

The survey showed that none of the above mentioned bioagents of San Jose scale were present in Thanedhar areas, a progressive apple-growing belt in Himachal Pradesh, although previous reports<sup>3</sup> have shown establishment of *E. perniciosi* and *Aphytis* sp. The cause of extinction of these two parasitoids may be either due to climatic conditions or excessive use of insecticides. In a few selected orchards incidence of San Jose scale varied from 60 to 67% (tree-wise), 30 to 100% (twig-wise) and 40 to 49.2% (axis-wise) during the year 1983. To the best of the knowledge of the authors there is no report of the presence of *C. bijugus* and *P. flexibilis* in Thanedhar areas, although the same have been reported feeding on San Jose scale in Kashmir<sup>1</sup>. After mass multiplication in the laboratory, a total of 60 (1983) and 260 (1984) adults of *C. bijugus*, 265 (1984) adults of *P. flexibilis*, 10,000 (1984) and 3200 (1985) wasps of *E. perniciosi*, 10,000 (1985) and 10,000 (1986) wasps of *A. sp. proclia* group were released against San Jose scale in selected orchards at Thanedhar from April to November. The number released per infested tree varied from 10 to 20 in case of beetles and 1000 to 5000 in case of wasps.

Recoveries made in the following years showed that both the predatory beetles, i.e., *C. bijugus* and *P. flexibilis* are established and coping effectively with San Jose scale population. However, both the parasitoids, i.e., *E. perniciosi* (Tower) and *Aphytis* sp. *proclia* group were not recovered and need further investigation and releases. The number of adult beetles and grubs per tree varied from 100 to 500 during September and October, 1986. Of these two beetles, *P. flexibilis* had low feeding capacity (averagely 15 scale per beetle per day<sup>4</sup>) and cannot cope effectively with rapid increasing population of San Jose scale, while *C. bijugus* has high feeding capacity (averagely 217 scale per beetle per day<sup>1</sup>) and controlled the pest effectively. Many trees heavily infested with San Jose scale were found completely devoid of pest showing only scars of scales. Due to the predacious role of the beetles, the incidence of San Jose scale in selected orchards decreased (10–39.7% tree-wise, 20–26.48% twig-wise and 10–23.81% axis-wise) as compared to previous record. It was also observed that these beetles have automatically spread to a radius of 10 km from the release sites. During winter months (December to March) only adults were seen in the field. Now, adults and grubs are very common in Thanedhar area during summer.

Therefore, it is concluded from the present study that the above predatory beetles are quite promising

as bioagents of San Jose scale in Himachal Pradesh and need protection in the field.

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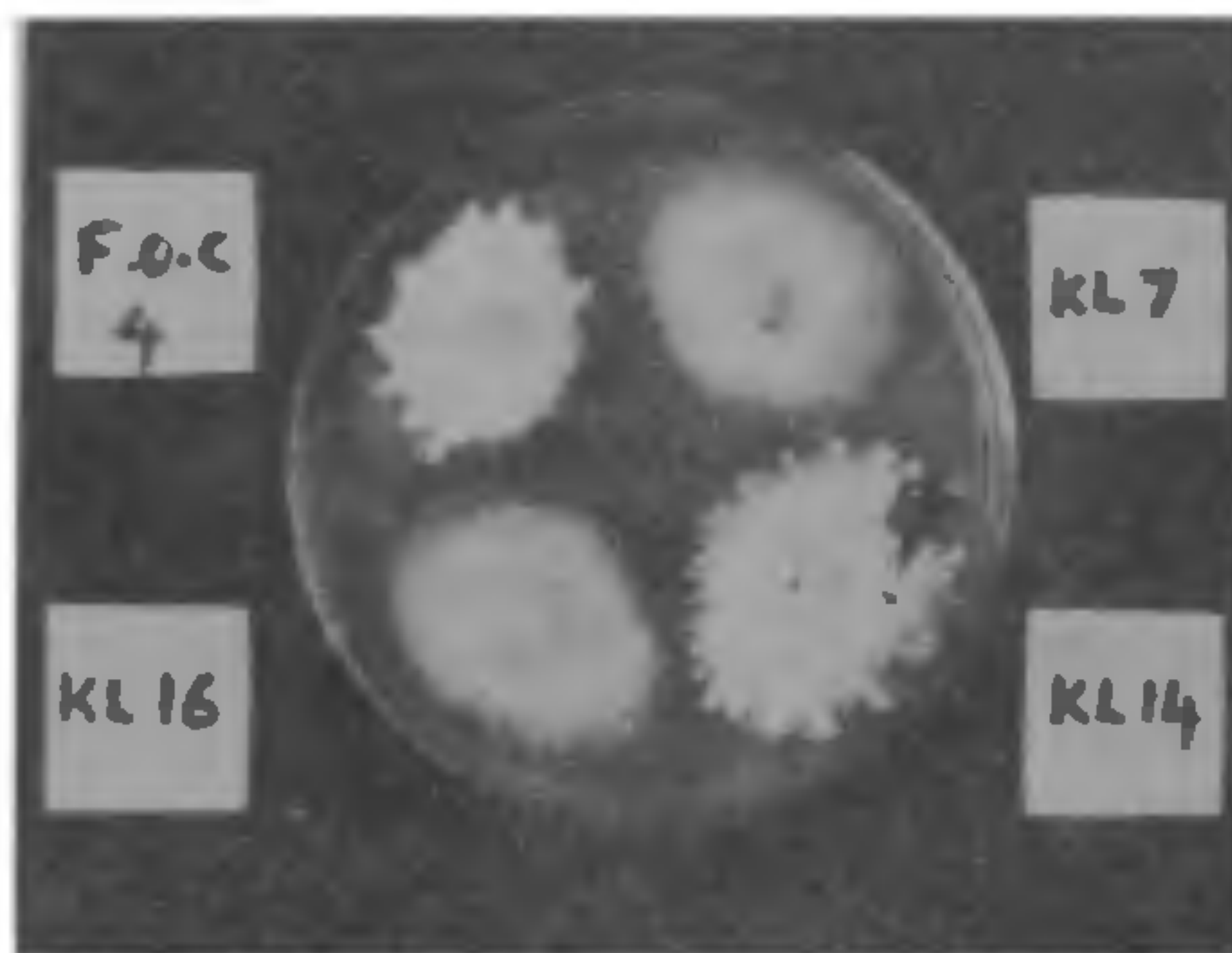
#### PRESENCE OF RACE 4 OF *FUSARIUM OXYSPORUM* F. SP. *CUBENSE* IN INDIA

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FUSARIAL wilt of banana caused by *Fusarium oxysporum* Schl. f. sp. *cubense* (E. F. Smith) Snyder and Hansen is commonly known as Panama disease<sup>1</sup>. The disease is quite widespread in banana-growing regions of Asia, Africa, Australia, the South Pacific and the Tropical Americas<sup>2</sup>. In southern India the incidence of Panama wilt was found high and in some districts disease incidence<sup>3</sup> ranged from 80 to 90%. There are 4 races of *F. oxysporum* f. sp. *cubense* found on members of musaceae. Races, 1, 2 and 4 cause wilt of bananas and race 3 attacks the wild *Heliconia* species<sup>1,4,5</sup>. Race 1 is distributed world-wide and attacks the common dessert variety of banana belonging to AAA triploids of *Musa acuminata*. The race 2 attacks the cooking variety of banana such as triploids of *M. acuminata* × *M. balbisiana* and is endemic to Central America<sup>6</sup>. The race 4 attacks the cavendish group of banana which is normally resistant to the Panama wilt<sup>7</sup>. This new race was first reported from Taiwan in 1967. Recent reports confirm the occurrence of race 4 of *F. oxysporum* f. sp. *cubense* in Australia, South Africa, Philippines and Canary islands<sup>8,9</sup>. Sivamani and Gnanamanickam recently reported the presence of races 1 and 2 from southern India<sup>10</sup>. From India there is no report on the occurrence of race 4 of the pathogen. This is the first report of the presence of race 4 of *F. oxysporum* f. sp. *cubense* from southern India.

Thorough and systematic surveys for Panama wilt disease was conducted in all the districts of Tamil Nadu and Kerala states. Isolations were made from the infected plant parts using modified Komada's selective medium (K2)<sup>11</sup>. A total of 59 isolates were obtained from the infected samples collected from all over Tamil Nadu and Kerala. The colony morphology of the fungus on the K2 medium was taken as the main criterion for race identification. Only the race 4 produces the typical laciniate colonies while the race 1 and 2 produce regular colonies on this medium<sup>11</sup> (figure 1). A race 4 culture of *F. oxysporum* f. sp. *cubense* was obtained from Dr S. C. Hwang, Taiwan Banana Research Institute, Taiwan for comparison. Mycelial plugs (7 mm) of isolates grown on PDA were placed mycelial surface down on K2 medium and incubated at 25° under continuous fluorescent light for 10 days. Pathogenicity tests were performed using standard procedures on 4-week-old seedlings of *M. balbisiana*<sup>12</sup>. For pathogenicity tests the fungus was grown in sterilized 10% rice-sand mixture with 30% water. After 2 weeks of incubation at room temperature in dark a 2 g volume of the inoculum was placed under the roots of 4-week-old seedlings of *M. balbisiana* raised from seeds. The control received 2 g volume of the sterile rice-sand mixture without the fungus. The inoculated plants were maintained in greenhouse conditions and observed after 4 weeks for symptoms of Panama wilt.

Of the 59 isolates of the fungus obtained from all over Tamil Nadu and Kerala only one isolate, KL14



**Figure 1.** Colony morphology of *F. oxysporum* f. sp. *cubense* on K2 medium. Top left: Reference isolate of race 4 *F. oxysporum* f. sp. *cubense* from Taiwan; Top right: a race 1 isolate; Bottom left: race 2 isolate, and Bottom right: race 4 isolate from Kerala.

isolated from an infected banana cv. Palayamkodan from Patancheri near Quilon in Kerala showed typical lacinations on K2 medium resembling the race 4 colony morphology of the reference isolate from Taiwan (figure 1). The seedlings of *M. balbisiana* inoculated with this particular isolate showed absolute wilting in 4 weeks and the infected seedlings on re-isolation yielded lacinate colonies of the pathogen on K2 medium.

The cv. Palayamkodan in banana-growing areas of Tamil Nadu is referred to as cv. Poovan and is resistant to races 1 and 2 of the pathogen. This is the first report of Panama wilt on cv. Palayamkodan. In just 3 years more than 200-fold increase in the disease outbreak caused by this race was observed<sup>7</sup> in Taiwan since 1967. This report ought to be considered significant in India due to the seriousness of the damage it can cause to the banana growers of this country.

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