The Pharma Innovation Journal 2021; 10(10): 1555-1561

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(10): 1555-1561

www.thepharmajournal.com
Received: 13-08-2021
Accepted: 27-09-2021

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Study on the incidence of cassava mealybug, *Phenacoccus manihoti* Matile-Ferrero in major cassava growing regions of Tamil Nadu

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Abstract
Incidence of *Phenacoccus manihoti* was assessed in 37 locations of four major cassava growing districts of Tamil Nadu, *viz*., Salem, Namakkal, Coimbatore and Erode. In all the locations, adult female mealybugs as well as infested plant parts were collected from February to July 2021. Identification of *P. manihoti* was done after slide mounting adult females by following standard keys. In each location, *P. manihoti* infestation level and density were assessed as per the standard methodology. Variation in infestation of *P. manihoti* was observed during the study period. Of the 37 sampling locations, the infestation was higher in Pagalpatti I (96.5%) and lower in Kallupalayam II (7.4%). Higher mealybug density was noticed in four locations. *P. manihoti* infestation and density were higher during the month of April as well as in the cassava grown in rainfed condition. Also, infestation was lower in early planted cassava than in late planted ones. Among the cassava varieties, *P. manihoti* infestation was higher in Mulluvadi variety.

Keywords: Cassava mealybug, density, incidence, infestation, *P. manihoti*

Introduction
Cassava mealybug, *Phenacoccus manihoti* Matile-Ferrero is an important pest of cassava (Bellotti *et al.*, 1999) [1]. It is a polyphagous pest, infesting the plants from 11 families (Garcia Morales *et al*., 2006) [7], but cassava (*Manihot esculenta* Crantz) is the most preferred host (Cox and Williams, 1981) [5]. The native of *P. manihoti* is South America (Löhr *et al*., 1990) [11]. The pest got introduced in Africa in 1970's and spread to all cassava growing regions within a short span of time (Neuenschwander, 2001) [12].
In Asia, *P. manihoti* was first noticed in Thailand (Wintoi *et al*.,2010) [21] and spread to neighbouring countries like Indonesia, Cambodia, Vietnam, Laos and Malaysia (Parsa *et al*., 2012; Sartiami *et al*., 2015) [15, 17]. In India, occurrence of *P. manihoti* on cassava in Thrissur district of Kerala was first reported by Joshi *et al*. (2020) [9] and subsequently the pest has spread to Salem and Namakkal districts of Tamil Nadu (Sampathkumar *et al*., 2021) [16].
P. manihoti infestation in cassava causes distortion of terminal shoots, yellowing and curling of leaves, stunting of plants, and severe infestation can cause yield loss of upto 80% (Nwanze, 1982) [14].
Since *P. manihoti* has the ability to spread at an alarming rate of 150 km per year (Wintoi *et al*., 2010) [21] due to its parthenogenetic type of reproduction and passive dispersal through wind (Parsa *et al*., 2012) [15], this study was planned to assess the incidence of cassava mealybug in major cassava growing areas of Tamil Nadu.

Materials and Methods
Sampling of mealybugs
Survey and collection of mealybugs were carried out in major cassava growing tracts of Tamil Nadu *viz*., Namakkal, Salem, Erode and Coimbatore districts during February to July 2021 (Table 1). Adult females and infested plant materials were collected from 50 randomly chosen plants per locale and the mealybug numbers per shoot tip were assigned according to damage scale given by Neuenschwander *et al.* (1989) [13], 0: No mealybug; 1: 1–9 mealybugs/shoot tip; 2: 10–99 mealybugs/shoot tip; 3: 100–999 mealybug/shoot tip; 4: ≥1000 mealybugs/shoot tip. Per cent infestation was calculated by dividing the mean density scale of 50 plants per field with maximum grade multiplied by hundred (Bhanderi *et al*., 2020) [2].

The specimens collected per field were taken to Insect Biosystematics laboratory at TNAU, Coimbatore for further identification and were separated using LEICA EZ4 microscope and stored in vials containing 70% alcohol.

Table 1: Occurrence of cassava mealybug, *Phenacoccus manihoti* in major cassava growing regions of Tamil Nadu

Sl. No.	Month of survey	Location	Geocoordinates	Variety	Irrigated/Rainfed	Age (months)	% infestation	Mealybug density
1	February	TNAU Orchard	11°00'25.4"N 76°55'51.1"E	YTP2	IR	7	-	-
2		Anaikattipalayam	11°27'20.0"N 78°09'25.2"E	MUL	IR	11	-	-
3		Kalkurichi I	11°23'36.9"N 78°16'14.9"E	MUL	IR	11	21.7	1
4		Kalkurichi II	11°24'18.7"N 78°15'43.2"E	MUL	IR	12	-	-
5	March	Pagalpatti I	11°42'25.5"N 78°02'35.6"E	WHT	RF	4	-	-
6		Pagalpatti II	11°41'56.8"N 78°03'19.7"E	MUL	RF	5	96.5	4
7		Elampillai	11°38'18.6"N 77°59'54.2"E	MUL	RF	6	86.9	3
8	April	Kandarakulamanickam	11°32'27.9"N 78°02'10.2"E	MUL	RF	7	88.6	4
9		P N Palayam	11°00'51.6"N 76°58'48.6"E	MUL	RF	8	87.4	4
10		TNAU Orchard	11°00'25.4"N 76°55'51.1"E	YTP2	IR	9	71.4	3
11	May	Palamthinnipatti I	11°29'41.5"N 78°07'29.4"E	MUL	IR	4	36.6	2
12		Palamthinnipatti II	11°29'31.3"N 78°07'05.4"E	MUL	IR	3	33.1	2
				WHT	IR	2	-	-
13		Pillanallur	11°26'42.0"N 78°07'22.8"E	MUL	IR	4	32.6	2
				WHT	IR	3	17.1	1
14		Munjanur	11°27'7.02"N 78°6'41.83"E	WHT	IR	4	20.6	2
15		Alampatti	11°29'41.7"N 78°07'29.2"E	MUL	RF	6	90.3	4
16		Kallupalayam I	11°26'19.1"N 78°06'28.4"E	WHT	RF	6	19.4	1
17		Kallupalayam II	11°26'18.9"N 78°06'28.1"E	WHT	RF	6	7.4	1
18	July second week	TNAU Orchard	11°00'25.4"N 76°55'51.1"E	YTP2	IR	12	31.4	2
19		Periyavadukapalayam	11°29'42.7"N 78°01'29.2"E	H226	IR	9	14.8	1
				MUL	RF	9	79.4	3
20		Koothanatham	11°28'4.97"N 77°58'45.1"E	MUL	RF	7	81.7	3
21		Avinasipatti I	11°25'42.1"N 78°00'21.5"E	MUL	RF	7	82.9	3
22		Avinasipatti II	11°24'51.9"N 77°59'48.7"E	MUL	IR	4	25.1	2
23		Avinasipatti III	11°23'28.0"N 78°00'32.5"E	MUL	IR	6	22.3	1
24		Athimarapatti I	11°23'37.9"N 77°59'30.2"E	MUL	IR	5	24.6	2
25		Athimarapatti II	11°23'46.6"N 77°59'18.2"E	MUL	RF	6	83.4	3
26		Athimarapatti III	11°23'20.9"N 77°59'30.6"E	MUL	RF	6	84	3
27		Beemarapatti	11°29'34.1"N 77°59'60.0"E	MUL	IR	5	26.3	2
28		Chittalandur I	11°18'43.4"N 77°54'56.7"E	MUL	IR	8	18.9	1
29		Chittalandur II	11°18'46.3"N 77°54'57.3"E	MUL	IR	8	20.6	1
30		Vavipalayam	11°16'11.2"N 77°58'01.0"E	MUL	IR	8	17.7	1
31	July last week	Merkuputhur	11°20'17.4"N 77°38'18.8"E	MUL	RF	5	74.3	3
32		Kannapalli	11°36'35.8"N 77°40'53.6"E	MUL	RF	8	64.6	3
33		Guruvareddiyur	11°38'49.3"N 77°41'02.3"E	MUL	RF	6	61.7	3
34		Komarayanur	11°38'53.4"N 77°40'57.4"E	MUL	RF	5	67.4	3
35		Pillukurichi	11°38'38.4"N 77°47'22.2"E	MUL	RF	7	53.7	2
36		Poolampatti	11°40'05.1"N 77°47'12.9"E	WHT	RF	6	39.4	2
37		Annamadu	11°34'06.4"N 77°35'56.5"E	MUL	IR	6	28.6	1
				YTP2	IR	6	32.6	2

MUL-Mulluvadi; WHT-White Thailand; IR-Irrigated; RF-Rainfed

Morphological studies

Adult females were slide mounted according to the protocol given by Sirisena *et al.* (2013) [18] and Systematic Entomological Laboratory, USDA (2014) [19] with slight modifications. Species identity was done by observing the specimens under Euromex iScope IS.1153-PLPHi phase contrast microscope and by following the keys of Cox and Williams (1981); Williams and Granara de Willink (1992) [5, 20]. The voucher specimens were deposited in the TNAU Insect Museum, Coimbatore.

Results and Discussion

Mealybugs collected from major cassava growing regions of Tamil Nadu were identified as cassava mealybug, *Phenacoccus manihoti*. The diagnostic characteristics used to confirm the species are nine segmented antennae, claw with denticle, 18 pairs of cerarii, multilocular disc pores numbering 5 to 15 located on the marginal side of the dorsal body, quinquelocular pores numbering 32 to 68 located in the anterior side of clypeolabral region, hind tibia without translucent pores and ox-yoke shaped circulus in the ventral side of abdomen between segments iii to iv (Fig. 1).

The live adult female of *P. manihoti* was ovoid and pinkish in colour with a fine layer of wax over its body. It has very short lateral wax filaments, a slightly longer caudal filament, and clear body segmentation. Females turned yellowish pink at the time of oviposition. Eggs are laid in whitish-woolly ovisacs, which were observed at the posterior end of abdomen. There were three nymphal instars (Fig. 2). The damage symptoms caused by *P. manihoti* infestation in cassava were bunching of the apical region, resulting in a bunchy top appearance, crinkling of leaves, shortening of internodes, and drying of plants (Fig. 3).

The study period (February to July, 2021) corresponds with the dry season followed by monsoon period and there was considerable variation in the *P. manihoti* population. *P. manihoti* percentage infestation and density observed in cassava are given in Table 1. Among the 37 sampling locations, *P. manihoti* infestation was higher in Pagalpatti I (96.5%) and lower in Kallupalayam II (7.4%) (Table 1). Higher mealybug density (scale 4) was noticed in four locations.

P. manihoti infestation and density was at peak during the month of April and declined during May probably due to the rainfall (Lema and Herren, 1985) [10] and the population started increasing during second week of July after the temporary cessation of rain (Table 1 & Fig. 4). Rainfall washes away mealybugs while crawlers and ovisacs are protected since they are present inside the bunched shoots and after the rainy season, crawlers emerge from the ovisac and cause a fresh infestation (Lema and Herren, 1985) [10]. This might be the possible reason for the gradual increase in *P. manihoti* population during July.

Similarly, higher incidence of *P. manihoti* was observed in rainfed condition than the irrigated. Also, *P. manihoti* infestation was lower in early planted cassava (November - December) than the late planted ones (February). This could be because of an increased mealybug population in late crop as a result of receiving less rainfall, leading to lower tuber yield (Emehute *et al.*, 1990) [6]. Hennessey *et al*. (1990) and Sampathkumar *et al*. (2021) [8, 16] also reported higher mealybug incidence in cassava during the drought period.

Higher mealybug population in cassava during drought condition could be attributed due to the synthesis of cyanogenic glycosides in cassava plants, which have phago-stimulating effect on insects (Calatayud *et al*., 1994) [4]. The same might be the reason for high mealybug incidence in rainfed condition than in irrigated fields. Among the varieties Mulluvadi had more incidence of *P. manihoti* (17.7-96.5%) followed by YTP 2 (31.4-71.4%), White Thailand (7.4-39.4%) and H226 (14.8%). This might be due to the presence of favourable secondary metabolites as observed by Calatayud *et al*. (1994) [4]. Further studies are required to identify the specific metabolite(s) responsible forsusceptibility/resistance of a cassava variety to mealybugs.

Lesser tuber formation was observed in about 40% of the field surveyed. This is in accordance with the findings of Nwanze (1982) [14] who reported yield loss of about 80.0% due to severe infestation of mealybugs in cassava.

In Tamil Nadu, Sampathkumar *et al*. (2021) [16] first reported the occurrence of *P. manihoti* in Namakkal and Salem districts. This study revealed the high incidence of this pest in neighbouring district (Coimbatore) also. We have observed the presence of *P. manihoti* in young sprouts in cassava stem bundles that were kept for planting. The aggressive spreading of *P. manihoti* in Tamil Nadu could be through the infested planting materials coupled with parthenogenetic mode of reproduction (Calatayud and Rü, 2006) [3].

So far, *P. manihoti* has been reported to infest plants belonging to 11 families (Garcia Morales, 2016) [7]. We observed the incidence of *P. manihoti* in *Portulaca* sp. (Family: Portulacaceae) in the cassava fields of Coimbatore district.

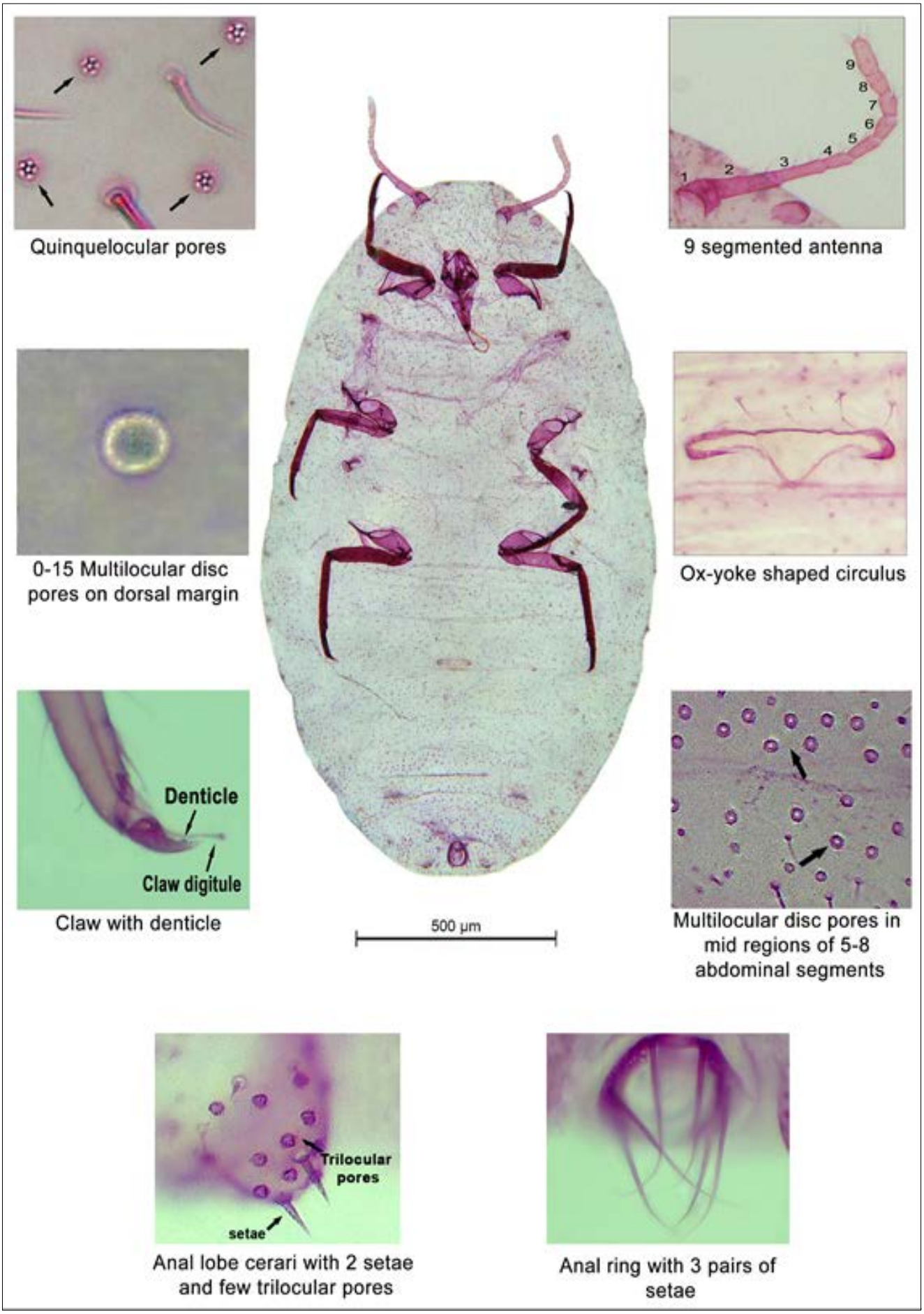

Fig. 1: Diagnostic characters used for identification of cassava mealybug, *Phenacoccus manihoti*

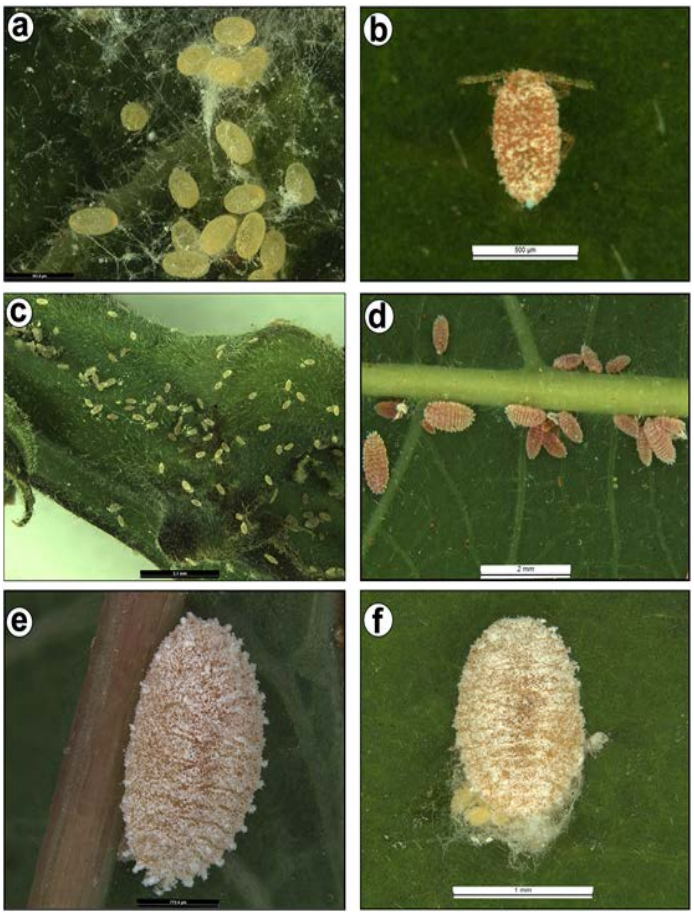

Fig. 2: Life stages of *Phenacoccus manihoti* a, eggs; b, crawler; c, crawlers in cassava twig; d, second and third instars; e, adult female; f, ovipositing female

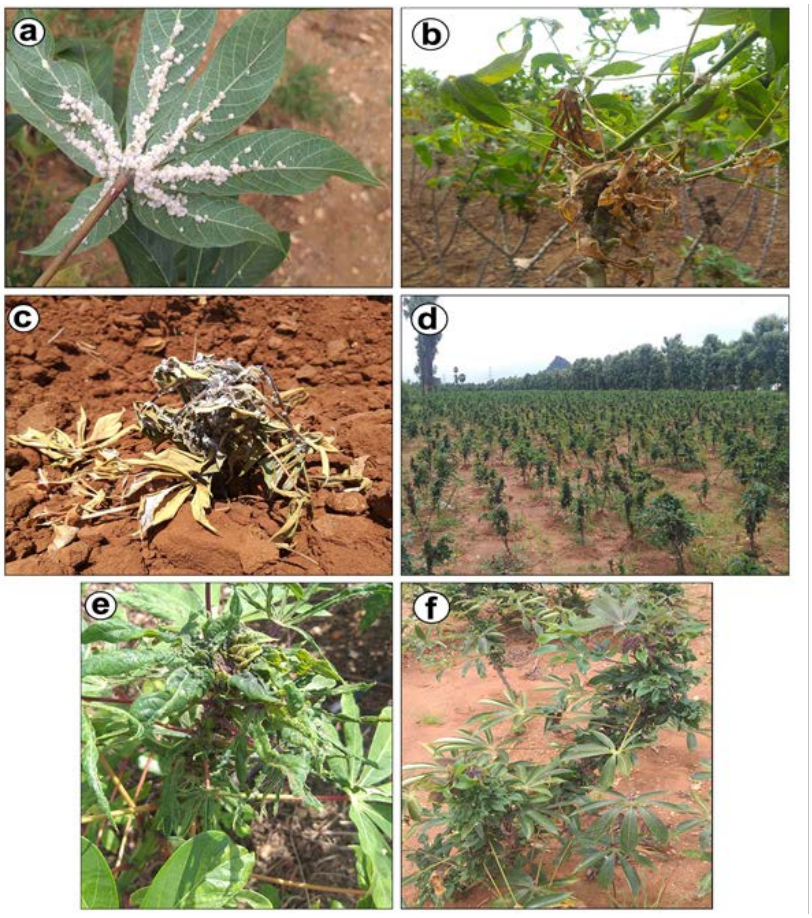

Fig. 3: Damage symptoms caused by *Phenacoccus manihoti* in cassava, a, Mealybug around leaf veins; b, drying of apical leaves and shoot; c, dried plant; d, stunted plants in the field; e, bunchy-top symptom; f, plant with shortened internodes and clumped leaves

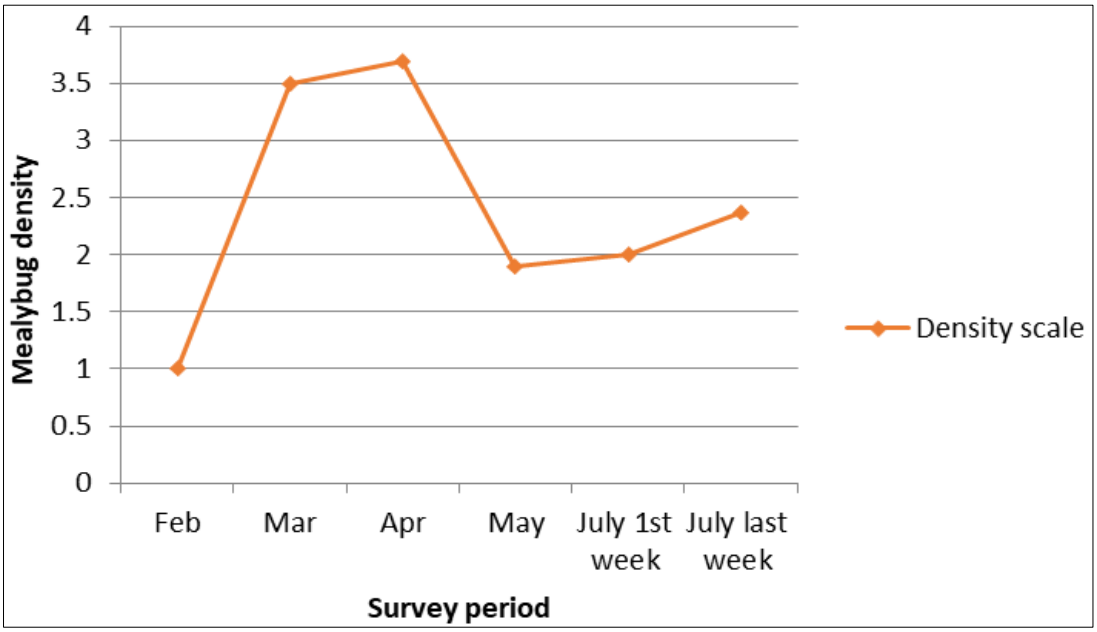

Fig. 4: Variation in mealybug density during the sampling period

Conclusion

This study revealed the occurrence of cassava mealybug in four major cassava growing regions of Tamil Nadu and the pest is rapidly spreading to other cassava growing regions of the state. To contain the infestation as well as to thwart the spread of *P. manihoti*, measures like destruction of infested plants, selection of pest-free planting materials and bio-rational insecticides are being recommended.

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