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EGYPTIAN MAJOR CEREALS IMPROVEMENT PROJECT

RESEARCH - EXTENSION

Technical Report

EGYPTIAN MAJOR CEREALS IMPROVEMENT PROJECT

"MAIZE PROGRAM"

September, 1981

by

Dr. V.E. Gracen

EMCIP Publication No.32

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INTRODUCTION

Maize is a major summer crop in Egypt, occupying approximately 1.9 million feddans. Although maize can be grown throughout the country, the bulk of the growing area is in the Delta (75%) and Middle Egypt (20%).

During my stay in Egypt, I had the opportunity to visit with maize researchers at each of the four stations associated with the Egyptian Major Cereals Improvement Project (EMCIP) (Giza, Sids, Gemmeiza and Sakha) as well as production fields and varietal demonstration plots on farmer fields. I was able to visit with plant breeders, plant pathologists, entomologists and agronomists associated with EMCIP, the Egyptian National Maize Program and the Ministry of Agriculture. I was accompanied on most of the trips by Dr. A.A. Ismail.

Considerable time was spent evaluating inbred lines, hybrids and populations at each station. Special emphasis was placed on observing differential reactions to the late wilt disease caused by Cephalosporium maydis currently the most serious disease of maize in Egypt. Discussions of disease and insect resistance evaluation techniques, breeding strategies and methodologies related to inbred and hybrid development and population and hybrid evaluation techniques were held at each research station. I also presented a seminar outlining the breeding methodologies employed at Cornell University to develop disease and insect resistant varieties, inbreds and hybrids.

In outlining my observations and recommendations, I realize that many of the strengths and weaknesses of the program that I mention have been previously recognized by the National Program and EMCIP staffs and that solutions to many of the problems are complex and will require a long term commitment of all involved. However, I feel that I should provide as much constructive criticism and praise as possible to help document, clarify and expand upon problem areas.

OBSERVATIONS AND RECOMMENDATIONS

I was impressed by the extensive research and extension programs I observed. Egypt is fortunate to have well trained and competent scientists available to the program, and competent leadership provided by Dr. A.H. Shehata. The population improvement and hybrid development programs show evidence of successful breeding for late wilt resistance and yielding ability. The variety Giza 2 certainly appears to be a suitable and productive variety for Egyptian farmers to use over the next few years. Some promising single cross hybrid combinations also appear to be nearing release. Farmer's yields should improve if high quality seed of these varieties can be produced and distributed and the varieties grown with proper management. The Giza 2 production fields I observed near Sids and the farmer production near Quwesna certainly indicate that both the seed and the management technology can be passed on to the farmer.

Although Giza 2 and promising hybrids are being developed, I observed several major constraints and limitations which will adversely affect both the rate and efficiency of hybrid production if not soon corrected. Also the long term success of the National Maize Program must continue to rely on population improvement as well as hybrid development to cope with potential problems such as Helminthosporium turcicum, downy mildew, and stalk boring insects which may become serious problems in the next few years. In order to improve the effectiveness of both population improvement and hybrid development and evaluation programs, I present the following evaluations and recommendations for the overall direction of the maize breeding program. I realize that my stay here was brief and that I cannot hope to be comprehensive, but I hope these recommendations will be given consideration by EMCIP and the national program.

1. The population improvement program appears to be utilizing a wide selection of germplasm ranging from the American early dent temperate composite to Eto, Tuxpenio and Blanco subtropical composites. However, the assignment of composites to each station for full sib and S1 improvement and progeny trials, although sound theoretically, has several important limitations. Due to poor water management resulting in water logging and excessive late wilt development even in non-inoculated plots, I feel that effective selections except for late wilt resistance at Gemmeiza would be difficult to make. The low level of late wilt at Sakha coupled with soil problems presumably

associated with high salt concentrations restrict the value of selections and evaluations at Sakha. Also, the presence of relatively heavy stalk borer infestations and H. curcicum in parts of the Sakha station also confound full sib and S1 progeny selection and evaluation.

2. The series of 10 single cross hybrid trials involving diallels of 10 lines each planted at two stations each gave some valuable information but involved a lot of unnecessary work. All 10 trials were planted at Sids, 5 each were planted at Gemmeiza and Sakha. Although late wilt incidence was not as high at Sids as at Gemmeiza, it was evident at Sids that most of the hybrid combination in most of the trials were at least moderately susceptible to late wilt. This susceptibility was especially evident at Gemmeiza. The only trials with high proportions of late wilt resistance and good yield and standability were trials AH6 and AH10. Proper evaluation of the inbreds and single cross hybrids involved in these trials in a single disease nursery before advancing them to multiple location tests would have reduced the number of materials to be tested at multiple locations drastically and allowed the scientists to expend more effort on monitoring performance of a reduced number of elite hybrids.

3. Inbred development programs at the 3 stations and at Giza appear to be poorly defined and excessively repetitious.For example, the station at Sakha has 2123 lines under development all within S1 to S3 generations. Since late wilt susceptibility appears to be the primary criteria for eliminating lines and Sakha has little late wilt, the breeders there are not able to eliminate susceptible materials early enough. Gemmeiza has 1344 lines between S1 and S4 generations. S1 and S2 lines are eliminated quickly because of late wilt susceptibility but there seems to be a block at the S4 and later generations in that potentially resistant but poor performing lines are not tested for combinability and are eliminated. The most efficient program for inbred development and hybrid testing appears to be that run by Dr. Ahmed El Fatah and associates, at Sids where good station management, good late wilt evaluations, and proper hybrid testing evaluations are combined.

4. Problems in evaluating a quantifying late wilt reaction and in identifying other potential pathogens were apparent at most stations. For example, during my two visits to Gemmeiza, inbred and hybrid

varieties showed excellent differential reactions to late wilt. Inbreds could be classified into resistant, moderately resistant, intermediate, moderately susceptible and susceptible classes. Hybrids showed similar differentials which suggested that primarily additive gene action was involved. Hybrids between resistant and resistant, resistant and susceptible and susceptible and susceptible lines exhibited clearly distinctive reactions. However, data taken on percentage plants showing black bundles at 35 days post flowering did not reflect the differential levels of resistance that were observed. Also several leaf blight and potential viral diseases at Gemmeiza have not been typed and identified. All of these diseases must be monitored and proper inoculation and evaluation techniques especially for late wilt need to be developed.

In order to help alleviate some of the problems inherent in the various aspects of the breeding program, I would suggest the following recommendations be implemented.

1. Develop a program of population improvement that takes advantage of each station's strengths to maximize contributions to the overall program. For example, the Gemmeiza station should be given top priority for developing a composite(s) resistant to late wilt. Resistant materials from all pools and current composites should be selected with late wilt inoculations and recombined on the basis of relative maturity to produce early and perhaps medium maturity late wilt resistant composites. Population improvement at the Sakha station should emphasize stalk borer and H. turcicum resistance. Downy mildew resistance may have to be added later. This program would require cooperation of entomologists and plant pathologists located at Sakha and Giza. (I will describe plans for a technical support unit to provide entomological, pathological, and physiological expertise in a later section.) Development of stalk borer and H. turcicum resistant composites and ultimately inbreds will help provide long term stability for the program and will prevent farmers who plant early or late from sustaining excessive borer damage now. The population improvement work at Sids should concentrate on selections of adapted, early maturity composites with at least moderate late wilt resistance. Current composites 2, 5, and 8 appear to contain some desira . families. Additional composites such as the Cornell ECB

material should be added as needed to find appropriate sources of insect and disease resistance. Emphasis should be given to developing composites of adapted, early white dent materials that could be used as sources of improved lines in future years.

2. The program should develop a central clearing house for inbred development. It is obvious that inbreds developed at Sakha and Sids could benefit from late wilt tests at Gemmeiza. Lines highly susceptible to O. nubilalis borers should also be identified at Sakha and discarded. Lines could be screened under moderate late wilt conditions at Sids. Close coordination of inbred development programs from each station for materials from S1 to S4 stages could effectively reduce the number of elite inbreds being advanced to hybrid tests each year. The exchange of early generation lines (S2-S4) between stations could also suggest crosses that may be developed and subsequently selfed to produce new lines with two or more resistances combined. For example, inbred G4 is moderately resistant to stalk borers but susceptible to late wilt. Inbred G221 is resistant to late wilt but susceptible to stalk borers. Selfs of the single cross between these lines could be selected at Sakha for borer resistance and at Gemmeiza for late wilt resistance simultaneously. Such a program would require one source through which all inbred development plans must be cleared to work effectively, else every breeder at each station could decide to ship several hundred lines to other stations producing a log jam of incomprehensible dimensions. I would suggest that Dr. A.A. Ismail coordinate inputs from the station leaders and make recommendations for inbred development to Dr. Shehata.

3. The hybrid development and evaluation program needs extensive revision. Some of the breeders appear to understand the fundamentals of population improvement very well but appear to have little comprehension of hybrid development procedures such as the use of testers to measure general and specific combinabilities. Furthermore, the hybrid evaluation trials are not well coordinated or managed at some stations. A well coordinated program responsible for inbred advancement beyond the S4 stage and based on tester hybrid crosses, preliminary hybrid evaluations both with and without disease and insect pressure and subsequent advancement of only superior hybrids to well managed, regional trials is badly needed. The agronomic management

of these advanced trials should be optimized, perhaps best done by putting them on special plots managed by the EMCIP soil and water management people, since often plots on most of the state farms are not well managed.

Such a program should utilize the intermediate late wilt and good management conditions at Sids to make up the tester crosses and start evaluations of the tester crosses. It should utilize the heavy late wilt conditions at Gemmeiza and the borer infestations at Sakha to evaluate resistance levels of such hybrids to these pests and should provide centralized coordination of advanced yield trials at all locations. I would suggest that both the inbred and hybrid development programs could utilize the special expertise of Dr. A.A. Ismail to help coordinate these specific activities within the very large and complex program administered by Dr. A.H. Shehata.

4. The project needs a highly technical group of support scientists preferably located at Giza to help support the entomological, plant pathological and physiological aspects of the project. These scientists will require the immediate upgrading and refurbishing of laboratories and will require support for lab supplies and materials.

   Several areas of immediate concern are:

   a. There is a need to modify late wilt inoculation and evaluation techniques to provide an efficient method of identifying and quantifying differential levels of resistance. Inoculation of hills at planting with the most virulent isolate of C. maydis available and subsequent ratings of the percentage of leaves showing wilt symptoms at several dates may provide better differentiation of moderately resistant types than the procedures currently in use.

   b. There is a need to develop a screening technique to identify late wilt resistance at very early stages of plant development. This might involve fungal produced phytotoxin assays or assays involving inhibition of fungal growth by plant root or stalk extracts.

   c. There is need to identify and characterize races of C. maydis and other stalk rotting and wilting pathogens such as C. acrimonium and Fusarium species. These three activities should involve Dr. A.H. Abdel Rahman in plant pathology as well as appro-

priate plant breeders.

d. Basic studies to determine whether polyphenol oxidase, peroxidase or related enzymes are involved in late wilt resistance are needed. This may be determined by the isozyme work already planned, but unless clear cut differences between maize lines are readily establishable, then correlations of isozymes with late wilt resistance may not be feasible. Other applications of isozyme and related techniques also need to be investigated. The development of isozyme and other similar laboratory studies could make the Egyptian program a world leader in physiological and genetical work on white maize germplasm. The expertise available within Dr. Shehata's group in this area should be utilized.

e. There is need to characterize pathogens other than C. maydis that could cause significant disease losses. H. turcicum, downy mildew, and the root rot pathogen observed recently on several inbred lines should be studied. Common smut, although recently established in Egypt, may be readily controlled by selections of resistant materials and should not become a major economic factor, but nevertheless, it should be monitored.

f. There is need for determination of changes in corn stalk borer populations, determination of relative damage to varieties, and measurement of levels of resistance or tolerance to stalk borers. Recent observations of apparent Sesamia damage at Gemmeiza and apparent Ostrinia damage at Sakha should be investigated. Ostrinia and Sesamia inoculum production facilities to provide artificial insect infestations for resistance work at Giza and programs for screening for resistance to Ostrinia at Sakha and perhaps later to Sesamia at Gemmeiza should be developed. These last two objectives should involve the cooperation of Dr. William Awadallah.

Additional laboratory support activities and facilities will be required in the future if the breeding program expects to continue to produce and utilize hybrids. Shifts in pest populations that are sometimes buffered against in open pollinated varieties could become significant on hybrids, but the history of high yielding and high quality exhibited by hybrids in rather uniform environments such as Egypt's suggests that hybrids will certainly be successful. With proper monitoring and anal-

ysis of disease and insect development, the development of stable, high yielding hybrids appears to be highly likely.

Finally, I would like to make some general observations about the overall project that will require some administrative as well as scientific solutions. These are problems that I'm sure have been recognized by Dr. Shehata and his staff and by EMCIP. Perhaps difficulties in either realizing the adverse impact of these problems on productivity or difficulties in jointly developing effective plans that both the Egyptian and EMCIP programs can support have hindered solutions. It is not my intent to blame or critisize any one aspect of this cooperative project since obviously these problems have complex origins and causes. Instead, I hope that by enumerating some of these concerns that EMCIP and the Egyptian Maize Program can work together towards solutions.

1. The station facilities are poor and poorly managed. Laboratory, field, and seed handling equipment should be upgraded immediately. I was especially distressed to see materials for constructing new facilities at several stations laying idle in fields. Construction of project facilities is way behind schedule and should be initiated immediately. Laboratories and field support equipment in current use should be improved now. The scientists cannot function effectively to meet the objectives of the project with the current lack of facilities.

2. Management of the experimental farms appears to be haphazard at best. EMCIP project scientists should have land made available to them on a long term basis to be used for nurseries and trials. Two breeding nurseries per year are certainly feasible and should be encouraged with appropriate land being made available. The development of well managed nurseries and trials is essential. The frustrations to scientists caused by poor station facilities and management are demoralizing and disruptive to the overall progress of the program.

3. Continuous involvement of scientists including breeders, pathologists and entomologists in the fields at all stations should be encouraged. Proper transportation should be provided. Restriction of per diem reimbursement to 10 days per month certainly hinders daily travel during peak seasons and such restrictions should be eliminated. Either more drivers of government cars or cars that scientists can drive should be provided to project scientists so that travel between stations is greatly facilitated.

4. There is a need for more active involvement of U.S. scientists in maize breeding, entomology and pathology. This could be provided through a permanent maize breeder with experience in disease and insect resistance being assigned full time to the project or through the use of additional TDY's.

5. There is a need for advanced training for Egyptian scientists in the program. Many are familiar with and competent in population improvement strategies but could use additional training in the areas of inbred and hybrid development and disease and insect resistance breeding This could be partially accomplished by sending selected scientists abroad for one year post-doctoral training leaves and/or by developing appropriate short courses and symposiums to be held at Giza. The latter would be especially attractive now so that both breeding goals and suitable trainees could be identified at this time. Specifically, I feel it is essential that the six maize scientists identified by Dr. Shehata be encouraged to attend the American Society of Agronomy meetings in Atlanta, Ga. from Nov. 29 - Dec. 4. They should also be allowed to attend the American Seed Trade Association Hybrid Corn and Sorghum Conference held the following week in Chicago.

6. There is a need to clarify the project's relationships with Pioneer and other private companies as well as with Egyptian national seed companies. Currently, there is some confusion as to whether project hybrids should be developed and sold in competition with Pioneer or developed and then produced and distributed in conjunction with Pioneer. There would be advantages inherent in either option, but there is little middle ground. I think that the project will find Pioneer a helpful and friendly competitor or cooperator but the project's policy should be established and made clear now.

These general administrative problems must be solved if the EMCIP Program is to be even partially successful at meeting its objectives of developing a multidisciplinary team of Egyptian scientists and upgrading facilities and personnel such that research and extension functions can be conducted more efficiently and effectively. Since I was unable in such a short visit to spend much time with either the Egyptian Director General or U.S.AID administrative personnel, it is difficult to identify the exact sources of these administrative problems. However, I was able to spend some time with Dr. E. Everson, who directs the U.S. EMCIP staff

and I feel that Dr. Everson has done an outstanding job of trying to administer this project under extremely difficult circumstances. These suggestions for the administrative and maize breeding parts of the project are not intended as criticism of any particular person or phase of this overall project, but only to identify problems that were readily apparent during my stay and which I feel should be corrected if the project is to be successful.

BREEDING METHODOLOGIES AND TECHNIQUES FOR DEVELOPING DISEASE AND INSECT RESISTANT MAIZE VARIETIES

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Pest problems in the Northeastern U.S. are generally not severe. The summer climate is normally very well suited to growing maize and not generally suited for pest build up and spread. However, we are constantly faced with changes in pest populations and local or seasonal environmental shifts which could result in severe pest outbreaks on susceptible varities. The development of the southern corn leaf blight epidemic caused by Helmin thosporium maydis race T in 1970 is an example. That disease eluded our normal programs for disease resistance by specializing in cytoplasmically controlled specificity (the first case of cytoplasmic control of disease resistance ever reported). Since the cytoplasmic factors controlling susceptibility were not manageable by conventional breeding techniques, virulent races of the pathogen were able to develop and inflect damage to a large percentage of the U.S. hybrid corn crop. The development of similar races with specificity for additional cytoplasmic or nuclear genotypes is always possible. Therefore, our breeding program must constantly evaluate and select lines for resistance to a complex group of leaf blighting pathogens.

Most of our production areas in the Northeast have relatively short growing seasons which require early maturing lines. As most of you are aware, decreased stalk quality and increased susceptibility to stalk rots and stalk boring insects are often associated with earlier maturity. Over the last 10 years, increases in populations of the European corn borer (Ostrinia nubilalis) in New York have resulted in increasing stalk breakage damage and yield loss in our early maturity lines.

Our varietal development program at Cornell has, therefore, emphasized the development of early maturity germplasm with good stalk quality, resistance or tolerance to EBC, and resistance to the leaf blight pathogen complex. Today I would like to describe the techniques employed to screen for resistance, the population and inbred development breeding strategies employed and the hybrid development and evaluation program.

ECB resistance - This insect attacks maize in the U.S. at two different stages of plant development. The first generation of the insect attacks corn at the mid-whorl stage of development where it feeds primarily on leaves. Resistance to leaf feeding has been identified and has been incorporated into U.S. hybrids since the early 1960's. The second generation of the insect attacks the plant shortly after flowering and tunnels into the stalks causing plant lodging and ear drop. Resistance to the stalk boring stage has not been readily available in U.S. germplasm. Since the stalk boring damage results in significant yield losses in the early maturity lines grown in the Northeastern U.S., resistance to this type of ECB damage has been a major concern at Cornell.

Techniques for rearing ECB on artificial diet, infesting plants and evaluating stalk damage have been developed at Cornell using modifications of techniques developed at the USDA corn insect research laboratory at Ankery, Iowa and at the International Center for Maize and Wheat Improvement (CIMMYT). Currently we produce about 200,000 ECB egg masses each year for artificial infestation. Plants are infested with ECB larvea mixed with an inert, corn cob powder using the "bazooka" device developed at CIMMYT. Plants are infested at the mid-whorl stage and subsequently rated for leaf feeding damage and then reinfested at flowering and rated for stalk breakage and length of tunnels at harvest. By using artificial infestation techniques, lines resistant to both leaf feeding and stalk boring have been identified.

The best sources of resistance to stalk boring identified in tests of an extensive collection of the world's maize germplasm are Coastal Tropical Flint varieties from Antigua and other Carribean islands. Although these materials were highly resistant to ECB, they were poorly adapted at New York growing conditions. Therefore, a full sib recurrent selection breeding system was initiated in 1971 to develop adapted, ECB resistant lines. Each year families of a Cornell ECB resistant composite are infested and evaluated for ECB resistance on a replicated basis. Resistant families are sibbed and subsequently recombined in a second winter generation. These recombinants are infested and evaluated, the most resistant 15-20% are selected for the next cycle of recombination. After 10 years of selection, the population is well adapted to New York and highly resistant to ECB, however, the full sibbed families are not readily usable in Cornell's hybrid development program.

Heritability of resistance and tolerance to ECB is apparently high. Studies of the genotypic components of resistance are underway. Additive gene action appears to be important but non-additive or dominant gene action is involved as well. Selfing of ECB resistant families results in segregation of S1 and S2 lines for resistance and agronomic quality. To date, none of the inbreds developed through selfing have shown the yield potential and quality in hybrid combination that is expressed by elite New York lines. Therefore, in 1974, a modified backcross program was initiated to try to transfer resistance from the ECB composite to elite inbred lines. In this program a generation of evaluation for ECB resistance and recombination of selected backcrossed lines is alternated with backcrossing to the recurrent elite inbred. This system is proving successful for transfering resistance and especially tolerance to ECB to elite lines. New inbreds from this modified, backcross program show good yield and quality in hybrid combinations, as determined by the hybrid evaluation techniques described below.

Leaf blight resistance - At Cornell, we have a series of leaf blight pathogens that attack our lines. Earlier maturing lines are especially susceptible to *Helminthosporium maydis* races T and O, *H. carbonum* races 2 and 3, *Phyllosticta maydis*, *Kabatiella zeae* and *H. turcicum* race 2. Our breeding program has been developing materials resistant to each of these pathogens for the past 10 years.

Plants are inoculated at the seedling stage of development by dropping spore suspensions into the whorls. Leaf blight ratings, usually on a 0.5 - 5 scale are made just before flowering and during the interval between flowering and harvest.

Resistance to most of these diseases is controlled by polygenic additive and dominant gene actions. Single genes for resistance are known for *H.maydis* (rhm) and for *H.turcicum* (Ht1 and Ht2). These genes are incorporated via backcrossing and used where feasible. The polygenic resistance is highly heritable and can be transferred rather easily through our elite inbred development program.

Since late maturing U.S. lines with high levels of resistance to all of these leaf blights have been identified, our disease resistance program does not have to utilize extensive population improvement. Crosses

between late maturing, resistant and early maturing, susceptible elite lines can be used to develop early maturing, resistant inbred lines of high quality. Resistant (late by early) single crosses are inoculated in our disease nursery and selfed. Self 1 (S1) plants are inoculated and early, resistant plants are selfed again (S2). These S2 lines are inoculated and early, resistant families are advanced to S3 and S4 generations. The S4 lines that are early and resistant to leaf blights are top crossed onto inbred or hybrid testers. Yield trials (inoculated vs. non-inoculated) of these hybrids are evaluated extensively to determine general and specific combinabilities and levels of resistance or tolerance to disease.

Hybrid Evaluation Trials

Hybrids that yield well in 1st year tests are advanced to regional tests (2-4 reps over 3-5 locations depending on maturity). The new inbred lines from the advanced hybrids are selfed to S5 and then sibbed in subsequent generations. They are also crossed onto sources of cytoplasmic male sterility and evaluated as potential male or female parents of Cornell experimental hybrids.

The best performing hybrids from the regional evaluation trials are identified as Cornell experimental varieties and incorporated into the N.Y. Seed Improvement Cooperative's (NYSIC) program for increase of foundation (breeders) inbred seed and certified hybrid seed. The experimental varities are entered into Cornell extension tests at 15-20 locations for 1 or 2 years of additional testing before being released or dropped. Hybrids released by Cornell are produced by NYSIC under contracts from commercial corn companies who market the Cornell hybrids.

In summary, the breeding program at Cornell emphasizes stalk quality and ECB resistance and leaf blight resistance of early maturing lines. Full sib population improvement is used to develop U.S. adapted, ECB resistant material from both temperate and tropical sources of resistance. This resistance is then transferred to elite U.S. lines via a modified backcross procedure. Leaf blight resistant lines are developed by crossing resistant, late by susceptible, early materials and selfing to new inbreds. S4 selections are put onto testers to determine yield potential. Hybrids are tested first in disease or insect inoculated yield trials at one location. Selected hybrids are advanced to regional yield trials.

Those selected as experimental varieties are advanced to extension trials, released, produced by NYSIC, and distributed by commercial companies.

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