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Socioeconomic and agricultural factors associated with mixed cropping systems in small farms of southwestern Guatemala

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SUMMARY. Many small farming communities in Latin America have modified their traditional cropping systems to incorporate non-traditional export crops (NTEC). The shift from subsistence to commercial agriculture is perceived by development agencies as an opportunity to alleviate poverty in rural areas. However, most small-scale farmers are not familiar with the production problems of NTEC, such as *Bemisia tabaci* and various geminiviruses transmitted by this whitefly species. In the absence of adequate technical assistance, due to drastic budgetary reductions in national agricultural research programs, farmers have relied on agrochemicals to protect their NTEC. This situation has led to considerable pesticide abuse and rejection of contaminated produce in international markets. This study analyzes some of the factors determining the adoption of NTEC and displacement of traditional food crops in southwestern Guatemala, and suggests possible measures to allow small farming communities to benefit from broad-based cropping systems that include both traditional and non-traditional food and cash crops.

KEY WORDS. Pesticide abuse, whitefly, *Bemisia tabaci*, geminivirus, *Bean golden yellow mosaic*, export crops, globalization, sustainability.

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INTRODUCTION

The "lost decade" or economic crisis of the 1980's caused drastic changes in traditional cropping systems throughout Latin America. In 1982, the total external debt of Latin America was US $ 333.5 billion, up from a total of US $ 2.3 billion in 1950 (BID, 1994). The impact of this crisis was particularly felt by the poorer countries in the region, which were still dependent on traditional agricultural products, such as coffee (*Coffea arabica*), cotton (*Gossypium hirsutum*), tobacco (*Nicotiana tabacum*) and bananas (*Musa* spp.), to counteract their growing trade deficits. Unfortunately, the value of most traditional export crops has been steadily decreasing due to economic factors beyond the control of developing countries. For Central America, one of the most economically-affected regions in Latin America, the growing demand for fresh vegetables and fruits in North America presented a timely opportunity for crop diversification (Stanley, 1999). This region increased the production of non-traditional export crops (NTEC), such as tomato (*Lycopersicon esculentum*), chili peppers (*Capsicum* spp.), melon (*Cucumis melo*), broccoli (*Brassica oleracea*), eggplant (*Solanum melongena*) and okra (*Abelmoschus esculentus*), over 75 % between 1984 and 1989 (Thrupp, Bergeron, and Waters, 1995). Guatemala, one of the most representative Central American countries, had approximately 250 organized exporters and over 100,000 farmers producing NTEC by 1996, which created an additional 83,000 jobs associated with these mixed cropping systems (GEXPRONT, 1996).

Unfortunately, the boom of NTEC in Latin America came at a time when most national agricultural research institutions were being drastically downsized, as a result of the economic recession and shift in research priorities from food production to natural resource management. The globalization of the economy and dismantling of trade barriers further downplayed the issue of food security as a regional priority (Robinson, 1998). A negative consequence of these new policies was the disruption of effective technical support for producers of NTEC. Thus, producers had to rely on pesticides to meet the strict quality standards for fresh vegetables in international markets. As a result, many shipments of NTEC were rejected due to high levels of pesticide residues, with consequent losses to both exporters and producers (Thrupp, Bergeron, and Waters, 1995). In the mean time, traditional food crops, such as corn (*Zea mays*) and beans (*Phaseolus vulgaris*), were displaced to marginal lands in most countries in Latin America, with a subsequent drop in their productivity and capacity to satisfy the internal food demand. Even the main common bean- and corn-producing countries in Latin America found themselves importing these food staples from Asia and some industrialized countries. Ultimately, these unsustainable mixed cropping systems started to collapse due to severe outbreaks of pests and diseases, which caused significant and often total production losses in both traditional and non-traditional food and industrial crops.

The objective of this paper is to point out some of the biological and socioeconomic factors associated with the mixed cropping systems currently found in southwestern Guatemala, and their impact on the environment and wellbeing of small-scale farming communities.

MATERIALS AND METHODS

Southwestern Guatemala was selected as the case-study area because of the existence of traditional and non-traditional crops, and the presence of *Bemisia tabaci.* This whitefly species is currently considered the most important pest and vector of plant viruses affecting both traditional and non-traditional crops in Middle America (Morales and Anderson, 2001). Moreover, *B. tabaci* has been largely responsible for the excessive application of pesticides in broad-based cropping systems; serious environmental and food contamination; and high crop production costs. Finally, the agricultural communities found in this region have undergone a gradual process of cultural change, from an indigenous to 'ladino' (defined as people who have never been or are not anymore part of an indigenous community) status, which has paralleled the shift from subsistence to commercial agriculture.

The municipality of Monjas has a population of approximately 28,000, of whom 55% live in the rural area. Additionally, three neighboring villages in the municipality of Santa Catarina Mita, and one village in the municipality of El Progreso, were also included because these villages were socioeconomically integrated to the community of the Valley of Monjas. Considering the need to conduct a limited but detailed examination of a relatively small number of people in each village, a "case study" methodology was chosen. Preliminary interviews with representative growers selected by local extension specialists of the national agricultural research program (ICTA) were conducted in each village to guide the survey and test the questionnaire. The "geographical area of coverage" was each of the 16 villages in the three municipalities selected for this study (Table 1). At the village level, the number of respondents was usually less than 100, and the subjects of the study were individual farmers selected at random. Sample size (n) was determined according to the formula: $n = Z^2 \times p \times q / S_E$, where Z = *confidence interval* (95%); p = proportion of growers reporting whitefly/geminivirus problems with their crops; q = proportion of growers that do not report whitefly/geminivirus problems with their crops; and S_E = *S*tandard error (Palma, 1999). The frequency of enumeration was a single visit to each respondent, and data was collected through individual interviews (Casley and Lury, 1989). The questionnaire was designed to collect basic information on: respondents' basic data, geographic location of farms; cropping systems; whitefly problem; climatic conditions; pest/disease management practices; production costs; and farmers'decision making process. A total of 56 variables were coded for statistical analysis (SAS). Some of the variables were further subdivided according to the various crops mentioned by farmers. The questionnaire had 43 questions, and was designed to be completed in approximately 30 minutes. The final survey was completed in two weeks.

RESULTS AND DISCUSSION

The total number of respondents was 138, with the majority (119) from the municipality of Monjas, department of Jalapa. This municipality spans an area of 256 km^2, and includes the main agricultural ecosystem of the region, the Valley of Monjas (14° 29' 34" N and 89° 52'32" W), located at 960 m above sea level. The annual mean temperature is 23.7° C, and the mean annual rainfall is 900 mm, distributed between May and October. The soils are fertile and there is an irrigation district in the valley. The analysis of the individual respondent variables, revealed that all of the 138 farmers interviewed were males. Of these farmers, 42.7% owned the land, 18.8% were tenants (cost of renting land ranged between $ 50 and 220 US/ha), and 37.6% were 'medianeros' (*i.e.* farmers who contribute all or most of the inputs and shared the profits with the owner of the land). The majority (47.4%) of the farmers had been working the same land for over 10 years, and only 10% of the respondents had been working the fields less than two years. The 'medianeros' constitute a relatively new group of farmers (the mode for this group was three years working the land in the Monjas area). A personal variable added later showed that only 3.6% of the farmers interviewed had any technical training, and that 54.7% of the respondents had only a primary school education. About 41% of the farmers had no schooling. The average age of the farmers was 45 years and the size of their families was six members. There was a negative correlation (- 0.4) between the age of the farmers and the cultivation of high value crops, such as tomato and chili pepper.

In the early 1970's, the major crop in this area used to be tobacco (approximately 1,400 has), followed by common bean (720 has), tomato (650 has), corn (498 has), broccoli (280 has) and chili peppers (5 has). At present, tobacco and tomato production were significantly reduced due to lower market prices and whitefly/geminivirus problems, respectively. Nevertheless, tobacco was still the predominant crop in the region because it is grown under contract for private companies, which guarantees its commercialization. Tomato and chili pepper were produced by the more advanced and solvent farmers in the region. The production of broccoli, on the contrary, increased relative to that of tobacco and tomato. However, the majority of farmers growing non-traditional crops had changed the composition of their cropping systems and corn was their main food crop (43.8% of the respondents). Common bean, on the contrary, was only cited by 5.1% of the farmers interviewed as their main food or cash crop. As for commercial crops, tobacco was mentioned as the main commodity by 32.8% of the growers, followed by tomato, broccoli, chili peppers, and cucurbits, according to 7.3, 5.8, 3.6, and 0.7% of the respondents, respectively. Average areas for these crops were: tobacco (4.1 ha), tomato (1.7 ha), common bean (0.9 ha), broccoli (2.3 ha), chili peppers (1 ha), corn (2.8 has), and watermelon and cucumber (1.4 ha). Approximately 88% of the farmers interviewed responded that they practiced crop rotation (using maize, common bean, tomato, broccoli, cucurbits, etc.) to maintain soil fertility and reduce the incidence of pests and diseases. The average number of crops grown per farm was 2.9. Table 2 shows the distribution of crops, production systems, proportion of producers, area and presence or absence of whitefly/geminivirus problems for the four major crops grown in the valley of Monjas. It is apparent from these data that irrigation was primarily used for tobacco production, whereas food crops were grown mainly under rainfed conditions. Regarding farmers' perception about profitability, the order of crops closely reflected the farmers' choice for their preferred cash crop: tobacco, tomato, broccoli, common bean, chili peppers and corn. In the case of food crops, corn occupied the last place of all crops in terms of profitability, whereas common bean was in third place.

In reference to the *B. tabaci* problem, nearly all farmers (99.3%) recognized the whitefly as an insect, and 96.4% considered it as an important pest. Approximately 65% of the farmers cited tomato, common bean, chili peppers and tobacco as the crops most affected by *B. tabaci*. Most of the growers believed that the whitefly and/or geminiviruses this vector transmits, could cause between 50 and 75% yield losses in tobacco, tomato, common bean, broccoli and chili. Hence, 90% of the tobacco and tomato growers used insecticides to control *B. tabaci*, whereas only 10% of the farmers interviewed utilized geminivirus- or whitefly-resistant cultivars. This observation is explained by the fact that only common beans have been bred for resistance to whitefly-transmitted geminiviruses in this region of the world. Most bean growers (84%) controlled whitefly-transmitted viruses with insecticides against the insect vector, and only 16% used resistant varieties. In the case of chili peppers, all of the farmers used pesticides to control the whitefly/geminivirus problems. Interestingly, only biological insecticides were used on broccoli due to a specific market demand.

The problem of pesticide abuse was notorious in these mixed cropping systems. Approximately 55% of the farmers claimed that agricultural 'technicians' helped them select agrochemicals. However, there was no common criterion among farmers for pesticide application. Approximately 23% of the farmers applied pesticides as a preventive measure; 12-15% applied pesticides on a calendar basis; and 1.5 to 8% applied when farmers noticed insect damage. The remaining farmers applied pesticides in an irregular pattern. Pesticide abuse was particularly apparent in the number of applications per crop. The number of pesticide applications in tobacco, tomato, common bean, broccoli, and chili ranged from 1 to 50 per crop cycle. According to the majority of the farmers interviewed, tobacco was usually sprayed 1 to 6 times, whereas tomato was treated from 3 to 30 times. Common bean was sprayed between two and four times, and chili peppers between four and 15 times. The more expensive systemic pesticides (*e.g.* carbamates and imidacloprid) were predominantly used in crops such as, tomato, tobacco, and watermelon. The remaining insecticides were mostly pyrethroid, organo-phosphate or organo-chlorinated compounds. Broccoli is an interesting case because growers are required to use only biological insecticides on this crop. For the remaining crops, farmers often use 'cocktails' of insecticides, fungicides and bactericides. The number of different pesticide products applied to each crop were: 11 commercial products in tomato, nine in tobacco, nine in cucurbits, eight in common bean, four in chili pepper, one in corn, and three biological products in broccoli. Pesticide abuse also resulted in high production costs (Table 3).

The apparent gender bias observed in this survey can be explained by the fact that males are in charge of most agricultural activities in these rural communities, except in home gardens (Noval, 1992). The farmers interviewed can be classified as traditional, small-scale farmers, according to the number of years they had been working in this region, and the average area (0.9-4.1 has) occupied by the different crops analyzed. Corn and common bean are traditional food crops grown since pre-Columbian times, whereas cash crops, such as tobacco, were introduced in the region soon after the creation of an irrigation district in the early 1970s. Thus, tobacco could still be considered as a NTEC for this area, although it is classified as a traditional export crop in national terms. The expansion of tobacco plantings in the 1970s was associated with the emergence of *B. tabaci* as a new pest in this region. The whitefly outbreaks brought about a new problem to common bean production, *Bean golden yellow mosaic virus* (BGYMV). This virus attacked the local common bean landraces causing significant yield losses. Fortunately, BGYMV-resistant common bean varieties were released in Guatemala in the early 1980s, and were rapidly adopted by most farmers in southwestern Guatemala (Viana, 1997).

With the collapse of tobacco prices in the mid 1970s, there was a significant reduction in the area planted to this crop. As an alternative, tomato production was intensified until the late 1980's, as one of the first NTEC grown in this region. Unfortunately, a geminivirus disease known as 'acolochamiento' reduced the tomato area from 650 has to about 70 has, and tomato was no longer considered a viable NTEC (GEXPRONT, 1996). At that time, broccoli became the predominant NTEC in this region, occupying approximately 650 has in 1998. Although broccoli is not significantly affected by *B. tabaci* or geminiviruses, the whitefly reproduces abundantly on the stubble of this crop after harvest (February-March), and generates *B. tabaci* outbreaks in April. Corn is not affected by either *B. tabaci* or geminiviruses and it remains the predominant food crop in this area, and most of Latin America. Nevertheless, both corn and common bean, have been gradually displaced from the irrigated and more fertile soils to marginal areas in this region of the world.

The composition of crops in southwestern Guatemala reflects the trend from subsistence to commercial agriculture in small-scale farming communities. This trend has been facilitated by the availability of additional sources of income from private investors or migrant labor (*i.e.* relatives working in the United States). This has helped to defray the high costs of producing non-traditional crops. For example, the cost of planting a hectare of common bean ranges between US $ 300-400, whereas tomato costs between US $ 2,000-4,000/ha. However, the net profit expected for common bean ranges between US $ 100-200/ha, whereas the net profit for tomato often exceeds US $ 2,000/ha (Morales *et al.*, 2000; Thrupp, Bergeron, and Waters, 1995).

Considering the high investment required to grow non-traditional crops, it is easy to understand the emphasis on preventive chemical control. In fact, up to 80% of the total cost of producing some NTEC corresponds to pesticides. Whitefly control accounts for 35% of the average chemical protection costs associated with the production of NTEC. The relatively low use of pesticides and crop protection costs observed for corn, are probably related to the crop's resistance to *B. tabaci* and the geminiviruses that this vector transmits. The cost for pest and disease protection in common bean was lower than for the other crops, which suggests that farmers are using improved bean cultivars (although only 16% of the bean growers interviewed acknowledged their use, probably due to seed exchange among farmers without proper identification of the materials). A preliminary field survey conducted prior to the implementation of this case-study, showed that most farmers were planting improved common bean cultivars (*e.g.* upright architecture). The lack of proper technical assistance is blamed by 43.5% of the farmers for the abandonment of various crops affected by *B. tabaci* and/or geminiviruses transmitted by this whitefly species. Only 24% of these farmers have attempted to grow whitefly/geminivirus-susceptible crops again, using new pesticides currently available to control *B. tabaci* (*e.g.* imidacloprid).

CONCLUSION

It is apparent that the traditional cropping systems of many small farming communities in Guatemala incorporated non-traditional, high value crops, as observed in previous studies (Carletto, Janvry and Sadoulet, 1996; Carter, Barham and Mesbah, 1996; Morales *et al.*, 2000). The trend from subsistence to commercial agriculture is interpreted by some development agencies as an indication of agricultural development. According to these agencies, NTEC help repay foreign loans, reduce dependence on traditional export crops, create jobs, and stabilize the economy (Thrupp, Bergeron and Waters, 1995; Stanley, 1999). However, the shift to commercial agriculture has often taken place at the expense of traditional food crops, such as common bean and corn. Fortunately, the price fluctuations and high risk associated with the production of NTEC have convinced most small-scale farmers of the need to reserve a significant portion of their land for food crops (Carter, Barham and Mesbah, 1996; Morales *et al.*, 2000). In this and a previous study conducted in the department of Baja Verapaz, Guatemala (Morales *et al.*, 2000), it became evident from the proportion of the available land planted to corn, that this cereal is the basis of food security in these communities. Common bean was regarded both as a food staple and alternative cash crop by over 60% of the farmers interviewed in the case-study conducted in Baja Verapaz.

Small-scale farmers were initially able to participate in the NTEC boom because the use of family labor reduced production costs for commercial exporters, who contracted them for production of NTEC. However, the tendency of small-scale farmers to abuse pesticides forced commercial exporters to re-introduce direct production of NTEC or contract their production only with large-scale farmers (Carter, Barham and Mesbah, 1996). The pesticide abuse problem is linked to the lack of technical assistance for most small-scale farmers. In this case study, only 23.4% of the farmers interviewed had received technical assistance. These problems have also prevented small-scale farmers involved in NTEC-production from acquiring more land (Carletto, Janvry and Sadoulet, 1996). Thus, policy makers will have to provide small-scale farmers with adequate support (*e.g.* credit, crop insurance and technical assistance), if they are to improve their socioeconomic situation through a 'broad-based sustainable development'. This concept is defined as "equitable opportunities for poor farmers; guaranteeing food security, and developing agricultural practices that are economically viable and environmentally sound" (Thrupp, Bergeron, and Waters, 1995). It is evident from various economic studies conducted on this theme that proper technical assistance in pest and disease control practices is critical for the production of both traditional and non-traditional crops by small-scale farmers (Thrupp, Bergeron and Waters, 1995; Carletto, Janvry and Sadoulet, 1996; Carter, Barham and Mesbah, 1996).

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TABLE 1. Geographic location of villages surveyed and number of farmers interviewed

Department	Municipality	Village	No. Farmers
Jalapa	Monjas	Achiotes	8
		Achiotillos	4
		Garay Viejo	6
		La Campana	13
		Llano Grande	23
		Mojarritas	6
		Morazán	9
		Piedras Blancas	5
		Plán de la Cruz	4
		San Antonio	18
		San Juancito	9
		Terrones	14
Jutiapa	Santa Catarina Mita	Jocote Dulce	7
		Magueyes	4
		Uluma	1
	El Progreso	El Ovejero	7
Total			138

TABLE 2. Cropping systems, producers and whitefly/geminivirus problems in the valley of Monjas, Jalapa, Guatemala.

	% Growers		**Area (Has)**		**Wf/Gv* problem**
Crops	Irrigated	Rainfed	Irrigated	Rainfed	
Tobacco	29.7	31.4	145	206	Yes
Maize	2.9	47.0	15	287	No
Tomato	8	10	19	71	Yes
Common bean	6.5	21	8	65	Yes

* Wf = whitefly; Gv = geminivirus

TABLE 3. Average crop production costs*, including crop and whitefly protection costs (USD/Ha), in the case-study region selected in southwestern Guatemala.

Crop	TCPC	CPC	CPC%	WFCC	WFCC%
Tobacco	$ 2,259	$ 1,950	86.3	$ 1,374	60.8
Tomato	$ 2,018	$ 1,968	97.5	$ 502	24.8
C. Bean	$ 414	$ 219	52.9	$ 52	12.5
Broccoli	$ 1,363	-	-	$ 191	14.0
Chili	$ 2,653	$ 1,559	58.8	$ 505	19.0
Cucurbits	$ 918	$ 437	47.6	$ 160	17.4
Corn	$ 850	$ 299	35.2	-	-

* TCPC: Total Crop Production Cost; CPC: Crop Protection Cost; WFCC: Whitefly Control Cost; % of TCPC; - = Data not available.

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Anil Shrestha, PhD, MS, BSc, is currently a Weed Ecologist with the University of California's Statewide IPM Program. He is based at the University's Kearney Agricultural Center in Parlier, California. Dr. Shrestha was born in Nepal and received his BSc from Narendra Dev University of Agriculture and Technology in Faizabad, India. After completing his undergraduate degree, he worked several years with the Department of Agriculture and with the FAO Fertilizer Program in Nepal as Assistant Agronomist and Regional Supervisor respectively. He completed his MS in crop and soil sciences as a Fulbright Fellow at Cornell University and his PhD as a C.S. Mott Fellow of Sustainable Agriculture in the Department of Crop and Soil Sciences at Michigan State University. Dr. Shrestha worked briefly as a research associate at the Center for Evaluative Studies of the Department of Agricultural and Extension Education at Michigan State. Later, he worked for five years as a postdoctoral fellow and as a research associate in the Department of Plant Agriculture's weed science program at the University of Guelph in Canada. Dr. Shrestha is committed to extension and research efforts in vegetation management, cropping systems, and agroecology, and has authored more than 25 refereed papers and several extension articles in these fields.

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From: Morales, Francisco (CIAT)
Sent: Tuesday, December 09, 2003 10:13 AM
To: Gonzalez, Olga Lucia (CIAT)
Subject: FW: Prepublication announcement for your book Cropping Systems: Trends and Advances

→ Cropping Systems

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Sent: Thursday, April 03, 2003 2:46 PM
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Thanks
Anil

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To: Shrestha, Anil
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