (Rs. 17919/acre). HDPS offer viable option to increase productivity especially under rain-fed region.

Keywords: HDPS, Bt-irm, sucking pests, bollworms, cotton

1. Introduction
Gujarat has glorious past and glittering present ahead of all the states on the national map of cotton production and productivity. The major cotton growing districts are Surendranagar, Rajkot, Bhavnagar, Amreli, Ahmedabad, Junagadh, Jamnagar, Sabarkantha, Banaskantha, Patan, Mehsana, Botad, Vadodara and Bharuch. Nearly 33 per cent cropped area of the state is occupied by the cotton which played pivotal role in economy of the state and providing employment to rural people. There was a wider gap in the productivity of irrigated and rain fed regions and the average yield of rain fed cotton seldom exceeds half of the theoretical potential yield (Anon., 2014) [2]. The concept of sowing cotton at closer spacing with developing short branched cotton varieties is known in India since sixties of the 20th century. However, at present conventional method of cotton sowing in rows at 90 to 120 cm apart and the spacing between two plants at 45 to 50 cm is practiced. High yielder countries are adopted dense population system facilitates for efficient utilization of sunlight, moisture and nutrients which balancing the vegetative and reproductive growth of cotton crop which ultimately increased earliness, harvest index and seed cotton yield. The success of HDPS at closer spacing also depends on proper agronomic practices and sound pest management criteria. The productivity of Australia (2151 kg/ha), Turkey (1484 kg/ha), Brazil (1465 kg/ha), China (1380 kg/ha), USA (926 Kg/ ha) is higher than our national (540 Kg/ha) and state (733 kg/ha) productivity (Anon., 2014) [2]. The alternatives to increase productivity further in comparison to global level, many scientists opined to adopt HDPS in cotton with improved agronomic management with appropriate pest management after reviewing global scenario. Recent research in this direction offered encouraging results (Singh *et al*., 2012) [21]. The earlier research in India for breeding mostly targeted for improvement in boll size and high yielding varieties. However, Suraj and G.Cot.16 genotypes found promising suited to high density planting system in the rain fed region due to their compact nature (Venugopalan *et al*., 2013) [22]. The earliness usually associated with high density planting makes this system suitable for rain fed areas where the cotton crop invariably experiences terminal moisture stress.

In different parts of India, in conventional method cotton is planted in rows 90 to 120 cm apart and the spacing between two plants is kept 45 to 50 cm. In pre Bt era repeated use of synthetic pyrethroids in cotton witnessed development of resistance in ABW especially on long duration hybrids. Over application of methomyl and thiodicarb insecticides lead to leaf reddening of cotton. In case of post Bt technology era, repeated application of fipronil, spinosad and pyrethroids caused tremendous increasing population of whitefly, mealybug and mite in *Bt* cotton. Use of neonicotinoid as seed treatment in initial window lead to reduction in efficacy of seed protection by 20 days (Kranthi *et al*., 2014) [12] and resistance problem leafhopper populations (Chaudhari *et al*., 2015, Kranthi *et al*., 2017) [4, 10]. Changing dynamics of pink bollworm incidence (Naik *et al*., 2012) [18], low adoption of refuge (Kranthi *et al*., 2013) [11], low spectrum of natural enemies (Naik *et al*., 2015) [16] lead to serious threat (Desai *et al*., 2015) [6] and field evolved resistance to *Cry1Ac* and *Cry2Ab* in pink bollworm (Naik *et al*., 2018) [17]. Hence, insecticide resistance management was the solution of longer and effective use of different insecticides for pests management. The different villages of Jambusar taluka of Bharuch district in general receive less rain where the HDPS demonstrations using two cultivars *viz.*, Suraj and G.Cot.16 were planned under Insecticide Resistance Management (IRM) umbrella during 2015-16 to know the adaptability and knowing the performance vis a vis normal Bt cotton cultivation as usual spacing and pest management.

2. Materials and Methods

The front line demonstrations on HDPS of cotton with IRM strategies were allotted to fifty farmers of Jambusar Taluka of Bharuch district (Gujarat State) in rain fed region in their fellow fields during *Kharif* 2015 under the centrally sponsored project on NFSM on HDPS-IRM. Out of total 50 FLDs, 40 FLDs on Suraj spaced at 75x10 cm (19) and 90x10 cm (21) was allotted whereas and 10 FLDs on G. Cot. 16 spaced at 75x10 cm (5) and 90x10 cm (5) allotted to the beneficiaries depending on the soil preparations and seed availability under the project through participatory mode. The allotted seeds of the FLDs were sown by the end of July in different villages on receiving the sufficient rainfall. The long dry spell of 21-25 days and the uneven rainfall restricted uniform growth of the plants in some of the allotted FLDs and the season was moderate. Under this HDPS demonstrations, IRM strategies for pest management following training and guidance for identification of pests at each stages, scouting through participatory approach with beneficiary farmers at fortnightly interval, biodiversity maintenance through eco-feast crops (maize/cowpea), selection and spraying of safer insecticides in initial crop window at ETL populations and following principle of group rotation and safer interval in subsequent spray. The whole package of practices along with low cost inputs in rain fed cotton (seeds for HDPS, slow release neem coated urea, pre-emergence weedicide, pendimethalin 30 EC, Flonicamid 50WG for sucking pest management and chlorantranilliprole 18.5 SC and chlorpyriphos 50 EC + cypermethrin 5 EC) were also provided under this project. During participatory scouting, observations on sucking pests were recorded on 10 randomly selected plants from all 50 HDPS-IRM FLDs (Suraj and G.Cot.16) as well as 5 plots of Bt-IRM and Bt-Non IRM plots sown at normal spacing of 120x45 cm for comparison purpose. The observations were recorded fortnight interval in each plots starting from thirty days after sowing to crop harvest. Whereas, number of bollworm larvae (Helicoverpa, Earias and Spodoptera) from 10 plants and Pectinophora damage from 20 green bolls were observed from each of the HDPS-IRM, Bt-IRM and Bt-non IRM plots. The insect pests data were compared by average population observed in IRM and non IRM plots. Advisory through text message was also sent to each of the beneficiaries. The seed cotton yield was also recorded on each of these plots. The impact of implementation of FLDs on HDPS-IRM in rain fed region was evaluated and visual observations and general views of the farmers were also obtained.

3. Results and Discussion

3.1 Season and Crop condition

All the FLDs were sown by end of July in different villages of Jambusar Taluka of Bharuch district on receiving sufficient rain. After sowing, there was long dry spell of 21-25 days which little bit affected the plant population. Further, uneven distribution of rainfall restricted uniform growth of the plants at different places. Total of 444.8 mm rainfall was received in 29 rainy days comprising of 131.5, 21.2 and 134.6 mm during the month of July, August and September, respectively. The average maximum and minimum temperature was 33.4 and 22.1 ^{0}C, respectively. Amongst sucking pests, jassid, thrips and aphid had crossed ETL whereas spotted bollworm and American bollworms infestation was managed effectively, however, pink bollworm affected the second pickings and farmers used 2 to 3 sprays for pink bollworm. Overall, the season was moderate for the FLDs sown in the Jambusar Taluka.

3.2 Incidence of sucking pests and management

Cotton sucking pests population recorded from FLDs on HDPS-IRM, Bt IRM and Bt non IRM plots (Table 1). Incidence of aphid was started from September I fortnight and gradually increased with onset of winter with maximum population during November and December. Aphid population crossed ETL twice under HDPS condition during the season. Leafhopper appeared from September I fortnight and continued throughout the crop season with 3-4 peaks observed through participatory approach during October I to December II fortnight on HDPS (Suraj and G.Cot.16) cotton whereas it observed 4-5 peaks on normal spacing in Bt cotton. In initial stage (September I and II fortnight), thrips population observed very high and crossed the ETL under HDPS and normal spaced Bt cotton hybrids. Whitefly and mealy bug were found below ETL on closer and normal sown crop. Thrips population was more in HDPS than normal spacing. Whitefly appeared from I fortnight of September, its population remained below ETL throughout the season both in HDPS of cultivars Suraj and G.Cot.16 and normal spaced Bt cotton hybrids. Thus, aphid, leafhopper and thrips were found above ETL during the crop season amongst sucking pests which required average 4.21 sprays when spaced at 75×10 cm and 3.33 sprays when spaced at 90×10 cm in Suraj variety. There was 4.40 and 3.20 sprays for sucking pests when G. Cot. 16 varieties spaced at 75×10 and 90x10 cm spacing, respectively. On Bt cotton spaced at normal spacing required average of 5.0 sprays against sucking pests in IRM plots as against 5.6 sprays in non IRM plots.

Thus, the above results revealed that the selection of insecticide using group rotation principle and spraying at ETL populations through effective scouting reduced the frequency

of sprays by extending time to population build up at ETL level. In general, the closed spacing attracted more number of sucking pests with high density but IRM strategies through effective scouting and tolerant nature of selected varieties kept the check on population built up unlike Bt cotton. Further, the overall mean population data of sucking pests revealed that the population pressure was remained low on account of advocating participatory IRM strategies in Bt-IRM and HDPS-IRM compared to Bt-Non IRM plots. The natural enemies' population was also comparatively more in IRM plots either sown at HDPS or normal spacings. Kalaichelvi (2008) [9] reported that closer spacing attracted more aphids than normal spacing in RCH-2 Bt cotton. Arif *et al.,* (2006) [3] reported that the population of leafhopper did not show significant difference when plant spacing was maintained at 18.5, 23.5, 30 cm with the row to row distance of 75 cm and the population of leafhopper was 1.39, 1.50 and 1.39 /3 leaves, respectively. Patel *et al.,* (2015) [19] found significantly highest population of thrips at normal spacing than wider spacing. Rajasekhar and Durga Prasad (2018) [20] did not find above ETL populations of whitefly either sown at normal or closer spacing. Aggarwal *et al*. (2006) [1] recorded the number of insecticide sprays per season in IRM plots (9.5) was less than in non-IRM plots (14.5). Due to the adoption of IRM strategies, Dhawan *et al*. (2009) [8] and Dhawan and Randhawa (2009) [7] recorded 41.2% reduction in insecticidal sprays in Punjab.

Table 1: Incidence of sucking pests in HDPS of cotton at Jambusar villages, Dist. Bharuch (2015-16)

Pests & Fields	Av. No. of sucking pests/ sq.m. (10 plants)										
	Sept.		Oct.		Nov.		Dec.		Jan.		Mean
	I	II	I	II	I	II	I	II	I	II	
Aphid											
HDPS (Suraj) - IRM	1.30	9.42	27.50	73.53	305.73	86.63	95.23	415.23	218.97	97.03	133.06
HDPS (G.Cot.16) - IRM	0.03	9.63	11.33	61.07	79.13	356.43	48.03	403.00	94.83	72.03	113.55
Bt - IRM	0.00	11.83	15.77	55.33	63.67	322.00	55.47	448.00	90.30	65.07	112.74
Bt - Non IRM	0.53	12.20	21.87	94.07	172.00	362.00	472.33	518.60	265.33	110.37	202.93
Leafhopper											
HDPS (Suraj) - IRM	23.33	54.53	82.87	60.00	94.77	108.37	70.33	45.53	22.03	7.00	56.88
HDPS (G.Cot.16) - IRM	15.03	23.00	62.63	32.00	84.73	40.77	72.40	58.00	30.23	21.67	44.05
Bt - IRM	10.00	20.53	62.00	22.53	75.57	33.93	56.93	85.77	26.03	12.37	40.57
Bt - Non IRM	12.43	44.00	68.00	52.13	88.17	99.07	102.00	87.27	54.03	22.33	62.94
Thrips											
HDPS (Suraj) - IRM	310.17	423.97	204.33	43.07	23.00	20.07	12.13	6.03	8.03	2.57	105.34
HDPS (G.Cot.16) - IRM	322.03	446.53	184.17	32.13	12.67	6.03	4.03	8.00	3.37	3.53	102.25
Bt - IRM	322.00	502.03	182.17	38.23	8.17	11.07	8.00	4.00	3.03	2.07	108.08
Bt - Non IRM	308.03	414.00	248.00	29.00	23.00	19.00	12.03	4.00	7.57	3.03	106.77
Whitefly											
HDPS (Suraj) - IRM	0.87	12.17	23.03	52.03	97.00	128.33	122.33	62.03	45.13	03.03	54.60
HDPS (G.Cot.16) - IRM	3.67	10.53	24.03	49.07	102.03	124.43	145.23	61.07	25.67	10.23	55.60
Bt - IRM	2.03	12.07	32.33	58.67	158.47	172.57	148.67	65.23	46.87	29.03	72.59
Bt - Non IRM	5.27	28.23	48.57	71.00	132.03	195.07	136.00	86.63	79.53	41.47	82.38
Mealybug (Grade/sq.m. or 10 plants)											
HDPS (Suraj) - IRM	0.00	0.20	0.20	0.40	0.40	0.60	0.70	1.10	1.60	1.70	0.69
HDPS (G.Cot.16) - IRM	0.00	0.00	0.00	0.30	0.20	0.50	0.80	0.90	1.20	0.80	0.47
Bt - IRM	0.10	0.10	0.10	0.30	0.80	0.60	0.80	0.70	1.80	1.60	0.69
Bt - Non IRM	0.00	0.10	0.20	0.50	0.60	1.10	1.20	1.50	1.70	2.00	0.89

3.3. Incidence of natural enemies

Population of natural enemies' *viz*., *Chrysoperla*, ladybird beetle and spider activity were found in fields of farmers (Table 2). The average larval population of *Chrysoperla* ranged from 0.86 and 1.00/sq. m. in HDPS Suraj and G.Cot.16 fields, respectively and 0.83 and 0.52/sq. m. in Bt-IRM and Non IRM fields, respectively. Lady bird beetle activity was found more or less similar in HDPS and normal spaced cotton. Both HDPS fields were recorded higher spider population as compared to normal spaced cotton (Bt IRM). This was in agreement with the findings of Kalaichelvi (2008) [9] who observed that closer spacing of 90 × 30 cm recorded more number of coccinellid beetles (4 beetles per 50 plants) than wider spacing of 120 × 60 cm (2 beetles per 50 plants).

Table 2: Incidence of natural enemies in HDPS of cotton at Jambusar villages, Dist. Bharuch (2015-16)

NEs & Fields	Av. No. of natural enemies/sq.m. (10 plants)										
	Sept.		Oct.		Nov.		Dec.		Jan.		Mean
	I	II	I	II	I	II	I	II	I	II	
Chrysoperla larval population											
HDPS (Suraj) - IRM	0.00	0.00	0.50	0.50	2.00	1.50	2.00	1.50	0.60	0.00	0.86
HDPS (G.Cot.16) - IRM	0.00	0.00	0.20	1.20	1.00	2.60	2.20	2.50	0.30	0.00	1.00
Bt - IRM	0.00	0.00	0.00	0.30	1.20	1.60	1.80	2.20	1.20	0.00	0.83
Bt - Non IRM	0.00	0.00	0.50	0.50	0.80	0.50	1.30	1.40	0.20	0.00	0.52
Ladybird beetle											
HDPS (Suraj) - IRM	0.20	1.00	2.90	3.90	6.30	4.00	8.20	6.00	3.20	3.00	3.87
HDPS (G.Cot.16) - IRM	1.00	1.10	3.00	3.50	5.30	6.70	4.00	5.10	3.00	4.20	3.69
Bt - IRM	0.10	0.40	2.20	2.90	2.70	6.30	5.80	6.00	5.60	1.90	3.39

Bt - Non IRM	0.20	1.30	2.00	3.60	2.00	4.50	5.20	3.00	6.20	3.00	3.10
Spider											
HDPS (Suraj) - IRM	1.00	3.00	6.60	7.00	6.20	10.20	5.30	3.70	0.60	1.00	4.46
HDPS (G.Cot.16) - IRM	0.60	4.20	7.30	6.20	4.80	11.40	5.20	4.30	2.20	0.60	4.68
Bt - IRM	0.70	3.00	4.30	6.00	8.00	6.50	3.50	2.50	2.00	1.50	3.80
Bt - Non IRM	0.00	1.00	3.30	4.30	5.90	4.00	6.10	4.40	1.00	0.50	3.05

3.4 Incidence of bollworms

The larvae of *Helicoverpa* observed under HDPS from II fortnight of September to II fortnight of January and its peak larval population was recorded during II fortnight of November (Table 3). Incidence of larval population of spotted bollworm was noticed from II fortnight of September to January I fortnight with peak activity during II fortnight of November in Suraj whereas I fortnight of November and December in G.Cot.16. On Bt cotton fields, the population of spotted bollworm and American bollworm was almost negligible. Spodoptera larval population was found very less in closer as well as normal spaced cotton crop. Pink bollworm infestation was recorded during October to January months under HDPS and normal spaced cotton. Under HDPS with Suraj and G.Cot.16 varieties, average larval population of PBW was 4.41 and 3.14/20 green bolls, respectively (Table 3). Even on Bt cotton, pink bollworm infestation was noticed with 2.51 and 2.68 larvae/20 green bolls in IRM and Non IRM fields, respectively. The present finding was almost in confirmation with Mahalakshmi and Prasad (2018) [14] who reported that the incidence of bollworms was almost similar in both close and recommended spacing at Lam, Guntur (AP) specifically on non Bt cotton. On Bt cotton, average of 2.51 sprays required in IRM plots specifically for pink bollworm management as against 2.68 sprays in non IRM plots for all three bollworms. The occurrence of pink bollworm infestation and damage on Bt cotton (Desai *et al*., 2015) [6] as well as field evolved resistance to Cry1AC and *Cry2Ab2* was reported from Gujarat also (Naik *et al*., 2018) [17]. For bollworm management, 2.37 sprays (75×10 cm) and 2.38 sprays (90×10 cm) were targeted by farmers under Suraj HDPS and 3.20 and 2.40 sprays on G. Cot. 16 varieties spaced at 75×10 and 90x10 cm spacing, respectively. Aggarwal *et al*. (2006) [1] recorded the number of insecticide sprays per season in IRM plots (9.5) was less than in non-IRM plots (14.5) with non Bt hybrids.

Table 3: Incidence of bollworms in HDPS of cotton at Jambusar villages, Dist. Bharuch (2015-16)

Pests & Fields	Av. No. of bollworms larvae/ sq.m. (10 plants)										Mean
	Sept.		Oct.		Nov.		Dec.		Jan.		
	I	II	I	II	I	II	I	II	I	II	
Helicoverpa											
HDPS (Suraj) - IRM	0.00	1.00	2.20	5.20	3.20	10.80	2.60	1.90	2.00	0.20	2.91
HDPS (G.Cot.16) - IRM	0.00	0.60	2.00	4.30	3.60	6.40	1.60	2.00	1.60	0.00	2.21
Bt - IRM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bt - Non IRM	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.02
Earias											
HDPS (Suraj) - IRM	0.00	2.20	2.60	4.20	3.20	6.00	3.20	2.10	0.60	0.00	2.41
HDPS (G.Cot.16) - IRM	0.00	0.60	1.60	3.40	4.00	3.80	4.00	2.00	0.00	0.00	1.94
Bt - IRM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bt - Non IRM	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
Spodoptera											
HDPS (Suraj) - IRM	0.60	1.60	2.00	3.80	0.00	0.00	0.00	0.00	0.00	0.00	0.80
HDPS (G.Cot.16) - IRM	0.00	0.60	3.90	4.00	0.60	0.00	0.00	0.00	0.00	0.00	0.91
Bt - IRM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bt - Non IRM	0.00	0.80	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
Pectinophora (20 green bolls)											
HDPS (Suraj) - IRM	0.00	0.00	1.90	3.00	6.00	12.00	8.00	8.00	3.20	2.00	4.41
HDPS (G.Cot.16) - IRM	0.00	0.00	3.20	1.00	4.00	6.00	7.00	6.00	3.00	1.20	3.14
Bt - IRM	0.00	0.00	0.20	2.30	6.30	8.30	4.00	3.00	1.00	0.00	2.51
Bt - Non IRM	0.00	0.00	1.00	1.00	5.20	8.60	5.00	3.00	2.00	1.00	2.68

3.5 Economics

Seed cotton **y**ield varied from 600 to 900 kg/acre and from 400 to 600 kg/acre when Suraj variety spaced at 75x10 and 90×10 cm spacing, respectively. For G.Cot.16, seed cotton yield varied from 825 to 950 kg/acre under 75×10 and 700 to 825 kg/acre under 90×10 cm spacing. The net return was found higher in G.Cot.16 HDPS cotton at both the spacing (Rs. 22966 and 17456/acre) than the Suraj HDPS (Rs. 16461 and 8234/acre) (Table 4). Present finding was similar with Kumar *et al.* (2017) [13] who reported that growing desi cotton at plant density of 148148 (45x15 cm2) provided highest seed cotton yield, gross and net monetary return, B: C ratio without significant effect on quality on the other hand, among *desi* cotton varieties PA 528 provided highest seed cotton yield, gross and net monetary return and B: C ratio with high quality parameters excluding halo length.

Table 4: Economics as influenced by Bt-IRM Strategies in comparison to Non-IRM farmers at Bharuch (2015-16)

Sr. No.	Name of farmers/ beneficiary	Spacing (cm)	Seed cotton yield (kg/acre)	Gross realization (Rs./acre)	Sprays		Fixed cost	Variable cost					Total expenditure (Rs./acre)	Net return (Rs./acre)	Variety
					SP	BW	Cultivation cost excluding picking	Seed and sowing cost	Nutrient and application cost	Insecticide & application cost		Picking cost			
										SP	BW				
Bt – IRM Farmers															
1	Patel Rajnibhai Chhaturbhai	120×45	855	42750	5	2	8000	1380	2530	3350	1540	8550	26080	16670	Ajeet 155
2	Patel Ashvinbhai Rameshbhai	120×45	995	49750	5	2	8000	1380	2530	3755	1540	9950	27885	21865	Bigboss
3	Patel Girishbhai Chhitubhai	120×45	952	47600	4	2	8000	1380	2530	2470	1540	9520	26170	21430	Solar 77
4	Rathod Harshad Rayajibhai	120×45	1045	52250	5	2	8000	1380	2530	3705	1540	10450	28335	23915	Ankur 3028
5	Mori Kamleshbhai Vinodbhai	120×45	1056	52800	6	2	8000	1380	2530	4305	1540	10560	29045	23755	Ajeet 177
Average		--	980.60	49030	5.0	2.0	8000	1380	2530	3517	1540	9806	27503	21527	--
Bt – Non IRM Farmers															
1	Patel Bipinbhai Keravbhai	120×45	945	47250	6	3	8000	1380	2530	5235	2140	9450	29465	17785	Ajeet 199
2	Gohil Vikrambhai Ratansinh	120×45	855	42750	5	4	8000	1380	2530	4335	2690	8550	28215	14535	Yuva
3	Patel Rakeshbhai Vashantbhai	120×45	1070	53500	6	4	8000	1380	2530	5235	2440	10700	31015	22485	Pratik
4	Parmar Devendrabhai Pratapsinh	120×45	905	45250	6	5	8000	1380	2530	5235	2990	9050	29915	15335	Yuva
5	Parmar Bhopatbhai Varajibhai	120×45	960	48000	5	3	8000	1380	2530	4535	1770	9600	28545	19455	Bigboss
Average		--	947.00	47350	5.6	3.8	8000	1380	2530	4915	2406	9470	29431	17919	--

Note: Information from the farmers collected through telephone the IRM farmers used Resistant Management Strategies based on ETL and group protection principle

Fig 1: FLD on HDPS (Suraj)

Fig 2: FLD on HDPS (G.Cot.16)

Fig 3: Scientists visit & data recording on insect pests in HDPS Plots

4. Conclusion

HDPS (G.Cot.16 at spacing of 75x10 cm) offer viable option to increase productivity and sustainability under rain-fed region. Though, there is need to develop good agro-techniques /implements for HDPS as beneficiary farmers faced difficulty in inter-culturing operation with existing type of implements. Further, Suraj variety was found more sensitive to water logged condition and inferior to G. Cot. 16 in performance. Through participatory approach IRM strategies must be followed for sustainability of the products and eco-friendly management of pests. There is need to develop suitable variety for HDPS and standardization of canopy management techniques in rain fed region of the Bharuch district.

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