Complexity of intercropped sorghum-maize production systems in southern Honduras[1]

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Abstract. A survey was conducted in 1996 to determine the agricultural practices used by subsistence farmers in planting sorghum and maize in southern Honduras. A total of 114 heads of households (5 women and 109 men) were interviewed. The survey form included questions on planting system (methods), date of planting, crop variety, weed control, fertilization, and pest control practices. Totals and percentages of responses were tabulated and analyzed. The survey revealed the complexity of sorghum-maize intercropped production systems in the foothills and on the coastal plains in this region of the country. The agronomic information obtained can be useful in developing integrated pest management strategies for the specific geographical regions in Honduras.

Keywords: Central America, survey, *Sorghum bicolor*, *Zea mays*.

Resumen. Una encuesta fue conducida en 1996 para determinar las practicas agrícolas usadas por agricultores de subsistencia que siembran sorgo y maíz en el sur de Honduras. Un total de 114 cabezas de familia fueron encuestados (5 mujeres y 109 hombres). La encuesta incluía preguntas sobre métodos de siembra, fecha de siembra, variedad, control de malezas, fertilización y control de plagas. Totales y porcentajes de las respuestas fueron tabulados y analizadas. La encuesta reveló la complejidad de los sistemas de producción intercalados, de maíz y sorgo en las laderas y en el área costera del país. La información agronómica obtenida puede ser usada para desarrollar estrategias en el manejo integrado de plagas para esta región especifica de Honduras.

Palabras claves: Centro América, encuesta, *Sorghum bicolor*, *Zea mays*.

INTRODUCTION

Southern Honduras is the most important region in the country for sorghum production (DeWalt and DeWalt 1982). Approximately 82% of the sorghum area in this region is intercropped with maize. Both crops are mainly produced by resource poor, subsistence farmers that work under extremely adverse economical, educational and environmental conditions. If the maize crop is lost to drought, farmers will use sorghum as a substitute to feed their families and animals (Dewalt and Dewalt 1987). A high percentage of yield loss can be attributed to a lepidopterous pest complex, commonly referred to as "langosta" by subsistence farmers in this region because of the extensive locust-like feeding damage to the plants caused by the insects. This complex of insect pests was described by Pitre (1988a).

There are two main types of farming systems used for the production of intercropped sorghum and maize in southern Honduras: the "foothills" system and the "coastal plains" system. Farmers use one or the other depending on the availability of land to be planted, the slope of the land, location of their homes and the amount of money and time they are willing to invest during the growing season. It is commonly known that farmers without economic resources will use the foothills farming system, while farmers with enough capital to invest in land preparation with ox-pulled plows will choose the coastal plains farming system. Farmers also have a choice among four planting methods currently in use in the region. These planting methods are "aporque", or sorghum planting delayed about one month after maize planting (generally used in coastal plains fields); "surco alterno", or sorghum and maize planted at the same time in alternate rows; "golpe alterno", or sorghum and maize planted at the same time

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in alternate hills; and "casado", or sorghum and maize planted at the same time in the same hill (site in the row). The latter planting systems are generally used in the foothills where the fields are full of rocks. In the «aporque» system, maize matures early and is harvested before the photoperiod sensitive sorghum initiates bloom. The sorghum continues growth without competition from the maize and is harvested in December-January. The type of planting method used by the farmer can influence agronomic production practices, including selection of maize and sorghum varieties, planting date, fertilization and weed control, as well as pest control tactics, such as seed treatment, and herbicide and insecticide sprays. A survey was utilized to identify planting systems and other crop production practices used by subsistence farmers in southern Honduras. It was conducted in greater agronomic detail than that performed by DeWalt and DeWalt (1982). The agronomic, economic, and entomological implications of the use of these practices are assessed and discussed in relation to information obtained in previous research.

MATERIALS AND METHODS

Subsistence farmers using foothills or coastal plains planting systems for sorghum and maize production in southern Honduras were interviewed during July and August, 1996. Farms were located in the Department of Valle (coordinates ca. 13° 31' N, 87º 43' W). The survey was composed of 11 questions (Table 1) and lasted 20 minutes on average for each farmer. One hundred and fourteen farmers or heads of households (5 women and 109 men) were interviewed in ten locations chosen at random: 64 at El Chorro, 24 at Piedra Blanca, 11 at La Coyota, 4 at Costa de Amate, 3 at Los Luises, 3 at San Rafael, 2 at Volcancillo, 1 at San Pedro Calero, 1 at Poza López, and 1 at La Garita.

RESULTS AND DISCUSSION

Eighty six farms included in the survey were in the foothills and 28 on the coastal plains. All farmers included in the survey produced sorghum and maize using different intercropped methods on a total area of 133 ha. The average field size (production area per farmer) was 1.2 ha. Of the 133 ha of intercropped sorghum and maize included in the survey, 89 ha were cultivated by farmers in the foothills and 44 ha by farmers on the coastal plains. The average field size in the foothills was 1 ha compared with 1.5 ha on the coastal plains. On average, farms located on the coastal plains were 67.3% larger than farms located in the foothills.

Planting methods

The four planting methods identified previously were used on farms in this survey. The number of farmers included in the survey using "casado", "surco alterno", "aporque" and "golpe alterno" was 60 (52.6%), 32 (28.1%), 20 (17.5%) and 2 (1.8%), respectively.

Of the 86 farmers in the foothills, 56 (65.1 %) planted "casado", 27 (31.4%) planted "surco alterno", 2 (2.3%) planted "golpe alterno", and 1 (1.2%) planted "aporque". The minimal use of "aporque" in the foothills is due to the near impossibility of using ox-pulled plows for land preparation due to the slope of the fields and soil conditions (extensive erosion and obstacles such as rocks and bushes). The popularity of "casado" in the foothills is due to the possible planting of two crops at a time, being less time consuming and maximizing the use of the area available for crop production.

Of the 28 farmers on the coastal plains, 19 (67.9%) planted "aporque", 5 (17.8%) planted "surco alterno", and 4 (14.3%) planted "casado". "Golpe alterno" planting was not used. The popularity of "aporque" on the coastal plains is due to the capability of using ox-pulled plows to prepare the flat or gently sloped land, as well as the better soil conditions (soil texture and structure, and fewer rocks and bushes in this area than in the foothills). The farmers using ox-pulled plows, either on the coastal plains or the few that use oxen in the foothills, are the wealthiest farmers who can pay the cost of owning or leasing the animals, feeding them and paying the cost of hiring extra help (a driver and another person that follows the plow correcting the damage caused by the oxen).

Most of the farmers (108, 94.7%) used their own early maturity "criollo" maize and local landrace sorghum varieties and only six (5.3%) farmers used hybrid maize and enhanced landrace sorghum cultivars developed and recommended by the Honduran Ministry of Natural Resources (MNR)-United States Agency for International Development (USAID) collaborative research support program on sorghum (INTSORMIL) (Gómez 1995). Farmers planted an average of 4.7 maize seeds and 6.5 sorghum seeds per hill in all planting methods considered. The large number of seeds used is intended, in part, to

Table 1. Form for survey of planting systems in southern Honduras (1996).

1. Area
Hills _____
Plains _____

2. Farmer's name _____

3. Location _____

4. Size of field _____

5. Planting date _____

6. Planting system [1]

Casado (S + M in same hill) _____
Golpe alterno (S + M in separate hills, same row) _____
Surco alterno (S + M in alternate rows) _____
Aporque (M first, sorghum delayed one month) _____

7. Varieties
Sorghum _____
Maize _____
Others _____

8. Number of seeds per hill
Sorghum _____
Maize _____
Others _____

9. Insect control
Insects _____
Insecticides _____
Seed treatment _____
Others _____
Number of sprays per year for langosta _____

10. Fertilization
Fertilizers _____
Others _____
Time of application _____

11. Weed control
Weeds _____
Herbicides _____
Manual weeding _____
Cultivation _____
Others _____
Time of control _____

[1] S = Sorghum, M = Maize

as pests of sorghum and maize in "casado" on the coastal plains.

Farmers that planted "surco alterno" on the coastal plains also reported that the most damaging insect pests on sorghum and maize were the fall armyworm (five farmers), *M. rogenhoferi* (five farmers), grass looper (three farmers), white grubs (three farmers), and grasshoppers (one farmer). The black armyworm, termites, and ants were not reported as pests. According to Trabanino *et al.* (1989), less seed damaged by insects, mainly fire ants [*Solenopsis geminata* (Fabricius)], and higher seedling emergence were observed in «surco alterno» than in «casado». No farmers in this survey planted "golpe alterno" on the coastal plains. Farmers planting "aporque" on the coastal plains reported the following insects to be the most damaging to sorghum and maize: fall armyworm (17 farmers), *M. rogenhoferi* (14 farmers), grass looper (12 farmers), white grubs (nine farmers), black armyworm (six farmers), termites (two farmers), and ants (two farmers).

All farmers planting "casado" or "surco alterno" reported that the fall armyworm and *M. rogenhoferi* seriously damaged sorghum and maize during the growing season, whereas those planting "aporque" appeared to limit damage to the crops by plowing the fields. This practice destroys pupae in the soil and/or exposes them to predators and desiccation.

Grass looper damage to the sorghum and maize crops was reported to be higher in "aporque" (reported by 63.1% of the farmers) than in "casado" or "surco alterno" (reported by 50% and 60% of the farmers, respectively). This may be associated with the feeding activities of the grass looper in mid- to late season, during which time they feed mainly on maturing grasses. The "aporque" planting method reduces the amount of grass weeds present during mid-season, thus increasing the numbers of grass loopers moving from the noncrop plants onto the crop plants once their food source is exhausted.

Only a few farmers reported white grubs as a problem in "aporque"; more farmers reported white grub damage in "casado" and "surco alterno". Termites and fire ants were reported to be a problem in "aporque" and grasshoppers in "surco alterno". Termites and ants are mainly seed feeders that may cause plant stand losses (Trabanino *et al.* 1989), whereas grasshoppers can damage the crop as defoliators in all plant growth stages.

Insecticide use

Farmers in southern Honduras usually depend on insecticides, if they can afford them, to protect their sorghum and maize crops against insect pests, particularly using spray applications against lepidopterous larvae in the langosta complex. Of 114 farmers interviewed, 92 (80.7%) indicated that they use insecticides. The remaining farmers did not use insecticides mainly because they lack monetary resources. The most popular insecticides used by farmers included in the survey area were Lannate® (methomyl), Dipterex® (trichlorfon), Folidol® (methyl parathion), malathion, and parathion. Of 86 farmers in the foothills, 68 (79.1%) used insecticides. Lannate was the insecticide used most often (used by 97.0% of the farmers); 6% of the farmers used Dipterex, 3.0% used Folidol and 1.5% used either malathion or parathion. Of 28 farmers on the coastal plains, 24 (85.7%) indicated that they used insecticides. Again, Lannate was the most used insecticide (used by 92.0% of the farmers) and Folidol ranked second. Farmers on the coastal plains did not use Dipterex, malathion and parathion. The greater number of farmers using insecticides on sorghum and maize on the coastal plains compared with the foothills suggests that farmers on the coastal plains have more money to spend for crop production technologies that will increase crop yields.

There were four insecticides that farmers used to protect seed and seedings from damage by insect pests on sorghum and maize in the survey area. These insecticides were Counter® (terbufors), aldrin, Semevin® (thiodicarb), and Baygon® (Propoxur). Of 114 farmers, only 33 (28.9%) used insecticide as either seed treatment or soil application. Eighty-one farmers indicated that they did not use insecticide at planting due to lack of money. Fourteen (16.3%) of the farmers in the foothills used insecticide at planting. Counter was the most used insecticide at this time. Semevin and Baygon were not used in the foothills. Of 28 farmers on the coastal plains, 19 (67.9%) used insecticide at planting. Again, Counter was the most popular insecticide used, followed by Semevin, Aldrin, and Baygon. Nine (32.1%) farmers on the coastal plains did not use insecticide at this time because they could not afford them. In general, farmers applying insecticide treatments at planting on the coastal plains invest more money in the sorghum-maize intercropping system that results in greater yields.

Trabanino *et al.* (1989) reported that fire ants, fall armyworm larvae, and termites (*Amitermes* sp.) were principal pests of sorghum in early stages of plant development in certain areas in southern Honduras. Promet® 40 SD (furathiocarb) (11g) plus 22 ml of adhesive (packaged with the insecticide) was recommended for best protection of seed and seedlings during the 20 day period after planting (Trabanino *et al.* 1987). Kerosene was routinely used by subsistence farmers to treat seed before planting, and was observed to be a low cost alternative for protection of seeds from ants.

The sorghum and maize production systems in southern Honduras are characterized by a relatively high number of foliar insecticide applications during the crop-growing season. Sixty-eight farmers included in this survey in the foothills applied insecticide to the crops. Of these, 21 (30.9%) applied insecticide one time during the growing season, 16 (23.5%) sprayed the crops two times, 23 (33.8%) sprayed three times, four (5.9%) sprayed four times, and four (5.9%) sprayed five times. Of the 24 farmers that applied insecticide to the crops on the coastal plains, three (12.5%) sprayed the crops one time, 12 (50.0%) sprayed two times, eight (33.3%) sprayed three times, and one (4.2%) sprayed five times. Insecticides are used more frequently in the foothills than on the coastal plains due to the higher level of pest infestation. In both areas, the insecticide sprays are routinely applied using hand-held, backpack sprayers. This method of application is dangerous to those applying the insecticide when toxic chemicals are used.

The excessive use of insecticides for lepidopterous pest control may not be a long-term solution for protection of the sorghum and maize crops. Extensive use of insecticides could result in insecticide resistance in pest species in this region. Some levels of resistance to insecticides in fall armyworm larval strains were demonstrated for insects collected on corn in Florida and Jamaica, and on sorghum in Mississippi and Honduras; the insecticides tested were frequently used to control this pest (Pitre 1988b). Mortality of third instar larvae from Honduras treated with Lannate and Lorsban was only 50.0% compared with 85.0% for larvae from Mississippi and Jamaica. The continued extensive use of insecticides, such as Lannate, may contribute to the buildup of insect population strains with resistance to the insecticides, thus impacting international crop production. To circumvent this potential problem, it would be wise to select insecticides in different classes to use in rotation as needed. Insecticides with novel insecticide action could be used to avoid or delay insecticide resistance in the pests, and would be safer to use when spray applications are made using hand-held sprayers.

Fertilizer use

Farmers in southern Honduras generally used more fertilizer than insecticide in their sorghum-maize intercropped plantings. Of 114 farmers surveyed, 98 (86.0%) used fertilizers. Those that did not use fertilizers explained that they couldn't afford to purchase it. The four types of fertilizers that were used in the foothills or on the coastal plains included urea (46.0 % N), 12-24-12, 18-46-0, and sulfates.

Seventy-four (86.0%) of the farmers in the foothills used fertilizers. All used urea, 19.0% used 12-24-12, and 4.0% used 18-46-0 or sulfates. Only a few farmers can purchase enough fertilizer to reach the levels recommended for sorghum and maize production. They used urea as a source of N and it is usually applied one month after crop emergence. A fertilizer like 18-46-0 should be applied at planting to assist in obtaining satisfactory crop establishment and to improve seedling survival when stress conditions exist. Nevertheless, only a few farmers applied 18-46-0. This is due mainly to lack of economic resources and information on fertilizer benefits.

Eighty six percent of the farmers on the coastal plains used both insecticide and fertilizer. They have sufficient resources to purchase these crop production inputs. Also, they apparently use the technical information available to them and are visited more often by government agricultural extension personnel or professionals with private organizations. Of the farmers that used fertilizers, all of them used urea as the source of N, 25% used 18-46-0 as the source of phosphorous, 8% used sulfates as the source of sulfur, and 4% used 12-24-12. The greater use of insecticide and fertilizer at planting by farmers on the coastal plains than in the foothills can be related to the farmer's income, their awareness of the benefits of specific crop production inputs, and to the professional activities of extension crop production specialists.

Herbicide use

Herbicides are the third most important crop production input used by farmers in southern Honduras. There were only two brands of herbicides that were used in the

region, Gramoxone® (paraquat) and Roundup® (glyphosate). Both have a broad spectrum of action. Gramoxone acts as a contact herbicide, destroying plant foliage, whereas Roundup is systemic and attacks mainly the root system. Of the 114 farmers surveyed, 89 (78.1%) used herbicides. They were generally used in the crop production system in the foothills, replacing the plow with respect to weed control before planting. Eighty four (97.7 %) of the farmers in the foothills system used herbicides. Although Gramoxone is the most commonly used herbicide in the foothills, it is often used alternately with Roundup for better weed control. Of the 28 farmers on the coastal plains that were interviewed in this survey, only five (17.9%) used herbicides. All five of these used Gramoxone, and two of the five (40.0%) used Roundup. These are the "wealthiest" farmers in the community. They may use herbicides even when the herbicides are not needed.

Weed control programs used by farmers in the foothills and/or on the coastal plains included ox-pulled plow, using herbicides followed by manual methods (machete), using slash and burn techniques followed by herbicides when necessary, or using manual methods only. Of the 114 farmers surveyed (86 in foothills and 28 on coastal plains), one farmer (1.2%) used ox-pulled plow in the foothills and 23 farmers (82.1%) used ox-pulled plow on the coastal plains; 83 farmers (96.5%) in the foothills and five farmers (17.9%) on the coastal plains used herbicides followed by manual weeding, and one farmer (1.2%) used slash and burn followed by herbicide application when needed in the foothills. Only one farmer used manual weed control practices as the only source of weed control in the foothills, whereas this practice was not used by farmers included in this survey on the coastal plains.

CONCLUSIONS

This survey in 1996 showed the complexity of the sorghum-maize intercropped production systems in the foothills and on the coastal plains in southern Honduras. The four planting methods identified were "aporque", "surco alterno", "golpe alterno", and "casado". In the foothills, "casado" was the most frequently used method of planting while 'aporque" was the most popular method on the coastal plains. Farmers in the foothills and on the coastal plains agreed that the fall armyworm, *M. rogenhoferi*, the grass looper, white grubs, and the black armyworm have been the most important insect pest species damaging these grain crops. Lannate was the most popular insecticide used in the foothills and on the coastal plains. Insecticides have been used more frequently in the foothills than on the coastal plains due to the frequent occurrence of pest infestations. Fertilizers were commonly used in both foothills and coastal plains regions, with urea being the most common source of N for the crops. Herbicide use is common in the foothills production system, mainly because this is an inexpensive and practical method of controlling weeds where tillage is not possible.

The main crop production problem reported by farmers limiting their adoption of crop management practices and other technologies that could increase their production capacity was lack of economic resources. Lack of information on basic crop production concepts such as ways to increase plant density per acre, to obtain better results from limited fertilizer application, and to improve pest control also contributed to the farmers' inability to optimize crop yields. Furthermore, an economic evaluation of insect pest management and integrated pest management (IPM) systems for production of sorghum and maize in the foothills and coastal plains cropping systems areas in southern Honduras is necessary to provide information on the question of, "Which production system is more efficient economically for low income, subsistence farmers?". Using the appropriate economic model, a suitable IPM technology package should be developed for recommendation to fit the actual needs of subsistence farmers in southern Honduras and areas with similar agroecosystems in Nicaragua and El Salvador. The publication «La Langosta del Sorgo y el Maíz» addresses management tactics for the langosta complex on intercropped sorghum and maize in southern Honduras (Pitre *et al.* 1999).

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