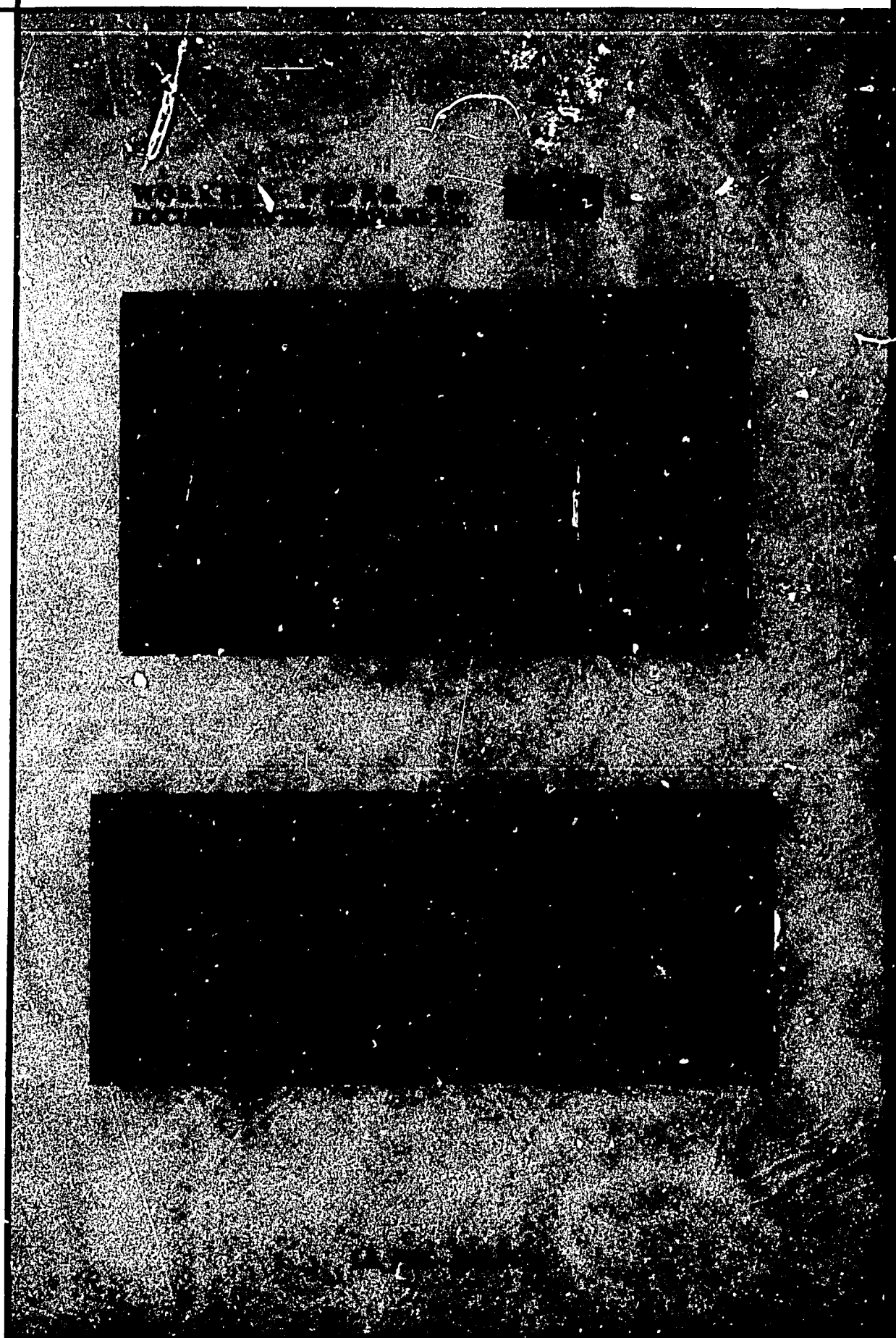
PD-AAJ-039 5110451005814

ISN = 224

CONSORTIUM FOR INTERNATIONAL DEVELOPMENT

CID

Colorado State University
Oregon State University
Texas Tech. University
University of California
University of Arizona
Utah State University



FINAL

002/76

~~AN ASSESSMENT OF THE ENTOMOLOGICAL PROBLEMS~~

AN ASSESSMENT OF THE ENTOMOLOGICAL PROBLEMS OF AGRICULTURE IN BOLIVIA

by

Charles R. Ward*

*Associate Professor of Entomology, Texas A&M University, Agricultural Research and Extension Center, Lubbock, Texas 79401; Short Term Consultant CID/MACA (March 20 - April 7, 1976).

August, 1976

This study was carried out by the Consortium for International Development (CID) in collaboration with the Ministry of Rural Affairs and Agriculture (MACA) under GOB/AID Contract 511-96 between CID and MACA.

AN ASSESSMENT OF THE ENTOMOLOGICAL PROBLEMS OF AGRICULTURE IN BOLIVIA

Charles R. Ward[a/]

INTRODUCTION

This report is the result of a two and one-half week tour (March 20 to April 7, 1976) and insect pest collection expedition of the experiment stations in three of the major agricultural production areas of Bolivia - Santa Cruz (Saavedra), Cochabamba (Toralapa,-- San Benito, Chipiriri, La Jota) and La Paz (Chulumani, Caranavi, Coroico). Due to the short duration of this tour, I have also drawn heavily upon the experience of the technicians of the Consortium for International Development (CID) and the Bolivian technicians working at these stations to determine the seasonal pest patterns of the crops to be discussed. Therefore, some specifics will probably need to be revised as more details are known concerning these pests.

AN OVERVIEW

Prior to the brief discussion of the individual stations and crops I will present an overview of the major entomological problems as I have assessed them. They are meant and should be interpreted as constructive suggestions and statements to assist in the identification of deficiencies to allow solutions of major food production problems. They are not intended to fault any individual, organization or agency.

---

a/ Associate Professor of Entomology, Texas A&M University Agricultural Research and Extension Center, Lubbock, Texas 79401; Short Term Consultant CID/MACA

A. <u>Establish, maintain and enforce stringent pest quarantine regulations to prevent or delay further pest introductions</u>. It appears that several of the key pests are not native to Bolivia but have been introduced at the time of the original introduction of the crop or along with the introduction of new genotypes that have been imported for use in plant improvement. The introduction of these improved crop genotypes is critical to crop improvement, but must be handled so that new pests are not introduced. Apple and Smith (1972) also stress the importance of this aspect of crop protection.

B. <u>Initiate and maintain a long term training program in pest management</u>. This should be done in two steps:

1. Send selected technical research assistants from the stations to appropriate research locations for short term training in pest management techniques. These men could then return to initiate new programs or revise ongoing programs based on their training.
2. Send interested qualified technicians for long term training programs at the PhD level. Upon their return, the technical assistants (from 1st. step) would then have enough experience to provide adequate support personnel for the technicians to achieve their research goals.

   Once the in-country expertise is developed, serious consideration should be given to the development of a pest

management curriculum in one of the Bolivian Universities such as the one in Santa Cruz where an experienced PhD entomologist, Dean Candia, could foster its development.

C. Establish and maintain a national insect collection as well as small, on-station collections to provide a pest identification resource. This is just as basic as a library to the research entomologist. A reference collection allows the researcher to obtain the positive identity of a pest with the appropriate scientific name so that a literature review can be made and allow others to more rapidly utilize the results of the research.

D. Continue, on a more sophisticated basis, the evaluation of short-term pest control techniques. Many of the currently successful integrated pest management programs in the United States and other countries still include pesticides as a basic management tool.

However, the integration of chemical control into a pest management system requires a broad-based knowledge of the effects of the pesticide in the overall system. Basically, the pesticide must be effective in reducing pest damage - and produce minimum side effects such as target pest resurgence and the outbreak of other insects to damaging levels (emergence of secondary pests) through killing their natural parasites and predatos, etc.

The effectiveness of these compounds must be tested in each area in which they are to be used to provide this data base. The establishment and refinement of economic thresholds also is a basic phase of this work. These measures will be necessary until the programs in E (below) become productive.

E. Initiate programs in host plant resistance and biological control. Although chemical control offers inexpensive, short-term control capabilities (when the technology and equipment for handling and applying them are available), the most inexpensive control measures in the long term are those that are self-perpetuating such as plants that are resistant to pest attack or a pest that is controlled by a native or introduced biological agent such as a parasite, predator, pathogen, etc. Slight changes in the current germplasm screening programs being conducted at most of the stations visited would allow preliminary screeing for possible resistant sources for use in future crop breeding programs. For example, possible resistance to nematode and insect attack in the potato varieties being screened for yield potential at the Toralapa station cannot be evaluated due to the entire planting being treated with pesticides that could be controlling the pests. Also, as far as I could determine, none of the technicians include observations of pest attack in their evaluations in variety or date of

planting trials whether pesticides are applied or not. However, if they are not relieved of the production for profit aspect of the station, they probably will never have time to make these observations.

It could be much more expensive, initially, to begin a biological control effort, but could be a very fruitful endeavor. However, the introduction of well known biological agents that have been used successfully in other countries would be fairly inexpensive and potentially very rewarding. Some recent efforts along this line were reported by Squire (1972).

These types of control that require no action by the producer would seem to offer the most satisfactory solution to pest problems where producer technology, equipment availability and financial resources may not allow the use of other control techniques. Apple and Smith (1972) have discussed these methods in more detail.

F. Initiate and maintain studies on the basic biologies of the pests. Data on the biology of the pest for which controls are needed are basic for the establishment of a pest management syste, irregardless of the management tools to be used. Much of this type of data could be obtained by the technicians currently working in the crops if some basic training is obtained as suggested above. For example, if damage ratings were made for the various pests in the soybean date of planting study being conducted at Saavedra,

much information could be gained on pest abundance during different periods of the growing season in relation to plant growth stage. If these data could be developed in relation to pest abundance data (such as light traps, etc) it might be possible to escape major pest damage simply by adjusting the planting date of the crop. Data on length of the life cycle, other hosts attacked, natural enemies, seasonal abundance etc. of the major pests could lead to other alternatives for control.

G. Establish and maintain a means for the scientific exchange of research results. As the number of technicians trained in pest management increases, the need for the exchange of information from station to station and from the stations to the outside world will become more critical. No country can afford unnecessary duplication of effort and one way to avoid this is through the publication of research results. However, the flow of information must be in both directions to achieve maximum benefit. Although annual reports for each station or progress reports (essentially status reports) issued irregularly may satisfy the in-country exchange, eventually an outlet for contributions with scientific merit must be developed to provide a means for the technician to develop his standing in the scientific community. Association with an established scientific society such as the Brazilian Entomological Society might be considered initially.

H. <u>Adequate funding for all phases of research at the Experiment Station must be committed on a long-term basis</u>. Pest management systems cannot be developed without the cooperation of plant breeders, agronomists, weed scientists, plant pathologist, nematologists, etc. Expertise in all production aspects must be available to provide data for the development of the best management systems. Therefore, a firm and substantial financial committment must be made to support the stations to provide suitable physical plant, equipment, power and maintenance and operation funds for all research aspects. A research station cannot be expected to be very productive in research results if the Stations are expected to provide much of their own financial support through the sale of the products from the station. For example, during one of my visits one of the technicians with entomological training could not stop to discuss the pest problems on the station with me because he was required to assist in the sale of the station products. At another station, the electrical generator has been inoperable for several months and the water system has been out for about a month. These are really intolerable situations. This is especially true when they are coupled with low salaries (See comments by Apple and Smith 1972).

Again, these comments are meant to be constructive and I hope they are received with this thought in mind.

DISCUSSION OF MAJOR CROPS AND THEIR PESTS

The following section is a brief appraisal of the visits to the individual experiment stations.

A. Santa Cruz

Saavedra Experiment Station visited March 24-27, 1976:

1. Corn (Maize): The major pest problems observed were:
   a. Stalk borers (*Diatrea* spp. and *Elasmopalpus* sp.?) - almost every stalk examined had been bored by one of these insects and were contributing to the considerable plant lodging observed.
   b. Corn rootworms (*Diabrotica* spp.) - several of the test varieties and a field of volunteer corn were heavily damaged, with most brace roots severaly pruned.
   c. Whorlworms and earworms (*Heliothis*, *Spodoptera*, *Mocis*, etc) considerable damage was observed in the volunteer corn; but little damage in the test plots was evident from theses pests.
   d. Several other species are known to attack corn in this area but are apparently not as severe as those given above.
   e. Comments: The research on lodging is good but the results could probably be improved if insect damage ratings were made also. The use of a calendar spray date for the borers (Anonymous 1976) is not accurate; must be based on egg hatch. Host plant resistance

sources to rootworms as well as high yield potential hybrids have been identified by researchers in Iowa and other corn producing states. Sources for the purchase or in-country production of hybrid corn seed should be considered.

A summary of corn insect problems in Bolivia has been prepared by Squire (1972) and workers at the Saavedra Station (Anonymous 1976).

2. Sorghum :

a. Stalk borers (*Diatrea* sp. and probably *Elasmopalpus* sp) - numerous plants were bored causing the heads to lodge.

b. Whorlworms and headworms (*Heliothis* and *Spodoptera* spp) no significant damage observed, but can be serious when heads are attacked.

c. Aphids (*Schizaphis graminum* - greenbug, *Rhapalosiphum maidis* - corn leaf aphid; and other spp.) greenbugs are key pests of sorghum in the United States but are not considered to be a major problem in this area.

d. Sorghum midge (*Contarinia sorghicola*)- although no adult midge were collected, midge larvae were found in infested heads and damage typical of midge attack were observed in numerous heads. This pest could greatly deter sorghum production if its basic biology in the area is known and utilized in avoidance by proper date of planting, host plant resistance, etc.

e. Other pests present - stink bugs, Diabrotica, rice weevils, flea beetles, etc.

f. Comments: The stalk borers were the main pests observed and varieties should be observed for possible resistant germplasm. The sorghum midge could seriously affect variety testing where blooming dates are different and midge populations unequal. Host plant resistance to insects and diseases is a major effort at the Texas A&M Agricultural Experiment Station at Lubbock and seed samples are available for testing if further work is desired. The development of a hybrid seed production program or other sources of hybrid seed will be needed to obtain maximum yield potential in this crop.

3. Soybeans: a list of fifteen species of insect pests has been prepared by Hebert Zurita O (Anonymous 1976). Of these pests, two were found to be the most important during my visit:

a. Stem borers (Epinotia aporema)- causing considerable damage in some of the varieties being tested. Little damage noted in the date of planting study.

b. Leaf feeders (several species present) - a leaf tier (Hedylepta indicata)was causing the greates damage, but other species of leaf feeders can be just as important.

c. Comments: Considerable more information could be

gained from the variety and date of planting studies if observations and ratings of insect damage could be made. Apparently leafhoppers (Empoasca spp.), - stink bugs and another borer (Elasmopalpus ligneoselus) can greatly affect yields in this area also.

4. Rice:

   a. Stem borers (Diatrea and Elasmopalpus)- considerable damage observed in some varieties being tested.

   b. Leaf feeders (Spodoptera, Mocis, etc.) - several species observed but none were doing significant damage at that time.

   c. Numerous other potential pests were observed but -- were in low numbers (stink bugs, leafhoppers, etc).

   d. Comments: Chemicals listed for control apparently have not been tested in the area and timing of sprays is questionable. Apparently economic thresholds are not known. No observations are made on possible - host plant resistance to these pests. Oscar Terán (1971) has prepared a publication on the rice pest complex in the Santa Cruz area.

5. Alubia: This introduced crop is attacked by two species of stem borers, wireworms, leafhoppers and various leaf feeders (and possibly nematodes). The crop was severely stunted and some plants were dying . It would appear to be a poor choice for a crop for the area.

6. Sunflowers: Several pests were observed but no major da-

mage was noted. Squire (1972) gives the scarab beetle (Euphoria boliviensis) Blanchard as a major pest of this crop.

7. Crops sampled in the area between the experiment station and the city of Santa Cruz.:

   a. Sugarcane: the sugarcane borer (Diatrea sacharalis), a weevil (Metamasus bilobus H.) that bores in the stalk and a spittlebug were the only pests observed. Both species of borers would appear to be serious pests. An excellent review of pests in this crop was published by Candia (1963).

   b Cotton: the pink bollworm (Pectinophora gossypiella) and two species of weevils would appear to form the key pest complex of this crop. Once chemical spraying is initiated to control these pests, numerous secondary pest problems may emerge (ex. Heliothis spp.) . Several reviews of the pest complex on this crop are available (Squire 1972, Candia 1971, Candia 19?,Candia 1974, Huddleston 1972, and others).

General Comments: Although there is pressure to produce high yields to make money to provide funds to support the experiment station, there appeared to be a considerable amount of good research being conducted at this station. However, I believe my comments on the entomological problems could improve the results of this research. Also, additional funding for improvement of facilities and equipment could greatly in-

crease the potential of this station.

The publication of a practical guide for production of the major crops in the area (Anonymous 1975) was an excellent idea and should assist in getting the research results to the producers where it can be used.

The probable scientific names and methods of control of the pests discussed in the previous section are included in this document.

B. Cochabamba

Four experiment stations were visited during the periods of March 22-23 and 28-31, 1976, inclusive.

1. Toralapa Experiment Station (including observations made on the same crops at a nearby town, Tiraque, and San Benito):

   a. Potatoes:

      1) Leaf tier - appears to be the most serious leaf feeder.

      2) Thrips, aphids (Macrosiphum solanifolli) and leafhoppers (*Empoasca* spp.) - are more serious during the seedling stage and apparently need to be controlled to get good early growth.

      3) White grubs (*Cyclocephala melanocephala* (F.), *Bothyrus burmeisteri* (Steinheil) and *Ontherus sulcator* (F.)) and cutworms (various Lepidoptera larvae) these insects feed on the tubers in the soil and were the most important insect pests of this crop

observed. Up to 25% of the tubers in one field were damaged by these pests which resulted in the putrification of some of the tubers.

4) Other pests include various other leaf feeding beetles, lepidoptera larvae and aphids but very few of these were collected during my visit. Squire (1972) lists the agromizid fly potato stem borers (Liriomyza spp.), the potato stem weevil (Trichobaris trinotata (Say)), a weevil (Premnotripes latithorax (Pierce)) and gelechild moth (Gnorimoschema operculella (Zeller)) that attack the tubers, and the potato leaf skeletoniser (Acordulecera sp.) as being serious pests of potatoes in certain areas. He indicates that the tuber infesting species can be spread by planting infested seed pieces, therefore, inspection of seed pieces and destruction of infested pieces could reduce the spread of these pests. Several other minor pests are also discussed.

5) Comments: The treatment of all plots with systemic insecticides and nematocides make it impossible to screen for host plant resistance to these insect pests or for the more serious nematode problem . The new introductions need to be screened in at least one row, replicated plots in an untreated, heavily infested area to get leads for

resistant genotypes. Tests need to be conducted to be certain that the nematocides also alleviate the white grub, cutworm and thrips and leafhopper problems.

b. Wheat, Oats and Barley:

1) Aphids (greenbugs - *Schizaphis graminum* and corn leaf aphids? - almost black in color) - appear to be the major pests but even these are said to be a problem only one year out of five.

2) Probably grasshoppers, cutworms and armyworms are problems in some years. Squire (1972) also lists the stem borers such as *Elasmopalpus lignosellus* (zeller)as pests.

3) Comments: Several chemicals are available for the control of the greenbug and host plant resistant sources will soon be available for wheat from Texas and Oklahoma. Oats and barley are not attacked by the greenbugs as severely as wheat. It may also be possible to introduce some of the greenbug parasites and/or predators under study of Oklahoma State University, Stillwater.

c. Arbeja:

No major insect pest problems were observed, this introduced forage type would appear to offer good possibilities from the pest standpoint.

d. Haba:

1) Aphids - two species of aphids were found, the smaller one was most abundant. Both species attack the seed head and appeared to cause blasting of the seed pods.

2) Lepidoptera larvae (unknown spp.) - attack the seed head and the plant terminal, causing considerable damage to both plant parts.

3) Comments: These pest problems will probably become more severe and become limiting factors as the number of acres planted increase. Permanent control measures should be sought if this becomes a popular crop.

e. Lupinus:

1) Stalk borer (Coleoptera - Cerambycidae?) - this pest was not collected or observed but the technician, Freddy Villazón, said almost total crop loss can occur from this pest early in the season. He thinks it is the same insect found in some of the native weed species.

2) Some leaf feeding was observed but I could not be sure which insect was involved. Probably the small lepidoptera larvae collected.

3) Feeding damage to the blossoms also was observed, but no insects were clearly associated with the damage. It could be due to the weevils, other beetles or small lepidoptera larvae found.

f. Alfalfa:

1) Aphids (spotted alfalfa aphid, *Theriophis maculata*, and the pea aphid, *Macrosiphum pisum*) - were present in small numbers. The pea aphid appeared to be under natural contol due to parasitism by the larvae of a small wasp (species undetermined)

2) Alfalfa caterpillar (Colias eurytheme) - was present in small numbers. Two diseases specimens were observed.

3) Comments: This crop was sampled near Tiraque. Varieties resistant to these aphid pests have been developed in Arizona if this source is needed.

General Comments: Mr. Freddy Villazón appeared to be very interested in the insect work, even has a small insect collection of his own, and might be a good candidate for the short or long term training program. In general, the station seemed to have a multitude of problems. There was no electricity and the physical structures seemed to be somewhat in need of repair. The most serious problems, however, were (1) an introduced weed that is becoming a very se rious problem and (2) an apparent lack of scientific approach (no or few replications in the experiments, no observations on plant resistance, pest species not known by scientific name, etc). However, I did not observe the pressure to produce products for sale, perhaps because

of the lack of suitable land. I believe a great deal of resources and effort should be put into developing this center, with major emphasis on potato research.

2. San Benito Experiment Station

a. Peaches:

1) Borers (*Chrisobothris* sp)-were the main problems. Several trees were apparently killed by this pest and secondary diseases, and numerous other trees were severely damaged. The entomologist, Ing. Agron. Raúl Hinojosa (1971), has studied this pest and has worked out a spray schedule with dieldrin for its control. But this may be the reason for the appearance of the spider mite problems.

2) Spider mites (probably *Tetranychus* spp.) - are an occasional problem, causing leaf damage and occasional foilage loss if not controlled.

3) Comments: Additional studies are needed to resolve the borer - spider mite interaction. I also noted some differences in the amount of damage from the borer in some varieties and differences in susceptibility are known in stone fruits to other borer species. This aspect should be investigated. Some trees were allowed to set too many fruit and resulted in severe damage to some trees. Better management of the trees is needed. San José scale (*Quadraspidiotus perniciosus* (Com-

stock)) is also a serious pest at certain times (Squire 1972).

2) Grapes:

Mr. Hinojosa said the main problem was bird damage and secondary insect invaders. Therefore, I did not spend much time with these plants. Squire (1972) lists the caterpillars of the sphingid moth *Pholus vitis* (L.) as a sporadic pest which can result in complete defoliation.

General Comments: Except for the wheat program, the major emphasis seemed to be on production to earn money for the station. The entomologist could not stop to discuss their problems with me on one of my visits because he was too busy helping sell the peaches.

Also, I saw no attempts being made to measure the yields of the various varieties. If this type of information is no longer needed, I question the need for the apparent emphasis on this crop. The same comments would apparently apply to the grapes, although they were not being harvested during my visit, and my assumptions could be wrong.

The wheat program seemed to be making progress, however, I did not discuss this program in great length. The number of replications being used could be a problem.

3. Chipiriri Experiment Station

a. Forage crops:

1) *Estilosantos* (tropical alfalfa) - although some

pest feeding damage was observed, the rapid growth of the plants seemed to overcome the injury. This crop also competed well with the native grasses, however, it was not under cutting or grazing pressure.

2) Phaesoleus macrophyllum - no major pest problems were observed, but the crop was not competing well with the native grasses. Stands would probably not compete under grazed conditions.

3) Centrocyma - this crop had many pest problems (various leaf feeding beetles especially) and had very poor growth. No potential shown.

b. Rice:

1) Grasshoppers (various spp.) - were causing considerable leaf damage and were probably the cause of some of the seed blasting I observed. A very serious pest.

2) Stink bugs - were collected in great numbers and feeding by these pests on developing seeds would result in reduced seed size and possibly abortion of the seed if feeding is done early.

3) Several other potential pests were seen in small numbers (rice stem borer, leafhoppers, etc.).

c. Citrus:

1) Ants - three pest species were observed in fairly large numbers. These are major problems during

harvesting due to the hazard of getting stung. Leaf cutting ants (Atta spp.) are a serious problem, especially in smaller trees.

2) Termites - these pests begin tunneling in dead wood in the tree and apparently begin to attack living wood, according to the technicians at the station. Squire (1972) indicated that these are not considered to be major pests.

3) Scales - several species were observed, the red scale seemed to predominate and was a fairly serious problem. Squire (1972) lists these as the major pests of citrus and gives a list of the major species involved.

4) Several lepidopterous leaf feeders were observed and had done considerable damage to some plants. Numerous species of leafhoppers were collected.

d. Cocoa:

1) Scales - seemed to be the most serious problem as the high populations were causing leaf death on many of the trees. The species probably involved was Pseudococcus citri (Risso) (Squire 1972)

2) Several other potential pests were observed. Several of the potential pests of this crop has been given by Squire (1972).

e. Rubber: no insect samples were taken, but these trees seemed to receive the best care. The capsid Helopeltis

sp. is given by Squire (1972) as the only known pest.

4. La Jota

a. Rice - very similar to the Chipiriri Station, except even higher stinkbug populations were observed. Also, fairly high levels of damage by stem borers was evident but the insects had emerged.

b. Rubber - several sweeps were made with the insect net but no major potential pests were collected, nor was there any apparent insect damage.

c. Banana - no major pests were observed.

d. Tea - considerable damage was being caused by leaf cutting ants.

General comments: The major problems with these last two stations probably stem from their remoteness. I saw a total lack of the scientific approach. But, living without electricity for almost a year and water for over a month would tend to dampen anyone's scientific approach. The rice variety trials were unreplicated except that they were repeated at the two locations. No observations were being made on pests or diseases, as far as I could determine.

Yield data are apparently not taken on crops other than rice as the workers took fruit from the trees at random to eat. From my brief visit, I certainly wondered what was being accomplished at these two stations.

C. La Paz

Three experiment stations were visited during the period April 1-5, 1976, inclusive. Due to the similarity of the problems, major crops at these stations are discussed together after brief comments on each station and their specialty crops. (I was accompanied on this trip by Ing. Jorge Alarcón M.).

1. Caranavi (Santa Ana, Vivero) Experiment Station:

   a. Beans (Forage) - had considerable leaf damage apparently from grasshoppers and beetle (Chrysomelidae) leaf feeders. Also caught a number of species of leafhoppers.

   b. Cocoa - was not being attacked by the scales found at the Chipiriri station, but heavy populations of aphids were found in some trees. Considerable damage could have occured if lady beetles had not begun to control the population. Also collected several treehoppers. Most of the fruit showed insect damage and it appeared that some flowers aborted due to insect damage (I could not determine the causitive agent).

   c. Avocado - no major pests were observed. Several leafhoppers and some butterflies were collected in sweeping the plants.

   d. Comments: no one was available at the station to discuss the crops or the experiments, so I could not learn much about their work. However, the

apparent lack of experiments is probably due to this station functioning as a nursery to provide root stock for the local producers. However, it would appear that a better image could be presented as the entire area was very weedy. I believe a better cover crop could be devised to give a better image and show a better utilization of the land for visiting producers.

2. Coroico Experiment Station:

a. Tomatoes - small plots of several varieties were being tested. Considerable plant death was observed and was apparently due to a combination of root feeding insects, nematodes and damping-off or other diseases. Some leaf damage was observed from leaf feeding beetles. Squire (1976) lists a number of serious pests of this crop, including the agromizid stem borers (*Liriomyza* spp.) that also attack potatoes.

b. Cyfromanda (Limatomate)- several plants around the station office were seriously affected by some pest or malady. The main planting was under heavy attack by two species of tree hoppers (Membracidae). Both terminal plant growth and flowering parts were being damaged, the latter apparently causes abortion of the fruit.

c. Comments: This station had a much better appearance

and several fairly well planned experiments (in comparison) seemed to be in progress. However, some of the tests (eg. coffee fertilization test) did not appear to be replicated and the drainage characteristics of the soil in the three areas being used seemed to differ greatly.

Also, it would help if signs were placed along the road as we spent almost an hour trying to find the station.

3. Chulumani Experiment Station: Ing. Alarcón explained that the principal function, again, was to provide root or seed stock to the local producers. However, some demonstrative type of work such as orchard renovation was in progress and was showing some good results. Certainly this was the station with the best appearance. I did not get a chance to see the inside of the buildings, but if the station grounds are any indication they were in better condition also. The station director seemed to be well informed as to what was being done on the station. I would consider this to be a good model to follow in these regards.

4. Major Crops:

   a. Citrus -

      1) Scales - at least three species were observed and one of them (red scale) was doing considerable damage at the Chulumani Station. The white

scale (mealybug?) was said to be under natural control by a species of ladybird beetle (brown with a black dot on each elytron). Aphids and other scales were being attacked by three or four species of smaller ladybird beetles (Scymnus?).

2) Mediterranean Fruit Fly (Ceratitis capitata) This introduced pest severely threatens citrus production and serious attempts should be made to slow its spread in this country. Squire (1971) briefly reported on attempts to use biological control.

3) Citrus rust mites (Phyllocoptruta oleivora?) are causing serious problems due to the discoloration of the fruit which makes it unsuitable for export.

4) Leaf cutting ants (Atta spp.) - cause considerable damage to all crops due to excessive removal of leaves from the plants, especially small plants.

5) Aphids - were attacking terminals on several plants but were being feed upon by the ladybird beetles. It appears the aphids would be a problem if the ladybird beetles were killed spraying.

b. Coffee - I was told that there were no major pests

of coffee, but I found evidence that 15-20% of the coffee beans in one area were badly damaged by some insect (s). Two species of treehoppers (Membracidae) and a spittlebug (Cercopidae)were found to be causing some damage. Numerous leafhoppers and several Hemiptera were observed also. It appears this crop may have some serious, unrecognized pest problems.

However, Squire (1972) did not recognize any serious pests.

c. Bananas - Although serious leaf death was observed in several areas, I was unable to sample this crop. The symptoms observed were reported to be the results of a disease.

d. Coca - appeared to be the most serious threat to agricultural food production in the area. It appeared that all new land being put into production was being devoted to this crop.

Only one major pest of this crop, larvae of the moth *Eloria captiosa* which defoliates the plants, was given by Squire (1972).

SUMMARY

In summary, Bolivia's agricultural food production potential could be greatly increased through increased research efforts and financial support in all areas of research. This would seem to be especially true in the field of entomology where few trained specialists are available. Bolivia is now plagued by many of its own, native pests as well as many introduced ones. Without a concerted effort in the near future, the insects could win.

During my visit I was able to collect many species of insects from the major crops of Bolivia. The quantity collected was largely due to the assistance of my wife, Norma Ward and the technicians of CID and the experiment stations. To provide a lasting contribution to the development of an Entomological program in Bolivia, the several thousand insects that were collected are being curated so that they may be sent to the proper specialists for identification. Once identified, this material will be returned to the proper Bolivian officials to provide a nucleus for the development of an agronomic insect pest museum collection. Although many of the pests I collected have been identified previously, as far as I could determine none of the specimens were returned to Bolivia to provide this valuable resource base. Such a collection will be invaluable to the development of the field of Entomology in Bolivia.

If the recommendations made in the overview section of this report can be fulfilled, it would appear that the realization of a very effective and well respected system of agricultural experiment stations could be achieved.

LITERATURE CITED

Anonymous. 1976. Guia práctica para el agricultor y ganadero. Ministerio de Asuntos Campesions y Agropecuarios, Estación Experimental de Saavedra, Santa Cruz, Bolivia. 35 pp.

Apple, J.L. and R.F. Smith. 1972. A preliminary study of crop protection problems in selected Latin American Countries. USAID Report, University of California, Berkeley. 41 pp.

Candia, J.D. (19?). Las plagas del algodón y su reconocimiento Ministerio de Asuntos Campesions y Agricultura, Oficina de Información Técnica. La Paz, Bolivia . 31 pp.

Candia, J.D. 1963. Problemas y soluciones de las plagas y enfermedades de la caña de azúcar en Santa Cruz. Ministerio de Agricultura, La Paz, Bolivia, Boletín Experimental No. 27, 47 pp.

Candia, J.D. 1971. Las plagas del algodón en Bolivia. Rev. Per. Entom. 14(2):395-397.

Candia, J.D. 1974. La presencia del medidor verde (Trichoplusia ni Hubner) en los algodonales de Santa Cruz. Revista de la Sociedad Boliviana de Historia Natural, Cochabamba, Bolivia. 1(1):36-37.

Hinojosa, T R. 1971. Insectos y enfermedades que dañan a los durazneros, manzanos, vides y frutillas. Misión Británica en Agricultura Tropical, Ministerio de Asuntos Campesinos y Agricultura. Cochabmaba, Bolivia. Boletín Técnico No. 6.

Huddleston, E.W. 1971. Pesticide usage and cotton insect control in Santa Cruz, Bolivia. Utah State University, Logan. Pub. Series 11/72. 9 pp.

Squire, F.A. 1972. Entomological problems in Bolivia. PANS. 18(3): 249-263.

Terán, F.O. 1971. Plagas del arroz en Santa Cruz. Ministerio de Agricultura y Asuntos Campesinos, Estación Experimental Agrícola de Saavedra, Santa Cruz, Bolivia. Boletín Técnico No. 45, 8 pp.