3.5. Distribution of *Bemisia tabaci* in Latin America

Objectives

Whitefly-transmitted geminiviruses are the most important constraint to common bean and horticultural crop production in the lowland tropics. Currently, over 30 distinct species of geminiviruses transmitted by the whitefly *Bemisia tabaci* attack common bean, tomato, pepper, cucurbits, and other horticultural crops in the lower altitude American tropics and subtropics.

The distribution of the whitefly seems to have been extending over the recent past. Whether this is because of increased crop production areas, better reporting, or actual introduction of the species is not clear. This study was an attempt to explain the present distribution in simple climatic terms to better understand the limits of the distribution, and to indicate possible areas of future spread.

Materials and Methods

We used 304 georeferenced points throughout Latin America drawn from a survey of *B. tabaci* and geminiviruses. These points were scored during the survey on a scale of 1 to 5 (where 1 shows low infestation, and 5 very high infestation) for severity of whitefly infestation. We used FloraMap to construct a general climatic probability model of the distribution on the 10-arc-minute climate grids. This gave unconvincing results with the distribution probability smeared over large areas, and areas of known incidence showing low or zero probabilities. This is a common occurrence when an accession set contains a number of distinct populations or climate types.

We therefore used Ward's method of cluster analysis within FloraMap to investigate this possibility. After a number of trials it was decided that six clusters explained the distribution best. The clusters showed a range of different climates, and the joint probability distribution gave a good description of the accession point distribution.

The mean climates of the six clusters were inspected, and a set of rules for a simplified climate description was devised. This was mapped against the distribution, and scored for success and failure. As a final check, the simple climate rules were mapped against a 1-km grid for Central America, and checked against the agricultural land cover classes.

Results

Figure 19 shows the composite distribution probability constructed by summing the six probabilities from the climate clusters as derived by FloraMap. Very few points fall outside this limit, which in this case is displaying all areas with a probability greater than 30%. On inspection of the climate types, we found a large variation. There were hot tropical high-rainfall climates, subtropical climates with cool winters and hot dry summers, hot dry tropical climates, and other combinations. However, one characteristic stood out in them all. They all had 4, or a few more, months of dry season with rainfall less than 80 mm.

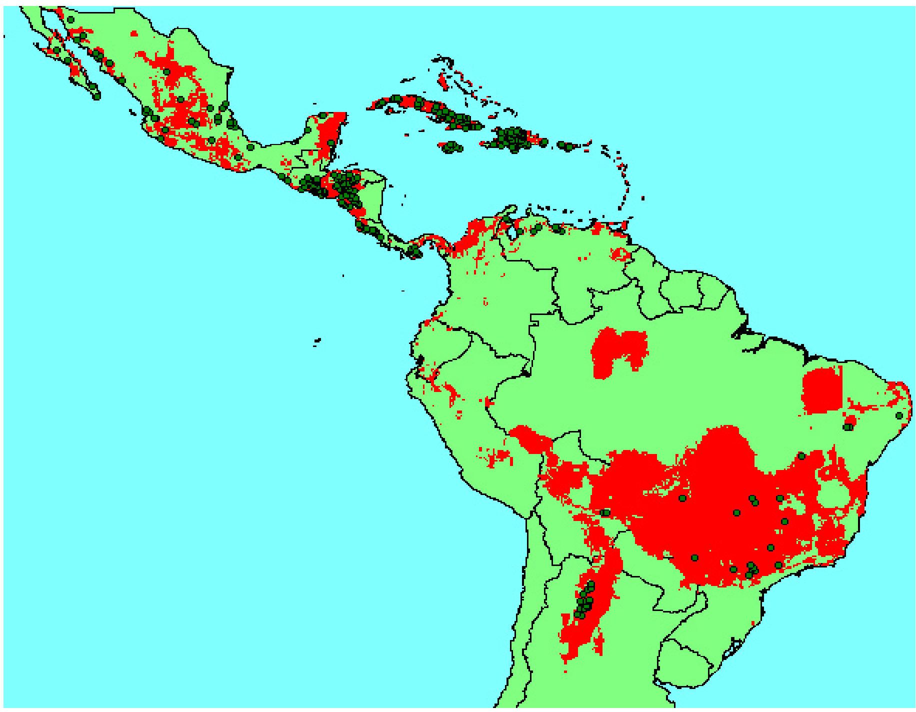

Figure 19. Distribution of *Bemisia tabaci* in Latin America with the climate probability derived as the joint probability of six cluster classes.

Whiteflies are hardly found above 1000 m throughout Latin America, but they are found more or less up to this limit regardless of latitude. This was a conundrum. The temperature regimes of the cluster classes varied widely, and the temperatures and annual temperature ranges vary greatly with latitude. How was it that the whiteflies would maintain the 1000-m limit in the face of this variation? The answer may be that, as we move away from the tropics, the annual temperature falls, but the annual temperature range increases. It is therefore possible that there are aspects of temperature that are constant with altitude over large latitude ranges. Figure 20 shows a case in point. As we move away from the equator, the temperature of the warmest month of the year is remarkably constant at an altitude of 1000 meters.

That this climate characteristic is actually determining the distribution of *B. tabaci* cannot be asserted from this study, but the coincidence is striking and could warrant some physiological investigation. In fact, the temperature of the warmest month in the six climate clusters never fell below 21 °C.

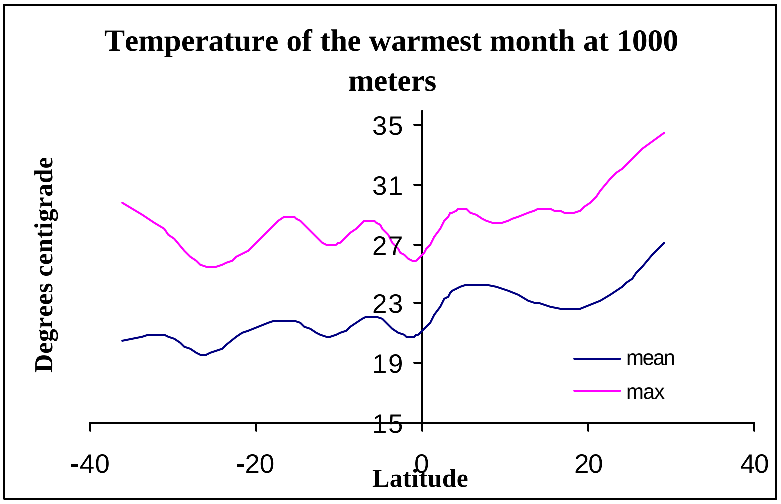

Figure 20. Temperature of the warmest month plotted against latitude for Latin America.

When we looked at the areas designated by the simple description of 4 dry months with less than 80 mm rainfall, and the temperature of the warmest month greater than 21 °C, we found a remarkable match with the survey points. The areas designated as *B. tabaci* should be present, but over 1000 m, predominantly in Mexico, are not primarily agricultural and so would not have been sampled.

Some of the points that missed the predicted distribution could be the result of fitting the model to a climate grid with pixels 18 km on the side. In mountainous areas, this level of precision is insufficient. We had available a 1-km precision grid for Central America, and so mapped the 103 survey points onto this grid using our derived climate bounds. Figures 21 and 22 show the result. The yellow circles highlight the six wrongly classified points.

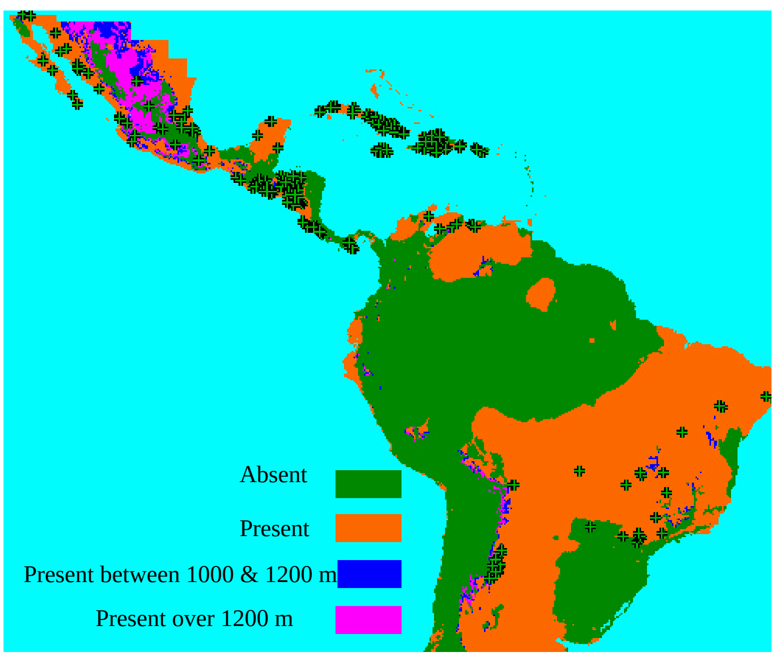

Figure 21. 304 accession points of *Bemisia tabaci* plotted in Latin America

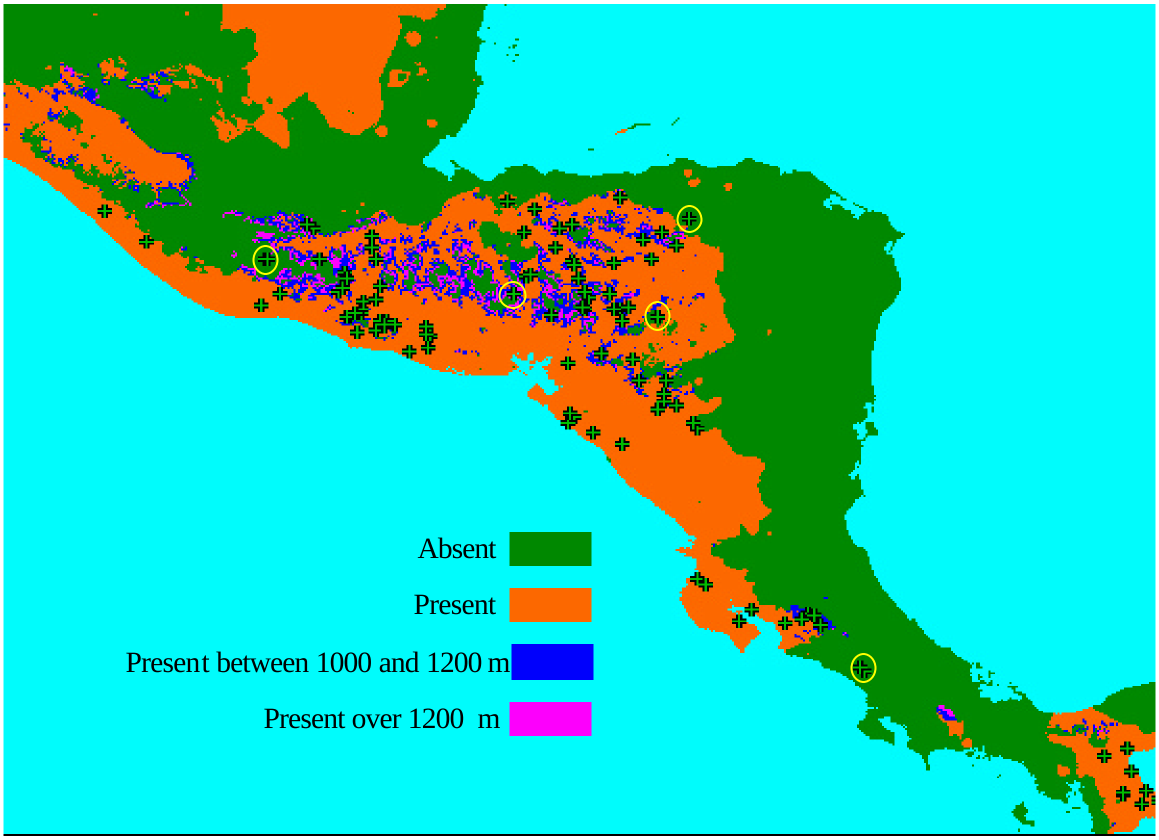

Figure 22. 103 survey points of *Bemisia tabaci* with derived climate limits, Central America.

Table 4 shows how the survey points were classed with respect to severity of infestation and elevation. None of the heavily infested areas was miss-classed by the classification, and the percentage of points miss-classed and the severity of infestation were very strongly related. Some eight points fell above the 1000-m limit, but almost none above 1200 m.

Table 4. Central America: 103 survey points of *Bemisia tabaci* and how they were classed.

Severity[a]	Wrongly classed (no.)		Correctly classed		
		%	Below 1000	Above 1000	Above 1200
2	1	20.0	5	0	0
3	5	8.5	53	6	0
4	1	4.0	23	1	1
5	0	0.0	6	1	0

a. On a scale of 1-5, where 1 shows low infestation, and 5 very high infestation.

It would appear that we now have a very simple, but effective, rule for determining if an area could be susceptible to whitefly. Some of these areas, such as that around Manaus, will presumably remain free of whitefly, because the density of cultivation of susceptible crops is very low. More worrying is the case of the area predicted in the Central Valley in Chile. This area has considerable horticultural production and a Mediterranean climate. Whitefly is a major pest around the Mediterranean, but do not appear to have arrived yet in Chile.

Outputs

This work was presented in May at the VIIIth International Plant Virus Epidemiology Symposium in Ascherleben, Germany.