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This report presents observations on pest management and pesticide management in Egypt, made by six United States participants in the Pest Management Colloquim during a seven-day visit in October, 1975. The team made several recommendations. Among them: A radically modified approach to pest control problems of cotton must be developed in Egypt if its cotton production is to be maintained. The model for this approach, called integrated pest control, is set forth in the FAO Guidelines for Integrated Pest Control on Cotton. Economic injury levels need to be scientifically established in Egypt for the bollworm, pink bollworm, and cotton thrips. Economic thresholds need to be developed for the cotton leafworm, and more effective insecticide programs developed. Studies should be initiated on the G. barbadense cottons of Egypt to determine the effects of thrips populations on yield. Importation of exotic beneficial parasites and predators should also be considered, as well as eventually mass release of beneficial species. The value of United States/Egypt exchanges of scientists was discussed. Also discussed were plans for the February, 1977, Pesticide Management Seminar/Workshop, and the possibility of establishing outside Cairo an Institute of Integrated Pest Control for Cotton.

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# Pest Management and Pesticide Management in the Arab Republic of Egypt

February, 1976

A Special Report on

# Pest Management and Pesticide Management in the Arab Republic of Egypt

Observations made during

A US/Egypt Colloquium on Pest Management by

Perry L. Adkisson, Andrew P. Gutierrez, F. Aubrey Harris
Harold T. Reynolds, Ray F. Smith and Theo F. Watson

25-31 October 1975

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February 1976

**Observations on Pest Management and Pesticide Management in the Arab Republic of Egypt**

**October 25-31 1975**

During the seven day mission in the Arab Republic of Egypt, six US participants in the Pest Management Colloquium carefully analyzed the current cotton pest and pesticide management situation. While the time in Egypt was short and not in the season in which pest and pesticide management practices could be observed, nevertheless, the intensive discussions with Egyptian experts provided the large amount of information on which this report is based.

Need for the Development of Pest Management Systems as a Rational Guide for Pest Control Activities:

A radically modified or fresh approach to the pest control problems of cotton must be developed in the Arab Republic of Egypt if its cotton production is to be maintained in the most efficient and economical manner in the future. The model for this new approach to pest control has been clearly demonstrated for cotton in many areas scattered around the globe. It has been labelled integrated pest control and has been set forth in the FAO Guidelines for Integrated Pest Control on Cotton (available from FAO/Rome in Arabic as well as English). In brief, integrated pest control is a multidisciplinary ecological approach to the economical management of the entire complex of pests in cotton.

The integrated control approach for management of the cotton pests in Egypt is strongly recommended because this approach can provide a rational system for responding to the real threats and the actual causes of pest damage to cotton rather than the apparent threats and the unreal causes. Furthermore, at low cost it can utilize effectively the multitudinous ecological forces governing pest populations rather than disrupting and destroying these governing factors.

It seems clear to us that if the current pattern of devoting a very high percentage of the research effort to routine pesticide screening and relying so heavily on pesticides in actual pest control practice is continued, then Egypt will never resolve its serious dilemma in cotton pest control. Furthermore, in a few years Egypt may well find itself facing a complete disaster in pest control and the deterioration of the cotton production so critical to its economy.

Of critical importance is the organization of teams including entomologists, plant physiologists and economists and perhaps some other disciplines to clarify the real economic status of different population levels of the several important pests of cotton which should have the highest priority. These economic injury levels could then be used as sound guides for the selective utilization as necessary of control measures among which application of pesticides would be only one.

As far as we were able to determine, at present there is no scientifically established economic injury level in Egypt for the notorious pink bollworm (Pectinophora gossypiella); nor the bollworm (Heliothis armigera); nor for cotton thrips; nor for any other pest reported to be important in damaging cotton in Egypt. Until such levels are established, the pest control program for cotton will be like a rudderless ship wandering aimlessly through uncharted seas. At best such pest control operations can only be pallative and usually they are ineffective and wasteful. Of more serious concern is the fact that such aimless pest control systems can be extremely harmful, and often they exacerbate the pest problems. It is our considered opinion that this is what has been happening in Egyptian cotton fields over the past 15 years.

In the following sections of this account, a number of specific suggestions are made as to ways the pest control situation can be adjusted and the risks described above greatly reduced.

Present Status of Egyptian Cotton Leafworm and Recommendations for Research Action:

The Egyptian cotton leafworm has long dominated entomological research in Egypt. It is considered to be one of the two "key pests" on cotton, the other being the pink bollworm. The damage potential of the leafworm is greatly feared by entomologists throughout this country, including top agricultural administrators, and in occasional outbreak years this concern is justified.

Two practices are routinely followed to reduce leafworm populations and thus the need for insecticide applications.

1. It is required by law, although the law is not strictly enforced, that irrigation in clover fields must be terminated by May 10. It is known that a high percentage of moths ovipositing on cotton early in the season originate in the clover fields. It is believed this practice has no harmful effects on natural enemies.

2. Hand-picking of egg masses by children is widely practiced and is believed to be 60-90% effective before the cotton plants become large. It was our understanding that resistance to employment of children for this method of control is developing, and continued utility may be in jeopardy.

When plants are large and hand-picking of egg masses is no longer efficient or when leafworm populations get ahead of this method, insecticides are applied when judged necessary. A problem exists at this time in that there is no consensus in Egypt on what population levels of leafworm justify insecticide applications. In recent years it has become increasingly important that insecticides be applied only when irrefutable data demonstrate that applications are necessary. First, insecticide resistance in the leafworm has developed to the point where a number of insecticides are no longer effective. The commendable resistance monitoring program has also demonstrated that a significant amount of cross-resistance also exists. Second, insecticide applications which

are unnecessary deplete beneficial insect populations without cause. Not only are the beneficial insects important for suppressing populations of leafworm, spiny bollworm and other pests, but the developing Heliothis armigera problem could become a limiting factor in cotton production, particularly if widespread resistance develops as it has in several areas of world cotton production. In these latter cases, the only reasonable method of control is to maintain beneficial insect populations at effective levels.

There are several research routes which justify immediate attention. Only more urgent research is noted; longer range, fundamental research is not mentioned.

1. Delaying or avoiding treatment is important and can only be accomplished through development of economic thresholds. The very great divergence of opinion on when populations justify treatment will necessitate carefully designed research programs to obtain data acceptable to entomologists throughout Egypt. Again, research on establishment of economic thresholds needs to be studied with the aid of plant growth analysis and the eventual effect on yield. It is known, for example, that G. hirsutum varieties in some areas of the United States can withstand as much as a 50% leaf loss at certain times in the season (both early and late), but no more than a 25% loss in leaf surface can take place during stages of growth when the plant is actively setting the major portion of its boll load without reduction in yield. However, G. barbadense may react differently than G. hirsutum, and fundamental studies are needed at various growth stages. Preliminary studies may provide indicative information through artificial removal of leaves.

2. When insecticide screening programs reach the point of field application, they should include effect of application on other species in the cotton ecosystem, including beneficial species. If a selective insecticide or selective dosage is discovered which is effective on the leafworm, recommendations for use should have priority over broad spectrum insecticides. This is very important as it is already recognized that certain insecticides, although effective on leafworm, destroy beneficial species which then results in more serious problems with leafworm, Heliothis, the spiny bollworm and quite likely other species, such as whiteflies.

3. There is a great deal of interest in the potential of diseases, particularly the baculoviruses, for cotton leafworm control. At present, little expertise exists in insect pathology in Egypt. It generally is recognized that specialized training is needed for field work with diseases. It is recommended that a young Egyptian scientist with outstanding potential seek training, perhaps to the Ph.D. level, in the United States. We suggest this individual take his training under a scientist strongly oriented towards field development of viruses (e.g., Dr. L.A. Falcon, University of California, Berkeley). There are developments in viruses with potential effectiveness in cotton leafworm at this

time. Although it may still be too early, a consultant would be helpful in initiation of research on diseases of this pest in the future.

Comments on the Pink Bollworm Situation in Egypt and What Should Be Done:

A. Current Situation:

The pink bollworm is currently considered a serious annual pest in Egypt, requiring insecticide control. Information available indicates that the pink bollworm overwinters entirely in the seed of small bolls left on the plant following harvest. After picking the cotton, the farmers pull the stalks and store them on the roofs of dwellings in the villages to be burned for fuel during the winter and spring. This practice concentrates diapausing pink bollworm larvae in the village under optimum overwintering conditions.

Again, based on information available, the subsequent year's infestation starts in a belt around the village as a result of moths emerging from the stalks on the rooftop and ovipositing on the nearest cotton. This light, first generation started as a belt around the village is the source of late season problems after subsequent generations have spread out to infest all the acreage. Because of the pink bollworm, insecticide sprays are applied to all the acreage as soon as the infestation level reaches 10% infested bolls in fields near the villages. This program consists of 3 or more spray applications made at 2-week intervals, usually starting in mid-July.

B. Analysis of Present Situation and Control Practices:

Based on knowledge of the population dynamics of the pink bollworm elsewhere, there is reason to believe that the seriousness of the pink bollworm in Egypt is somewhat overrated. An infestation level of 10% infested bolls around the villages in mid-July means that relatively little of the cotton acreage is infested at this time and that it would probably require at least 2 more generations to reach damaging levels over all the acreage. This would place the time when economic injury levels are reached near the end of the growing season.

The practice of applying insecticides at 2-week intervals to control the pink bollworm would be totally inadequate under severe pink bollworm pressure. These applications would hardly serve to slow down population growth. Experience elsewhere with pink bollworm control indicates that, in areas where the pink bollworm usually reaches damaging levels prior to the end of the season, repeated insecticide applications separated by periods greater than 6 to 7 days will permit a population to continue to climb.

C. Solution:

In view of the additional pest problems on cotton, serious consideration should be given to determining the actual need for pink bollworm control, particularly the possibility of delaying applications until late season. Basically, this simply means: (1) re-examination of the economic threshold, (2) new investigations on the possibility of better treatments during the first boll generation, precluding the need for later treatments to the entire acreage and, (3) research on hand removal of

unopened bolls at time of stalk harvest for storage separate from the stalks themselves. This would permit burning all infested material before cotton begins fruiting the following spring and still leave the remaining stalks for later use.

In summary, the most significant advances in insect pest management of cotton pests in Egypt can be made by intensive research to redefine the economic injury levels of the two key pests, the cotton leafworm and pink bollworm.

Causes for Recent Increases or Other Changes in Old Pests and Development of New Pests:

The status of the cotton leafworm, Spodoptera littoralis (Boisd.), and the pink bollworm, Pectinophora gossypiella (Saunders), has remained relatively unchanged during recent years. During 1974, the first generation of cotton leafworm on cotton was unusually high in certain areas of Egypt (see report by Watson and Sterling, dated Aguust 8, 1974), but later generations were near normal. Apparently, the pink bollworm occurred at near normal levels both in 1974 and 1975.

These two pests have been considered for years as the primary pests of cotton in Egypt and those on which insecticidal control is usually needed. The reliance on insecticides seems to have increased in recent years, seemingly with little effect on long-term population levels of the cotton leafworm and pink bollworm but apparently with increasing effects on the total arthropod fauna of Egyptian cotton fields or the entire agroecosystem.

In 1972, the bollworm, Heliothis armigera (Hubner), was noted as a serious pest of cotton in Egypt for the first time, even though it had been recorded there as early as 1905. Other insects that have risen to pest status in recent years are the whitefly, Bemisia sp., stink bugs, Nezara sp., and jassids, Empoasca sp. These insects are now considered serious pests where heretofore they were present but only incidental to the major pests of cotton leafworm and pink bollworm.

History has shown that pest upsets are common in areas following the extensive use of insecticides. This occurred in the United States, particularly after the organochlorine compounds became ineffective or unavailable and organophosphate substitutes were used instead.

In the late 1950's and throughout the 1960's, Egypt began using a wide array of insecticides for control of cotton pests, particularly the cotton leafworm and pink bollworm. The rise to pest status of the additional insects mentioned earlier follows the course experienced by other countries after such insecticide use. These insects that have recently risen to pest status are those known to be controlled effectively by natural enemies in undisturbed areas. These biological upsets are probably the reasons why the new pests are now appearing.

Solution to Changed Pest Picture:

The immediate solution of such pest problems where the situation warrants artificial control measures to prevent serious losses is usually insecticides. This is a dangerous course, however, as the problem have been shown to intensify rather than to lessen. The most pressing problem is to reestablish long-term control of these "new" pests by their biological control agents. This usually cannot be done immediately, but will take some time to reestablish a favorable pest/natural enemy ratio. In any event, the key to such control is interwoven with the control practices used against the key pests, the cotton leafworm and pink bollworm. The real solution is to refine the insecticidal control practices directed against these key pests. This could be done through reduced dosages, different insecticides, better timing, etc. More likely, however, improvements will only be made after realistic economic injury levels are established. This would insure the use of broad-spectrum insecticides only when the actual need arose.

Analysis of Present Status and Recommendations for Research on Thrips:

*Thrips tabaci*, when adundant on seedling cotton plants, cause misshap stunted leaves, and the small plants appear very unthrifty. With the adve of warm weather, the plants quickly recover and grow out of this condition the evidence of the earlier plant effects disappearing entirely. In most cotton production areas of the United States, it has been found that thrips have no effect upon ultimate yield, and even though an insecticide application (spray or systemic granule) sometimes improves the plant appearance through thrips suppression, treatment is not recommended. Only in very few areas have yield responses followed treatment, and these responses have been generally marginal. These few latter situations occur when the cotton production season is short or where plant growth at best is weak. In our brief observation of cotton in Egypt, it would seem that the production season is neither short nor is plant growth weak.

This research has all been performed on *G. hirsutum* varieties, and insofar as is known, none has taken place on *G. barbadense* varieties.

Thrips normally are by far the most abundant species on seedling cotton. It is widely believed they provide a major host for several very important hemipterous predator species at this stage of plant growth, aiding in their population increase and helping retain them in the cotton ecosystem. Thus, their presence is thought to be important to generating populations of predators which may provide invaluable assistance in suppression of more serious cotton pests later in the season.

Application of chemicals to control thrips populations not only has a direct mortality to the predators, but removel of the thrips may force surviving or immigrating predators to search for food sources out of the cotton environment.

The economic threshold adopted in Egypt for thrips, according to our discussions, has reduced early season applications of insecticides significantly. This threshold recommends treatment when 8 to 12 thrips are found per seedling plant. Although the threshold adopted is useful, no data was available concerning eventual effect on plant growth, fruit set and yield of lint.

It is recommended that studies be initiated on the G. barbadense cottons of Egypt to determine the effect of thrips populations on yield. It is also recommended that this study be accompanied by plant growth analysis to study the impact of various population levels on time and amount of fruit set. This portion of recommended research is relatively simply but will likely have to be performed in several areas over several years.

Status of Information on Biological Control Organisms and Suggestions for Future Research:

Considerable information exists in Egypt regarding biological control organisms affecting cotton pests, judging by discussions and the Working Paper prepared by M. Hafez and A. Khalifa (FAO/UNEP Consultation on Pest Management Systems for the Control of Cotton Pests, 13-16 October 1975, Karachi, Pakistan). Research accumulated over the years has identified the most abundant predators and parasites, including the relative abundance and noting a general collapse of most predator populations in late July. The impact of at least some insecticides on beneficial insect populations has been studied. As in other areas, the broad spectrum chemicals in use suppress populations drastically, and there is strong evidence supporting resurgence of target and increases in secondary pest species as a result of this suppression.

The general decline in predator populations to about one-fourth of the levels existing 20 years ago is very disturbing as are the reductions in parasitism of important pests by a number of parasites. The tachinid parasites of cotton leafworm are almost nonexistent at present, whereas years ago they were abundant, providing parasitism as high as 75% of this pest. Other examples of this decline in effectiveness have been documented, including the decline in egg parasitism of Nezara which is believed to be a possible cause of this recent increase in importance of this pest.

The application of insecticides to cotton is less than in many cotton production areas of the world, at least in normal years, averaging 4.4 applications/feddan in 1975. It was noted that 1975 was a light insect problem year. However, most insecticides used are broad spectrum, and depending on the time of application, often result in pest resurgence and secondary problems. There was consensus that treatments should be avoided if possible in June and early July. One Egyptian scientist felt this was so important that if deleting treatment at this date resulted in a small crop loss, it would be worthwhile.

Cropping patterns also have changed to some extent over the years in Egypt. It is possible that increases in some crops, e.g., tomatoes, may require more insecticides than the crops they replaced with additional effects in reducing benenficial insect populations. In addition, it is possible changed cropping patterns do not provide as good a reservoir for beneficial species as existed in previous years. Perhaps with changed cropping patterns, destruction of the clover crop in May does in fact have a strong detrimental effect on beneficial insect carry-over to cotton, creating an imbalance more important than additional survival of cotton leafworm moths which may move to cotton.

We note that importation of exotic beneficial insects to Egypt has not been considered successful. Yet we note that many species of beneficial insects of importance in areas remote to Egypt are not listed. For example, one of the most efficient and abundant predators found on cotton in the USA is the big-eyed bug, Geocoris spp. Species in this genus are reported to occur in Egypt but are not listed as occurring on cotton. In general, countries that have imported the most beneficial insects report the most successes, e.g., Hawaii, California, Australia, etc.

In view of the importance of beneficial insects to suppressing populations of pest species, several facts of research should be undertaken. Some will be difficult and several years of very complex ecological research may be necessary.

1. It is important to understand why some formerly abundant beneficial species are no longer effective. This may involve several avenues of inquiry. The impact of broad spectrum insecticides certainly warrants study. This may necessitate use of rather large blocks of cotton on field station property which would receive no insecticide treatments even though the cotton may be severely damaged or even destroyed. It should be noted also that history tells us that it sometimes takes several years for beneficial insect populations to regain their former effective levels. In this study, it might be worthwhile to include at some date year-round production of berseem or alfalfa (Medicago spp.) in association with the untreated cotton fields. It should be borne in mind that this type of experiment could prove to be disastrous for the cotton (and eventually for the clover also), but the information on beneficial insects obtained could be eminently worthwhile. This type of experiment is time consuming as it will necessitate a great deal of season-long population sampling. These must be faunistic in nature. One sampling device suggested, in addition to usual sampling methods, is the use of D-Vac machines and funnel separators (modified Burlese devices) to collect the fauna in alcohol while withholding the plant parts. Plant growth analysis in the untreated field would also be helpful.

2. Importation of exotic beneficial parasitesand predators should also be considered. In view of the retirement of Dr. Hafez, a consultant would be desirable. There are relatively few biological control entomologists with experience on cotton, but the names of capable people for short-term consultantships can be suggested.

3. Eventually mass release of beneficial species might be considered. Mass production and release has been successful in several areas of the world, particularly in the People's Republic of China and the USSR in the case of Trichogramma, but the method is expensive due partly to high labor costs, although economically feasible in certain countries where labor is not costly. This is not rated as high a priority at this time as 1 and 2 above, and further research in other countries may provide more effective and less expensive rearing and release techniques.

4. As research and experience develop, other research may be undertaken. It should be noted, however, that the above recommendations all fit into an integrated pattern with the other recommendations, many of which will add to knowledge and tactics to aid beneficial insect activity. It is also suggested that a thorough review of the biological control section be made of "Guidelines for Integrated Control of Cotton Insect Pests," AGPP:MISC/8 Oct. 1973 (Revised, November 1974), Food and Agriculture Organization of the United Nations, Rome, Italy.

The Basis for Current Economic Injury Levels and Their Use:

It is axiomatic that sound pest management depends upon the establishment of accurate, scientifically based economic thresholds for pest population damage. The basic notion of an economic threshold implies the cost of some pest control measures must be less than the damage caused by the pest to the crop. Realistically, it must be dynamic enough such that the growth stage of the crop, as well as losses resulting from pesticide-induced pests, are incorporated. It is essential that the methods for comparing this cost/benefit relationship be simple enough for field application.

Reasonable economic thresholds for the pests of cotton in Egypt do not exist, and hence excessive pesticide usage has occurred. The fallacy of current practice does not readily become apparent until harvest.

The following general recommendations for developing sound economic thresholds are made for all pests of cotton in Egypt:

1. Conduct all experiments in large plots.

2. Situate untreated check plots so as to eliminate pesticide treatment interactions.

3. Compare the control costs to yield enhancements using the unsprayed check as the base line.

4. Compare different levels of pest populations to untreated check plots.

5. Compare the effects of different levels of pest damage during different times in the season.

6. Detailed field investigations relating the pest damage on a micro-scale (i.e., plant growth analysis of damage) are required to clarify these pest damage relationships.

The Significance of Plant Growth Analysis and Mathematical Modelling to Pest Control, Its Place in Egypt:

Copies of a paper (Gutierrez et al, 1975, Environ. Entomol., 4(1):125-136) illustrating the utility of the plant growth analysis (PGA) technique in cotton have been provided to our Egyptian colleagues.

An economic analysis of the cotton production system in Egypt should be undertaken immediately stressing the following points:

1. A cost benefit analysis of pesticide use.

2. An analysis of government policy as regards

   a. prices paid to Egyptian farmers for their cotton

   b. pesticide subsidies

   c. the compulsory cotton acreage requirements for each farmer.

3. Current pest control research (e.g., the testing of unlabelled compounds).

4. The efficiency of individual research versus multidisciplinary research teams.

Undoubtedly the list of problems to be reviewed is much larger; the ones listed here are the more obvious ones.

While the construction of a mathematical model for Egyptian cotton should not be given the highest priority, the data required to develop such a model in the very near future should begin to be collected (i.e., PGA and related plant damage data). Below are outlined the specific experiments to be conducted and the types of data to be collected. These studies may appear to be rather extensive, but our experience has shown that they can be obtained in a reasonably short period of time.

First year's research -- Plant growth analysis of plants grown under pest-free conditions and with adequate mosture and nutrients should be studied to establish the base line (pattern) for the growth of Egyptian cotton. Two groups of five plants from each of three planting densities should be collected twice weekly during the growing season and mapped for main stem node production, fruit production and retention patterns and determination of the dry weight of the various plant parts (see Gutierrez et al. 1975 for complete details).

Second year -- The same procedure as above should be followed in sprayed and unsprayed plots at the standard planting density. In this case, the main interest is to see the effects of plant damage on crop growth and development. Intensive data on the association of the various pest life stages on the plant parts should be noted. General insect counts (e.g., bag counts, sweepnet counts, etc.) should be made in the test plots. The general biologies of each of the pest species should be studied under laboratory conditions. These studies should include:

a. The thermal threshold and developmental times

b. Longevity (lx)

c. Fecundity (mx)

Behavioral observations on each of the pests should be made in field studies. These should include site preferences, diurnal movement patterns, plant-part age preferences, etc. A mathematical model could be developed during the winter period.

Third year -- Studies on the impact of natural enemies in large unsprayed plots should be undertaken. These studies should determine the host preferences of each of the natural enemies, whether they feed on the plant and what part of their fecundity relates to prey capture and what part relates to plant feeding. Preliminary testing of the plant model could also occur.

Fourth year -- Models for the Egyptian cotton production system could be formulated to devise optimal crop production strategies.

The Organization and Administration of Insecticide-Testing Programs in Egypt and Recommendations for Improvement:

The Egyptian scientists repprted that they test 30 to 40 new insecticidal chemicals for cotton per year. This may include coded compounds about which little is known concerning efficacy against cotton insect pests or toxicology to man and other animals. The question was asked: Of the total scientific man years in Egypt that are devoted to cotton entomology, what percentage is involved in the testing of insecticides? The answer varied from 60 to 80%. Thus, it is obvious that the greatest part of the scientific effort on cotton insect control in Egypt is expended in insecticide screening work. Although this research is supported by the chemical industry, the amount of Egyptian scientific resources put into this is far too great.

Insecticidal screening work is being done at all 11 field research stations and in most university laboratories. Because of this, research on pest population dynamics, biological control, economic thresholds, microbial control, cultural control, host plant resistance and habitat modification suffers and in many cases is not done at all. The only conclusion that can be made from this was well summed up by Dr. Ray Smith who said to the Egyptian pest research group, "The type of research you are now conducting, mainly on pesticides, will not solve the types of problems Egyptian cotton growers now face, not in one year, or two years,

or in the next 200 years. If you are to solve Egyptian cotton problems, research emphasis must be broadened to include many fronts" (see also general comments on pp. 1-3 of this report).

The common method for evaluating insecticides for Spodoptera is to spray small plots of cotton with the test compound, collect treated leaves and place 2nd to 4th instar larvae on them. The criteria for selection of insecticides is as follows: (1) initial kill of larvae must be 95% or better, and (2) the compounds must show an average residual kill over a 9 day post-treatment period of 70% or better. Compounds which meet these criteria then are evaluated in large field plots and a final selection made. It was reported that it is easy to get the field stations to do laboratory screening, but it is difficult to get them to do the field tests. Also, yield data in the experimental plots seldom is taken. Because of this, the entire field testing program leaves considerable to be desired. No mention was made of testing procedures for thrips, aphids, pink bollworms or American bollworm. Apparently, when this is done, it is conducted in much the same way as the Spodoptera tests.

As mentioned earlier, the US delegation suggested that far too much of the total scientific resources of Egypt are involved in pesticidal screening. The same results could be obtained by a smaller but more tightly organized and administered effort. The US delegation suggested that as a first step the Egyptians should require the companies to furnish more data on pesticidal efficacy and toxicology of coded compounds. This would reduce the total number of compounds brought to Egypt each year for testing (most of which never survive preliminary testing). Secondly, there should be only one central laboratory involved in preliminary laboratory screening. This laboratory could maintain colonies of the various pest species, conduct the preliminary screening and select the compounds that should be placed in field tests. Thirdly, 2 or 3 (but no more) of the field stations, perhaps in the Upper, Mid- and Lower Delta, should do all the field evaluations. Evaluations should include data on effectiveness against pest species, impact on parasites and predators, possible effects on the cotton plants, treatment intervals, dosage rates and yields. It was emphasized that in some cases an insecticide that provides a lower level (75 to 85%) of control but with moderate kill of parasites or predators might be more desirable in an integratee control program than one that kills high percentages of both the pest and its enemies.

If the pesticidal screening could be consolidated into fewer locations more intensive research and better data might be collected because the industry grant funds could also be consolidated into fewer laboratories. The funds then might be spent to employ the technicians, students and field workers required to collect intensive data on all aspects of the chemicals being tested.

The consolidation also would free the time of a great many other scientists who then could place more effort on studies of economic thresholds (the results produced in this research could save the government and farmers much of the funds now being spent on insecticides), biological control, population dynamics, environmental manipulation and host plant resistance. Work on economic thresholds and host plant resistance should receive the highest priority. Economic thresholds for the pest species

provide the foundation on which integrated pest management is built. Also, there are lines of cotton which have been tested in other countries which show a good level of resistance to Spodoptera. Thus, it is our recommendation that one research team composed of an entomologist, cotton breeder and plant pathologist be formed to initiate the host plant resistance work. This team might come to the US to Texas, Mississippi and California for a short period (2 to 3 months) to be trained in the principles and techniques of breeding cotton for resistance to pests in an ongoing program that is proving to be highly successful.

Of course, these changes in direction of research if undertaken will require the government to provide more funds to the research teams involved. This would be an excellent investment as the results produced may be the only way to save the Egyptian cotton industry from pests that are increasingly becoming more resistant to pesticides. The additional research costs involved most certainly would be far less than the gains that can be made from the greatly reduced need for pesticides that this research will produce.

Possible Effects of Insecticides on the Physiology of the Cotton Plant:

The Egyptian cotton entomologists raised the question with their US counterparts: Do you know of any instances where insecticides applied to cotton for control of pests may have had an adverse effect on the physiology of the cotton plant? The answer was yes. Poor stands and delayed maturity have been observed in Texas and the Mississippi Delta when cotton seed treated with disulfoton or phorate have been planted in wet, cold soils that were not optimum for rapid germination and seedling growth. The intensive treatment after emergence of cotton in Mississippi and California with certain organophosphorus insecticides, particularly methyl parathion, also has been observed to delay maturity and cause the plants to set smaller bolls. To the contrast, similar treatments with dieldrin-DDT and toxaphene-DDT have been known to hasten maturity.

There appears to be two main periods of the growing season when insecticides have shown effects on the physiology of the plants: (1) treatments made during the early fruiting stages and (2) multiple treatments applied late in the season.

In-the-furrow treatments of aldicarb have favored early boll set and hastened maturity when weather conditions have been very favorable for the growth of the cotton. Under unfavorable climatic conditions, aldicarb has been observed to delay maturity, promoting a lushness in the plants and causing them to be more favored for oviposition by Heliothis spp.

In Texas several experiments have shown that during an average growing season with cotton making yields of 1 to 1 1/4 bales, the average insecticidal treatment program has not adversely affected maturity or yields. However, in California where cotton is grown under irrigated, desert conditions that produce exceptionally high yields, a few applications of methyl parathion may delay maturity.

In summary, insecticides may affect the flowering rate, boll size and maturity of cotton plants. Effects produced apparently depend on the type of insecticide used, climatic and soil conditions and stage of plant growth when applied. It seems advisable that experiments be conducted in Egypt to better define conditions there when insecticides may (or may not) affect the physiology of the cotton plant. There may be varietal differences in the response of cotton to insecticide such as methyl parathion. Also, the response of G. barbadense cottons to insecticides may be entirely different than that of the G. hirsutum.

New Approaches to Cotton Pest Control in Egypt:

The need for redirecting the cotton insect pests research efforts in Egypt from predominantly pesticides oriented to new approaches has been pointed out in previous sections. Considering the problem of limited resources for cotton pest management research, the first priority for redirection should be determination of realistic economic injury levels for cotton pests. This will provide the sound basis for pesticide application decisions and consequently will allow for minimum insecticide usage for adequate pest control.

Careful consideration must be given to the assignment of remaining resources to research on new insect control techniques. The following are several new approaches discussed during the Egypt visit.

Host Plant Resistance -- Cotton plant resistance to insect pests is probably the most important approach that can be taken to cotton pest control in Egypt. Once a resistant variety is developed, its use by the farmers will cost no more than old varieties. Resistant varieties can be interrelated with other control measures with little chance of adverse disruptive influences. Plant resistance of relatively low levels can contribute greatly to insect management in an integrated control system. Cotton insect resistance research is underway all around the world, thus providing a large source of expertise from which the Egyptians can draw to obtain information, technical assistance and plant material.

Host plant resistance research requires a team approach in the truest sense of entomologist-plant breeder working together for a common goal, so care must be taken in appointing compatible team members and in properly managing, supporting and promoting the team effort. Host plant resistance researchers must carefully avoid the trap of unilaterally selecting and breeding for resistance to a single insect. The utilization of a resistant character must be broadly evaluated for effect on all pests and non-target insects. Multiple character resistance may be necessary for suitable released varieties.

A cotton host plant resistance research team should be appointed and set to work in Egypt as soon as possible.

Cultural Control -- Cultural control cannot be considered as a new approach for Egypt since it is a basic component of the S. littoralis control program and is promoted to some extent in P. gossypiella control. However, cultural control, particularly of the pink bollworm, should be emphasized further. Cotton insect researchers should search for potential cultural practices that can be integrated into the current Egyptian socio-economic situation related to cotton production and the use of cotton stalks for fuel. It would be advisable for the entomologists to seek the aid of economists in this venture.

Basic to the development of cultural control methods, as well as other methods, is sound information as biology, behavior, host plant succession, biotypes, etc., of pest species. Research to obtain such basic information should be emphasized.

Biological Control -- Control of cotton pests through conservation of indigenous parasites and predators is one of the cheapest and most effective techniques available in Egypt or any other cotton growing area. Lack of attention to this area has caused many of Egypt's current cotton pest problems. Emphasis should be given to identification, evaluation and conservation methods for these indigenous natural enemies.

Use of exotic parasites and predators may provide effective control of some cotton pests. Egypt should have at minimum an effort in the area of biological control sufficient to cooperate with biological control institutes and laboratories around the world and to take advantage of potential exotic parasites and predators for Egypt cotton pest control.

Rearing and inundative release of natural enemies probably will require too much of Egypt's resources for research and implementation, thus, this approach probably should not be given the highest priority in utilization of biological control.

Microbial Control -- Based on Dr. Tinsley's comments, the fungi and protozoa have practically no possibility of utilization in pest management in Egypt's arid environment. Viruses for control of S. littoralis and H. armigera should be investigated for potential utilization. Egypt probably should not undertake to set up a classical virology research program, but should investigate the field utilization of viruses as they become available, taking into account the following; (1) viruses will require stringent safety standards in their use at least equal to chemical pesticides, (2) viruses should be looked upon as a component of a pest management system rather than a unilateral approach to pest control.

Pheromones and Hormones -- These techniques offer promise in cotton insect control. Egypt should maintain a research program that can take advantage of pheromones and hormones that become available.

Sterile Insect Release Method -- Although this technique has been used successfully to control certain pests, it is an expensive approach to research and to implement. It requires a complicated and expensive system of developing a scheme in which the technique can be used, developing the technology for implementation and evaluation, and application itself. Furthermore, the probability of success in a reasonable time is low.

Thus, the sterile insect release method would probably be an excessive drain on Egypt's cotton insect research resources for the returns to be expected.

Training and Exchange of Scientists:

During the meetings in Egypt there was discussion of US/Egyptian scientist exchanges on PL-480 and US/AID projects. Whilt it was emphasized that our delegation had no authority for exchanges and program funding, however, the concept of scientist exchanges and training of Egyptian scientists in the United States was strongly supported. The US delegation and the Egyptian scientists were encouraged to seek every possible means for Egyptian scientists to receive training in pest management in the United States. Previous sections of this report contain recommendations on special fields of training in the United States for young Egyptian scientists, e.g., host plant resistance and insect pathology.

Pesticide Management Seminar/Workshop - February 1977:

Plans for a Pesticide Management Seminar/Workshop were discussed with the Minister of Agriculture, Badran; the Supervisor General, Mohib Zaki of the Agricultural Research Center; representatives in the Institutes of Plant Protection; the Rector of the University of Alexandria, Dr. A.H. E. Sebae and others in the Faculty of Agricultural Sciences, University of Alexandria; and members of the Faculty of Agricultural Sciences in Ain Shams University. This seminar/workshop would be developed in collaboration with the UC/AID Pest Management Project. Because of two other large important pesticide-related meetings scheduled by FAO for 1976 in the Arabic-speaking countries and which would involve essentially the same audience, it was agreed to postpone the earlier suggested time to February 1977 as the target date for the Pesticide Management Seminar/Workshop. Ray F. Smith agreed to clarify the problem of conflicting dates with FAO in Rome during the following week. (This was done and FAO is agreeable to this postponed date.) Personnel in all discussions agreed that it would be most desirable to involve those concerned with pesticides in North Africa (probably including countries from Ethiopia to Morocco). The Minister of Agriculture agreed to approach the Arab League for support for travel to the seminar/workshop. To handle the logistical problems in Egypt associated with the seminar/workshop, it was agreed that an Egyptian Steering Committee would be formed. The UC/AID Pest Management Project would deal directly with this Steering Committee in its relationship to the seminar/workshop. It was agreed that the UC/AID Pest Management Project would provide five or six experts to participate in the seminar/workshop and projected pest seminar/workshop training (but this was subject to a request from the Minister of Agriculture submitted through proper channels to USAID/Cairo and AID/W). The Rector of the University of Alexandria indicated that he would approach the Minister of Higher Education for a similar request. It was agreed that both the agricultural sector and the public health sector should participate in the seminar/workshop. The Minister of Agriculture specifically agreed that it was appropriate to involve not only the Ministry of Agriculture but also the Ministry of Public Health, Ministry of Higher Education, the several universities, and representatives of the chemical pesticide industry.

The Rector of the University of Alexandria invited the seminar/workshop to be held in Alexandria. This invitation undoubtedly will be accepted by the Steering Committee. Cairo currently has a severe hotel shortage and other logistic problems. As a first step toward the development of the technical program of the seminar/workshop, Dr. E. Sebae will review with his Egytian colleagues in the universities and the Ministry of Agriculture the agenda of the seminar/workshop held in San Salvador, Jakarta and Manila and develop a tentative agenda for the Alexandria seminar/workshop. This draft agenda will then be sent to Ray F. Smith, Director of the UC/AID Pest Management Project for review and comment. On a very tentative basis, pesticide residue analysis, cotton plant growth analysis and decision-making in pest management systems were suggested as appropriate topics for intensive post seminar/workshop training. After approval by AID/W, a representative of the UC/AID Pest Management Project will visit Egypt to work out additional details of the agenda and training.

Institute of Integrated Pest Control for Cotton:

In some quarters the concept of a new institute emphasizing the integrated pest control approach was suggested to us. The US Pest Management team favored this idea as it would permit the development of a multidisciplinary ecological attack on the pest control problems of cotton. It was suggested that such an institute should include not only scientists representing traditional plant protection disciplines, e.g., entomologists, plant pathologists, nematologists, weed scientists, but also plant breeders, plant physiologists, agricultural economists, s statisticians, etc. If a request is generated through appropriate channels, a representative of the UC/AID Pest Management Project could assist in developing plans for the new institute. It would appear important to make a serious effort to staff the new institute with younger scientists capable of taking a fresh approach and providing new leadership for pest control programs rather than through a simple transfer of existing staff and administrators to this new institute. It is important to establish the terms of reference for the new institute in such a manner that the stultifying compartmentalization of existing institutional arrangements is avoided as much as possible. If, of course, goes almost without saying that the new institute will require an adequate support budget to carry out its responsibilities. It will be useless to go to great lengths to bring together the right kind of people if they are not provided with adequate facilities to carry out their responsibilities. As this must be a field-problem oriented institute, it is essential that the staff have adequate transportation and per diem to visit branch field stations and to otherwise go into the field frequently and with ease. In fact, the institute itself should be located outside Cairo in a rural setting with adequate field facilities and experimental land. Finally, the creation of another institute in a Ministry already divided into many institutes, of itself creates a bit of a problem. Perhaps at this time some thought should be given to phasing out some existing institutes when the new one is established.

FAO/UNEP Cooperative Global Programme for the Development and Implementation of Integrated Pest Control in Agriculture:

This Cooperative Global Programme was initiated in Rome in October 1974. In October of 1975 a Consultation on this Programme was held in Karachi, Pakistan. Mostafa Hafez and A.E. Khalifa represented Egypt in the Karachi meeting. Ray F. Smith and H.T. Reynolds of the UC/AID Pest Management Project were among the US representatives. The results of this consultation were discussed at several levels in Egypt, including the Director of the Agricultural Research Center and the Minister of Agriculture. The role of Lukas Brader, as FAO/UNEP Coordinator for the Cooperative Global Programme, and his projected visit to Cairo to discuss the North African Regional Programme for cotton pests was explained. The Minister of Agriculture expressed great interest in this Cooperative Global Programme indicating that Egypt would be pleased to cooperate with the Sudan in the Regional Programme, and in other ways he also expressed his interest.

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Dr. Ahmed El Kashif, Ain Shams University

Dr. Tom W. Tinsley, Invertebrate Pathologist, Oxford University, Oxford, England, participated in several parts of the colloquium

## Itinerary of UC/AID Team

Saturday, October 25, 1975

Arrival in Cairo

Sunday, October 26, 1975

Meet with Dr. M.M. Zaki, Supervisor General, Agricultural Research Center, Ministry of Agriculture

Visit the Plant Protection Center

Monday, October 27, 1975

Meeting between Egyptian and US participants at the Foreign Relations Department

Tuesday, October 28, 1975

Travel to Alexandria to visit the Faculty of Agriculture, Alexandria University

Wednesday, October 29, 1975

Visit the Faculty of Science, Ain Shams University

Visit the Faculty of Agriculture, Ain Shams University

General discussions at the office of Dr. Zaki, Agricultural Research Center

Meeting with Dr. Osman Badran, Minister of Agriculture

Dinner given by Dr. Badran, Minister of Agriculture

Thursday, October 30, 1975

Meeting with Dr. Ralph Edwards of the American Embassy

Meeting with the Pest Control Policy Committee at the Foreign Relations Department, Ministry of Agriculture

Friday, October 31, 1975

Departure