Yam pests in the Ashanti and Brong Ahafo regions of Ghana: A study of farmers’ indigenous technical knowledge and control practices

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ABSTRACT

In Ghana, yam is a very important indigenous subsistence and cash crop that is now the most popular non-traditional export food crop, despite years of scientific neglect. There is a general paucity of technical information on yam production and marketing constraints, but especially so for pests and their management. To understand and document farmers’ needs as a basis for developing technologies to meet their requirements, this study surveyed yam farmers’ indigenous technical knowledge about pests on their crops and their pest management practices over the years in two districts in Brong Ahafo Region and one in Ashanti Region. Pre-tested questionnaires were administered to 30 randomly selected farmers in five villages in each district. The results showed that farmers’ knowledge about pests and the pest spectra were similar for the three districts. Farmers knew about insect pests on their yams, but were neither able to draw interrelationships between pest populations and damage nor the cultural practices that they follow or the ecological state of their farms. Termites (Amitermes spp., Macrotermes spp., and Microtermes spp.) were considered more important pests than millipedes (Peridontoyge spp.), tuber beetles (Heterolygus meles and Prionorcytes rufopiceus), mealybugs (Pseudococcus brevipes, Planococcus dioscorea and Ferrisia virgata), and scale insects (Aspidiotus destructor and Aspidiella hartii) in that order. Out of 12 white yam varieties cultivated in the area, “Pona” was identified to be most susceptible to pest attack and “Dentepruka” least susceptible.

Anthropological factors such as farmer’s origin or residency status, level of education, age, marital status, family size, and the land tenure system were also found to play key roles in the technologies adopted in cultivating yams. The implications of the findings, particularly in identifying appropriate experimental variables for technology generation and transfer to improve yam resource productivity, are discussed.

RÉSUMÉ

BRAIMAH, H., ANCHINAH, V. M. & ADU-MENSAH, J.: Les ravageurs d’igname dans les regions d’Ashanti et de Brong Ahafo du Ghana: Une etude de la competence technique indigene d’agriculteurs et les pratiques de la lutte. Au Ghana l’igname est tres important en tant que culture de rapport et culture vivriere Indigene qui a attaint recemment la place d’une culture vivriere d’exportation non-traditionnelle la plus populaire malgre des années d’abandon scientifique. Il y a une disette generale d’information technique sur la production d’igname et des contraintes de commercialization, surtout sur les ravageurs et la lutte contre eux. Pour comprendre et documenter les besoins d’agriculteurs comme un eventual point de depart pour le developpement de technologies pour satisfaire leurs besoins, un sondage etait entrepris de la competence technique indigene d’agriculteurs d’igname au sujet de ravageurs sur leurs cultures et leurs pratiques de la lutte contre les ravageurs pendant des annees en deux districts de Brong Ahafo et en un district d’Ashanti. Les questionnaires mises a l’essai etaient administrés aux 30 agriculteurs selectionnes au hazard de cinq villages de chaque district. Les resultats revelent que la connaissance d’agriculteurs au sujet de ravageurs et d’échantillons de ravageurs etait semblable pour les trois districts. Les agriculteurs savait que les insectes ravageurs existaient sur leurs ignames mais ils n’ont pas pu etablir ni les rapports entre les populations de ravageurs et les ravages de pratiques culturaux qu’ils emploient ni l’état ecologique de leurs champs. Les termites (Amitermes spp., Macrotermes spp. et Microtermes spp.) etait considere que les ravageurs plus importants que les mille-pattes (Peridontoyge spp.), les coleopteres de tubercule (Heterolygus meles et Prionorcytes rufopiceus), les aleurodes (Pseudococcus brevipes, Planococcus dioscorea et Ferrisia virgata), et les coccides (Aspidiotus destructor et Aspidiella hartii) dans cet ordre-la. Sur les 12 varietes de l’igname blanc cultivées, “Pona” etait identifie d’etre le plus predispose a l’attaque de ravageurs et “Dentepruka” etait le moins...
Introduction

Yams (*Dioscorea* spp. Poir), native to the West African sub-region (Coursey, 1967), are important staples in Ghana where they are cultivated in almost all the regions, except for the semi-arid Sudan Savanna zone and the dry Accra plains. However, the main cultivation areas are in the Forest-Savanna transition and the Guinea Savanna belts where rainfall above 1000 mm is recorded annually. Yams are cultivated as subsistence and commercial crops. They are eaten in various preparations and have very important sociocultural uses. In some parts of northern Ghana, the size of a man’s yam farm is indicative of his wealth. In other areas, yams constitute a major component of the bride price for customary marriages. Yams are so important in the culture of Ghanaians that they are the only crops that have several tribes celebrating festivals on their first harvest. They rank second only to cassava among the root and tuber crops in volume of production, but they command better value by weight for weight and from the nutritional point of view (Bell, 1983). They are, therefore, ranked number one above all other root crops in importance of yam and the fact that it originates from the sub-region and has been cultivated in the country in the past several centuries, little research attention was paid to the crop until the National Agricultural Research Project (NARP) was established in the early 1990s.

Several problems hinder efforts to produce yams in desirable quantities (Nutsugah et al., 2001; Tetteh & Saakwa, 1994). Important among these problems are declining soil fertility, drudgery and labour-intensive cultural practices, low-yielding varieties, the ravages of pests and diseases and poor marketing facilities, especially storage and avenues for processing and adding value to the crop and, thus, low prices in peak harvest seasons.

Field pests attacking yam include yam tuber beetles (*Heterolygus meles* Bilb. and *Prionorcytes rufopiceus* Arrow), termites (*Amitermes* spp., *Macrotermes* spp., and *Microtermes* spp.), vine beetles (*Crioceris livida* [Dalm.] and *Lema amata* [Fab.]), and nematodes such as *Meloidogyne* spp. and *Scutella bradys* (Steiner & Lehew) (Jatala & Bridge, 1990; Missah & Peters, 2001). The storage pests include mealybugs (*Pseudococcus brevipes* [Ckll.], *Planococcus dioscorea*, and *Ferrisla virgata* James), scale insects (*Aspidiotus destructor* Signoret and *Aspidiella hartii* [Ckll.]) (Emehute *et al.*, 1998), and vertebrate pests such as rats. These pests reduce productivity and quality and, thus, the profitability of the yam industry. They act either singly or together to cause sub-optimal yields and deterioration in storage (Emehute *et al.*, 1998). The relative
importance of each of these pests depends on
the yam cultivar, ecological zone, cropping system
as well as field and storage management practices
adopted (Emehute et al., 1998).

Although more recently, through renewed
initiatives under the Root and Tuber Improvement
Project (RTIP), the importance of yams has been
acknowledged by the research systems, little
sociological studies have been carried out to
identify production, marketing and other
constraints for research interventions. Similar
information needs to be gathered for pests to
facilitate research planning. After all these years
of cultivating and evolving the crop, the farmers
should have a wealth of technical knowledge that
researchers need to tap into to start developing
farmer-friendly production technologies.

The objective of this study was to record
farmers’ indigenous technical knowledge about
pests and the remedial measures they apply. The
information generated would form the basis for
research to develop cheap, economically
sustainable and environmentally friendly pest
management technologies to minimize the effects
of such pests on yam productivity.

Materials and methods
The field study was conducted in June 2000 in
two districts (Wenchi and Atebubu) in the Brong
Ahafo Region and one district (Ejura/
Sekyedumase) in the Ashanti Region. All the three
districts fall under the Forest-Savanna transition
vegetation zone of the country which forms the
most important segment of the yam belt. The
districts were selected based on discussions with
regional agricultural administrators and extension
specialists, who confirmed that the three districts
covered the predominant yam-producing areas
within the two regions. Farmers were selected
through a combination of simple and systematic
random sampling techniques. In each district,
five villages were randomly selected from a list of
the predominant yam-growing farming
communities. Six farmers were then randomly
selected from each village, giving a total of 30
farmers per district and a total of 90 respondents
for the survey. A structured pre-tested
questionnaire was then administered to these
farmers and the results analyzed.

Results
Except for rare situations in which the names and
emphasis on particular pests differed, the results
did not differ between the two regions. The results
are quite representative of yam production and
pest management practices within the districts
surveyed. They are, thus, presented generally
for the farmers surveyed.

Social and demographic characteristics
The average yam farm size in the area studied
was 3.2 acres as compared to 4.3 for other crops.
Most (71.3%) farmers interviewed had cultivated
yams since the last 10 years. About 12 per cent
of the farmers had been cultivating yam since the
last 20 years. The average age of a yam farmer
was 48 years, and 34 per cent of yam farmers
were above the age of 50 (Table 1). The average
population of a yam farmer’s household was 10
persons. Most (79.1%) yam farmers were settlers
and 92.3 per cent were males. Few farmers (11%)
had had basic education while 67 per cent were
illiterate.

Varieties planted and pest infestation
Over 16 varieties of yams are cultivated in the
area, of which "Akaba" and "Matches" are
popular water yam varieties; the rest are white
yams. Yam farmers were generally aware of insect
pests on yams. Over 90 per cent of the 60 yam
farmers interviewed indicated that they
encountered insect pests in their farms. Most
could also associate some pests with some
varieties of yams. About 81 per cent of farmers
thought that some varieties of yams were more
susceptible to some yam pests than others. The
remaining 19 per cent were unaware of any such
relationship. "Pona" was adjudged the most
susceptible to insect pest attack, with 32.4 per
cent of farmers ranking it first (Table 2). Amongst
the white yams, "Lilli" was ranked second to "Pona" in susceptibility to insect pests, while "Matches" was thought to be more susceptible to pest damage than "Akaba" among the water yams (Table 2). "Dentepruka" was thought to be least susceptible to pest attack. Termites (Amitermes spp., Macrotermes spp., and Microtermes spp.) were adjudged the most important insect pests on yams (Table 3).

Mealybugs (P. brevipes, P. dioscorea, and F. virgata) were ranked second to termites and more important as pests than millipedes (Peridontoyge spp.); but on account of their rankings, they seemed to be equally important (Table 3). Scale insects (A. destructor and A. hartii), vine beetles (C. livida and L. amata), and tuber beetles (H. meles and P. rufopiceus) followed in that order of importance as pests. Caterpillars and crickets

<table>
<thead>
<tr>
<th>Yam variety</th>
<th>Type of yam</th>
<th>% farmers ranking the variety as most susceptible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lilli</td>
<td>White yam</td>
<td>14.1 13.4 13.2 11.4 5.6</td>
</tr>
<tr>
<td>Matches</td>
<td>Water yam</td>
<td>12.7 22.4 15.1 37.1 27.8</td>
</tr>
<tr>
<td>Pona</td>
<td>White yam</td>
<td>32.4 14.9 11.3 0.0 5.6</td>
</tr>
<tr>
<td>Labrokor</td>
<td>&quot;</td>
<td>7.0 9.0 3.8 2.9 0.0</td>
</tr>
<tr>
<td>Dentepruka</td>
<td>&quot;</td>
<td>1.4 4.5 3.8 2.9 0.0</td>
</tr>
<tr>
<td>Akaba</td>
<td>Water yam</td>
<td>5.6 1.5 20.8 11.4 16.7</td>
</tr>
<tr>
<td>Muchumudu</td>
<td>White yam</td>
<td>4.2 0.0 5.7 2.9 0.0</td>
</tr>
<tr>
<td>Yeji</td>
<td>&quot;</td>
<td>1.4 0.0 0.0 0.0 5.6</td>
</tr>
<tr>
<td>Chirikumasi</td>
<td>&quot;</td>
<td>1.4 0.0 0.0 0.0 0.0</td>
</tr>
<tr>
<td>Morinyia</td>
<td>&quot;</td>
<td>2.8 1.5 0.0 2.9 0.0</td>
</tr>
<tr>
<td>Logbere</td>
<td>&quot;</td>
<td>4.2 6.0 1.9 2.9 0.0</td>
</tr>
<tr>
<td>Asobayere</td>
<td>&quot;</td>
<td>4.2 1.5 5.7 0.0 0.0</td>
</tr>
<tr>
<td>Nananto</td>
<td>&quot;</td>
<td>0.0 4.5 0.0 5.7 0.0</td>
</tr>
<tr>
<td>Dokoba</td>
<td>&quot;</td>
<td>0.0 1.5 0.0 2.9 0.0</td>
</tr>
<tr>
<td>Afebetua</td>
<td>&quot;</td>
<td>0.0 1.5 0.0 0.0 0.0</td>
</tr>
<tr>
<td>Others</td>
<td>-</td>
<td>8.6 17.9 18.9 17.1 38.9</td>
</tr>
</tbody>
</table>
Yam pests: Farmers’ indigenous technical knowledge and control practices

Order of Ranking Insect Pests of Yams by Farmers in the Ashanti and Brong Ahafo Regions of Ghana

<table>
<thead>
<tr>
<th>Arthropod</th>
<th>% of farmers ranking it as</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
</tr>
<tr>
<td>Termites</td>
<td>38.1</td>
</tr>
<tr>
<td>Mealybugs</td>
<td>20.2</td>
</tr>
<tr>
<td>Millipedes</td>
<td>13.1</td>
</tr>
<tr>
<td>Vine beetles</td>
<td>7.1</td>
</tr>
<tr>
<td>Scale insects</td>
<td>11.9</td>
</tr>
<tr>
<td>Caterpillars</td>
<td>1.2</td>
</tr>
<tr>
<td>Tuber beetles</td>
<td>7.1</td>
</tr>
<tr>
<td>Crickets</td>
<td>1.2</td>
</tr>
</tbody>
</table>

(Brachytrupes membranaceus Drury) seemed not to be serious pests in the study area. Only few farmers reported them as pests (Table 3). It is surprising that yam tuber beetles were not considered serious pests in the area. It was only in the Atebubu area and the northern fringes of the Ejura District that some farmers recognized the tuber beetle as a pest of yams.

Source of planting material

Farmers either used their own planting materials or collected them from friends or the local market or both. Some 86.7 per cent of yam farmers relied on their own planting materials, while 11.1 and 2.2 per cent collected their planting materials from the market and friends, respectively.

Seed yams constituted 23.1 per cent of the planting materials farmers used, while use of small whole tubers and pieces of large tubers as planting material was equally important (11.5%). Yam farmers also used combinations of planting materials. The combined use of small tubers and pieces cut from large tubers was the most popular practice among farmers. The type of planting material used varied with type of yam. For those yams that are amenable to ‘milking’, seed yam was the most important source of planting material. For water yams that are only harvested once a year, the use of small whole tubers and pieces of large tubers was more popular. Most yam farmers thought that planting material had no effect on the incidence of pests on the farm. About 20.2 per cent could attribute pest problems on their farms to their source of planting material. Only 20 per cent of the farmers thought that planting material could affect the population of insect pests on yams, while 46 per cent opined that planting material was inconsequential in pest attack on yams. The remaining 34 per cent of the farmers could not draw any relationships between planting materials and pest problems.

Cultural practices and incidence of insect pests

Cultural practices such as weeding, mulching and staking were commonly practised among yam farmers in all the three districts. As many as 92.2 per cent of farmers mulched their yams. Only 7.8 per cent did not carry out the practice. For those who mulched their yams, 80.5 per cent did so at planting, 13.8 per cent mulched after planting, and 5.7 per cent mulched before planting (Table 4). Most farmers (56.3%) mulched with leaves, but 42.5 per cent used weed stubble left on the field at mound preparation, and 1.1 per cent used yam vines (Table 4).

All farmers weeded their farms several times before the harvest of yams. About 89.7 per cent of the farmers interviewed indicated that they weeded their farms at least three times before harvest (Table 5). The most common weeds encountered on yam farms were the grasses (66.3%), with the broadleaved weeds (30.3%) ranking second (Table 5). Shrubs were generally of low significance (2.2%) (Table 5). Despite this clear weed pressure on yams, only 33.7 per cent of the farmers thought that weeds affected incidence of pests on the farm. Among this group of farmers, 90.3 per cent (Table 6) thought the effect would be due to an increase in insect populations and the damage that they caused. Again, 14.5 and 17.1 per cent thought weeds increased the populations and damage of
millipedes and termites, respectively (Table 7). Only 8.1 per cent of farmers associated increased yam tuber beetle populations and damage with increased weed density of yam fields. Most (38.7%) farmers could not establish any relationship between weed densities and the population and damage of any particular insect pest. Few (13.9%) yam farmers were of the opinion that weedy yam fields could result in increased populations and damage of all insect pests (Table 7).

Generally, farmers stake their yams in the study area, with as many as 95.6 per cent of them adopting the practice. About 23.9 per cent of the farmers who staked yams could establish a relationship between staking and pest incidence. As many as 71.6 per cent intimated that staking did not affect the pest population and damage on yams (Table 8). For those who thought staking influenced the incidence of pests on yams, equal proportions (18.8%) thought that it caused an increase or a decrease, while 16.7 per cent were unable to draw any relationship (Table 8).

Control of insect pests

Despite the general awareness of farmers about insect pests on yams, only 26 per cent ever attempted any control of these pests. About 51.9 per cent of the farmers who attempted to control pests on their yams dipped their seed yams and other planting materials in pesticide solutions before planting, 28.0 per cent applied chemical pesticides after planting, while 31.9 per cent used a combination of these

### Table 4

<table>
<thead>
<tr>
<th>Time of mulching</th>
<th>% of farmers involved</th>
<th>Mulching materials</th>
<th>% of farmers using material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before planting</td>
<td>5.7</td>
<td>Leaves</td>
<td>56.3</td>
</tr>
<tr>
<td>At planting</td>
<td>80.5</td>
<td>Grass stubble</td>
<td>42.5</td>
</tr>
<tr>
<td>After planting</td>
<td>13.8</td>
<td>Dead yam vines</td>
<td>1.1</td>
</tr>
</tbody>
</table>

### Table 5

<table>
<thead>
<tr>
<th>Common weeds</th>
<th>% of farmers reporting it on farm</th>
<th>Frequency of weeding</th>
<th>No. of weedings</th>
<th>% of farmers who practise it</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grasses</td>
<td>66.3</td>
<td>1</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>Broadleaved herbs</td>
<td>30.3</td>
<td>2</td>
<td>8.1</td>
<td></td>
</tr>
<tr>
<td>Shrubs</td>
<td>2.2</td>
<td>3</td>
<td>60.9</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>1.1</td>
<td>&gt;3</td>
<td>28.8</td>
<td></td>
</tr>
</tbody>
</table>

### Table 6

<table>
<thead>
<tr>
<th>Perceived effect</th>
<th>% of respondents holding perception</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increases</td>
<td>90.3</td>
</tr>
<tr>
<td>Decreases</td>
<td>6.5</td>
</tr>
<tr>
<td>Can’t tell</td>
<td>3.2</td>
</tr>
</tbody>
</table>

### Table 7

<table>
<thead>
<tr>
<th>Arthropod</th>
<th>% of farmers attributing incidence to weeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Termites</td>
<td>17.1</td>
</tr>
<tr>
<td>Millipedes</td>
<td>14.5</td>
</tr>
<tr>
<td>Tuber beetles</td>
<td>8.1</td>
</tr>
<tr>
<td>Mealybugs</td>
<td>1.6</td>
</tr>
<tr>
<td>All insects</td>
<td>13.9</td>
</tr>
<tr>
<td>None at all</td>
<td>4.8</td>
</tr>
<tr>
<td>Can’t tell</td>
<td>40.0</td>
</tr>
</tbody>
</table>
measures (Table 9). About 4.1 per cent of the farmers used wood ash applied at planting to control pests, and an equal proportion (4.1%) tried to avoid insect damage by planting early (Table 9). For those who controlled pests, 51.9 per cent indicated that their control measures were quite effective, 8.0 per cent found their measures ineffective, and 12.1 per cent could not tell whether their measures were effective, while 28 per cent said their control measures were only partially effective (Table 10).

**Discussion**

The results of demographic information about yam farmers in the study area show that yam farmers in Ashanti and Brong Ahafo regions are mostly settler farmers with low standard of education. It was also indicated that yam farming is a male-dominated job, probably because of the physical nature of all the cultural practices involved. The drudgery and cost of labour probably explain the relatively large family sizes, although family size may also reflect the farmer’s prosperity. The drudgery and high labour input and cost required of yam farming may also explain the low level of female participation. But despite similar labour requirements and costs, female participation in yam production in western Nigeria has increased recently as a result of increasing economic returns (Manyong, Asiedu & Olaniyan, 2001).

Most yam farmers were above the age of 50 (Table 1), indicating a serious problem that is looming over yam farming. Unless efforts are made to entice the youth into yam farming or to reduce the physically demanding cultural practices associated with yam cultivation, it may be difficult for the aged farmers to continue to meet the yam production targets of Ghana.
Manyong et al. (2001) made similar observations and recommendations when they studied the resource management constraints of farmers in western Nigeria. If the land areas devoted to yams and other crops are compared, it is noted that yams are important crops as already stated by other workers (Dapaah, 1994; Manyong et al., 2001; NARSP, 1994). This may be because the survey targeted yam farmers who considered yam as a major commercial crop. Also, the need to raise mounds for yams means that more land area may be required for a relatively small population of yams. However, the size of the yam farm could be limited by the availability and price of suitable land, because yams require well-drained fertile soils and are still cultivated once in a 3 to 5-year fallow period on a piece of land. The size of yam farms may also be limited by availability of planting material, extensive labour requirement, and other resources such as mulching materials and stakes needed to cultivate yam profitably. The need is to find suitable alternative cultivation practices that are less physical for the profitable cultivation of yams.

Despite the overwhelming desire for innovations to solve farmers’ cultivation problems, it is probable that their low educational standard, large family sizes and settler status (which affects land tenure arrangements) could hinder the adoption of technologies involving major investments. In western Nigeria where land is still abundant, yam farmers practise shifting cultivation to solve some resource management problems (Manyong et al., 2001). Unlike the situation in western Nigeria, land suitable for yam cultivation in the three districts studied is quite scarce and in high demand. Consequently, shifting cultivation is no longer a practical solution to land and other resource management problems of farmers.

The results also indicated that most yam farmers in the study area knew that insects were associated with their yams had on the crop. Also, only few farmers associated various insects with the weather, and most did not know the exact relationship between the farm environment and insect populations. Practices such as mulching, staking and weeding seemed to be part of yam cultivation routine that had to be followed to the letter, without any regard for their effects on productivity of the crop. Therefore, farmers did not relate these practices with populations of organisms associated with yams. This attitude could contribute to the inability to associate important ecological factors, such as weed densities on their farms and types of weeds, with insects. It was, for example, surprising that although most yam farmers thought that termites were the most important pest species on yam farms, some continued to use grass stubble to mulch their yams. The predominant use of stubble mulch also presupposes that grass stubble is left on the farm and would serve as a good source of food and refuge for termites. Yam farmers in other areas where yams are cultivated across Africa face similar problems of pests and diseases on their yams; and invariably, as for yam farmers in this study area, they have no solution to this constraint (Acquah & Evange, 1994; Kapinga et al., 2001; Manyong et al., 2001).

Farmers showed a general lack of competence in ranking varieties of yams for susceptibility to insects, and in ranking insects for importance as yam pests. Detailed research involving characterizing yams for pest resistance across the sub-region, and ranking insects associated with yams as pests would be necessary to facilitate further research and standardization of pest management approaches. If such information were available to farmers, it would help them to select and cultivate only varieties that are most suited for the pest stresses in their localities.

The results also indicated that contrary to earlier expectations, termites, mealybugs and millipedes, rather than yam tuber beetle, were the most important insect pests on yams in the study area. "Pona" was ranked the most susceptible
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...yam variety to most insect pests recorded (Table 2). This suggests that it is under serious threat of extinction, unless serious efforts are made to mitigate the ravages of pests on it.

Farmers also had little understanding of the relationships between planting materials, their sources and the pest activity on the resultant crop. They were generally ignorant about the effects of types of weeds, weed density, and other ecological factors in the farm on the activities of insect pests. These areas need to be investigated to establish the necessary relationships to facilitate the development of effective strategies for managing pests. Invariably, pest management was limited to dipping plant materials in pesticide solutions before or at planting. Investigations that will show safer and more effective pesticides and methods for applying pesticides are necessary to boost continued, profitable yam production. Furthermore, because farmers were not well informed about the role of cultural practices such as staking, mulching and weeding on pest populations and their damage to the crop, it would be necessary to investigate them; or to disseminate technologies, where available, to assist the effort to develop strategies for managing pests.

Acknowledgement
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