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# SEED PROGRAM DEVELOPMENT

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Technical & Economic Factors Associated with Establishment of a Seed Industry in the LDCs.

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MISSISSIPPI STATE UNIVERSITY
STATE COLLEGE, MISSISSIPPI

# SEED PROGRAM DEVELOPMENT

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PREPARED UNDER
CONTRACT AID/csd-1203
BETWEEN THE
AGENCY FOR INTERNATIONAL DEVELOPMENT
AND
MISSISSIPPI STATE UNIVERSITY

June, 1971

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Substantial and invaluable assistance in the formative stages of the study on which this "handbook" is based was given by an advisory committee organized soon after the project was initiated in 1966. Members of this committee were: T. H. Roberts, Jr., President, DeKalb Agresearch, Inc., Dekalb, Illinois; Harold Loden, Director of Research, ACCO Seeds, Belmond, Iowa; A. S. Carter, former Director of the Seed Inspection and Regulatory Service at Purdue University, Lafayette, Indiana; A. D. Ayers, AID/W, Washington; John Osguthrope, AID/W, Washington; and Jack W. Wells, FAS/USDA, Washington. Mr. John Sutherland, Executive Vice-President, American Seed Trade Association, Washington, served as ex-offico member of the advisory committee and his good offices were responsible for the excellent cooperation of the U.S. seed industry in the study.

During the course of our study and reflections we discussed seed program development with USAID personnel, other U.S. foreign service staffers, FAO specialists, technical assistance specialists from the Foundations, private seedsmen, cultivators, government officials and seed specialists in and/or from countries ranging from Afghanistan to Zambia including the U.S. and other "developed" countries. The cooperation of these hundreds of men and women deeply involved in improving the food, feed, fiber, and human resources of our world, and the many courtesies extended to us by them, are greatly appreciated.

Basically we are teachers, and in this capacity we have been privileged to work with students from more than 40 countries - all of them interested in and concerned with seed production and supply. Our students have been and are a constant and very fruitful source of information, ideas, experiences and professional and personal satisfaction. In many diverse ways we have received much more from them than we were able to give. They have influenced enormously the tone and content of this handbook. We are grateful for their contributions and friendship.

The "results" of the basic study undertaken in 1966 were reported to AID/W in the form of a rather voluminous draft report in two parts in 1969. During subsequent discussions with AID, the decision was made to drastically condense the report into a concise "handbook on seed program development." The task proved to be formidable - not because the authors were inordinately enamored with the organization and phraseology of the draft report, but rather because of the difficulty and near impossibility of tying the many facets of a seed program-industry into one small neat bundle. Dr. Lew Humphreys (USAID retired) was asked to assist with the preparation

of the handbook. Although his 35 page draft was expanded considerably, its organization, style and content are the most solid components of the present effort. We acknowledge the substantial contribution of Dr. Humphrey and are grateful to AID for the opportunity to visit and work with him during a few weeks in August, 1970.

Many discussions with T. V. Tibbutt, TAB/AID, on the economic-management dimensions of seed program development profoundly influenced several sections in this handbook. He pinpointed some aspects of a seed program-industry that are all too often neglected.

The role of Mike Galli, TAB/AID, as "pusher" of this handbook was crucial. Its birth is largely due to his efforts although he may want to disclaim parentage.

We also want to acknowledge here the generous assistance of our associates in the Office of International Programs and Seed Technology Laboratory, Mississippi State University: Dean Bunch, Hunter Andrews, Jim Beck, Bill Boyd, George Dougherty, Bill Gregg (presently with our AID contract seed team in India), Ken Matthes, Charles Vaughan, and Burns Welch (now with our team in Brazil). They are the anonymous "staff" credited on the title sheet.

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Although the ideas, experiences and suggestions of many people are in this handbook, we must finally insist that full responsibility for the form in which they are expressed, their juxtaposition with other ideas or experiences, and the emphasis given is ours.

June 14, 1971
Mississippi State University
State College, Mississippi

J. C. D.
H. C. P.

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# FOREWORD

In June, 1966, the Mississippi State University (MSU) and the Agency for International Development signed a contract under provisions of which, MSU undertook a study of the "technical and economic factors associated with establishment of a seed industry in the less developed countries."

The study had three broad objectives:

(1) To study the present status of and plans for seed programs in the less developed countries.

(2) To identify the major technical, economic and socio-political factors that impede or foster seed program development.

(3) To study the current participation and interest of the U.S. Seed Industry in seed operations in the less developed countries and experiences that have resulted from their involvement and participation.

"Information gathering" aspects of the study were completed at the end of 1968. Since that time, we have been attempting to sift the relevant and meaningful out of the data and information collected and impressions retained from on-site visits - all unavoidably tempered by our subsequent and current experiences in seed program development. The task has not been easy. Although, we have been actively involved since 1958 in consultation work with AID on seed programs and seed problems in the various countries, our thinking has had to be restructured to accomodate some facts, ideas, and concepts that have become quite clear as a result of this study and attendant reflections. In a sense the project has been a long learning and "re-newing" experience for us. And, it is our hope that the perspective now in focus can be intelligently communicated to others concerned with seed programs in the less developed countries.

The period of this study coincided with a truly dramatic resurgence of interest in seed improvement. It was (and is) a time of "miracle rice," "wonder seed" and the "green revolution." To the over-sophisticated these phrases may be trite and somewhat weary cliches, but to cultivators in countries round-the-world, they touch on the real qualities of the new wheat, rice, millet, sorghum and maize varieties and hybrids.

Improved seed have suddenly come to the forefront in the strategy for agricultural improvement. Old seed programs that had sputtered along for years are being refurbished and geared to produce the quantities of seed needed of the new varieties. New seed programs are being initiated. Unfortunately, most of the old unresolved problems that plagued seed program development in the middle and late 1950's remain. They are all too evident in the often uncoordinated, incomplete, poorly planned, and ineffective programs in many countries today.

It has become very clear to us that the major problem in establishing a seed program-industry in the less developed countries is an incomplete understanding or concept of just what a seed program is and what it is not. Most of the other difficulties and problems derive wholly or in part from this misunderstanding. In some countries a few elements of a seed program have been actively promoted, supported and highly developed while others have been left unattended. In others, the activities in the various components of the program are poorly coordinated or completely uncoordinated. And, in a few cases, seed program development has been attempted with complete disregard to essential requisites for the program. These are generalizations and do not apply to all countries. Under the pressure of heavy demand for improved seed, a few countries have established progressive and effective seed programs and the beginnings of a seed industry are already evident. They serve as examples of what can be accomplished.

This "handbook" represents an attempt to place the total seed program and its various components in proper perspective relative to agricultural improvement in general. Our approach has been positive, that is, the role, objectives, composition and coordination of the seed program are discussed without emphasis on specific mistakes and disappointments of the past. Yet, our debt to the past must be acknowledged. We have learned from it, perhaps not fully, but hopefully enough to avoid some of the previous difficulties.

# Justification, Planning, Organization and Implementation

Part 1

## ROLE OF SEEDS IN AGRICULTURE

Agriculture began with man's discovery of the generative function of seed some 10,000 years ago. And, since that time seed have continued as a key element in crop husbandry. The seed contains - in one small, remarkably designed package - all the potentialities for the plant. Most of the practices and materials used for crop production have been primarily developed to allow full expression of the seeds' genetic and physiological potential. On the other hand, no agricultural practice - fertilization, cultivation, irrigation, etc. - can improve crop production beyond the limit set by the seed; thus, the crop can be poorer than the seed planted, but it cannot be better.

Seed are also the mechanism through which plant populations are distributed over both time and space, and - in our era - the only practical means of transmitting and multiplying into succeeding generations the improvements genetically engineered into small populations of improved varieties by modern breeders. Recognition and understanding of the seed's primal and catalytic roles are crucial to the formulation of an effective strategy for agricultural and rural development.

The quality and orientation of a country's agriculture are closely related to availability and use of good seed. No country or society in our time has developed or can develop a highly productive, market-oriented agriculture without an effective seed supply system. Agricultural specialists and planners should, however, recognize that agricultural development cannot be based entirely on superior seed - other inputs are also necessary. Yet, seed do possess qualities and potentialities that make them unique among agricultural inputs: they are alive, can be rapidly multiplied, are required in relatively small quantities, have alternative uses other than as a production input (i.e., food, oil, feed), and are familiar to all cultivators. These same qualities that make seed unique are also the root causes of the many technical and socio-political problems that invest seed programs and require that they be distinctive in certain critical ways from those for other inputs.[1/]

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[1/] Our experiences suggest that a major problem in establishing a seed program-industry in the developing countries is an incomplete understanding or concept of just what is involved in a seed program-industry and what is not involved. Many of the other difficulties and problems that attend seed program development derive wholly or in part from this situation. We suggest, therefore, that persons using this manual review the elements and structure of a seed program-industry presented in Part II before preceding further in this section.

Figure 1. "Agriculture began with man's discovery of the generative function of seed some 10,000 years ago."

## JUSTIFICATION FOR A SEED PROGRAM

In traditional agricultural as practiced for hundred of generations and still prevalent in many areas today, the cultivator sets aside a part of each season's production to plant the succeeding crop. Beyond this practice, little distinction is made between the edible grain and regenerative seed. A progressive agriculture, however, requires the rapid and effective multiplication and dissemination of improvements in crop varieties as they are effected. Traditional methods will not suffice.

A well organized, effective seed program-industry is as important - and really more basic - to continued agricultural progress as are supply programs for fertilizers, pesticides, irrigation, credit and so on. Considerable progress can be made by introducing and widely disseminating large quantities of seed of high yielding varieties obtained from foreign sources. In a season or two many of the cultivators will be planting the improved seed with dramatic short term gains in productivity. But what of the long run? How long will it take for the improved germ plasm to be effectively neutralized through dilution in the "local" gene pool by field contamination, mechanical mixing and/or outcrosses? How can "second generation" varieties of the same general plant type and statue but with improved nutritive value, disease resistance, and yield potential be introduced without almost immediate loss of identity?

Most countries have established good to excellent varietal testing, introduction and breeding programs, the productivity and output of which are being greatly accelerated by their own intensified efforts, through the waxing flow of genetic stocks from the international crop research centers, and by dramatic demonstrations of just what can be accomplished by determined, mission-oriented crop breeding and improvement research. New and improved crop varieties, however, become a significant agricultural input only when pure, high quality seed are available to and planted by cultivators. The justification and mission of a seed program, therefore, are extension of superior varietal performance demonstrated in breeding nurseries and test plots to all crop lands where the variety is adapted. This is best accomplished through an organized, systematic and cooperative effort involving both private and public sector institutions and personnel - a seed industry.

Although it seems to us that the need for and justification of a seed program-industry are implicit in any strategy for accelerated agricultural development, we recognize that initial policy decisions and planning have to be based on "facts and figures" as well as precedent and experience. Projections have to be made of the benefits to be derived from the expenditure of a given level of funds and energy.

Analysts involved in assessing the economic benefits to be derived from a seed program should take into account the following considerations:

(1) The seed program per se is probably not the proper focus for strict cost benefit ratio analysis. Rather, such analysis should be applied to the total crop improvement or plant breeding program of which the seed program is an essential extension.

(2) Seed of most major crops are a reproducible, multiplying input (exceptions: seed of hybrids and possibly some vegetable and forage crops). A specific acreage of the immediate crop is benefited by the level of primary input (quantity of new seed planted), while geometrically progressing acreages of succeeding crops are (or can be) benefited by the progeny of the primary input. In this manner, seed are unique among production inputs in crop husbandry.

(3) An efficient seed industry serves not only in agricultural development but also as a mechanism for the rapid rehabilitation of agriculture in the wake of natural disasters such as floods, drought, epiphytotics of plant diseases, etc. Witness, the marvelous efficiency of the U.S. seed industry in replacing southern corn leaf blight susceptible TMS corn hybrids with blight tolerant hybrids in less than two years, or the urgent need for seed after the natural disaster in East Pakistan in 1970. Thus, the potential of a seed program-industry as a sort of disaster insurance cannot be overlooked in computing its benefits.

(4) In some countries, or states therein, a completely objective economic and technical justification for a comprehensive seed program may not be possible. Importations and/or establishment of a distribution-marketing system might be adequate in the context of current and/or projected development plans. Politically, however, seed program - at least for major food crops - is almost always a necessity for no government can afford to "jeopardize" food production by placing its cultivators at the "mercy" of external suppliers of such a basic item as seed. Furthermore, all countries, provinces, villages, and individual cultivators already have a "seed program." If this were not the case, there would be no seed to plant. These programs differ only in scope, level of sophistication, and degree of effectiveness or ineffectiveness.

Specific benefits of a seed program-industry that produces and supplies high quality seed of superior varieties include:

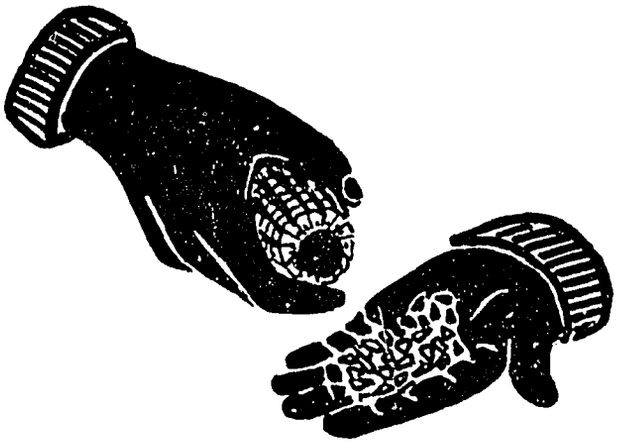

Figure 2. "Seed . . . are a reproducible, multiplying input."

(1) Increase in total yield resulting from the introduction and distribution of superior varieties or hybrids into the cropping pattern of the country or sub-division thereof.

(2) Increase in "recoverable yield" as a result of greater varietal purity, more uniform maturation, and so on.

(3) Increase in yield resulting from higher physiological quality of planting seed. This increase in yield is distinct from the "genetic" component and is derived from better stands and individually more productive plants. Experiments have shown that high germinating, high vigor seed can produce 10-20% higher yields than low quality seed of the same variety in equivalent populations.

(4) More efficient utilization of fertilizers, irrigation and pesticides because of greater uniformity of emergence and growth, better stands, and more vigorous plants.

(5) Reduction in planting rate. When high quality seed are available, seeding rate can generally be reduced by about one-half, thus, effectively adding a like amount to the food supply.

(6) Higher quality of produce because of less contamination with other varieties, and more uniform maturation, thus, fewer immature and/or weathered seed. For example: hulling and milling turnout of rice is much higher for uniform grain (same variety) than mixed grain.

(7) Less re-infestation of the land with weed seed.

(8) Less disease and soil insect problems in seed beds and fields as a result of minimization of plants infested with "seed-borne" diseases in seed production fields and seed treatment.

(9) More rapid and efficient periodic replacement of varieties with newer and better varieties.

(10) Facilitates introduction of new crops into the agriculture of a region or country.

The above listing is by no means an exhaustive compilation of the benefits of a seed program-industry. On the other hand, the applicability and importance of the benefits that are listed will vary with each situation. Careful analysis, however, should permit identification and quantitative assessment of cost-benefit ratios for a well defined seed program-industry in a specific country or subdivision thereof.

## PLANNING THE SEED PROGRAM

A seed program is an integral element of the national (or subnational) strategy for agricultural improvement. Its role, basic objectives and relationship to other elements in the scheme should be defined and established at the time the national plan is elaborated.

The first step in planning is to decide whether or not a seed program is needed and will contribute to attainment of established goals. This decision should not be difficult. If the main thrust of agricultural improvement is based on the development or introduction of high yielding varieties or hybrids of food, feed, fiber or industrial crops, a seed program is essential. On the other hand, if the major improvement effort involves only land reclamation, market development, fertilizer procurement, etc., and varietal improvement is not provided for, then a seed program is of doubtful value. Only the most modest seed program could be justified and then only as a vehicle for training and gathering experience for the future.

The high level decision to organize a seed program and allocate sufficient resources for its implementation is only the first step. A seed program does not automatically issue forth from this decision. Most often, it only sanctions the next stages in planning and provides a favorable climate in which they can be undertaken. Subsequent phases of planning will involve many more diverse, specific and detailed considerations.

### Background Information Needed

The mission of a seed program is production and supply of high quality seed of improved varieties. Accomplishment of this mission requires careful and considered planning, effective organization, coordination and cooperation. Planning defines the need for and scope of the program, establishes its goals, integrates it into the overall strategy for development, identifies resources required and available, provides for the necessary support, coordination and cooperation, and specifies an organizational frame for the program.

Seed program planning must be based on a thorough, realistic, and objective review and assessment of existing conditions relating to seed use, benefits to be derived from introduction and use of superior varieties, the technological base for development, availability of resources, and the prevailing socio-economic climate. Information and data are specifically needed in the following areas.

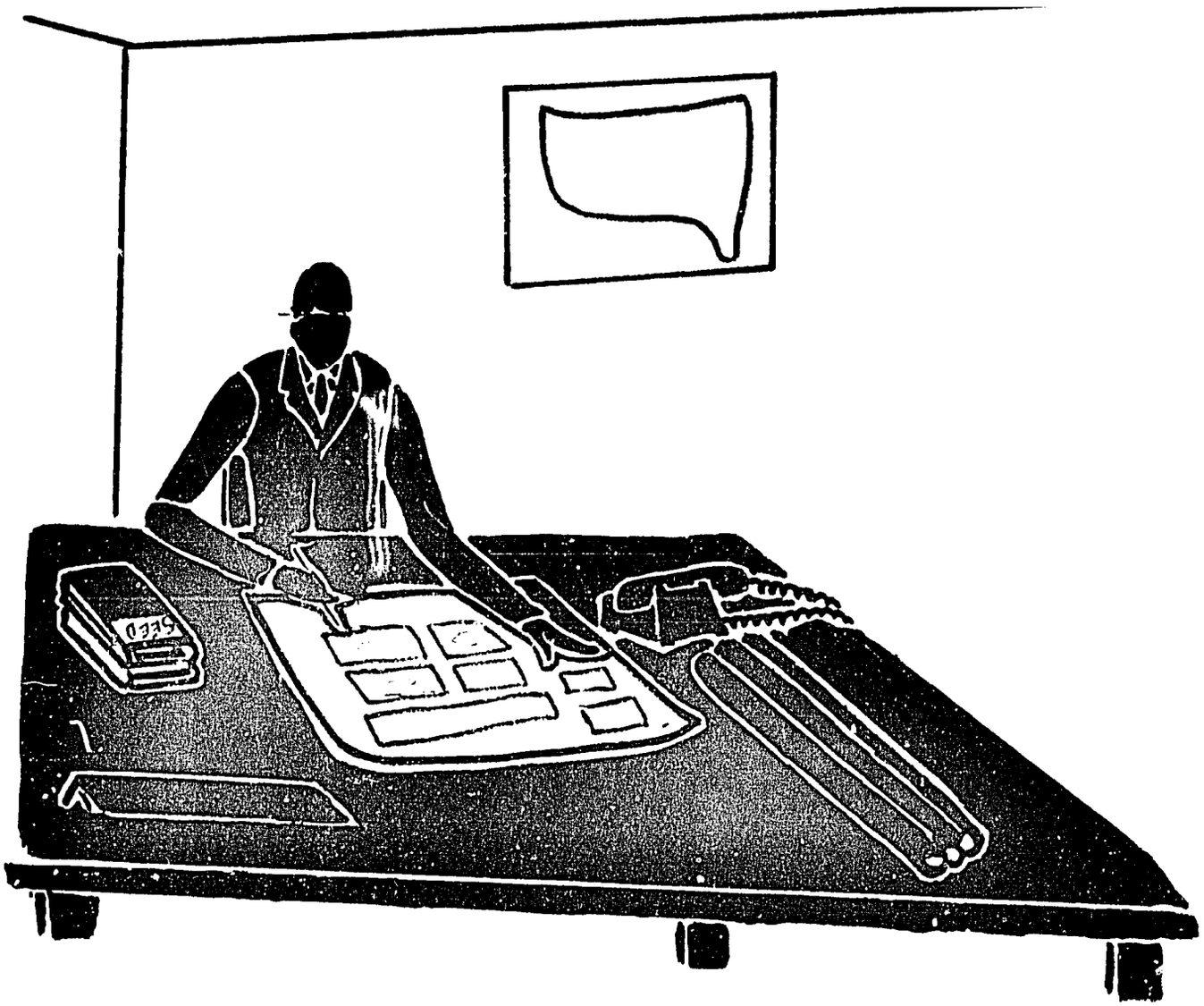


Figure 3. "Planning defines the need for and scope of the (seed) program, establishes its goals, integrates it into the . . . strategy for development, identifies resources required and their availability, provides for the necessary support, coordination and cooperation, and specifies an organizational frame for the program."

Review of Prevailing Conditions

(1) Progress, support and proficiency of crop improvement research (plant breeding, introduction, testing).

(2) Current pattern and effectiveness of seed production, distribution, and use, and quality thereof.

(3) Status and proficiency of related programs (fertilizers, irrigation, pesticides, credit, etc.).

(4) Motivation of cultivators and resourcefulness of change agencies (extension service).

(5) Types of agribusinesses and their areas of specialization (oil seed extraction plants, rice mills, etc.).

Availability of Resources

(1) Production and preparation resources: availability of land, equipment, facilities, trained manpower; experience and expertise in seed operations; level of technology; public and private institutions, agencies, firms, and persons capable of participating in the development of a seed program.

(2) Distribution and marketing resources: alternatives available for distribution and marketing; expertise and efficiency of agricultural supply and marketing systems; availability of marketing information and statistics; types and efficiency of communication services.

(3) Educational and informational resources: level of literacy of cultivators; training and motivation of change agents; resourcefulness and effectiveness of extension-demonstration programs and their coverage; institutional capacity for training manpower; receptivity of cultivators to new ideas, practices and materials.

(4) Financial resources: public and private funds available for capital investments in a seed program-industry; prospects of loans; availability and cost of production (short term) credit; foreign exchange situation; extent of subsidization of agricultural inputs.

(5) Organizational resources: existing public and/or private organizations or agencies that can be tailored into a suitable vehicle for the seed program; supporting institutions and agencies; status of agribusiness.

(6) Industrial resources: expertise in design, manufacture, and construction of agricultural equipment and facilities; allied industries (rice mills, grain elevators, oil seed extraction plants, etc.); expertise of maintenance and repair services.

Socio-Economic Climate

(1) Degree to which economy is socialized. A complete and philosophical commitment of the political system of a country to development, organization and production of basic agricultural inputs, and control of their allocation and utilization, effectively excludes - de facto or de jure - private sector participation. Any seed program developed, therefore, will be wholly public. On the other hand, opportunities for substantial participation of the private sector exist when the government restricts its role to planning, financing (and credit), initial development and organization of agricultural inputs, and advice and regulation of their allocation, marketing and use.

(2) Extent of public agency involvement in production of agricultural inputs. The government of a country can be tolerant of or even encourage private sector production of inputs while at the same time being involved in production itself. If the public production units are organized and managed in a business-like manner with full accounting of costs (not-subsidized) and price policy based thereon, then private enterprises have a chance for success. Many public production units, however, write-off investment, capital and maintenance costs in the name of "public welfare" and base prices only on current operational costs. The private sector will be hard pressed to survive against such "competition."

(3) Extent to which political system of the country encourages, regulates, and/or tolerates foreign participants in economic development. This aspect relates to the political "climate" for entry of foreign companies or persons into the seed program independently of or in partnership with indigenous firms or persons. U.S. or other internationally experienced seed companies have much to "offer" the less developed countries in the way of expertise, experience and genetic materials provided there is a sizeable potential market and regulations are not unduly restrictive.

(4) Stability of political system and economy of the country. The "seed business" involves risks that are common to both farming and manufacturing (or industry) plus some that are unique. When political and economic instability are added, the prospects for any real private sector participation in the seed program become very dim indeed.

## Scope of Program

Politicians, planners, technicians and farmers can and do justify "seed programs" rather easily in food deficient countries. The critical decision, however, is usually not whether a seed program is needed, but rather what should be its initial scope in the context of needs, capabilities and resource availability. Experiences suggest that beginning with a modest, soundly planned, and well supported program of limited scope is much more likely to develop into the type of seed-program industry needed for sustained development than a complex, broad scale, high volume operation. The managerial and technical skills and experiences required for a broad scale, high volume seed operation will simply not be available. We strongly believe that until the capability for producing and marketing 100-500 tons of good quality seed is developed and demonstrated, 10,000 tons should not be attempted or programmed. The program-industry must first learn to walk before it can run!!

## Lessons from Experience

Several "lessons" can be drawn from a review of seed program-industry development in both developed and less developed countries.

(1) Skilled, knowledgeable manpower was basic. The initial efforts in the seed program should be scaled to developing manpower resources. Conversely, manpower resource development must be accorded high priority in the time frame of over-all development. Since skilled, knowledgeable manpower will be limited if not non-existent in most countries, initial implementation must also be limited.

(2) Early development efforts were concentrated. Diffusion of effort, fragmentation of resources, and dispersion of operations are not ways to build a program. Initial efforts and available resources must be concentrated, centrally managed and closely coordinated until the program attains the "critical mass" stage and becomes self-sustaining. Only then can the program be broadened rapidly in an orderly, efficient, and successful manner.

(3) The quality of inputs into the program was more important than their quantity. If a program is built with makeshift, piecemeal and haphazard inputs then its outputs are unlikely to be different. The "bandwagon" approach to seed program development has not succeeded although it has often been tried. Construct the program with quality inputs - good workers, good equipment, good organization, good support. Should resources be insufficient to support more than a very modest but good effort - then so be it.

(4) The time-frame was realistic. The "crash program" approach to building a seed program-industry has also not succeeded. Ample time for development must be alloted. A modest base solidly constructed a few years in advance of the anticipated urgent need for large volume seed production is the best approach.

(5) Planning, evaluation and implementation were continuous. One evaluation, one plan and a single implementation effort do not build a program. They can only start one. The "plan" must be revised, expanded, contracted, redirected, on the basis of periodic assessments of progress. Even after the program-industry has become "on-going" there will still be a need for further evaluation, planning and implementation to increase its efficiency, versatility, and scope, or just to keep up with the times.

Considering these five "lessons" and the limited resources and experience in most developing countries, the initial scope of the seed program should be limited even though a broad based, comprehensive program is needed and is the ultimate goal. Among the seed program components discussed in Part II, the one that lends itself best to the "limited scope" approach is the FOUNDATION SEED PROGRAM.[2/]

Pilot or Model Program

The Foundation Seed Project or Program is almost ideally suited to serve as a vehicle for launching a comprehensive seed program. In many ways the Foundation Seed Program is or should be a complete seed program. It starts with breeder seed, engages in seed production, harvesting, drying, processing, storage, marketing and distribution, is often legally sanctioned, and has a training-education component. Furthermore, production and supply of foundation seed of publicly developed varieties is a public sector function. Since the first steps in seed program development in most of the less developed countries will have to be within the Ministry of Agriculture or equivalent, why not structure and identify them as a Foundation Seed Project or Program?

In the early stages the Foundation Seed Program might have to (and probably should) produce and supply seed for use by cultivators. Its orientation, however, can be maintained as an elite organization whose primary functions and role are to produce seed for seed producers, catalyze commercial seed production, and serve as a center of expertise, training, and information for the developing seed program-industry.

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[2/] See page 35 Part II for additional information on Foundation Seed Programs.

We recognize that enormous pressure for expansion into general seed production-supply will be generated if the Foundation Seed Program is at all successful, and the private sector is not alert and aggressive. Indeed, it (the Foundation Seed Program) might have to expand into general seed production if private sector participation doesn't materialize, and the demand for seed builds up. "Containment" of the Foundation Seed Program in its proper sphere and roles should not be too difficult, however, provided it was correctly structured and organized in the beginning and the government really wants the private sector to participate in the seed program and shoulder the bulk of the work in commercial seed production, processing, distribution and marketing.

Development of the Foundation Seed Program as a multi-purpose supply and service base of a seed program-industry requires that its staff consist of the very best plant scientists, specialists, and technicians possible, that it be well equipped and supported for its several functions, and that it be under the over-all management of an imaginative, resourceful, and thoroughly professional administrator.

This section can be summarized with the traditional words of caution - Proceed Slowly. The urgency of seed needs may (and probably will) generate such enormous pressures that something will have to be done and done rapidly. If this is the case, employ makeshift and temporary arrangements to relieve some of the pressure but do not incorporate them into the program and be sure they are temporary.

## Establishing Needs and Goals

After the general need for a seed-program industry has been identified and at least tentatively justified, the needed background information has been collected, assembled, and analyzed, and the program's initial scope has been established, the next step in planning is establishment of specific seed needs and supply goals.

The specific needs for improved seed over at least a 5-year period should be defined as accurately as possible, always bearing in mind that new developments and/or newly arising situations can render obselete - almost overnight - even the best of projections. Initial determinations of seed needs will have to be based primarily on the availability of superior varieties, judgements on the level of benefits that will be realized from the introduction and periodic resupply of high quality seed of these superior varieties in the different regions of the country where they are adapted, receptivity of cultivators to new ideas and programs, the relative urgency of the overall seed development program, and effectiveness of change agencies (to create demand). After the program-industry gets underway, and a "market" surfaces, seed supply should be determined by traditional market analysis methods and projections.

Considering the factors indicated above, specific seed needs (or goals) should be quantified for a 5 to 10 year time frame.

(1) Determine the kinds (and number) of crops to be included in program, and the number of superior varieties that are available or will soon be available in each crop for multiplication and distribution.

(2) Determine the acreage of crop land and its distribution within the country or region for which seed of each kind and variety needs to be supplied.

(3) The seasonal quantity of seed needed for each kind and variety included in the program is the product of NUMBER OF HECTARES X AVERAGE SEEDING RATE (per ha.) plus, 20% to compensate for replantings, divided by a realistic REPLENISHMENT FACTOR. The replenishment factor relates to the frequency cultivators can realistically be expected to (and should) re-new their seed stocks. It is determined by such factors as the ease with which seed can be "saved", mode of pollination of the crop, price of seed relative to price of grain, rate of replacement of varieties, acreage worked by cultivators, efficiency of distribution-marketing system, and so on. While the replenishment factor will vary for the same kind and variety among countries and even within countries, the following factors are generally applicable:

Hybrids of All Crops

Resupply every planting. Examples: maize, sorghum, millet.

Composite or Synthetic Varieties

Resupply every 3-4 plantings. Example: maize, forage legumes, grasses.

"Pure-Line" Varieties--Self Pollinated Grain Crops

Resupply every 4-6 plantings. Examples: wheat, soybeans, rice, beans, barley, cowpeas, peanuts.

"Pure-Line" Varieties--Cross Pollinated Grain Crops

Resupply every 3-4 years. Examples: open pollinated maize, rye, grain sorghum,[3] broadbean.

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[3] Sorghum is sufficiently cross pollinated to cause seed production problems; thus, it is classified as cross-pollinated here.

Vegetables and Forage Varieties

Resupply factor varies widely depending on ease of "saving" seed, duration of crop (annual, perennial), and familiarity of cultivators with crop. For garden vegetables plan on resupply every 1-2 plantings.

(4) EXAMPLE: Goal is to extend superior variety ABC of wheat to 50,000 ha. in a development district. Planting rate of 40 kg./ha. Kilograms of seed needed each planting equals 50,000 x 40 = 2,000,000 kgs. plus 20% = 2,400,000 kg., divided by 5 (re-plenishment factor) = 480,000 kg. = 480 MT of variety ABC needed for cultivators each planting season (excluding previous steps of multiplication).

Realistic quantification of seed needs in this manner phased over at least a 5-year period will provide a good basis for other steps in planning the seed-program industry. If the necessary background information has been assembled, quantification of seed needs is not difficult. Determination of current and projected seed needs by the manner indicated above, however, only establishes desirable goals. These goals, therefore, must be balanced against the quantity and quality of the physical, financial and human resources available for attaining them and modified - usually downward - as necessary, always keeping in mind that the country and the seed program will probably benefit far more from 100 MT of seeds higher in quality than presently available than from 1,000 MT of "common seed".

## Economic Order and Structure of Program

How should the seed program be structured and who is to participate in it are questions that have to be answered at an early stage in planning. The seed program can involve only public sector institutions, the private sector, or both sectors acting in concert to accomplish desired objectives. Experiences in seed program-industry development in both developed and developing countries indicate that private sector participation is highly desirable during initial stages (including planning) and essential for long-term success. Yet, it must be recognized that in many developing countries governmental agencies will have to undertake the major portion of program planning and development because the private sector is not involved, interested or experienced in agri-business. Even in such situations, however, plans should be so ordered that seed production and seed distribution will gradually be taken over by non-governmental agencies, such as seed cooperatives, seed grower's associations and private companies.

Government has a major role in seed program development but it should not be an exclusive role. If the seed program is to evolve into a viable industry, private sector particpation is mandatory. Initial planning,

therefore, should provide for private sector participation at the earliest possible date. Indeed, it is highly desirable to involve the private sector in the planning process itself. Participation of the private sector in seed production and marketing should not only be provided for, but actively encouraged through incentives: special credit, tax concessions, lease purchase arrangements for facilities and equipment, low rental land, technical assistance, relaxation of restrictions on land holding, accessibility to foundation seed stocks of publicly developed varieties, etc.

There are no formulae for the proportions of public-private participation in a seed program-industry. Cooperative attitudes and mutual trust of both sectors are more important than a mere parcelling out of areas of responsibility, or components of the program. Nevertheless, experience does suggest the most fruitful roles for each sector are as follows:

Government (public sector)

(1) Leadership in program planning and development.

(2) Integration of the seed program in the national strategy for agricultural development.

(3) Research--development of superior varieties, improvements of cultural practices and cropping patterns, determination of optimal input levels for production, etc.

(4) Education--demonstrations of improved practices and materials including improved seed and promotion of their use.

(5) Maintenance of breeder's seed stocks of publicly developed varieties and hybrids.

(6) Control of the production and allocation of foundation (basic) seed stocks of publicly developed and introduced varieties.

(7) Technical assistance to private persons or companies involved in the seed program: training courses, personal consultations, informational material, trouble-shooting.

(8) Economic assistance to private persons or companies involved in the seed program in the form of tax concessions, special dispensations from land use and holding limitations, credit, lease-purchase arrangements for equipment and facilities, liberalization of foreign exchange and import restrictions to permit procurement of equipment not locally available, etc.

(9) Services--certification, seed testing, marketing information and assistance, seed statistics.

(10) Regulation--control of seed distribution and marketing through legislation, regulations and systematic inspection procedures.

Private Sector (including cooperatives, farmers' association, etc.)

(1) Production, distribution, and marketing of commercial seed of publicly developed varieties and hybrids planted by cultivators.

(2) As expertise, confidence, and financial resources increase, development of private varieties and hybrids or introduction of new and adapted varieties in partnership with offshore seed companies.

(3) Production, marketing and promotion of privately developed varieties subject to certain standards of quality, performance capability and ethics as established by governmental regulations. Such regulations should serve the interests of both the farmer and seedsman, and not be so restrictive as to stifle private research in crop improvement.

The above listing of activities of the public and private sectors in the seed program/industry may appear to be over balanced in favor of the public sector. It will be noted, however, that many of the functions prescribed for the public sector are in support of private sector activities and operations. Further, that the key activities of production, distribution, and marketing of commercial seed are within the sphere of the private sector.

A seed program patterned so that both public and private sector institutions are woven into its fabric is most likely to succeed. The aspect of the pattern and the texture of the weave will vary with the needs, economic order, and stage of development in the various countries.

## ORGANIZATION AND INITIATION OF THE SEED PROGRAM

It is not possible to identify or specify an organization for a seed program-industry. This will have to be determined within the context of each country's needs, resources, and political structure. The only real pattern that can be discerned in a study of the seed program-industries of the developed countries is that organized effort, coordination, cooperation, and mutual trust were more important than organization per se. Nevertheless, some suggestions can be made as to the steps that need to be taken to get the program underway - to implement the plan.

### Steps in Getting Started

A. Secure the highest possible level of solid enthusiastic support for a seed program integrated into the over-all agricultural development plan. This support should be no lower than a Minister of Agriculture or equivalent. Without such support the effort will be unproductive and should not be undertaken. Develop an understanding and appreciation of the importance and catalytic role of improved seed in the strategy for development.

B. Obtain the advice of qualified advisors in the planning, organization, and early implementation stages of seed program development and periodically thereafter until the program is well underway and productive.

C. The Minister or equivalent should sponsor enabling legislation or promulgate administrative decrees, prepared by qualified advisors, under which the following would be provided for, within, or under the guidance of, the Minister of Agriculture or subordinate agents.

1. A research agency or section charged with the introduction, breeding and testing of new crop varieties. This organization would also be responsible for the production of suitable quantities of "breeder seed."

2. An extension service whose duty is to educate the cultivators in proper farming techniques including use of required inputs - seed, fertilizer, pesticides, etc. It should also conduct field demonstrations of these techniques and inputs.

3. Establishment of a high level board or committee to guide the overall development and operation of the several segments of the seed program and insure coordination and support. Such a board might be

F. Promote agricultural credit programs to assist both the cultivators and basic agricultural supply enterprises including seed producers and companies. After initial investments, seed production and supply should function on a non-subsidy basis. A repayable farm production credit program can be used to finance the actual production of seeds for which seed growers should receive a premium above grain prices, only when they perform services and meet quality standards above normal production practices. Most individual seed producers must be paid for their seed immediately after harvest. Thus, when the seed program operates to accumulate the seeds from several seed growers, i.e. cooperatives, private companies, government contract production, etc., for distribution and marketing, working capital must be available to the "accumulator" to (a) pay the seed grower upon receipt of the seed, and (b) finance the seed until these costs are recovered, often 4 to 9 months later. Unfortunately, money for use as working capital is often lacking in agricultural credit programs. It should be provided.

Other suggestions regarding organizational features for specific components or elements of the seed program-industry are considered in discussions of the various seed program-industry components in Part II.

## Participation of Foreign Seed Companies [4/]

Many countries could profit from the technical expertise, marketing experience, managerial skill and financial resources of established, successful seed companies operating on an international basis. Although participation of foreign seed companies in the seed programs of the less developed countries has not been too successful - primarily because of political reasons - the potential for such involvement should not be ignored or forgotten.

The primary advantages of a competitive private, as opposed to a monopolistic public, seed industry are (a) less drain on tax revenues, (b) increased tax base for government, (c) greater efficiency and higher quality seed. These advantages, however, are not usually recognized. In many countries experiences are that private sector enterprises are likely to be as monopolistic, arbitrary and inefficient as public monopolies. There is simply little experience with competitive agri-business.

In many situations, it is simply not feasible for a foreign seed company to risk an investment of its time, creative energy, germ plasm, financial resources, and reputation in seed operations based on self-pollinated crops - rice, wheat, peanuts, soybeans, sorghum or even open

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[4/] Typical impediments to indigenous and/or foreign private sector participation in seed program development are briefly discussed in Appendix III.

pollinated crops such as varieties of corn. These are, of course, the major crops in most developing countries. Except for heavy initial demand for new varieties marketing is likely to be unpredictable, and market price only a shade above that of "grain." It is too easy for the cultivator to save his own seed or to acquire some by barter from a neighbor.

In countries where hybrid seed have been successfully introduced and where substantial emphasis is given to production of vegetables and forages, a substantial opportunity for foreign seed company participation does exist provided the political climate is not adverse. Farmers cannot produce seed of hybrids so they must renew the seed each season. And, they usually do not have the experience and know-how to produce seed of vegetables and crops that are grown for parts other than seed (forages, some fiber crops, etc.).

The most successful involvements of foreign seed companies in the seed programs of the less developed countries have been in partnerships or joint-ventures with indigenous companies. Such ventures, however, have not been without problems.

The major reasons why foreign seed companies ( and in some cases indigenous private enterprises) have not participated widely in the seed programs of the developing countries are:

(1) Lack of consistency in the government's attitude toward foreign investments and the ever present threat of nationalization.

(2) Scarcity of competent, experienced indigenous managers, technicians and workers to carry on an agri-business.

(3) Absence of an effective extension program to assist in the promotion of improved seed.

(4) Lack of coordination and cooperation between the various public agencies involved in agricultural development and supply and between them as a group and private sector enterprises.

(5) Hostility of lower echelon officials to private sector involvement in agricultural supply enterprises.

A foreign seed company should certainly thoroughly investigate the total climate in a country before making any substantial investment.

## FINANCING THE PROGRAM

Review and assessment of available financial resources during the early planning stage as previously suggested should identify several alternative means for financing the development and operations of a seed program-industry. Adequate and consistent financial support of the program is so essential to success, however, that addition discussion is warranted.

A one-time funding of sufficient scale might "purchase" a very modern seed testing laboratory and/or drying-processing plant but it will not and can not "purchase" a seed program, or establish a seed industry. Other integral elements of the seed program must also be developed and supported: seed must be multiplied, produced, and marketed; people must be trained; funds and credit must be provided to finance production, processing, storage, distribution, marketing, salaries, labor, maintenance, fuel, supplies and so on.

### Types of Financing Needed[5/]

Establishment of a seed program-industry of any appreciable scope is going to require investment capital and working or operational capital. Characteristically, seed operations require a relatively high level of slow "turnover" working capital or credit as compared to level of investment in facilities and equipment.

#### Investment Capital

Investment capital will be needed at the beginning for acquisition of the equipment and facilities essential for efficient, effective seed operations. Since the major portion of the equipment will have to be procured from off-shore manufacturers, a substantial percentage of the investment capital must be convertible into hard currencies as foreign exchange. The remainder of the investment capital can usually be in local currency.

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[5/] Representative capital investment costs for equipment needed for seed operations of varying sizes are discussed in Appendix I, and check-list of production-operational costs for a seed program-business is given in Appendix II.

Capital investments will be in -

(1) Land as needed for seed production.

(2) Equipment needed for harvesting, threshing, shelling, drying, processing, treating, packaging, and transporting seed.

(3) Facilities such as drying sheds, processing plants, bulk storage bins, and storage warehouses.

In addition, the capital investment requirements for any agricultural production operation apply equally to seed production: tractors, cultivators, irrigation system, land leveling, etc.

For the public sector elements of the program, the capital needed for initial investments will most likely come from grants, developmental loans, or direct appropriations. For the first 3 to 5 years, additional capital will be needed for replacement of equipment and for expansion. This should be relatively minor, however, if the programs were adequately planned in the beginning with provision for expansion, and the equipment and facilities are properly maintained. After 3 to 5 years, the public sector components of the seed program-industry should be well established and revenues from sales and/or services should be sufficient to retire loans or bonds issued to satisfy periodic needs for additional investment capital.

Capitalization of facilities and equipment - especially the foreign exchange portion - will probably constitute the most serious financial barrier to entry of private participants into the seed program. The government can be most helpful in this sphere. It can grant a loan in needed foreign exchange with provision for repayment in local currency, purchase equipment and then make it available to private seedsmen under lease-purchase agreements, guarantee loans from international investment banks or indigenous financial institutions, or participate in organization of a "mixed company" providing the needed foreign exchange as its share. Additional helpful actions might include dispensation from import duties on seed equipment, relaxation of restrictions on foreign exchange, property "tax holidays" for a specified period and so on.

## Working Capital

Working or operational capital in relatively large amounts will be needed for both public and private sector operations. Seed production must be financed whether on owner-operated land or under contract with select farmers just as in the case of grain production, except that production costs are greater for seed. This type of financing does not differ significantly from ordinary production credit. After harvest, however, contract growers are usually paid, and then drying, processing, treating, packaging, storage and

marketing must be financed before returns are realized from sales. Since the period of time from planting of the seed crops through sale ranges from 6 to 9 months, the turnover of working capital is relatively slow.

Provision for an adequate flow of working capital is critical for successful seed operations. In far too many cases, ample investment capital is provided to initiate a seed program-industry, but appropriations for public agencies ·encharged with "operation" of the various elements of the seed program are not increased. Thus, the program almost immediately enters into a serious financial crisis, which effectively stifles operations. The most modern seed drying and processing facility is just so much construction material and metal if funds are not available to purchase fuel, power, bags, chemicals, employ labor, finance contract growers, and distribute the seed.

Operational capital for private operations is usually available, although it may be so tightly regulated or expensive as to prohibit its acquisition. The broadening of provisions pertaining to production credit to include "working capital" credit needed for seed operations at reasonable interest rates is one method by which the government can encourage and help with establishment of a seed industry. A properly managed seed program-industry that produces and markets high quality seed of truly superior varieties for which demand has been established should become self-supporting in its public-sector component and reasonably profitable in its private sector component. Beginning seed programs or businesses, however, will probably not be properly managed and will most likely initially produce seed of rather indifferent quality for an ill defined market. They cannot be realistically expected to achieve self-supporting or profitable status in 6 months, or 18 months or even in 2 years. Committment of financial resources sufficient to sustain the scheduled level of operations for a 3 to 5 year period is essential for establishment of a seed program-industry. After this period, profits or "reserve funds" accrued from sales should be sufficient to support operations and/or to finance loans for working capital if the operations are managed with reasonable proficiency.

## Financing Public Services

A few elements of a comprehensive seed program-industry fall within the classifications of public services or regulatory activities, and, thus, are obligations of the government in the same manner as agricultural research, extension-education, customs inspection, etc. In the seed program these might include: seed testing services to farmers, inspection and control of seed marketing, breeder seed production, foundation seed production of "minor" crops, training in seed technology, technical assistance and advisory services to seed producers, adaptive seed research, seed marketing information and statistics, and certification (partial support). These activities should be supported under designated line items in the over-all budget for agricultural research, extension and development.

# Elements of Program

Part 2

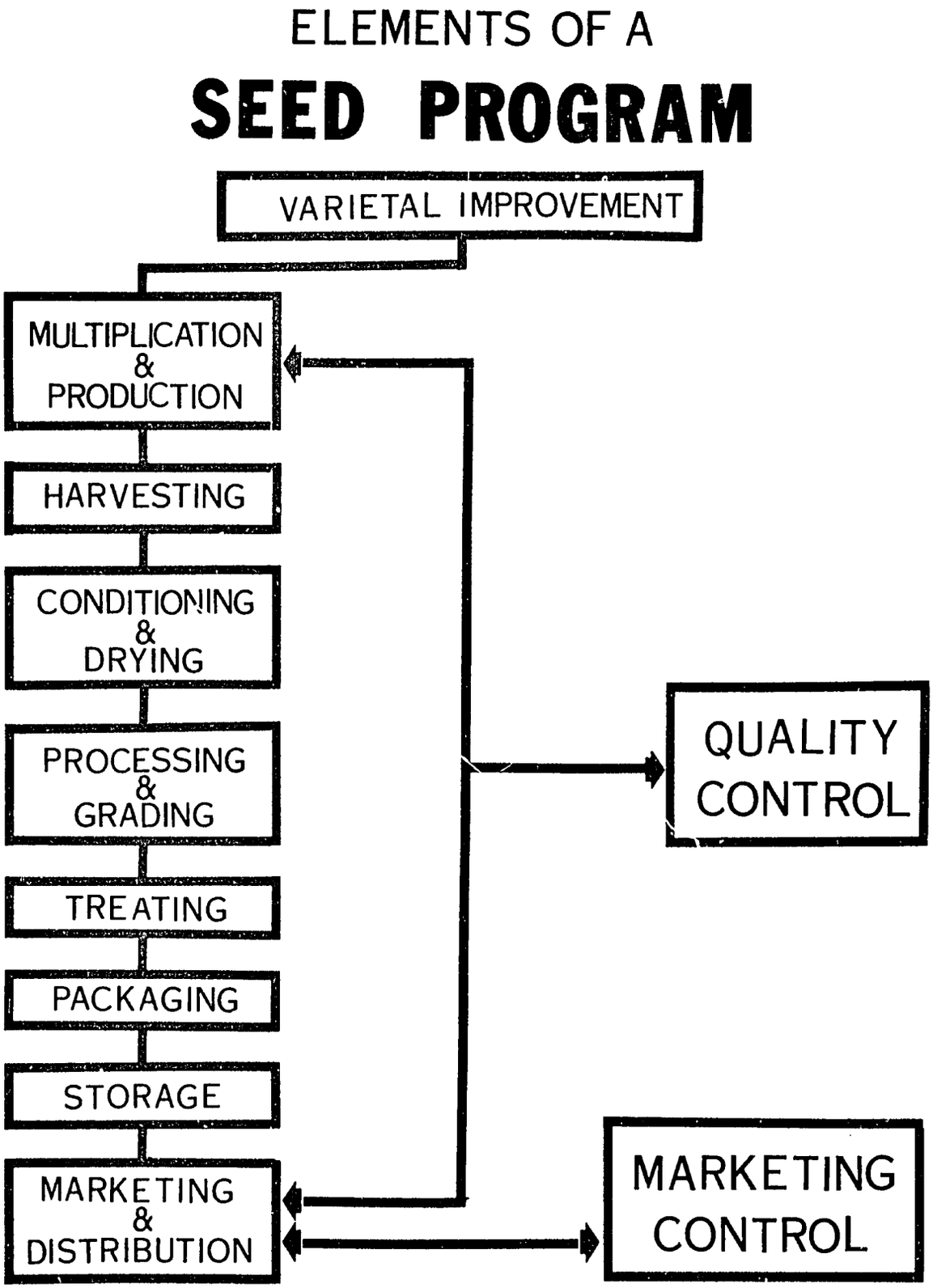


Figure 4. Elements of a comprehensive seed program and their sequential relationships.

## SEED RELEASE AND MULTIPLICATION

"A good seed program . . . involves a number of components, each of which may be likened to the links in a chain. And, like a chain if one of the links is weak the chain is also weak. Some of the links are common to all agriculture; others are peculiarly related to seed."[6]

Our experiences suggest that one of the most serious impediments to establishment of a seed program-industry in the less developed countries is an inadequate and/or incomplete understanding of just what a seed program is and what it is not. Many of the other difficulties, problems and frustrations that attend developing seed programs derive at least in part from this misunderstanding.

In some countries a few elements of a seed program have been actively promoted, supported and developed while others remain unconceived or unhatched. In other countries, the various components of the program are so unevenly developed that the "weak links" become bottlenecks and stifle progress.

A clear concept and understanding of the varied and often unique elements of a balanced seed program and their inter-relationships logically constitute a part of the background needed for informed planning and effective organization. Because it is so critical to planning and organization, however, the components of a seed program-industry are described and discussed in this separate section.

Before discussing the components of a seed program *per se* we must briefly consider the essential bases on which the program must be constructed.

(1) Productive varietal testing, introduction and development research. In the absence of on-going varietal improvement research, a seed program can be justified only under the most unusual circumstances.

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[6] D. D. Hill. Seed and the World We Live In. Foreign Agriculture. FAS, USDA. January, 1961.

(2) Resourceful extension-education service. Establishment of a seed production-supply system will involve many changes in agricultural practices and traditions. This cannot be accomplished without the assistance of an effective, resourceful change agency.

(3) Programs for development and supply of other essential inputs. The main contribution of improved seed is elevation of potential yield (or genetic ceiling) of crop varieties. The degree to which this potential is achieved will depend on the adoption, use, and supply of other improved practices and materials: fertilization, plant protection, water management, credit, marketing, etc.

## Variety Release Procedures

One of the first steps in development of a seed program is establishment of an orderly mechanism for the "release" of a new variety and its entry into the seed multiplication and production scheme (Figure 5 ). Generally, the decision to release an improved variety is made by the Administrator in charge of the agricultural research agency responsible for varietal improvement on the basis of a recommendation made to him by a VARIETY RELEASE BOARD. The Variety Release Board is an advisory group of 6 to 8 persons representing research, extension, development, and credit agencies and the private agricultural community, appointed by the Minister of Agriculture or equivalent. The functions of the committee are to review the history and performance record of nominated varieties, determine their potential contribution to the national agriculture, make recommendations pertaining to their release and entry into the seed multiplication and production scheme, and equally important - to make recommendations on discontinuation of obselete varieties.

Other decisions that have to be made before multiplication and production of seed of new varieties are undertaken pertain to: (1) the agency that will maintain breeder and/or foundation seed in the case of an imported variety; (2) method and schedule of multiplication; (3) level of supply that needs to be attained.

## Seed Multiplication Scheme

Seed of a new improved variety usually cannot be multiplied or increased up to the quantity needed by cultivators in one year or season. Several rigorously controlled step-wise multiplications or increases are necessary. In order to maintain variety purity and quality, this step-wise multiplication must be continuously repeated until the variety is obselete and discontinued. One time-tested and proven system for the controlled multiplication and production of seed is seed certification. The mission,

# SEED IMPROVEMENT

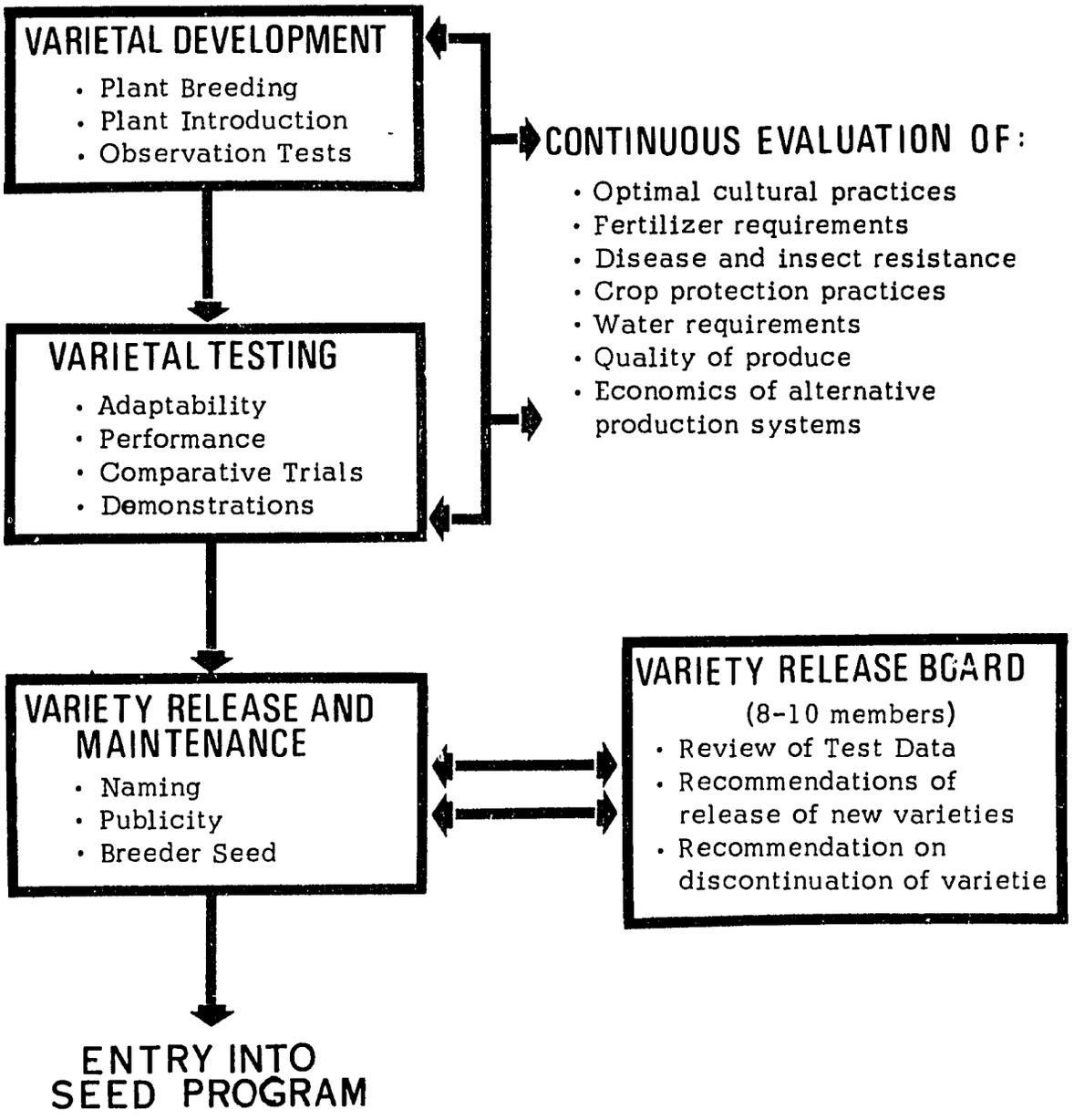



Figure 5. Steps in development, testing and release of improved varieties with emphasis on the role of a Variety Release Board.

functions and operation of a seed certification service are discussed in a later section.

A time-framed generalized scheme for multiplication and production of seed of a new variety is shown in Figure 6. NOTE THAT:

(1) The scheme starts with the quantity of seed released by the breeding program.

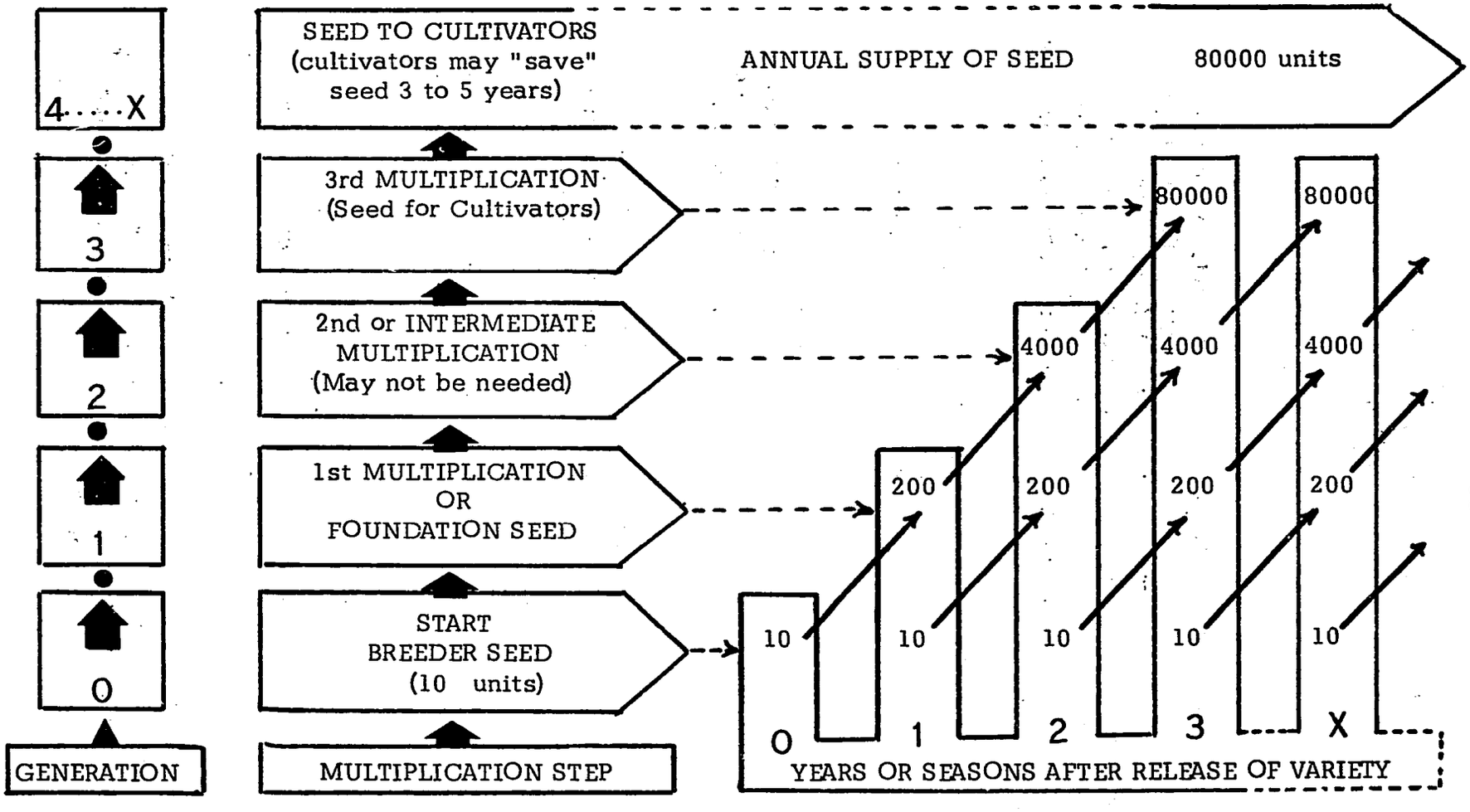
(2) Three years are required to attain the seasonal (or annual) supply of seed needed for cultivators. (It is often advisable to divert a portion of seed produced by 2nd and 3rd mutliplications to selected farmers for early farm increase and further evaluation. In turn, the selected farmers "save" seed for themselves and supply some to their neighbors.)

(3) Three years or seasons after release all multiplication steps are operative each season. (Exception: the breeder may elect to produce a 2 to 3 year supply of seed at appropriate intervals rather than each year. This is a sound procedure provided conditioned storage is available.)

(4) The source of seed produced by any of the multiplication steps through the commercial seed class (produce of 3rd multiplication) is traceable to breeder seed.

(5) Since the assumption was made in the generalized scheme in Figure 6 that the crop was self pollinating, the scheme indicates that farmers can "save" their own planting seed for 3 to 6 years provided reasonable precautions are taken to minimize mixtures with other varieties. With proper isolation and attention, seed of cross pollinated crops can also be "saved" for several years by farmers. The point we wish to make is this: it is not necessary to plan for annual resupply of non-hybrid seed to all farmers. Rather emphasis should be directed toward getting the farmer to renew seed about every 4 years. Thus, the planned seasonal annual supply of seed should be sufficient to plant 25% of the total acreage.

The generalized multiplication-production scheme in Figure 6 is applicable to all kinds of non-hybrid seed. Moreover, many variations are possible. For example, the 3rd multiplication step can be eliminated when the seed multiplied is of a crop with a high seed multiplication factor and relatively low planting rate, e.g., millets, rice, sorghum, forage crops, etc.




Requirements: Annual supply of 80,000 units of seed of improved variety.
Assumptions: (1) Variety is self-pollinated and newly released; (2) breeder has 10 units of seed available; (3) multiplication factor = 20.

Figure 6. GENERALIZED SEED MULTIPLICATION - PRODUCTION SCHEME.

# Seed Multiplication-Production

## General Procedures

The actual production of seed of basic crops is within the capability of the agriculture of any country, otherwise, the crops would not be basic. Basic crops are nearly always grown for their "seed" (e.g., rice, wheat, sunflowers, soybeans, corn, peanuts, sorghum, etc.); thus, the requirements and procedures for seed production up to harvest are much the same as those needed for good "grain" production except that they are much more rigorously applied than for grain production.

Basic seed production practices include the following:

(1) Source of seed: The planting stock used for seed production must be varietally pure and of known origin.

(2) Land selection: Seed should not be produced on land that was planted to another variety of the same or similar crop the preceding season. This prevents varietal mixtures resulting from "volunteer" plants. The land should also be relatively free from troublesome weeds.

(3) Isolation: Seed fields have to be physically isolated from other fields planted to other varieties to prevent out-crossing and mechanical mixtures. The isolation distance is determined by the mode of pollination of the species, and the prevailing environmental conditions.

(4) Roguing: Seed fields are "rogued" several times to remove off-types, other varietal contaminants, diseased plants, other crop plants, and troublesome weeds.

(5) Inspections: Seed fields are inspected at least once to check on isolation distance, presence and incidence of off-types, other varieties and crops, troublesome weeds and diseases. The equipment used for planting, harvesting, drying, processing and storage should also be inspected for cleanliness.

The basic fertilization, irrigation, and other cultural practices recommended for commercial grain crops of the same kind are used in seed production with special attention to prevent moisture stress during seed formation and development and to control weeds.

Figure 7. "The actual production of seed of basic crops is within the capability of the agriculture of any country. . . "

Thus far, we have only considered seed production in non-hybrid crops that are grown for their seed (or grain). What about hybrid crops and crops grown for products other than seed - fiber, fruit, leaves, stems, roots, etc.? Production of hybrid seed and seed of crops grown for parts other than the seed themselves requires skills and knowledge that are not available among general cultivators. Consequently, selected cultivators will have to be trained in seed production of such crops. It is well to remember that training of and assistance to seed producers of specialty and hybrid crops is most worthwhile. A commercial seed industry has the best chance for development in the area of production and supply of seed that general cultivators cannot produce and "save" themselves.

Seed of specialty crops such as vegetables and forages are usually produced at locations that are especially favorable for seed production. Such locations might be substantial distances from the area where the seed will be used for planting. Since specialty crop seed are required in relatively moderate quantities, however, distribution is usually not too difficult. Seed of basic crops, on the other hand, are produced in the general area where they are to be planted. The quantities required are simply too great, and seed prices too low to support out-of-the-area production.

## Breeder Seed

The "handful of seed" that represents a newly developed variety is the end of the breeders principal job and the beginning of the seed specialists job. The release of a small quantity of breeder seed may represent the culmination of many years of dedicated work by the breeder involving hybridization, inbreeding, selection and testing, but cannot be considered the end of his responsibility. He must maintain a small annual or seasonal increase of the breeder seed, for if cut off, the variety will deteriorate and disappear in a few years. It is essential that the originating breeder, his assistants and his institution assume the responsibility to see that this job is done.

Breeder seed are produced on a very small scale (usually less than a hectare) so that it can be rigorously rogued of all off-types and other contaminants. Breeder seed must be the "purest" seed. Otherwise, the tasks of the foundation and commercial seed producer become nearly impossible.

Another type of breeder seed should be mentioned because it can play a major role in the seed programs of some countries. This results from the import of quantities of seed of a variety or varieties from foreign sources. Some local breeder must be assigned responsibility for maintaining purity and producing a quantity of breeder seed each season or at periodic intervals.

Although breeder seed are produced in small quantity, the breeder must be provided with or have access to plot size harvesting, drying and cleaning equipment. Additionally, the research station should provide a controlled environment (dry and cool) room for storage of breeder seed. This will serve two purposes: the breeder will not have to devote time to seed production every year, and a reserve of breeder seed can be maintained as a safeguard against loss of the supply of breeder seed through a disaster of any kind.

## Foundation Seed

Foundation seed are the progeny of breeder seed so handled as to most nearly maintain genetic purity and identity. Thus, they constitute the second link in the multiplication chain and the base for commercial seed production. The essential task of the foundation seed program is to multiply breeder seed up to quantity required for large scale production of commercial seed. The size of the foundation seed multiplication operation may be small or large depending upon the number of varieties that must be increased and the amount of seed required to service further multiplication steps.

Foundation seed production cannot be a haphazard operation. It must be carried out under the close supervision of a well trained and thoroughly competent plant scientist with a good working knowledge of plant breeding and agronomy and major training or experience in seed technology. His assistants must likewise be well trained, competent and dedicated. Furthermore, the program must be adequately equipped, supplied, and funded to do the best job possible.

### Organization

Foundation seed production is variously organized as a section or project of an Experiment Station, Extension Service or Department of Agriculture, a non-profit corporation or growers cooperative, a division of a private breeding firm or company, or some combination of these. In developing countries it is supported by the Ministry of Agriculture or by a semi-autonomous governmental corporation under the general guidance of the Ministry of Agriculture but not subject to the bureaucracy and rigid fiscal policies of government.

The following organizational suggestions are made regarding a Foundation Seed program: (See Figure 8)

(1) It should be administratively or legislatively sanctioned.

(2) It should operate under the control of a Board of Directors in accord with the provisions of a constitution and by-laws.

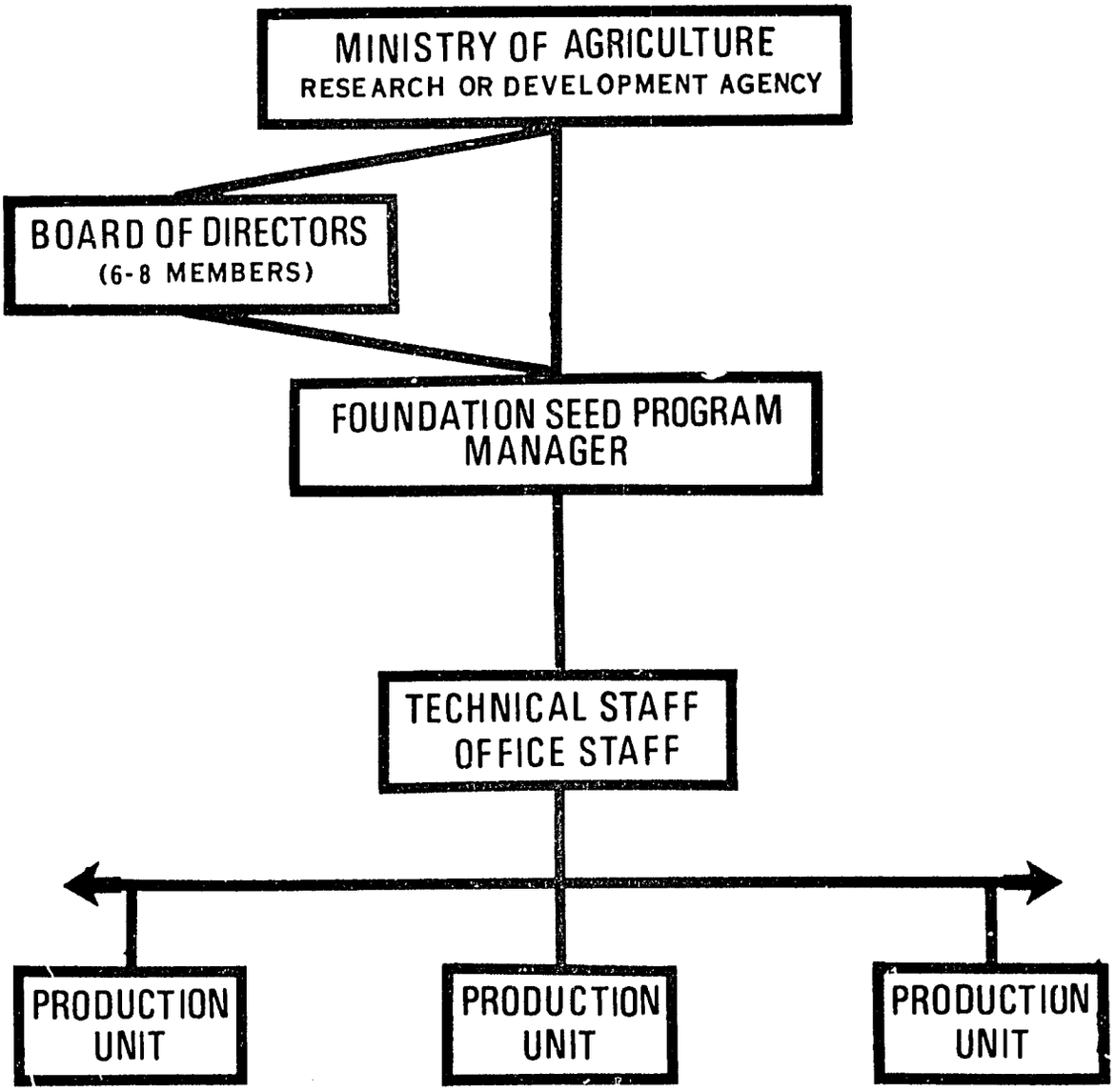



Figure 8. Organization of a Foundation Seed Program or Project under general supervision of Ministry of Agriculture but governed by a Board of Directors. The program can be quite small and consist of only a manager, several technical aides or laborers, and a clerk and modest facilities, or it can be corporate in structure with several divisions or units based upon crop kind and/or location under the supervision of unit managers.

(3) The Board of Directors (6 to 8 members) should be selected from interested organizations or parties such as the research service, extension service, agricultural administration, the seed regulatory agency, banks, private producers, farmers or any other concerned or interested organizations or individuals.

(4) The production, processing and handling of foundation seed should be under the direct technical supervision of a qualified manager in accord with policies established by the Board of Directors.

(5) The organization should be financed from public funds until it becomes self sustaining through sales of foundation seed to commercial producers. This may take 3 or 4 years or more.

(6) There should be only one Foundation Seed Program for publicly developed varieties per country or political subdivision in the larger countries.

## Operations

The foundation seed agency performs the same functions as any seed production organization except that its product must meet the highest standards of genetic and physical purity and overall general quality. Special considerations include:

(1) The number and identity of varieties and the acreage of each must be decided. The decision as to which varieties are to be released to the foundation seed agency should be made by the Variety Release Board before breeder seed are supplied to the Foundation Seed Program. The decision as to acreages of each variety to be planted must be made by the manager working with a small committee appointed by the Board of Directors.

(2) Obtaining sufficient breeder seed to plant all the required acreage of some varieties may not be possible. This situation can easily be handled by producing one or two preliminary foundation seed crops to build up enough seed for the principal crop.

(3) The actual production or growing of the seed crops may be done on the program's own land, entirely under contract by private growers or a combination of the two. Seed grown under contract should be limited to large progressive farmers with land enough for the required isolations and equipment to do a good job. A legal contract between the Foundation Seed Program and the farmer should spell out all of the details of the operation and the crops should be subject to the same rigid inspection and control as those on the program's own land.

Figure 9. "Foundation seed production cannot be a haphazard operation."

(4) The harvesting and processing of foundation seed - as for any kind of seed - requires adequate equipment and facilities that will facilitate timely harvesting and drying in a manner that maintains the quality of the seed, permits cleaning of seed to a high degree of physical purity, as well as treating and packaging.

(5) Storage will be required for foundation seed between the time it is processed and delivery to the companies or others who will use it. Store rooms must be ample, clean, dry and vermin proof. It is also recommended that a reserve supply of foundation seed of each variety equal to 15-25% of normal seasonal demand be maintained as a safeguard against crop failure. Storage for this reserve will have to be conditioned in most cases, either dehumidified or cooled or both, to maintain high viability and vigor of the seed.

(6) Allocation of foundation seed to seed producers should be handled according to policy set by the Board of Directors. In order to avoid complaints and dissatisfaction no deviation from the policy should be permitted. The minimum requirement should be that foundation seed will be distributed only to qualified commercial seed producers. Details must be worked out by the Board and the manager. All foundation seed marketed should be properly identified and labeled for the usual quality factors.

## Commercial Seed

The purpose of the final step in the seed production chain is to make available to the cultivator a supply of genetically pure seed of good quality so that when he plants it he may be reasonably certain to obtain a good stand and produce a good crop - assuming that he uses other required inputs, follows good practices, and the climate is favorable. "Commercial seed" are produced from seed obtained by multiplication of foundation seed or directly from foundation seed and should be as near to the varietal purity of foundation seed as possible.

When a developing country initiates an agricultural program, of which the seed program and industry are a part, the ideal situation is that the political climate favor, and provisions are made in planning and sanctioning legislation and decrees, for the development of a commercial seed industry in the private sector. It must be recognized, however, that for a number of reasons this may not be feasible or possible in the early developmental stages.

(1) The socio-political philosophy may not favor private enterprise.

(2) There may be no private persons or firms with the expertise to undertake such an enterprise.

(3) The hazards of production, harvesting, processing and storing a semi-perishable product such as seed under the local conditions may be prohibitive to private investment.

(4) The capital necessary for land, buildings and equipment may not be available to private individuals.

(5) The development of a private seed industry may be too slow to fill the immediate requirements of the country.

These are perhaps the chief reasons why a seed industry in the private sector might be slow to develop, but this should be no deterrent to going ahead with the production of seed for the cultivator. If any or all of the above circumstances prevail then consideration should be given to starting commercial production along the same lines as those followed for foundation seed production.

A similar organization but on a much larger scale than the foundation seed agency could accomplish two important things: (1) produce a supply of good seed for the cultivators, and (2) through the use of contract with private farmers provide an opportunity for training in many of the essential operations in seed production so that at a later date these farmers, or some of them, after gaining experience, might become the nucleus of a private seed industry. This is one possibility; there may be others.

## HARVESTING AND DRYING

### Harvesting

Harvesting and drying are critical operations in the seed program. The basic quality of planting seed is never higher than it was at harvest - but it can be infinitely worse. All harvesting and threshing operations, therefore, must be performed in a careful and timely manner.

Harvesting and threshing of seed of crops normally grown for their "seed" or grain follow essentially the same procedures as used for grain except that they are usually done at a higher seed moisture content (16 to 25%) to minimize field deterioration and damage of the seed by adverse weather, molds, insects, birds, rodents, etc., and strict precautions are taken to prevent damage to the seed, and mechanical mixture with seed of other varieties or crops. Normally, company labor will carry out the harvesting operations, or if the seed are being produced by a private farmer under contract he will usually handle these operations himself, but under close supervision.

In countries such as the U.S. which have a highly mechanized agriculture, the combine harvester has reduced most harvesting operations to one step. Harvesting in developing countries, however, still encompasses at least two operations - gathering and threshing - and most often three operations - gathering, partial air drying, (shocking, windrowing, etc.) and threshing. Harvesting in this manner does not always permit the proper timing of operations and the seed can deteriorate rather badly while they are drying sufficiently for threshing. Thus, at least partial mechanization of harvesting on larger seed production units is recommended.

### Drying

As indicated above seed should be harvested at moisture contents above 16-18% to minimize deterioration, damage and losses. While this procedure is almost essential for production of high quality seed, producers following it are immediately confronted with a serious problem. High moisture content seed in a warm temperature environment rapidly lose viability and vigor. Thus after harvest, seed moisture content must be rapidly reduced to 13% or less (11% or less for oil and vegetable seeds).

Figure 10. "Harvesting . . . (by traditional methods) . . . does not always permit the proper timing of operations and the seed can deteriorate rather badly while they are drying sufficiently for threshing."

Since seed production is usually concentrated in fairly large acreages, traditional shocking and sun drying methods are generally too cumbersome, inefficient and ineffective. Some system of forced air drying with or without heat is required. Seed drying is a highly specialized subject and the design of seed drying systems that will operate effectively in tropical climates requires engineering skill and experience. If these skills and experience are not locally available, then the assistance of a specialist-consultant is highly recommended.

All seed drying systems consist of essentially five components: (See Figure12).

(1) Fan or blower - the fan forces air through the seed and must be capable of delivering the required volume of air against the resistance (static pressure) of the seed layer. The fan is powered by electricity, preferably, or by gasoline motor.

(2) Heater - the heater provides the heat energy needed for drying (evaporation) and increases rate of drying by raising the energy level of the water molecules and the drying capacity of the air (lowers relative humidity). The heater usually burns L.P. gas or fuel oil, but it can also be fueled with wood or other combustible materials.

(3) Bin - the bin holds the seed to be dried and channels the heated air in the plenum chamber (air chamber) through the perforated floor on which the seed rest on through the seed mass. There are many variations in shape, size and construction of bins and in the arrangement of bin, plenum and ducting.

(4) Controls - controls consist of thermostats, humidistats, automatic valves and switches, etc. They are essential because drying air temperature must not exceed 110 $^{o}$F. and the fire hazard must be minimized.

(5) Loading and Unloading System - seed must be loaded into the drying bin and then unloaded from the bin when drying is completed. The drying system, therefore, must be coupled with an adequate conveying and handling system - elevators, drag conveyors, belt conveyors, etc.

Seed drying is a very critical operation. Moisture content of the seed has to be rapidly reduced without thermal injury. The manager of the drying facility must be thoroughly trained and competent in the mechanical operation and management of the drying system. Failure of the mechanical components of the system and poor management can ruin a batch of seed in a few hours.

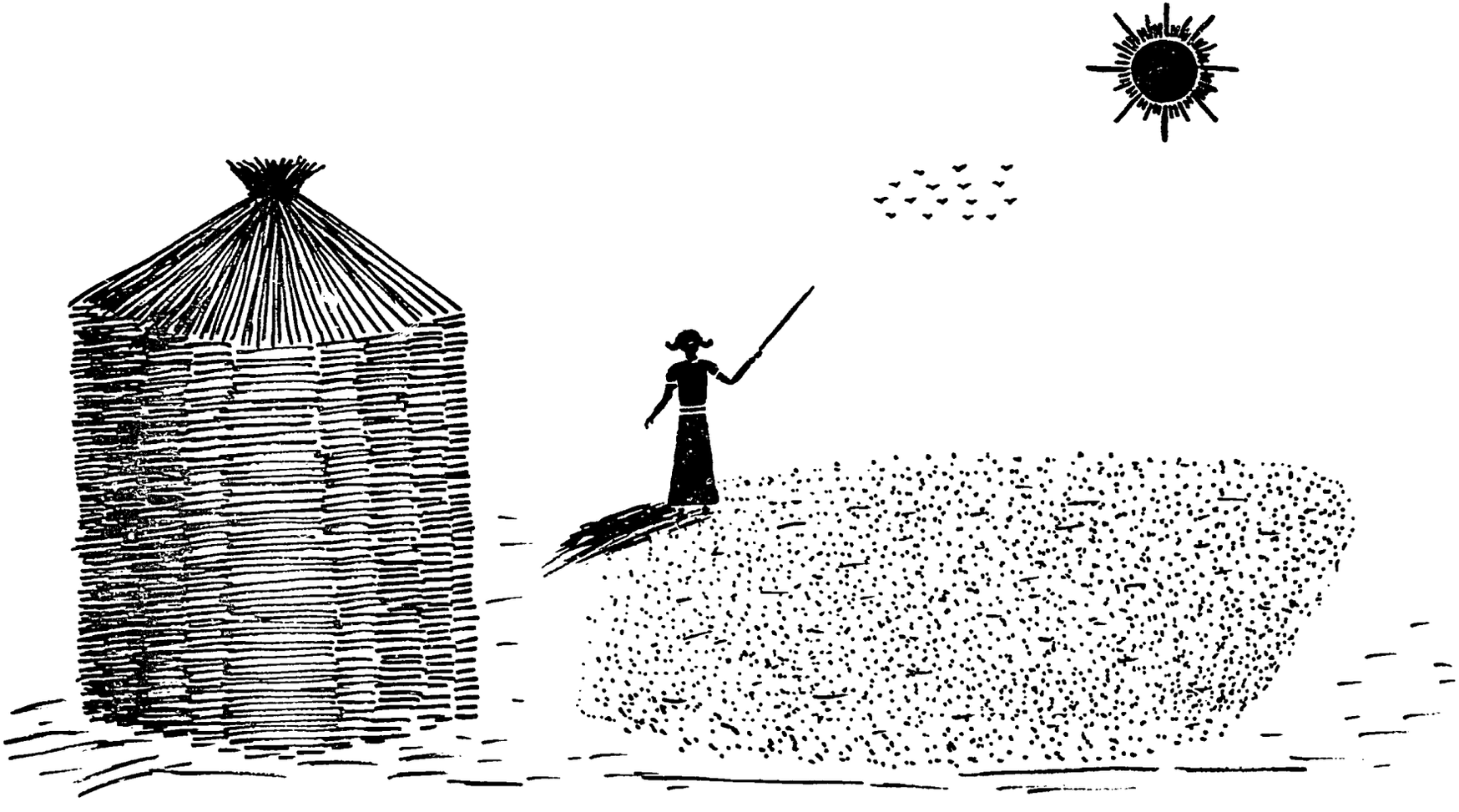


Figure 11. "Since seed production is usually concentrated in . . . large acreages (for efficiency), traditional drying methods are . . . inadequate."

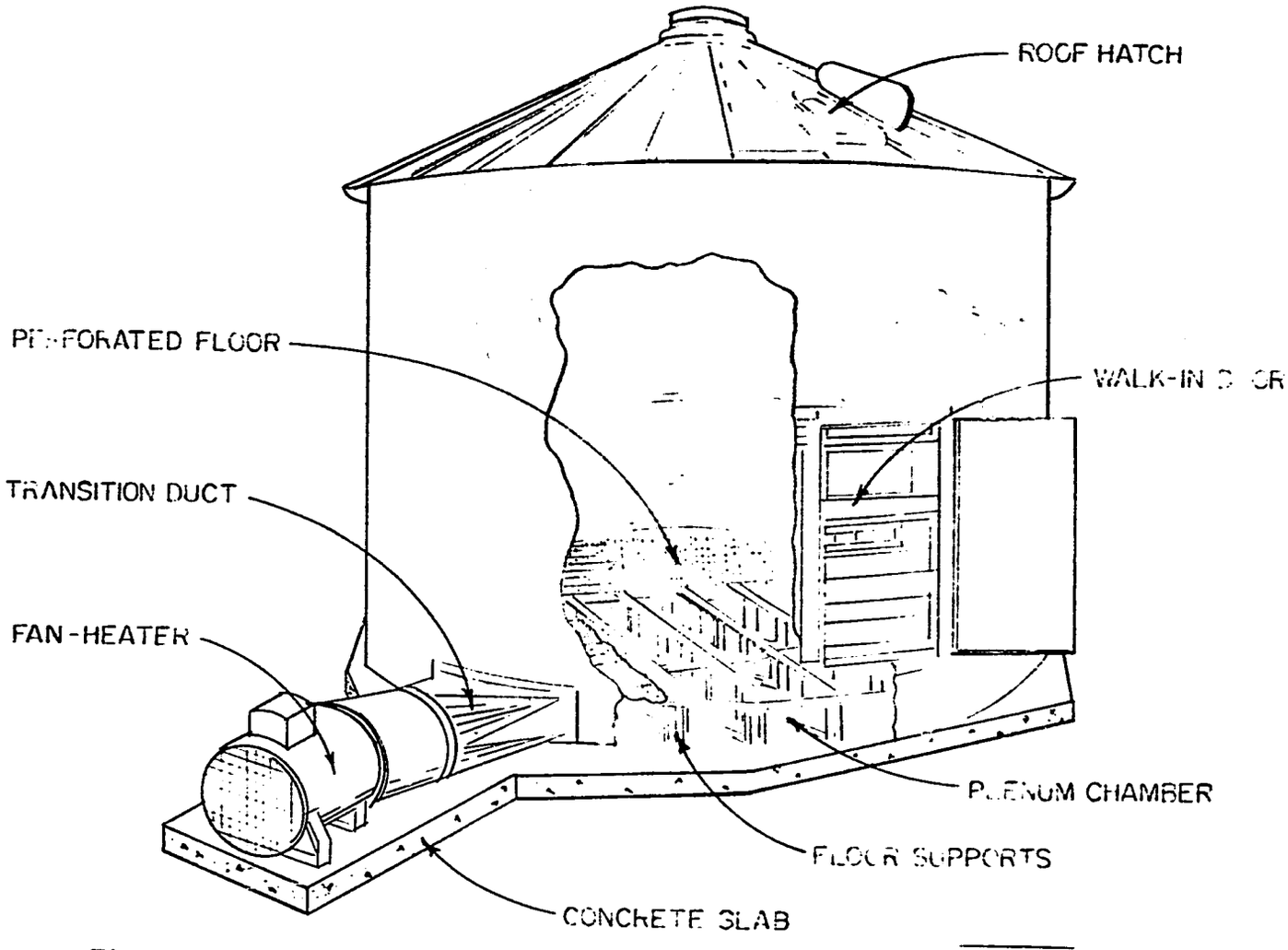



Figure 12. Components of a simple bin drying system equipped for heated air drying.

# PROCESSING

## (Cleaning, Sizing, Treating, and Packaging)

Drying is sometimes considered as part of processing. For our purpos here, however, we have separated them. The purpose of processing is to prepare the seed for distribution, marketing and planting. (See Figure 14).

### Temporary Storage

The seed drying operation - as previously discussed - cannot be delayed. It must commence immediately after harvest and proceed to completion without interruption. Operations subsequent to drying, however, are not as urgent. It is usually neither necessary nor desirable to match rate of processing with rate of drying. In most cases the costs of processing equipment would be prohibitive. Processing, therefore, takes place over a longer time span than drying. As a consequence, temporary or holding storage facilities are required for the dried seed until they can be processed and packaged. These may encompass the drying bins themselves with additional metal or wooden bins, or warehouse (flat storage) storage units. During processing the seed are unloaded from holding storage and moved to the processing plant by conveyors, preferably, or by hand.

### Cleaning

The dried seed normally contain contaminants and foreign material mixed in with the good seed: broken, diseased, and insect damaged seed, chaff and straw, weed seeds, other plant parts, etc. The first step in seed processing is removal of these contaminants and foreign matter. In undeveloped agriculture, the seed are "cleaned" by winnowing and simple sieving. Such methods, however, will not suffice for the quantities of seed handled in a seed program. Better and more efficient procedures are needed.

Basic seed cleaning is usually accomplished with an air-screen cleaner. These cleaners are available in many variations of size, shape, capacity, etc., but basically consist of integrated screening (sieving) and air systems. The seed are fed from a hopper through a series of vibrating screens to remove contaminants smaller and larger than the good seed, and through one or more air systems to remove contaminants lighter than the good seed.

Figure 13. "Traditionally seed are "cleaned" by winnowing and simple sieving. Such methods . . . will not suffice for the quantities of seed handled in a seed program-industry."

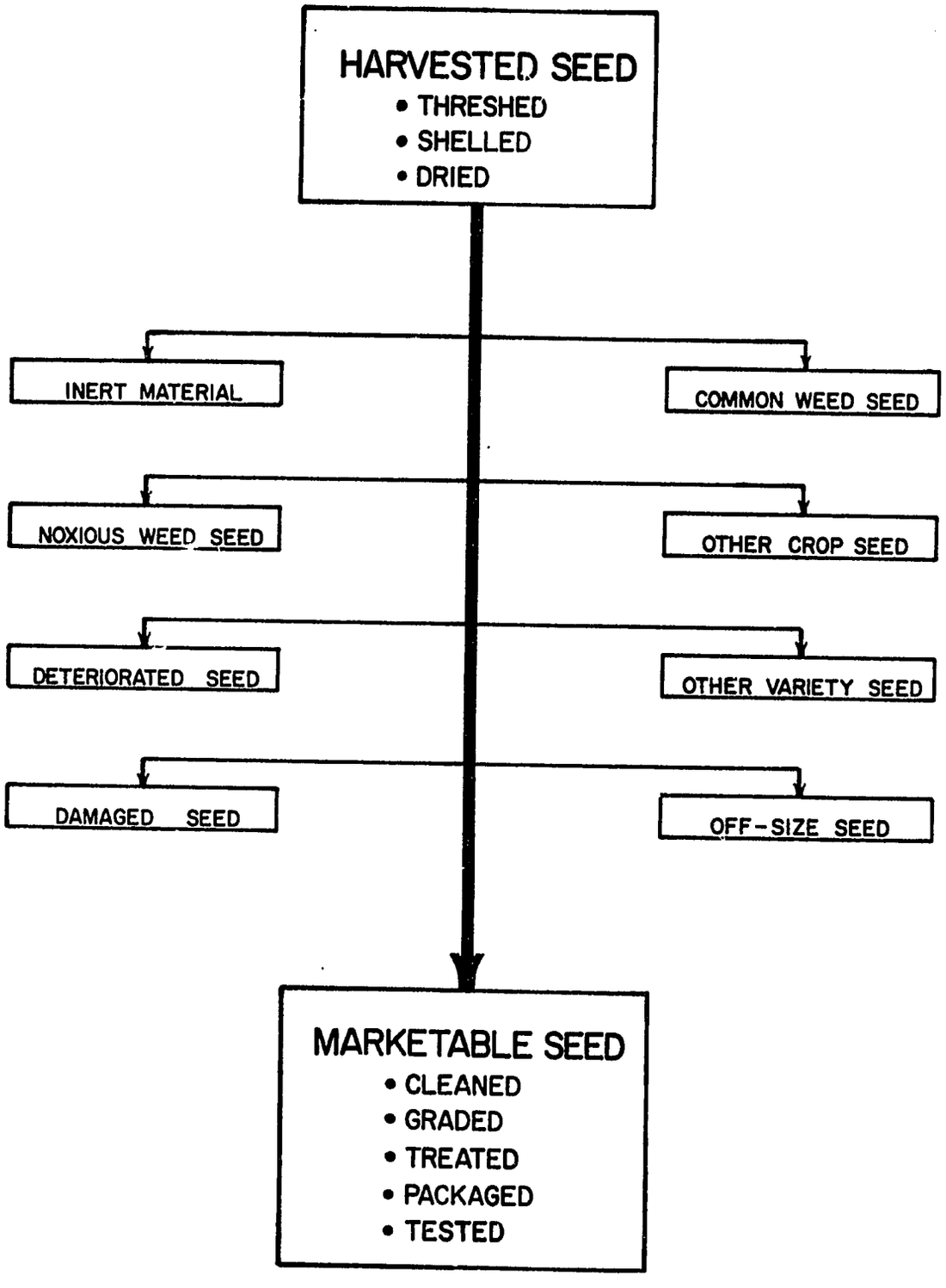



Figure 14. Flow chart illustrating the types of material that are removed from seed during processing.

In its simplest form a seed cleaning system consists of an elevator to lift seed into the hopper of the air-screen, the cleaner itself, and bagging-weighing-attachments (Figure 15). Depending on the characteristics of the contaminants that have to be removed, other cleaning machines are added to form a cleaning or processing line - length separators, width and thickness separators, spiral separators, aspirators, gravity tables and so on. Each machine is linked to the ones before and after with conveyors so that the seed flow continuously through the processing line. Thus, the various cleaning machines used have to be matched for capacity or cleaning rate.

## Sizing

During or after cleaning it may be desirable to size grade certain kinds of seed to improve plantability, and/or quality. Size grading becomes more important as planting is mechanized. Some size grading is usually done in corn and peanut seed. Of course, very small, immature and shriveled seed are removed from all kinds of seed during cleaning along with other contaminants.

## Treating

Treatment of seed with various fungicides and insecticides to protect them from storage and soil borne insects and fungi is a recommended practice for many kinds of seed: corn, wheat, peanuts, sorghum, rice, etc. Since the dosage and uniformity of coverage of the chemicals are important, treatment is best accomplished with a seed treating machine that applies the chemicals at the desired rate and distributes them uniformly on the seed.

Seed treating is usually done during processing just before packaging. It should be recognized, however, that seed treatment chemicals are poisonous and treated seed that are not used for planting cannot be used for food, feed or industrial purposes. As a result of this situation it is often desirable to treat only a portion of the seed during processing (the highest quality seed with assured market) and/or to delay treatment until just before the shipping season. In some cases the treatment materials can be supplied to the cultivator along with the seed so that he can treat the seed just before planting. Strict precautions must always be taken to safeguard the health of the workers and to prevent the diversion of treated seed to food, feed, or industrial markets.

## Packaging

The final step in processing is packaging. Weighed quantities of clean seed are packaged in cloth, paper and/or plastic bags, the bags are closed by sewing (or gluing or heat sealing), and tags are attached. Bags

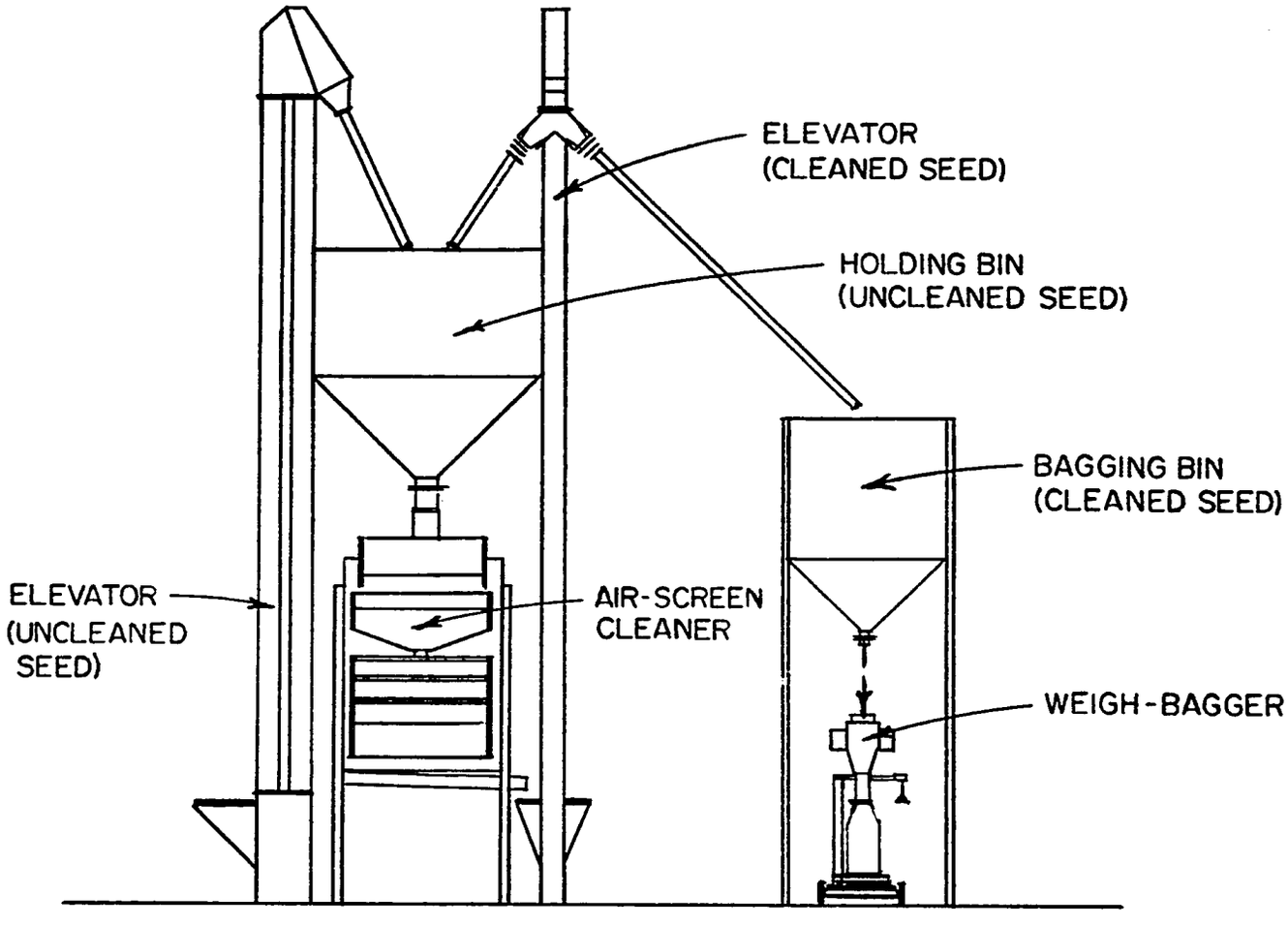



Figure 15. Components and layout of basic seed processing system.

are an expendable supply item and should not be reused for seed. They may of course be used for other purposes if the seed were not treated.

In most seed operations a bagger-weighing machine is required. These range from relatively simple and inexpensive devices that consist of an adjustable dump hopper, platform scale, and portable bag closer, to devices with an integrated weighing-dumping system, bag closer and bag conveyor. Bagger-weigher machines will generally permit bagging of seed at the rate the clean seed are discharged from the cleaning line, while a completely hand bagging and weighing operation will not "keep" up with rate of cleaning and becomes a bottleneck.

Typical processing plant layouts and sequences are illustrated in Figures 16 and 17.

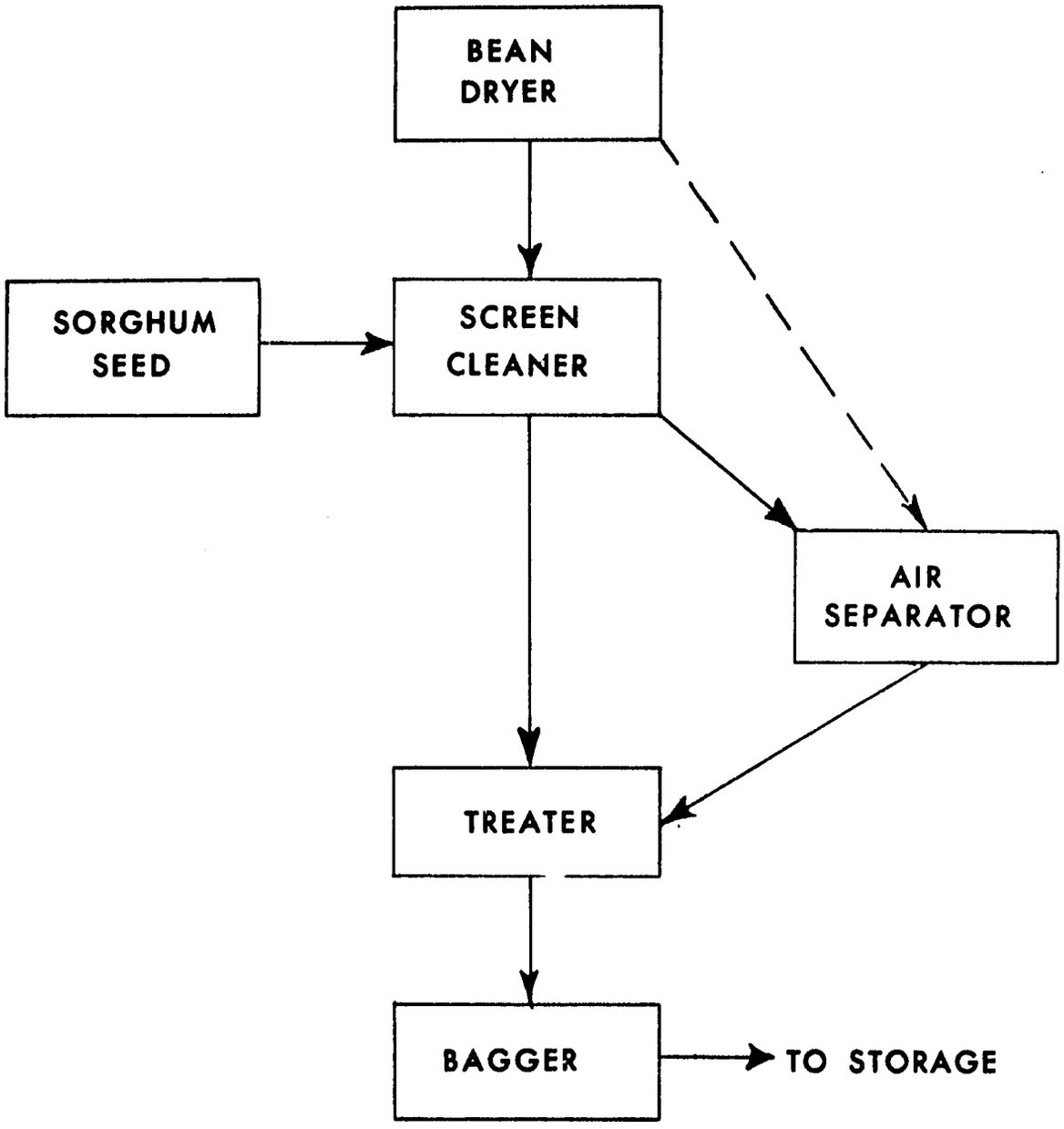



Figure 16. Typical seed processing layout and sequence for bean and sorghum seed.

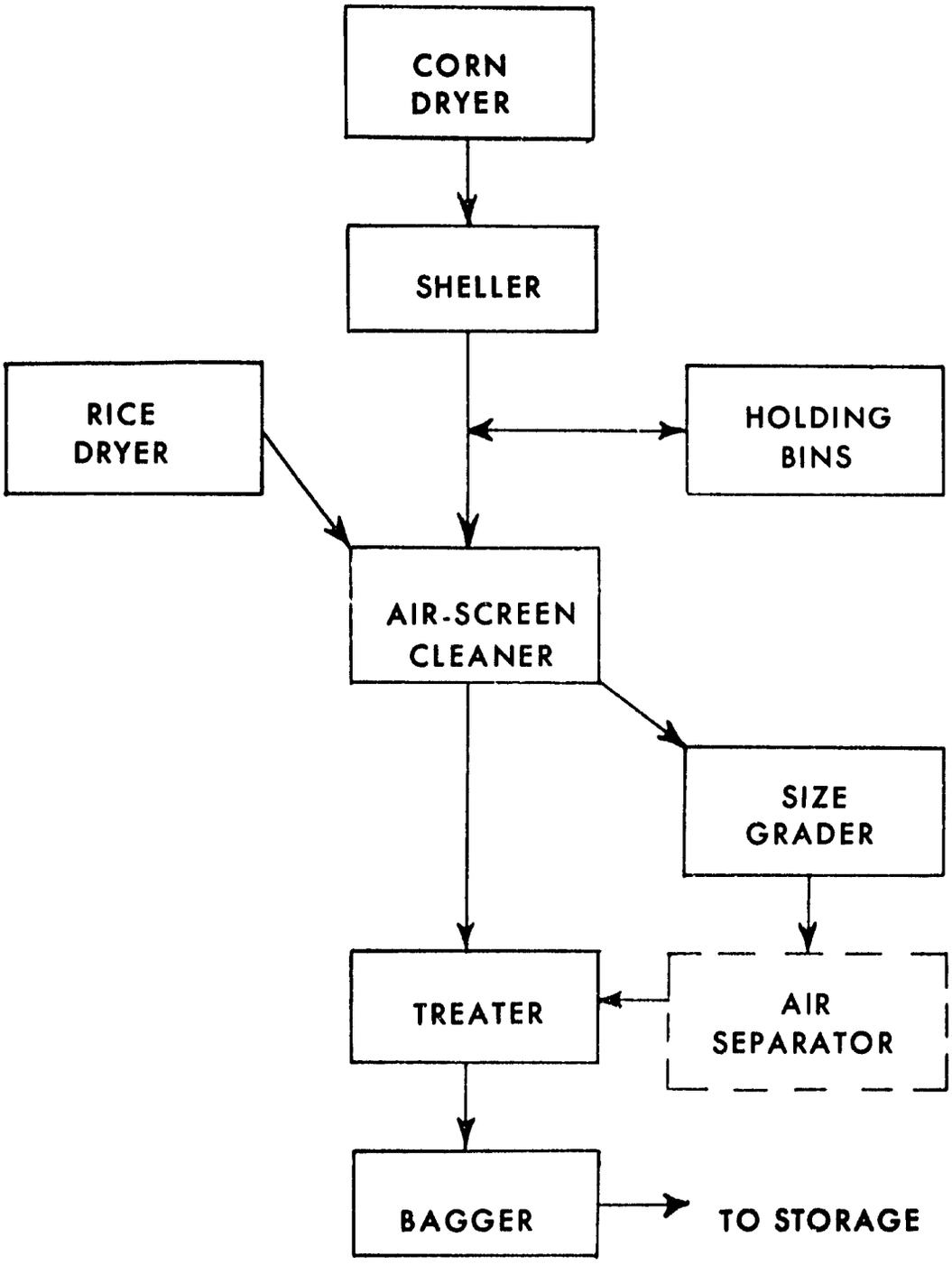



Figure 17. Typical seed processing sequence and layout for corn and rice seed.

## SEED STORAGE

One aspect of storage has already been considered, viz., temporary or holding storage for the seed after drying but before processing. The period of temporary storage ranges from a few weeks to 2 to 3 months. Following processing and packaging the seed must again be stored until they are finally delivered to the cultivator for planting. This final or packaged seed storage period ranges from a month or so to 7 to 9 months or even 2 to 3 years in the case of reserve stocks of breeder and foundation seed.

### Factors Affecting Storage of Seed

Storage problems are among the most common ones that plague seed program development in the less developed countries. A major cause of these problems is the relatively adverse climates - high temperature and humidities - that prevail in most of these countries, but it is not the only cause. Almost equally important is the generally low quality of seed produced and processed before storage. Low quality, rapidly deteriorating seed do not store well even under very good conditions. Put another way, good storage facilities do not fully compensate for improper and poorly managed harvesting, drying, processing and packaging. The first principle of successful seed storage, therefore, is to start with clean, high quality seed.

The contribution of tropical climates to seed storage problems - or storage problems of any type - can not be minimized. That is not our aim. Rather we only wanted to place them in proper perspective. High temperatures and relative humidities affect seed directly and indirectly. Seed are hygroscopic so that their moisture content is in equilibrium with the ambient relative humidity. When relative humidity is high, seed moisture content is also high; when it is low, seed moisture content is low. High seed moisture contents combined with warm temperatures greatly accelerate the natural processes of degeneration of biological systems (the seed) so that under such conditions seed rapidly lose vigor and somewhat later their capacity to germinate.

Storage molds and insects are also more prevalent and active in warm, moist environments and can quickly exact their toll of seed quality. The converse is also true, viz., storage molds and insects are less active under dry, cool conditions. Cool, dry storage, therefore, not only reduces the rate of physiological deterioration of seed but also helps to control storage molds and, especially, insects.

Figure 18. "Storage problems are among the most common ones that plague seed programs in the less developed countries."

Inherent differences in storage potential or longevity among seed kinds (and even varieties within a kind) should be recognized. For example, rice seed is a "good storer" and this characteristic probably accounts for the fact that it is the only major seed propagated crop in many tropical areas. Soybean seed, on the other hand, are "poor storers" and just barely survive from harvest to planting (7-9 months) even in temperate climates. These inherent differences in storability among seed kinds must be considered in planning for storage. Several major kinds of seed are classified as to storage potential below:

| Good Storers | Fair to Poor Storers |
|---|---|
| Rice | Soybeans |
| Corn | Peanuts |
| Wheat | Other oil seed |
| Sorghum | Edible beans |
| Millet | Most vegetable seed |

## Requirements for Storage

The general prescription for storage is to store seed under dry, cool conditions. Just how "cool" and "dry" is determined by the kind of seed, period of storage, initial quality of the seed, and the acceptable loss of quality.

Storage like drying is a complex element of the seed program that must be planned for within the context of local environmental conditions. In most seed programs several "qualities" of storage conditions ranging from "open" or ambient to highly conditioned are needed. Expert advice should be sought early in program development to assist with the formulation of short and long range plans for seed storage.

Several general principles pertaining to seed storage are given below.

(1) High quality seed store better under any conditions than low quality seed.

(2) Seed kinds differ inherently in storage potential.

(3) Seed moisture content (or relative humidity) and storage temperature are the two most important factors in storage of seed. Of these two, relative humidity (seed moisture content) is most important.

(4) Good quality seed of the cereal grains (wheat, rice, corn, etc.) will store well for 6-9 months under most temperature conditions encountered provided seed moisture content is maintained below 12% and insects are controlled. Oil seeds and seed high in proteins will usually store well under the same conditions and for the same period provided moisture content is maintained below 10%.

(5) Sealed storage of seed (metal cans, moisture vapor proof plastic, aluminum foil laminated paper-plastic bags, etc.) requires that seed moisture content be reduced even further for safe storage - to 10% or less for cereal seed and 9% or less for oil seed. The safe storage period, however, will be extended by sealed storage.

(6) Sanitation - rigorous and continuous sanitation - is a must for successful storage. The area inside and surrounding the storage house should be clean and free of trash, weeds, straw, spilled seed, and so on. Periodic spraying of interior of warehouse and around the outside is very helpful in controlling insects as is periodic fumigation. Seed should not be stored next to fertilizers or herbicides. Elevation of the floor of a storage warehouse about 1 meter, close fitting doors, and cleanliness around the storage building will minimize rodent problems.

## Types of Storage

Types of storage in terms of shapes and sizes of facilities and construction materials used, are endlessly variable. From the standpoint of utility and quality, however, three basic types are recognized: bulk storage, flat ambient storage, and conditioned storage.

### Bulk Storage (Figure 19 )

Bulk storage refers to storage of seed en masse as contrasted to storage in sacks or other packages. The temporary or holding storage needed to "hold" seed after drying but before processing falls into the bulk storage category. Bulk storage is usually in bins which may be constructed of wood, concrete, brick or metal. It is not conditioned except under the most unusual circumstances but it is often equipped with an aeration system to "even out" temperatures within the seed mass and prevent moisture migration and accumulation. The floor of a bulk storage bin should be separated from the soil by an air space and/or moisture vapor barrier. Otherwise, ground moisture will be directly absorbed by the seed in contact with the floor and transferred to the seed above.

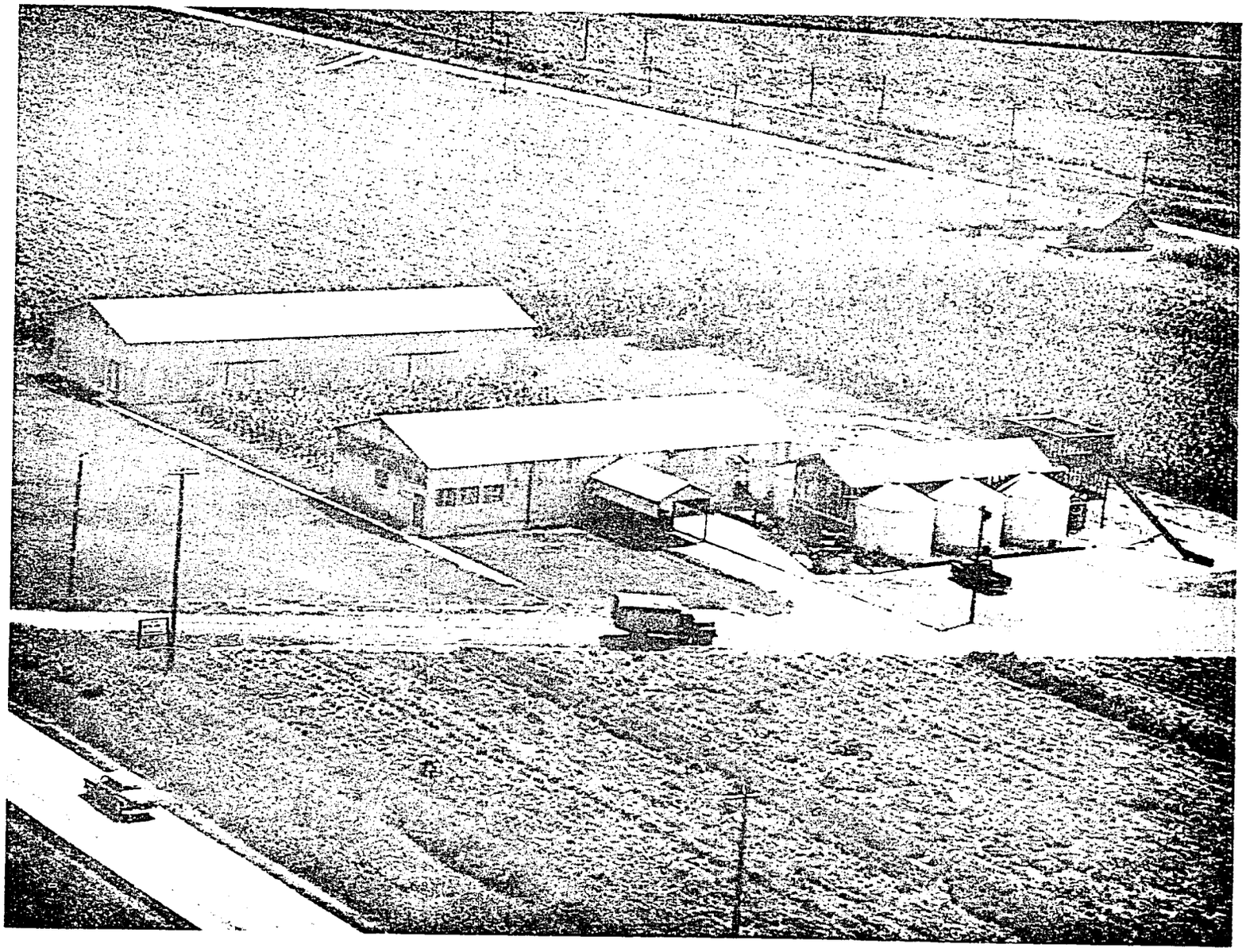


Figure 19. Metal storage bins adjacent to corn seed dryer for temporary storage of shelled seed after drying.

Reabsorption of atmospheric moisture in bulk storage after drying can be retarded by metal or well constructed concrete bins. This is important for little is gained from drying if the seed reabsorbs moisture to high moisture contents before packaging. Nonporous bins also facilitate fumigation for insect control.

Flat Ambient Storage (Figure 20)

Flat ambient storage differs from bulk storage only in that the seed are usually cleaned and in bags, and the storage structure is a building or warehouse rather than a bin. The same precautions regarding diffusion of gound moisture through floors indicated for bulk storage are applicable to flat storage, as are the sanitation practices previously discussed.

The major part of the commercial seed production of basic crops will be in some type of flat storage from the time of packaging through sale to the cultivator. The quantities of seed involved are usually too large for complete conditioned storage of all the seed except when absolutely necessary.

Conditioned Storage (Figure 21)

The purpose of conditioned storage is to prolong the storage life of seed by moderation of the two most important factors influencing storability of seed: relative humidity (seed moisture content) and temperature. Storage temperature can only be moderated by air cooling, while relative humidity can be moderated in two ways: moisture vapor proof packaging and dehumidification

After drying, reabsorption of atmospheric moisture by seed with a resulting increase in moisture content can be retarded or entirely eliminated by packaging the seed in completely or partially moisture proof containers. Metal cans, glass containers (properly sealed), aluminum foil-plastic laminated bags and 7 mil or thicker polyethylene bags are essentially moisture vapor proof. As indicated previously in this section, seed stored in moisture vapor proof (retardant) sealed containers must be dried to a moisture content 2 to 3% lower than that used for unsealed (open) storage.

In moisture vapor proof packaging, the atmosphere inside the package is conditioned because its relative humidity comes into equilibrium with the seed moisture content of the dry seed. Temperature, however, is not affected. Relative humidity, of course, can be moderated on a much larger scale. The entire storage room can be dehumidified to the desired level.

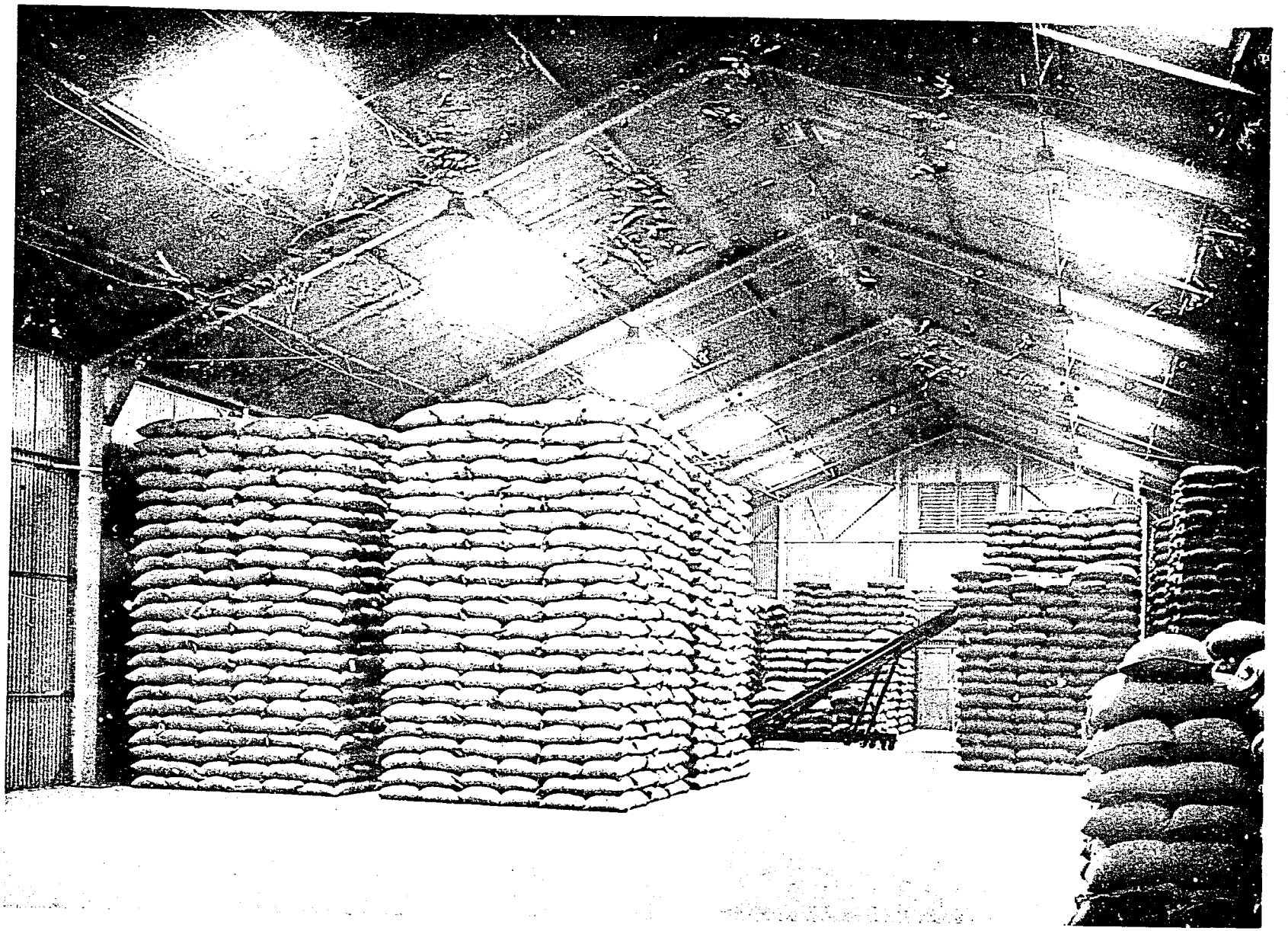


Figure 20. Flat storage of bagged seed in an open warehouse.

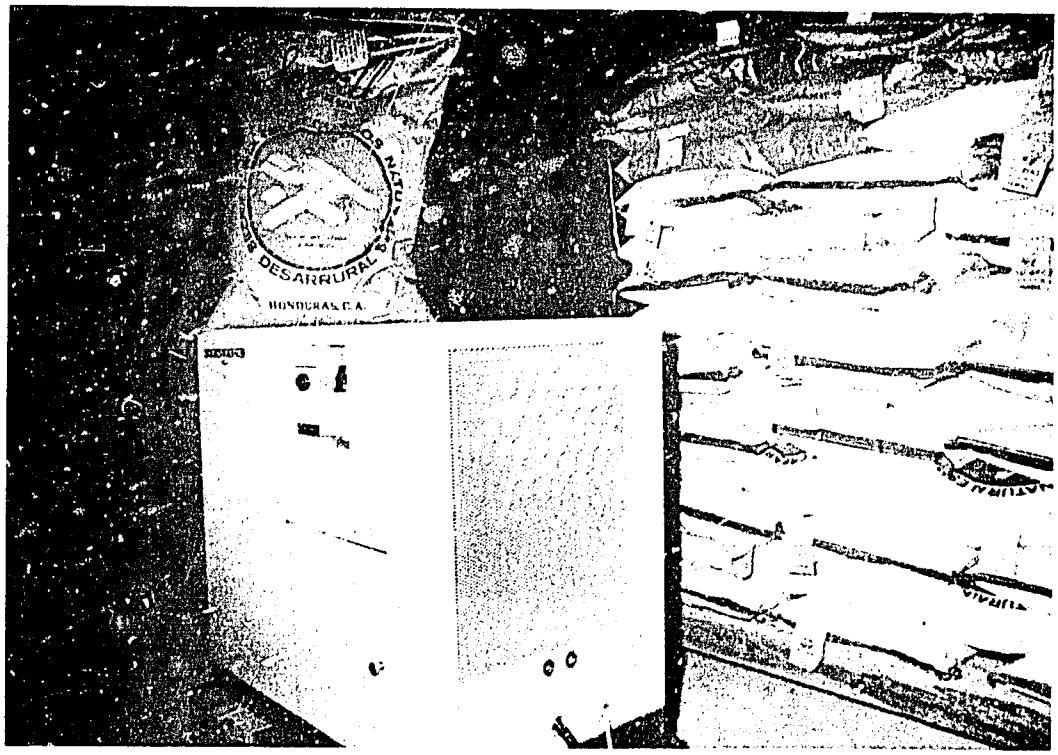


Figure 21. Interior view of conditioned storage rooms for seed. Top: condensation type dehumidifier. Bottom: dehumidifier and air conditioner.

Effective dehumidification of a storage room requires, first of all, that the room be well constructed and reasonably tight against moisture infiltration. Incorporation of vapor barriers in walls, floor and ceiling is recommended as is use of heavy duty, tight fitting doors (no windows). Dehumidification can be accomplished in two ways - by condensation or adsorption of moisture vapor.

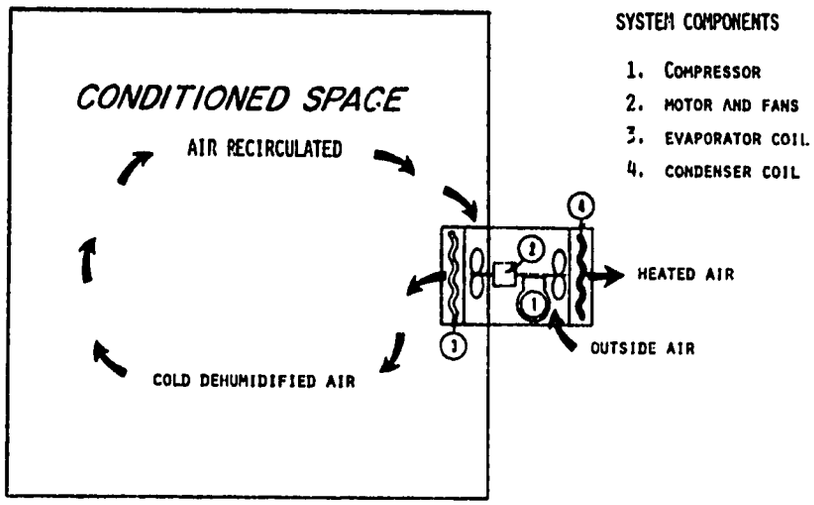
Condensation-type dehumidifiers are much like a refrigeration unit. The air inside the room is drawn across the cold coils where it is condensed, collected, and piped out of the room. In an absorption type dehumidifier the air is drawn through a bed of silica gel or other desiccant where it is dehydrated. The desiccant beds are periodically reactivated (dried) by heating.

The efficiency of a condensation-type dehumidifier decreases rapidly as air temperature is lowered, while that of the desiccant dehumidifier remains about the same at any temperature.

Dehumidification always produces heat a fact that is all too often forgotten in designing conditioned storage facilities. Condensing or adsorbing one pound of water vapor liberates as much heat as is required to evaporate the same quantity of water. Consequently, dehumidification in environments where temperature is already high should be coupled with air cooling to prevent detrimental heat buildup in the storage room.

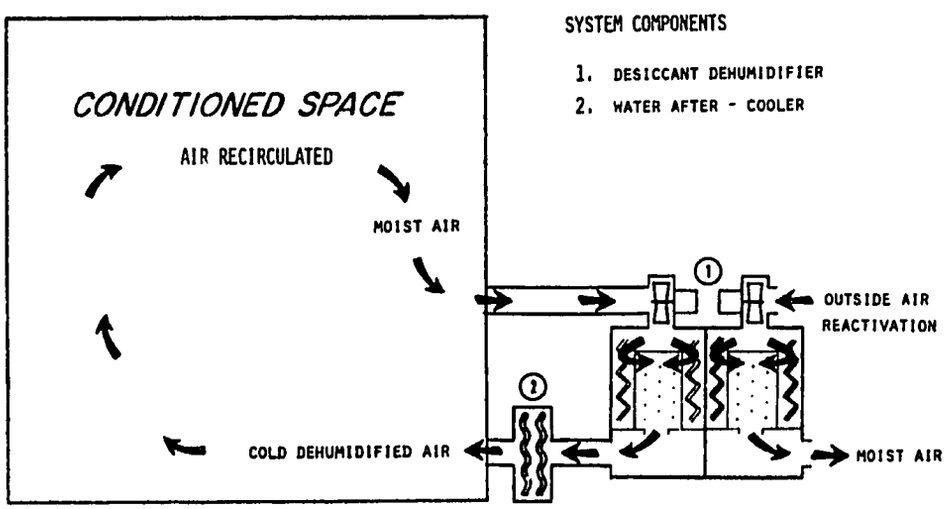
Conditioned storage is expensive, therefore, its use must be restricted to valuable seed stocks, such as breeder and foundation seed, hybrid seed, vegetable seed and so on, and to situations where the climate is so adverse that specific kinds of seed will simply not survive to planting time under ambient conditions.

Schematic diagrams of several types of storage conditioning systems are shown in Figures 22 and 23 .

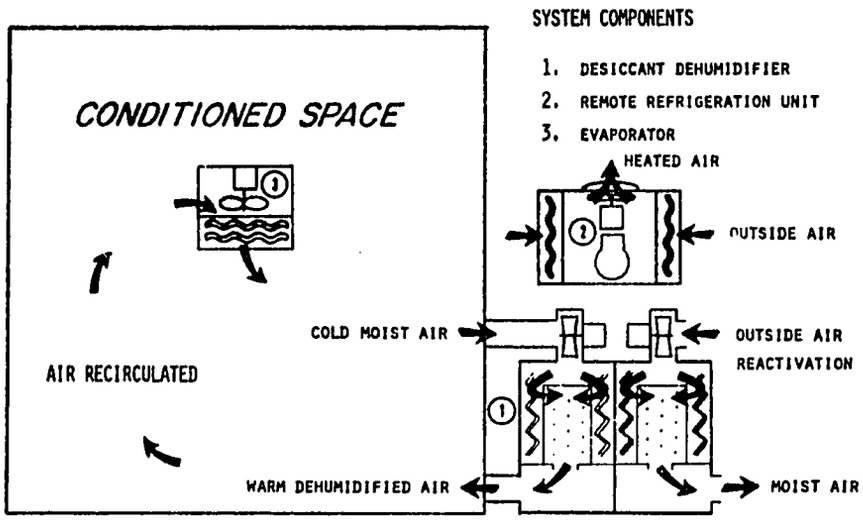



DEHUMIDIFICATION AND COOLING SYSTEM, TYPE III

Figure 22. Components of various conditioning systems for seed storage.

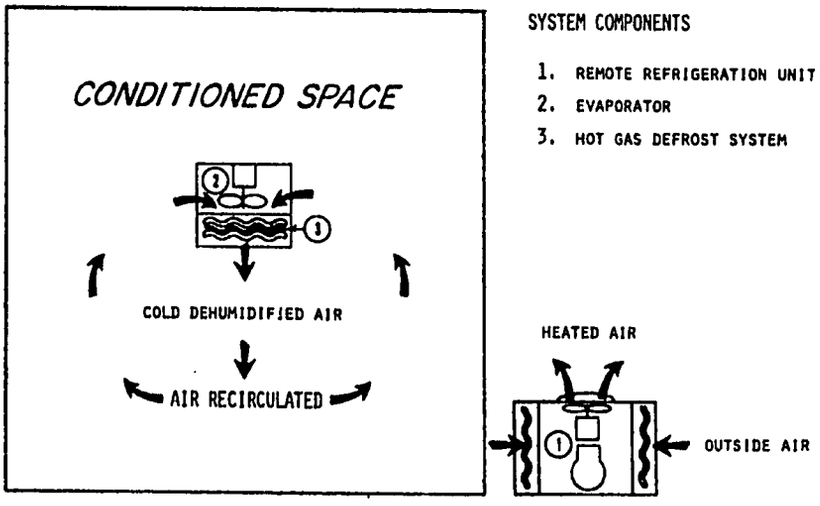



DEHUMIDIFICATION AND COOLING SYSTEM, TYPE IV




DEHUMIDIFICATION AND COOLING SYSTEM, TYPE VII

Figure 23. Components of various conditioning systems for seed storage.




DEHUMIDIFICATION AND COOLING SYSTEM, TYPE VIII

## QUALITY CONTROL AND EVALUATION

Quality control is the systematic approach toward achievement and/or maintenance of desired quality standards of a production or service - seed in our case. In terms of the seed program quality control has several aspects. It is -

(1) A system and procedures for achieving specific seed quality standards.

(2) A system for maintaining seed quality once standards have been achieved.

(3) A method of approach in identifying seed quality problems (actual or potential) and effecting their resolution.

The ideal of high quality and the concept (and application) of quality control must permeate all phases of the seed program. Concern about quality and action to insure it begins with selection of the seed for multiplication, extends through production, harvesting, drying, processing, storage and distribution and ends only with satisfactory performance in the cultivators field.

Quality control integrates random and uncoordinated activities directed toward achievement and maintenance of quality standards into a comprehensive, systematic program. It does not permit vital operations or procedures to be accomplished or ignored by chance or the momentary whims of a technician.

### What Is Seed Quality?

Although the phrase seed quality has been used throughout this manual and is generally understood by agriculturalists, we should pause and consider more exactly what it means. Seed quality is the sum of many seed attributes or characteristics. In terms of individual seeds these attributes include trueness-to-variety (genetic purity), mechanical damage or injury, viability (germinability), vigor, disease infections, insect damage, treatment coverage, size, and appearance. Extended to the population of seed (the seed lot), quality characteristics include moisture content, incidence of contaminants (noxious and common weed seed, other crop seed, inert matter), uniformity (homogenity of the lot) and performance potential. Highest quality seed are genetically pure, germinable, vigorous, intact, free from diseases and contaminants, properly sized, adequate treated (if treatment is recommended), and of over-all good appearance.

The ideal of highest quality is seldom achieved - few seed lots meet "ideal" specifications. For this reason, minimum quality standards are adopted or imposed in most seed operations. The minimum standards are established not as a goal - the goal is always highest quality - but as the lowest levels of the various quality factors that are acceptable under the usual conditions.

The quality control specialist has at his disposal many methods for evaluating and controlling seed quality. Quality control, however, is unfortunately often restricted to certification-type procedures (to be considered later) and "standard seed testing." These are excellent controls but they are passive rather than active. They do not involve positive actions to insure timely harvesting, control mechanical abuse, maintain or upgrade viability, etc.

Seed testing usually occupies a very prominent and disproportionate role in seed program planning and development. The seed testing laboratory is very important but it is only a service element in the seed program. Seed testing laboratories and certification agencies do not produce, process, or distribute seed to cultivators - which constitutes the main thrust of the program.

Seed are tested for the following reasons:

(1) To determine their quality, i.e., their suitability for planting.

(2) To identify quality problems and their probable cause.

(3) To determine the need for drying and processing and specific procedures that should be used.

(4) To determine if seed meet established quality standards or labeling specifications and requirements.

(5) To establish quality and provide a basis for price and consumer discrimination among lots in the market place.

## Seed Testing

Well established evaluation and testing procedures are available for the important quality attributes of seed. Routine or standard seed testing, however, encompasses a rather specific set of tests. These include physical and biological purity, incidence of noxious weed seeds, germination percentage and moisture content. To the extent that varietal purity can be determined in the purity test, then it too is routinely assayed.

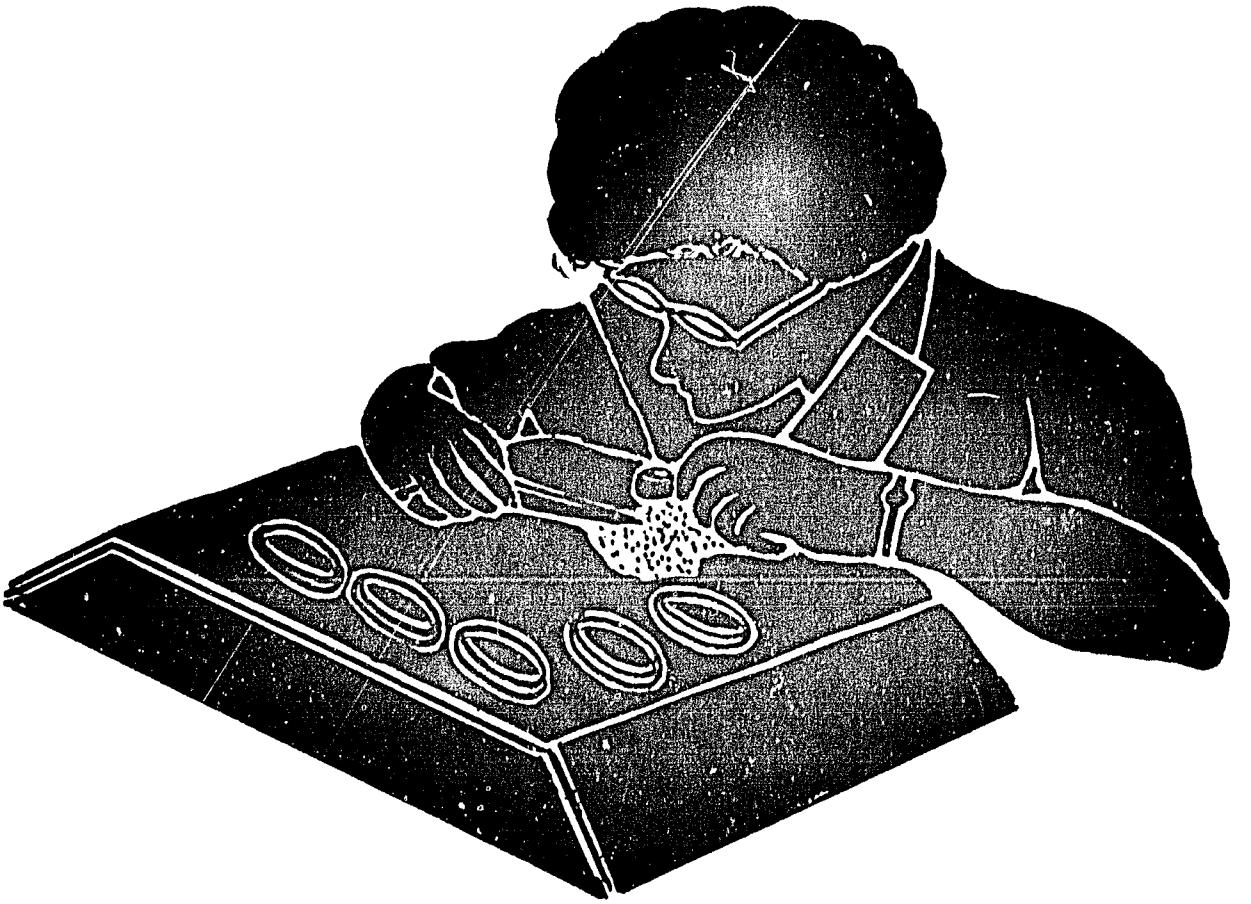


Figure 24. "Well established evaluation and testing procedures are available for the important quality attributes of seed."

(1) Purity Test - The purpose of the purity test is to determine the physical and biological composition of the seed lot: (a) % pure seed - kind and variety under consideration; (b) % other crop seed - seed of other crops and varieties admixed with pure seed; (c) % weed seed - seed of plants recognized as weeds by law, regulation or common usage; (d) % inert matter - refers to seed-like structures of both crop and weed plants and all other material in the lot that is not seed.

(2) Noxious weed seed examination - The incidence or rate of occurrence of certain weed seeds designated by law as noxious (very bad weeds) is determined.

(3) Germination test - The germination test measures the ability of the seed to germinate and produce normal plants. Test results are expressed as the % germination (normal seedlings).

(4) Moisture content - Moisture content needs to be determined many times in the movement of seed from seed field to the cultivator. It can be determined by a variety of methods, but the air oven and electric meter methods are most suitable and practical.

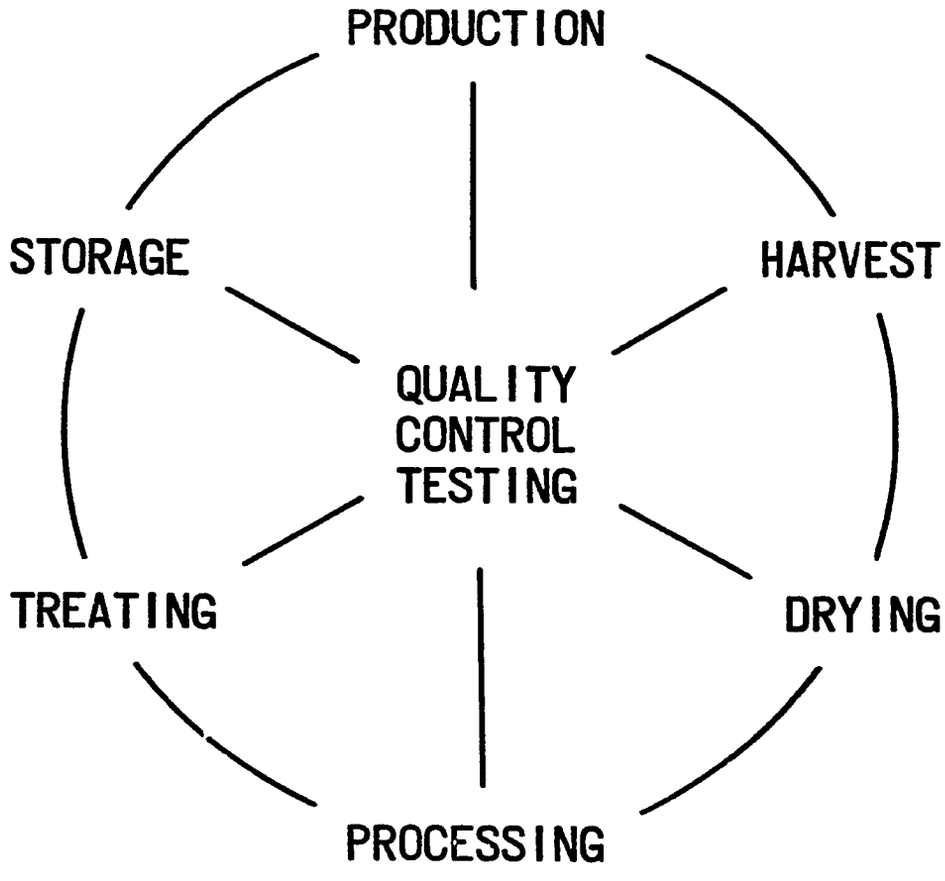
In a comprehensive quality control program many other tests and determinations are made. These include: special tests to assay trueness-to-variety; seed density; incidence and identity of seed borne diseases; efficacy of seed treatment; vigor; homogenity (for lot uniformity); incidence of mechanical damage; biochemical assays (tetrazolium, etc.), and so on.

## Quality Control Procedures

The quality control or testing laboratory is the hub of the seed quality program. It may be no more than a small table with pertinent equipment operated by the seed producer or one of his workers, or it may be a large, staffed and equipped, versatile seed testing laboratory. Regardless of size it is the place where quality control tests are made on which many management decisions are based.

While the laboratory is the hub of the quality control program, quality control activities are by no means confined to its location; rather they extend to all seed operations (Figure 25).

Quality control is most important in the developing seed program because most persons involved in it will be relatively inexperienced and the program will be beset by many serious quality problems. If they are not soon controlled and minimized, the cultivators will simply lose confidence in "improved seed" and the intent of the program frustrated.




THE QUALITY CONTROL LABORATORY IS THE HUB
OF A SEED QUALITY CONTROL PROGRAM

Figure 25

## Seed Certification

Anyone even casually familiar with seed programs and seed improvement knows that seed certification is somehow involved. Seed certification has performed and is still performing a vital function and service in the seed industries of the developed countries. Its potential for service in developing seed programs is even greater.

The need of organization and systematic procedures for and control of seed multiplication and production have already been discussed. Seed certification is a time tested and highly perfected system for accomplishing these tasks.

Seed certification is a legally sanctioned system for the quality control of multiplication and production of seed. Its basic purpose is, "to maintain and make available to the public sources of high quality seed and propagating materials of superior varieties grown and distributed so as to insure genetic purity."[7] Put another way, "the purpose of seed certification is to give the consumer (cultivator) an assurance regarding some important points of quality when they cannot be readily determined by an examination of the seed itself."[8]

### What Certification is Not

Perhaps no other aspect of a seed program has caused as much confusion and as many disappointments in developing countries as seed certification. Thus, it seems advisable at this point to list some "things" that seed certification is not.

(1) Seed certification is not the seed program. It is only one supporting element.

(2) Seed certification is not seed multiplication and production. It is a system for accomplishing these tasks.

(3) Seed certification is not seed control legislation and seed marketing regulations although it is legally sanctioned.[9]

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[7] A. W. Young. The Purpose and Benefits of Seed Certification. Seed World. March, 1960.

[8] Anonymous. The Seed Certification Process. World Seed Campaign News. FAO. No. 4, May, 1959.

[9] Exception: Seed certification is seed legislation and control when it is compulsory and marketing of non-certified seed is prohibited by law. We do not recommend such legislation.

(4) Seed certification is not governmental production of seed. Certification is not concerned with who produces seed so much as how it is produced.

(5) Seed certification is not seed labeling although certified seed should carry a distinctive label. All seed - certified or non-certified - should be labeled.

(6) Seed certification is not seed marketing and distribution.

(7) Seed certification is not a panacea for all the ills that beset seed program development, although it can be most helpful in eliminating and/or preventing some.

## Organization

Seed certification is a declaration (guarantee or validation) that the seed certified were produced in accord with published regulations and procedures and meets the minimum standards established in the regulations regardless of the identity of the specific producer.

The certification of seed should be conducted by an incorporated, non-profit service organization, association, or cooperative or by a governmental agency. It must be legally sanctioned or chartered by appropriate legislation as being in the public interest and granted exclusive rights to "certify" seed produced in the area of jurisdiction of its sanction or charter.

Main organizational features of a certification agency or program include: (See Figure 26 ).

(1) Certification Agency or Association - An agency performs a service for clients - seed producers, while an association performs similar services for its membership - again the seed producers. Regardless of type, the Agency or Association is a legal entity enjoying certain monopolistic privileges. It is also a physical entity in the sense that it has offices, staff, and certain equipment.

(2) Board of Directors - To ensure that the certification operation is in the public interest as stipulated in its charter, constitution and by-laws, and to help it fulfill its potential, it should operate under the guidance of a Board of Directors consisting of not more than 8-10 persons, elected and/or appointed from sections of the Minister of Agriculture concerned with crop improvement, extension, credit, etc., from farmer's association and cooperatives, and from among private farmers and seed producers. The Board of Directors establishes policy

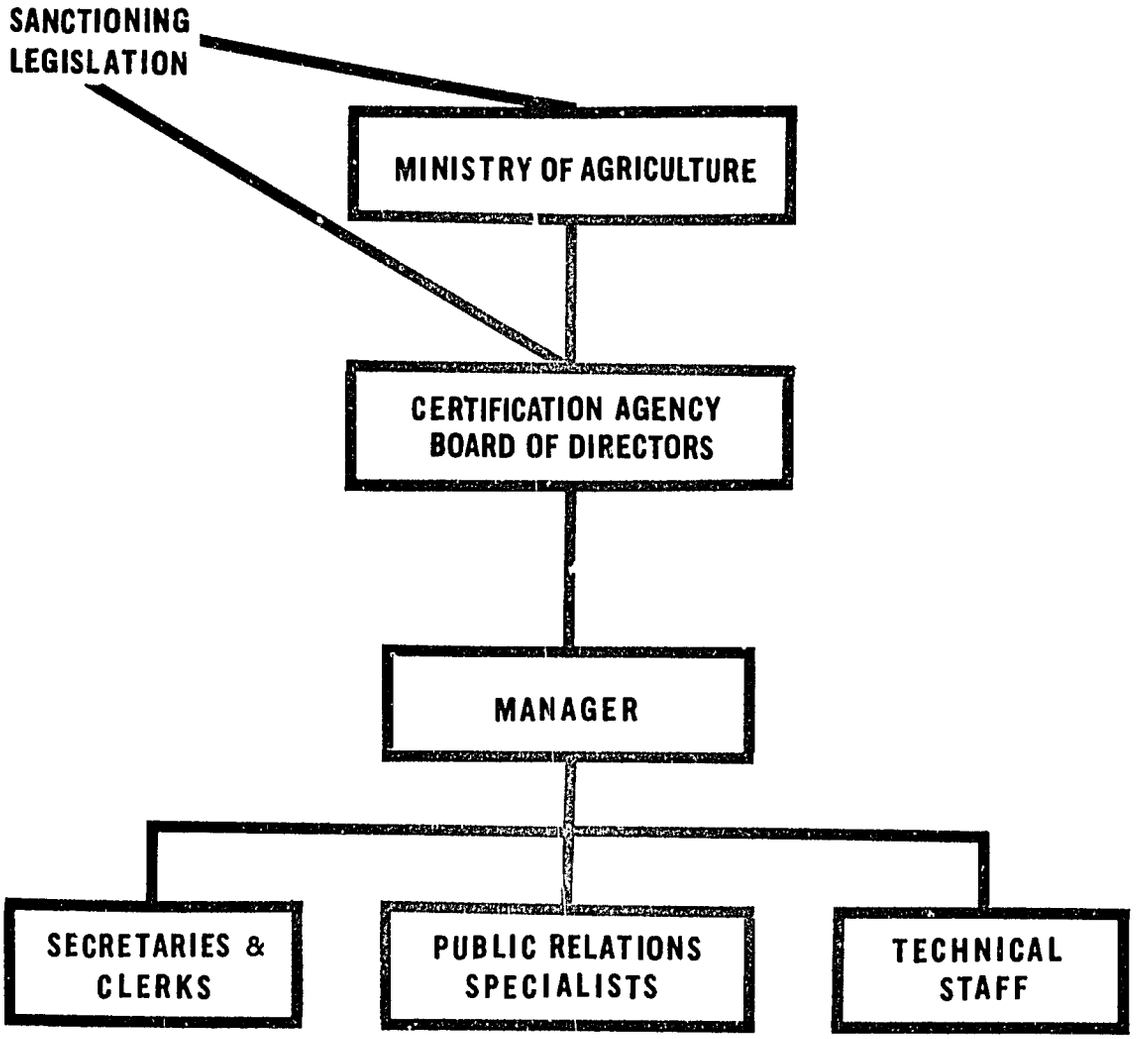


Figure 26. General organizational structure of a seed certification agency.

as authorized by the charter, sanctioning law, constitution and by-laws, forms committees as needed, reviews and approves their recommendations or actions, sets fees and dues, prescribes standards and regulations, approves budgets and employment of personnel, acts in a judicial capacity in disputes, and renders such other decisions as necessary.

(3) Manager and Staff - The routine business and technical operations of the certification agency or association should be managed by a supervisor, executive officer, or head, appointed by the Board of Directors or competent authority as provided in the constitution and by-laws. The manager is the executive officer of the Certification Agency responsible for implementation of policies, procedures and practices established by the Board as well as the chief technical advisor to the Board. Additionally, he often serves as secretary-treasurer of a certification program organized as an association or cooperative. In short, he is the key individual in the program and must be a thoroughly professional man with broad competency in seed and crop improvement work and administration. The rest of the agency staff consists of the inspectors, laboratory technicians, and secretarial-clerical personnel as needed to accomplish the agency's work.

(4) Membership or Clients - Membership ought to be voluntary and open to all seed producers who meet qualifications as prescribed in the constitution and by-laws if certification is organized as an association. If organized as an agency, then seed producers ought to be free to use or not use its services. Certification is a service element in agricultural development in general and seed program development in particular. It should assist its members or clients as well as prescribe and inspect their procedures, operations, and produce. It should never develop the "policeman" syndrome or be operated as an exclusive social-business club - the greater the exclusion, the better.

## Operations

The certification agency formulates and prescribes procedures and standards for the multiplication and production of seed and related harvesting, drying, processing and bagging-tagging activities. It assists its members in following established procedures and meeting standards, and inspects their production, harvesting, processing and other operations to determine if procedures are (were) followed and the seed meet minimum standards. A seed lot that is produced in accord with the procedures and regulations of certification and meets minimum standard is so certified by the agency. Seed that do not meet standards are not certified.

## Certified Seed Classes

Since the main purpose of seed certification is maintenance of varietal identity and purity, the program is built on a system for achieving this end. Certification begins with breeder seed and ends several generations later with "certified class" seed in a continuous cycle. Thus, seed multiplication and production are restricted to a limited number of generations from the original seed stock - breeder seed. Four classes of certified seed based on the generation system are commonly recognized.

(1) BREEDER SEED - breeder seed are seed directly controlled by the originating or sponsoring plant breeder, institution, and/or firm, and which supplies the source for initial and recurring increases of foundation seed. (See Figure 6 , page 3 ).

(2) FOUNDATION SEED - foundation seed are the progeny of breeder or foundation seed so handled as to most nearly maintain specific genetic purity and identity. (Figure 6 ).

(3) REGISTERED SEED - registered seed are the progeny of foundation seed so handled as to maintain satisfactory genetic purity and identify. (2nd or intermediate multiplication of scheme in Figure 6 ).

(4) CERTIFIED SEED - certified seed are the progeny of foundation or registered seed so handled as to maintain satisfactory genetic purity and identity. (3rd multiplication, or cultivator planting seed, in the scheme in Figure 6 ).

## Regulations and Standards

The regulations governing certified seed production include rules and procedures for production and minimum quality standards, which should be published and freely available to all interested persons. The procedural rules pertain mostly to seed source, cropping history of land, other land requirements, types and number of certification units permissable on one farm or by one grower, application datelines, roguing, harvesting, sampling, storage, processing, packaging and labeling. The standards are of two types: field standards and seed standards. Field standards stipulate required isolation distance, and allowable numbers or percentage of off-types, other varieties, other crops, weeds, and diseased plants permitted per unit area in the production field.

Seed standards are concerned with varietal purity (as can be determined in a purity test), allowable numbers or percentages of other crop seed, weed seed, inert matter, diseased seed, volume/weight of seed, maximum moisture content, and germination.

The specific procedures, rules and standards for certification vary among the different crops. Adherence to procedures and attainment of standards is determined by field and facility inspections, and laboratory seed quality analyses.

## Related Activities

The progressive certification agency tries to serve its members or clients in all ways that it can. It assists interested cultivators and agri-businesses in becoming certified seed producers. It gathers and communicates the latest technical information pertaining to seed to its growers. It places them in contact with suppliers of needed materials, or equipment, and potential markets. And, it always strives to develop in all its growers the spirit of dedication and service that is the hallmark of a successful certified seed producer.

## SEED LEGISLATION AND CONTROL[10/]

Seed legislation (and control activities thereunder) is another often misunderstood component of the seed program/industry. Confusion arises with regard to the purposes and uses of legislation pertaining to seed and what can be expected of it in furtherance of overall program objectives.

Seed legislation is generally of two types:

(1) SANCTIONING LEGISLATION - that authorizes, establishes or otherwise legally sanctions such activities as a foundation seed program, seed certification agency, official seed testing laboratory, and so on.

(2) CONTROL LEGISLATION - that has the purpose of regulating the intra-country distribution and marketing of seed and seed imports (and often exports).

Sanctioning legislation has already been considered. Seed certification and, in some cases, foundation seed production and seed testing, must be legally sanctioned activities. Legal statues or charters pertaining to seed certification and similar activities should be concerned only with these activities and not with seed marketing in general.

Seed control is often taken as synonymous with certification or vice versa, but optimally they are separate and distinct activities. We hold this view in spite of the fact that a few developed countries have successfully combined seed certification and seed control into one package.

A seed law and control program - like the seed testing laboratory and certification agency - are all too often accorded a place in seed program plans far out of porportion to their potential contribution. We cannot emphasize too strongly that seed law and control activities basically regulate seed trade practices - the marketing of seed. They cannot be expected to have much impact on seed usage if "seed trade" is non-existent, inconsequential, involves only barter among neighbors, or is restricted to government production, distribution and marketing.

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10/ "Control of Production and Distribution of Seed," published by FAO (1969) contains guidelines for seed legislation.

## Need for a Seed Law

There is not general agreement among seed specialists as to the exact role and importance of seed control legislation in a developing seed program. Some advocate early enactment of a seed law so that novice seed producers and seed traders can become accustomed to its discipline from the beginning. Others believe that an effective seed law cannot be drafted and implemented until seed trade has developed to the extent that its form and structure are evident. They do not see the need for preventive or anticipatory lawmaking.

The decision to draft and submit a law to the legislature should not be taken lightly. First, the extent and nature of seed trade should be surveyed. Is there any real trade or marketing of seed? Is it organized? What are the principal abuses in marketing practices? Can a seed law correct these abuses? Would the law be enforceable? After a determination is made that a seed law is needed and would contribute to agricultural development, one can be drafted to correct major abuses in seed trade practices and protect cultivator-consumers and legitimate seed companies. The law must be enforceable for a seed law that cannot or will not be enforced is worse than no law at all - it only contributes to disrespect for all laws.

## Philosophy of Seed Legislation

Two philosophies prevail with respect to seed control. In the first, the foremost consideration is for agricultural development and the view is that the interests of agricultural improvement are best served by excluding seed of "low or uncertain" quality from the market. Seed laws based on this philosophy are very broad and very restrictive. The law regulates everything from the release of varieties through variety performance testing to the very specific quality of seed that can be marketed. Compulsory certification is likely to be a feature of such laws.

The other basic philosophy of seed legislation is truthfulness-in-labeling. Laws under this philosophy basically require that all seed marketed be labeled for seed quality attributes specified and that the person or firm marketing the seed be identified on the tags or labels attached to each container of seed. The only "standards" prescribed in such laws relate to very liberal restrictions on minimum germination, maximum weed seed content, and validity of germination percentage on label (test date). (Strict specifications or standards are restricted to things such as prohibitions or limitations on noxious weed seed content and seed treatments, which might cause injury or losses to neighbors or others and not just to the cultivator who knowingly purchased the seed.)

## Enabling Law and Regulations

Seed control must have a legal basis just as does control of traffic or immigration. If a law is needed, the Ministry of Agriculture or its equivalent should sponsor an enabling law that identifies the need for control and regulation of seed marketing, establishes the authority of the government to regulate and control seed marketing, defines the specific intent of the law and the specific areas in which the government chooses to exercise its authority, specifies, designates or creates a seed control agency, and mandates it to develop and adopt appropriate rules and regulations for carrying out the intent of the legislation.

Incorporation of the detailed standards, regulations and procedures used in seed control in the body of the law is not advisable. Such matters become out-dated and it is far too cumbersome to return to the legislature every year or so with needed amendments. Furthermore, emergency situations sometime develop that require suspension of certain provisions or requirements in marketing regulations. This can be most speedily done when legislative action is not required.

A high level commission representing both private and public interests in seed should be appointed by the Minister to draft the detailed standards, regulations, and procedures needed for implementing the law. When the basic draft is complete, it should be published in public media, and public hearings scheduled on the draft regulations and procedures. After the hearings the draft is revised as necessary and the rules, regulations, standards and procedures are promulgated on the authority of the Minister of Agriculture or other administrator designated in the law. Amendments and changes in the rules, procedures, etc., are made in the same manner - draft proposal, public hearings, revision, promulgation.

## Labeling

The most important feature of the seed law and regulations promulgated thereunder will be the mandatory labeling requirements. The purpose of mandatory labeling is to require the seed vendor to identify himself and to furnish the buyer of seed important information(as specified in the law) on the physical and biological quality of the seed he offers in the market. Further, that the information provided be accurate within allowable tolerances and conspicuously displayed on a label (or tag) securely attached to every seed container within each lot.

Common mandatory labeling requirements for seed are as follows: (See Figure 27 ).

Weight _____ Net  Lot No. _____

Kind and Variety _____

Pure Seed _____ %  Germination _____ %

Inert _____ %  Hard Seed _____ %

Weed Seed _____ %  Date Tested _____

Crop Seed _____ %

Grown in (Province) _____

NAME _____

ADDRESS _____

TREATMENT:* _____

*May be placed on separate tag.

Figure 27. Seed tag illustrating labeling information usually required.

(1) Name of kind and/or variety or hybrid

(2) An identification mark (lot number)

(3) % of pure seed

(4) % of other crop seed (including seed of identifiable other varieties)

(5) % of weed seed

(6) % of inert material

(7) Kinds of noxious weed seed present and their rate of occurrence per unit weight of seed

(8) % germination (and % "hard" seed when present)

(9) Date (month) that germination test was made to obtain information for labeling in (8)

(10) Origin (state, province, or country where seed were produced)

(11) The accepted chemical name of any treatments applied to seed and dosage use. (Appropriate warning symbols are also required - skull and crossbones, etc.)

## Enforcement of Law

The seed law must apply to all lots of those kinds of seed designated as "controlled" in the law itself or regulations promulgated thereunder, that are entered into the market place. It should not matter that the seed are certified, non-certified, imported, or produced by another government agency.

Operationally the seed control agency is usually divided into two sections: (1) inspection-public relations and (2) analytical or technical services. Both sections are usually under the Chief Seed Control Officer with competent assistants responsible for routine operations.

It is the duty of the inspectors to explain the provisions of the law to all persons affected, to assist them with compliance, and then make inspections to determine compliance, investigate violations, and execute enforcement orders and penalties.

The analytical or technical services section analyses samples sent in by inspectors, reports results of analyses to the inspection section, assists in investigations, and advises the inspection section and Chief Seed Control Officer on technical matters.

Identification and proof of violation and recommendation of penalties and corrective actions are the functions of the inspection section. Ultimate decisions on corrective action and assessment of penalties rests with the Chief Seed Control Officer (or the Courts of competence when cases are referred to them). If a mislabeled seed lot can be brought into compliance the vendor should be permitted to re-label. Until this is done, however, the lot should be suspended from sale by a stop sale order. Other corrective actions and penalties available to the Seed Control Officer for enforcing the law include - in addition to suspension by stop sale orders and relabeling - revocation of licenses (if licenses required), fines (after appropriate hearings), publication of names of violators, and referral of case to a court of competent jurisdiction for trial and possible judicial punishment (usually a fine).

Seed laws and seed control represent a drastic change in the tradition and customs in most countries. The seed inspector will be a key change agent in the transition. He must be uncorruptible, competent, dedicated and ever mindful of the public relations aspect of his job.

## SEED DISTRIBUTION AND MARKETING

The last major sequential step in the seed production-supply program is distribution and marketing. It is a giant step, however, and one that must be successfully taken to justify all that has gone before. The improved seed must be delivered in adequate quantities at the right time, and to markets accessible to the cultivator-consumer. Unfortunately, agriculturalists - including seed producers - are not noted for their proficiency in either distribution or marketing. Thus, the advice and assistance of marketing and financial specialists as well as experienced commercial distributors should be obtained at an early stage in seed program planning and development, and during implementation thereof.

Distribution and marketing involves three basic activities: (1) storage (accumulation), (2) transport (distribution), and (3) selling.

### Storage

Seed are stored for periods of a few weeks to several months during their movement from production-processing centers to collection points and then on to the markets. Time in transit must also be counted in the storage period.

The basic considerations of seed storage have been discussed previously. They apply equally to storage during the distribution-marketing phase. They cannot be ignored for experiences of seed lots "going bad" during distribution are too numerous to be the result of chance alone. Leaky tarpaulins on transport trucks, broken containers of herbicides or fertilizers in common carriers, rail cars sitting on sidings for several days in 100°F., high humidity weather, damp, rodent infested market places - all have been the ruination of many good seed lots.

### Transportation

Seed can be transported in common carriers in the same manner and to the same places as other semi-perishable or fragile products. They can move by truck, rail, air, boat, camel back, bullock cart or head load just as do fresh vegetables, sugar, bottled beer, powdered milk and cigarettes. Utilization of the established transportation system should be encouraged, but first its effectiveness, reliability, range, and capability to move large quantities of seed in relatively short periods must be carefully studied.

Figure 28. "Seed can be transported and distributed by truck, rail, boat, bullock cart or head load in the same manner as vegetables, beer, powdered milk, and cigarettes."

A separate transportation system just for seed is seldom economically feasible until seed companies are operating on a large volume basis and then only for short hauls.

Finally, it should be pointed out that private entrepreneurs seldom encounter "insurmountable" distribution problems - witness the availability of popular soft drinks, beer, cigarettes and fuel oil (in 55 gal. drums) at even the remotest places.

## Marketing

It has been demonstrated in the past 4-6 years that truly superior seed will almost "sell" themselves. Marketing difficulties, however, are encountered when the seed represent a solid, demonstrable, but only modest improvement over the seed presently planted by cultivators (e.g., yield advantage of less than 20%). Seed with this level of improvement are important to agricultural development and will become more so in the future. It is most unlikely that some new rice variety will be as superior in yield to IR-8 in the next 15 years as was IR-8 to the types planted before its release. Advances in rice, wheat and maize in the future are likely to be in modest steps rather than "quantum leaps."

Marketing requires promotion - intense continuous, consumer directed promotion. It requires the establishment of a distribution network reaching into all potential markets. It requires timely, accurate marketing and "crop reporting" information. It requires efficient communications and transport. And, finally it requires salesmanship. (Parenthetically, we wish to comment that in our experience salesmanship is a highly developed art and skill in even the most underdeveloped countries. It has only to be harnessed into the seed arena.)

In the early developmental stages of an agricultural and seed program it may be necessary to organize a governmental agency to distribute and market seed as well, perhaps, as other agricultural supplies. If this is really necessary, then the government supply agency should make maximum use of the established commercial transport system, commercial warehousing, and local marketing system. In some countries - including the U.S. - farmer's cooperatives and associations have performed well in organizing and financing agricultural supply and marketing systems.

Considering all the various aspects and components of a seed program, government involvement has been least effective and most grossly inefficient in the distribution and marketing phases. Thus, private sector participation in distribution and marketing should be encouraged and assisted in all possible ways: credit on liberal terms to finance purchase of trucks, construction or remodeling of godowns, and to provide the working capital needed in

distribution-marketing operations; special incentives in form of partial tax dispensation on purchase of trucks and trailers, and/or tax refunds on motor fuel used in transporting agricultural supplies, etc.

Regardless of the types and modes of distribution-marketing used for seed, it is in these phases that the costs incurred in producing, processing, and transporting seed are finally (hopefully) recouped with a reasonable profit. It is also well to bear in mind that the costs of distributing-marketing themselves can constitute up to 50% of the total costs involved in producing seed and placing them in the cultivator's hands. Unfortunately, the distribution-marketing segment is all too often forgotten in the planning of seed programs. Monies and credit are often generously transfused into most other components of the seed program, while the distribution-marketing system chronically suffers from financial anemia.

## TRAINING AND EDUCATION

The success of the seed program/industry will be determined in large measure by the efficiency and expertise of the producers, managers, salesmen, technicians and workers who produce, harvest, dry, process, distribute and market the seed, and recognition by the cultivator of the value of improved seed and acceptance of it into his farming operation; the first aspect requires training, the latter education.

### Training

Contrary to some opinion, seed production-processing-distribution requires knowledge and skills that are not part of the usual background and experiences of agronomists,other plant specialists, agricultural engineers, and economists. Persons with backgrounds and experiences in these areas are excellent prospects for training - but they must be trained.

Training can be accomplished by enrolling good prospects in participant training programs and sending them for training to locations in one of the developed countries where crops are similar. This is important because in our experience, generalized and theoretical training - although important - will not suffice. Most trainees have a low capability for recognizing relationships, e.g., they do not readily see any relationship between seed production-processing of rice and, say, corn. Thus, rice seed training usually does not prepare a trainee for work with corn seed, and vice versa. This seemingly low capacity to relate one thing with another - to generalize - probably reflects the type of educational background of the trainees, which is usually in theory with minimum application.

Once a small corps of persons with some training in seed work is available, in-service, on-the-job training can be established at an early stage in seed program development. For, if the program flourishes, many trained workers will be needed to man both private and public elements and operations. A well organized and supported foundation seed program can become a center of training, expertise, technical information and service for the entire seed program-industry.

All efforts should be made to retain competent, trained managers and technicians in the seed program. Routine and periodic transfer of managers and administrators just as they gain enough experience to be effective upsets the whole program and impedes orderly, progressive development. It takes quality people to produce quality seed.

Figure 29. "Contrary to some opinion, seed production-processing-distribution requires knowledge and skills that are not part of the normal expertise and experiences of agricultural specialists."

## Education

Many cultivators and even agricultural workers in developing countries do not make any distinction between seed and grain. To them there is no difference and will be no difference until one is clearly and conclusively demonstrated.

Field demonstrations are best. High quality seed of superior varieties should be planted side-by-side with seed of traditional varieties in trials involving other inputs singularly and in various combinations. The levels of other inputs used - fertilizer, irrigation, pesticides, etc. - should be available. The cultivator should never have to say, "If I had or could get fertilizer and water, I could get yields like that too."

During the early development of the seed program, information-education workers should be thoroughly familiarized with the objectives, potential and time frame of the seed program, and assigned responsibility for informing the cultivators of the uses and benefits of improved seed through meetings, demonstrations, use of progressive farmers as change agents, and so on.

The timing of educational-demonstration programs is of utmost importance, particularly at the farmer level. Development of a keen interest in and strong desire for improved seed too long before seed are actually available leads to disappointment, loss of interest, and frustration of the program. Experience has also shown that broad spectrum "Plant Good Seed" programs are of little value and should be avoided until maybe after good seed are in general use. The early efforts in education on use of improved seed should be directed to specific targets - a few progressive farmers, a whole village, a specific district, etc. As the program gains momentum, then the target area can be broadened.

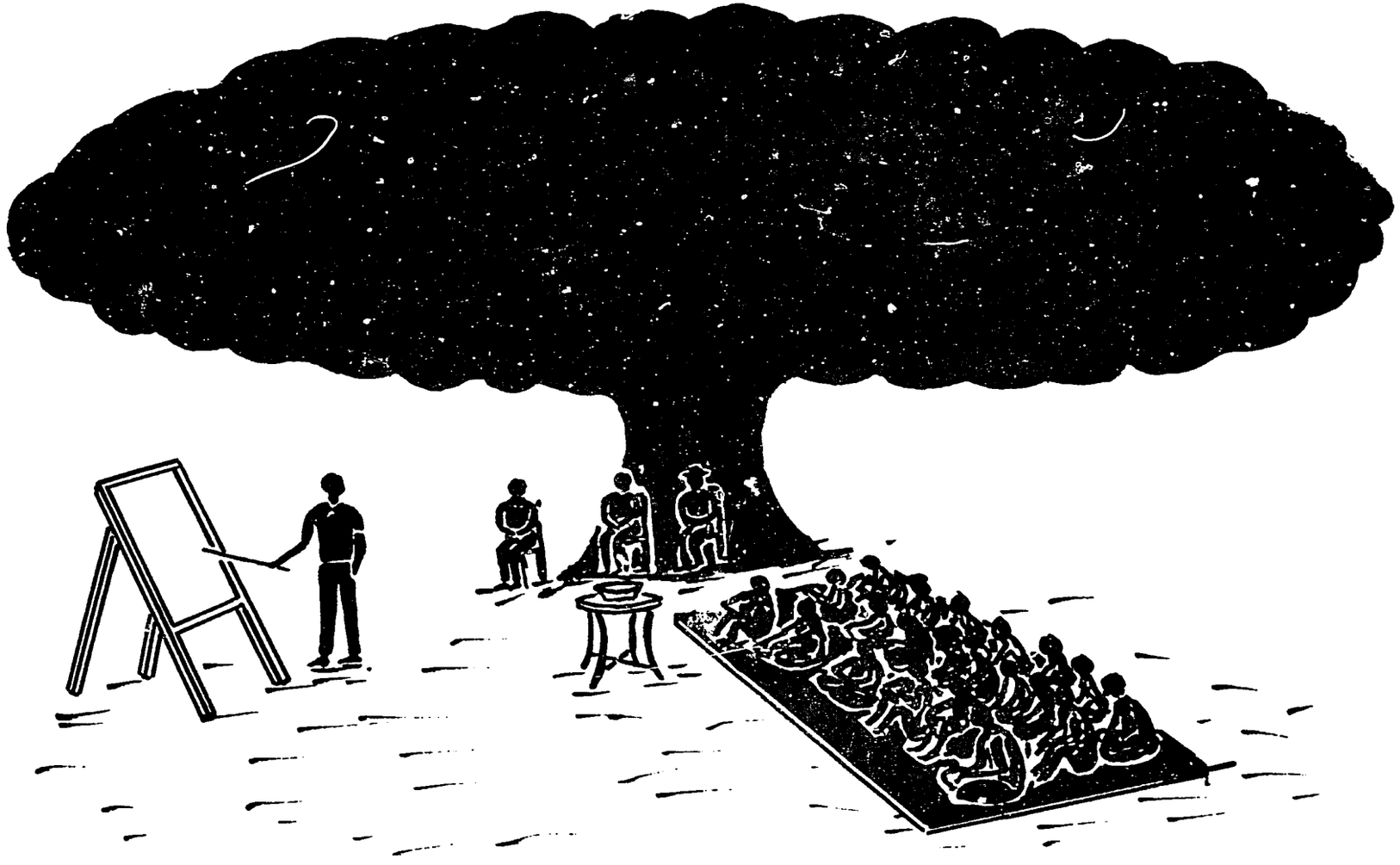


Figure 30. "Early efforts in education of cultivators in use of improved seed should be directed to specific targets - a few progressive farmers, a whole district, . . . "

## EVALUATION OF PROGRESS

Before progress can be measured there must be some factual information available concerning the seeds presently in use. "Educated guesses" or "official figures" are rarely useful in this respect. Two or three significant facts concerning production, processing, distribution and marketing of the principal seed crops are preferable to volumes of "guesstimates" concerning many species. These few, accurate facts can be very useful in the broad educational program. The cultivators will know if the facts are accurate and should be the primary source of this information.

The ultimate measure of success of a program is in increased crop productivity and quality per unit area. However, the planned targets and courses of action to meet this overall goal are vital to success and should be developed on a time phased basis recognizing that most, if not all, seed program operations will require a period of training. Several intermediate indicators of progress should be defined for each element of the program. All targets should include a measure of both quality and quantity because improvement comes from utilization of higher quality seed, as well as larger quantities of seed (e.g., larger acreage planted).

Frequently such program inputs as processing facilities, numbers of persons receiving training, etc., are listed as targets. These, however, are not targets, but inputs. Concrete outputs, i.e., 200 tons of seeds having a purity of 98% and a germination of 80%, or a 20% increase in the utilization of superior variety XX, etc., represent measurable targets.

In most countries it will be necessary to establish some of the technical facilities prior to starting on an education type effort. The modern proverb, "crash programs do just that" is applicable here.

It has been our experience and observation that comprehensive seed programs often fail because of poor fiscal and technical management and marketing. On the other hand, multiplication and production are often very successfully implemented. For these reasons, assistance and advice from competent consultants should be concentrated in the areas of planning, management, drying-processing, quality control and marketing.

# Appendices

## APPENDIX 1

## REPRESENTATIVE EQUIPMENT COSTS FOR SEED INSTALLATIONS

A seed program of any size will require an investment in hard currency for equipment and facilities associated with seed drying, processing, testing and storage. The number and capacity of the units will differ for each county and will usually have to be purchased off-shore. Buildings and other construction to house the facilities are usually of local fabrication and construction.

Readers of this section should be mindful that the design and layout for each installation must be specific. The facility can be very simple, consisting of only one or a few pieces of equipment, or very complex incorporating high capacity equipment with automatic devices. In effect, seed equipment can be compared to building blocks which are available in a wide variety of sizes (capacities) and prices. Through duplication, rearrangement, and substitution of the specific equipment cited it is possible to develop physical facilities to meet most situations. Prices used are approximate for 1971 and do not include freight, installation, or electrical wiring. Crating and freight add an average of 30-40% to the cost of the equipment, while material and labor for installing the equipment add another 25-40% (local currency).

### Seed Drying

A modern seed drying system includes (a) a fan and air distribution system which forces the air through seeds, (b) a controllable source of heat, (c) a drying chamber, (d) a means of loading and unloading the system, and (e) a source of energy to operate the mechanical equipment. The capacity of each of the components must be matched within the system, while the total system must be designed for the environment of the region in which the facility is to be located.

For drying seeds the "batch" drying system is preferred and alternate systems are not considered here. Two types of batch drying systems are recommended. One is the tunnel type sack dryer in which seeds in porous sacks are placed over openings in the air distribution system. The sack dryer is especially adaptable for breeder and foundation seed of agronomic crops, some vegetable seeds, and, in general, for situations wherein moderate size lots of several varieties of seed have to be dried at approximately the same time. Since the seed are in sacks, opportunities for mechanical mixing of varieties are minimized.

The second type of drying unit recommended for batch drying of seed is the bin system in which bulk seed (or sacked seed in some cases) are placed in bins and air is forced through the entire seed mass. Batch-in-bin drying is adaptable for all kinds of seed and for larger quantities of seed than can be efficiently handled with a sack dryer.

The heater and fan are the heart of any drying system. These can and should be purchased as complete units including the safety controls. The specific heat capacity and air delivery rate needed in the unit is determined primarily by the desired daily drying capacity. Drying units are available to fulfill needs for drying from a few bushels to many tons per day and range in cost from $500 to $15,000 or more.

The air distribution system must provide a uniform release of air through the seeds. The drying chamber can be steel, concrete, or wooden bins or other containers which restrict lateral air movement (or sacks in the case of the sack dryer). The loading and unloading of the dryers can be accomplished by hand, or perferably, elevators, drag or belt conveyors.

EXAMPLE 1. Tunnel or Sack Dryer (Figure 31 ).

The 256 sack (approximately 1000 bu) dryer illustrated utilizes a heater-fan unit capable of delivering a maximum of 1 million BTU/hr. and a 7 1/2 HP fan motor rated at 20,000 CFM air at 1 inch static pressure. It burns fuel oil and the complete unit costs approximately $4500. The drying deck, air tunnels and protective shed were all constructed of local materials. Loading and unloading of sacks is best accomplished by hand. It is ideal for a foundation seed program.

Summary of Costs for Example 1

Fan-Heater Unit with Controls . . . . . $4500
plus local construction of tunnel and shed

EXAMPLE II. Bin Drying System (Figure 32 ).

This example illustrates what can be termed a "typical" seed drying facility. The basic unit of the drying system consists of a 1000 bushel steel drying bin with a matched fan ($1200) and a 500,000 BTU portable heating unit ($600). It is multiplied by adding another independent drying bin and two sets of two bins each with common heater-fan/units (Y ducting). Additional capacity could be obtained either by adding more bins or by utilization of larger capacity bins (up to 20,000 bu), fans, and heater units.

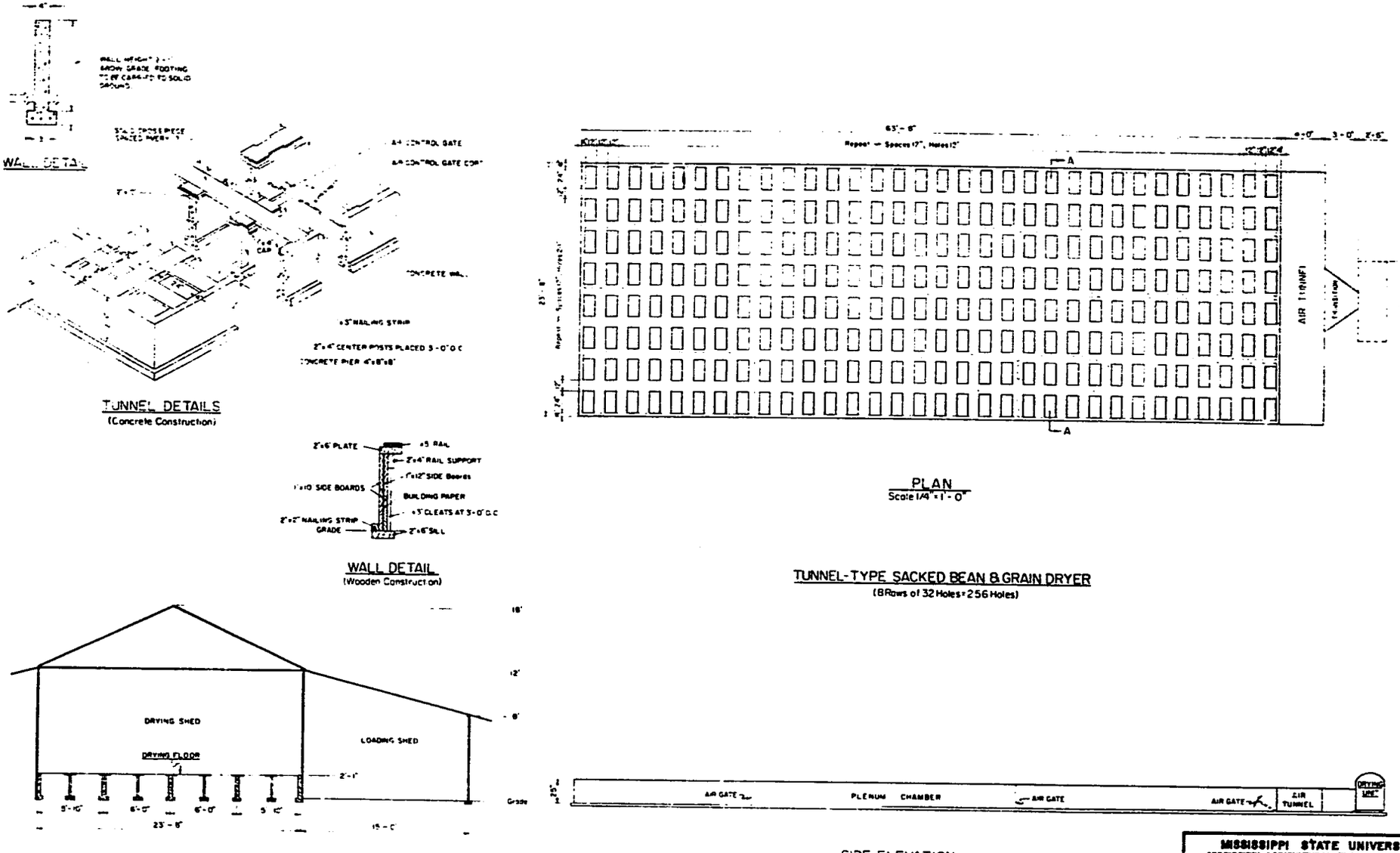

WALL DETAIL
TUNNEL DETAILS
(Concrete Construction)
WALL DETAIL
(Wooden Construction)
2"x6" PLATE
2"x4" RAIL SUPPORT
BUILDING PAPER
GRADE
PLAN
Scale 1/4" = 1'-0"
TUNNEL-TYPE SACKED BEAN & GRAIN DRYER
(8 Rows of 32 Holes = 256 Holes)
AIR TUNNEL
DRYING SHED
DRYING FLOOR
LOADING SHED
ELEVATION SECTION A-A
Scale 1/4" = 1'-0"
AIR GATE
PLENUM CHAMBER
AIR TUNNEL
SIDE ELEVATION
Scale 1/4" = 1'-0"
MISSISSIPPI STATE UNIVERSITY
MISSISSIPPI AGRICULTURAL EXPERIMENT STATION
SEED TECHNOLOGY LABORATORY
STATE COLLEGE, MISSISSIPPI
BEAN DRYING FACILITY
HONDURAN SEED PROGRAM
TEGUCIGALPA, HONDURAS
DESIGNED BY: JCD, GMD, DW, JB
DRAWN BY: JMB
APPROVED BY: JCD
DATE: JANUARY 1966
FILE NO.
SHEET
4 of 7

Figure 31

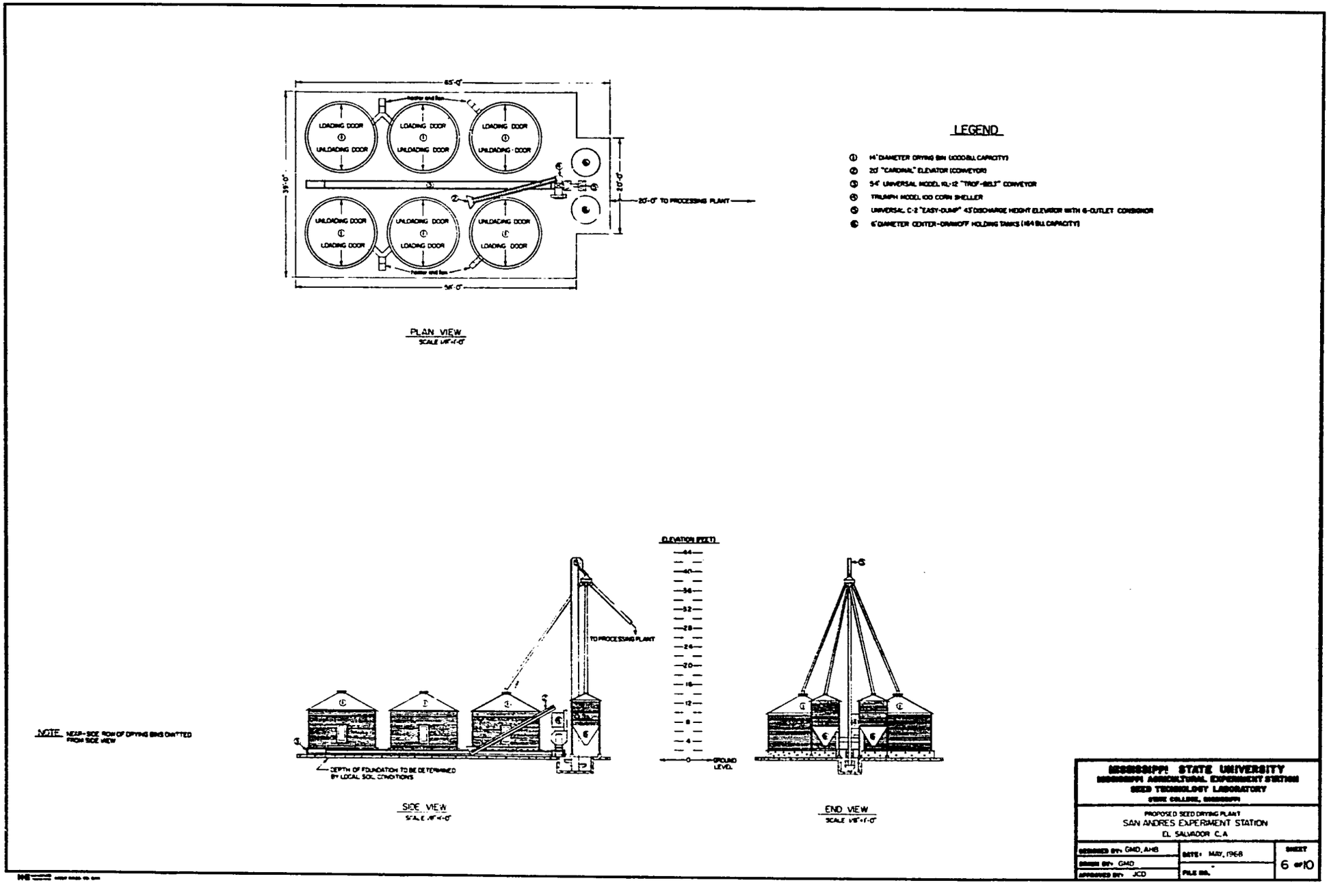

LEGEND
① 14' DIAMETER DRYING BIN (1000 BU. CAPACITY)
② 20' "CARDINAL" ELEVATOR (CONVEYOR)
③ 54' UNIVERSAL MODEL KL-12 "TROF-BELT" CONVEYOR
④ TRIUMPH MODEL 100 CORN SHELLER
⑤ UNIVERSAL C-2 "EASY-DUMP" 43' DISCHARGE HEIGHT ELEVATOR WITH 6-OUTLET CONSIGNOR
⑥ 6' DIAMETER CENTER-DRAWOFF HOLDING TANKS (164 BU. CAPACITY)
LOADING DOOR
UNLOADING DOOR
20'-0" TO PROCESSING PLANT
PLAN VIEW
SCALE 1/8"=1'-0"
TO PROCESSING PLANT
DEPTH OF FOUNDATION TO BE DETERMINED BY LOCAL SOIL CONDITIONS
SIDE VIEW
SCALE 1/8"=1'-0"
ELEVATION (FEET)
GROUND LEVEL
END VIEW
SCALE 1/8"=1'-0"
NOTE: NEAR-SIDE ROW OF DRYING BINS OMITTED FROM SIDE VIEW
MISSISSIPPI STATE UNIVERSITY
MISSISSIPPI AGRICULTURAL EXPERIMENT STATION
SEED TECHNOLOGY LABORATORY
STATE COLLEGE, MISSISSIPPI
PROPOSED SEED DRYING PLANT
SAN ANDRES EXPERIMENT STATION
EL SALVADOR, C.A.
DESIGNED BY: GMD, AHB
DRAWN BY: GMD
APPROVED BY: JCD
DATE: MAY, 1968
FILE NO.
SHEET 6 of 10

Figure 32

All seed are received and dried in bags, or bulk, therefore, loading and unloading conveyors are provided. A 30 ft. drag conveyor ($800) is utilized to top load the bins. After the seeds are dry the bins are unloaded onto a belt conveyor ($2000) and moved to a 10 ton/hr. capacity elevator ($1500) where they are lifted into the surge bins of the processing plant.

The system illustrated was designed for a capacity of 6-8 tons of dried seed per day. Since the incoming ear corn is too moist to shell it is partially dried, then shelled and finally drying is completed. To accomplish this a 5T per hour corn sheller ($900) with 20 ft. drag loading conveyor ($600) were included with a recirculation from sheller to the dryer accomplished by the main elevator. The two small hopper bottom holding bins ($450 ea.) are utilized for holding small lots of dried seeds adding to the flexibility of the entire unit. The total equipment costs for this facility are $16,300. Total capacity of the system could be increased 67% for less than 40% of the basic cost by adding four additional drying bins with fans ($4800), two heater units ($1200) and extending the belt conveyor 30 ft. ($750).

Summary of Equipment Costs in Example II

| No. | Item | Rating | Unit Price | Total Cost |
|---|---|---|---|---|
| 6 | 14 ft. diameter steel drying bins/with fans | 24T | $1200 | $7200 |
| 4 | Heater units and ducts | 500,000 BTU | 600 | 2400 |
| 1 | 30 ft. drag conveyor | 10T/hr | 800 | 800 |
| 1 | 20 ft. drag conveyor | 10T/hr | 600 | 600 |
| 1 | 52 belt conveyor | 15T/hr | 2000 | 2000 |
| 1 | 43 ft. belt-bucket elevator | 15T/hr | 1500 | 1500 |
| 1 | Corn sheller - tractor powered | 10T/hr | 900 | 900 |
| 2 | 6 ft. diameter holdings with hopper bottoms | 5 T | 450 | 900 |

Plus, site preparation, concrete foundation work, etc.

TOTAL $16,300

## Seed Processing

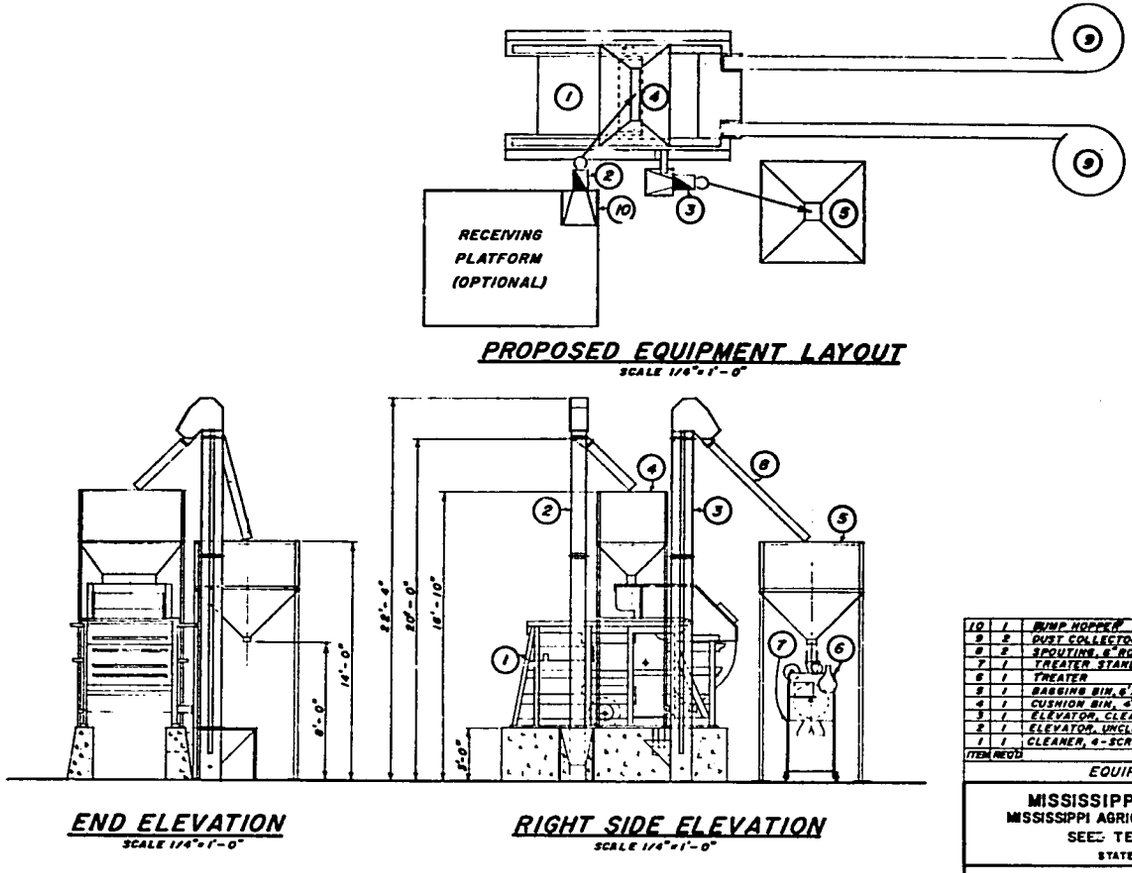
The basic machine of a seed processing facility is an air-screen cleaner. The minimum recommended is a 3 screen - 1 air system cleaner with an operating capacity of 1.0 to 2T per hr. An air-screen machine of this type costs approximately $3500. Add to it a 10 T/hr belt bucket elevator ($750) to lift the seed to the hopper of the air-screen cleaner and another to lift the clean seed to a bagging bin and the basic processing system is complete for an equipment cost of about $6000. This unit will have an effective capacity of about 12 tons of seed per 10 hr. working day. By adding a weigher-bagger ($500) and a small portable sewing machine ($350) the same personnel can be utilized but capacity will be increased to 15 T per day due to added efficiency. Procurement of a portable seed treater ($1750) will permit treatment of all or selected lots of seed with insecticides or fungicides before bagging.

EXAMPLE III. Basic Seed Processing Unit (Figure 33).

The equipment for the basic processing plant illustrated in Figure 33 costs approximately $7600 (FOB manufacturer). Additional items such as spouting, dust collectors, holding bins, machinery bases, electrical controls, wiring and the building can be purchased or fabricated locally in most countries at a lower cost than importing these materials. These, however, must be added to the costs.

Summary of Costs - Example III

| No. | Item | Rating | Unit Cost | Total Cost |
|---|---|---|---|---|
| 1 | 3 screen - 2 air cleaner | 2-3T/hr | $3500 | $3500 |
| 1 | Slurry or liquid seed treater | 10T/hr | 1750 | 1750 |
| 2 | 20 ft. belt bucket seed elevators | 10T/hr | 750 | 1500 |
| 1 | Semi automatic bagger-weigher | | 500 | 500 |
| 1 | Heavy duty portable sewing machine | | 350 | 350 |
| 1 | Heavy duty scales | 5-20 T | local purchase | ($3000) |
| 2 | Holding bins | 2 1/2 T | local fabrication | ($300 ea.) |




| ITEM | REQ'D | DESCRIPTION |
|---|---|---|
| 10 | 1 | BUMP HOPPER |
| 9 | 2 | DUST COLLECTOR |
| 8 | 2 | SPOUTING, 6" ROUND |
| 7 | 1 | TREATER STAND ON WHEELS & WITH BAG PLATFORM |
| 6 | 1 | TREATER |
| 5 | 1 | BAGGING BIN, 6'x6' |
| 4 | 1 | CUSHION BIN, 4'x6' |
| 3 | 1 | ELEVATOR, CLEAN SEED |
| 2 | 1 | ELEVATOR, UNCLEANED SEED |
| 1 | 1 | CLEANER, 4-SCREEN, TWO AIR TYPE |

EQUIPMENT SCHEDULE

MISSISSIPPI STATE UNIVERSITY
MISSISSIPPI AGRICULTURAL EXPERIMENT STATION
SEED TECHNOLOGY LABORATORY
STATE COLLEGE, MISSISSIPPI

SEED CLEANER-ELEVATORS-TREATER
SEED INSPECTION STATION
RIO GRANDE DO SUL, BRAZIL

DESIGNED BY: J. M. BECK
DRAWN BY: JMB
APPROVED BY: HDB
DATE: SEPT - 1963
FILE NO. LA - 0563
SHEET 1 OF 1

Figure 33

| No. | Item | Rating | Unit Price | Total Cost |
|---|---|---|---|---|
| 2 | Dust collectors | | local fabrication | ($300 ea.) |
| | | Total Equipment Costs | | $7600 |

plus, cost of controls, electrical equipment, miscellaneous supplies, installation, and construction of processing shed.

The processing unit in Example III is satisfactory only if the seed are relatively free of inert material and other seeds of the same size and weight as the seed being cleaned, contain little insect or disease damaged seeds, and the seeds do not require precise grading. Most seed lots, however, require additional processing beyond cleaning with the air-screen cleaner. Machines are available which can precisely separate seeds on the basis of differences in physical properties, i.e., length, width, thickness, degree of roundness, specific gravity, texture of the seed coat, and color. Before cleaning is possible, seeds of some species must be pre-conditioned to remove unwanted parts of the fruit, break up seed clusters, remove hulls, etc.

By adding a gravity separator ($1500), another elevator ($750), and another holding bin to the basic layout in Example III, the quality of seed lots with insect damage, diseases, or damaged seed can be improved. If seed lots which normally contain material of different lengths, i.e., broken seeds, stems, other crop or weed seeds, are to be processed, rice for example, the addition of a disc separator ($1750-3000) may be necessary as well as another holding bin and elevator.

EXAMPLE IV. Multi-Purpose Processing Plant (Figure 34 ).

When seeds that require grading (ex. corn) are to be processed, sizing equipment must be added along with holding bins and elevators. Example IV is a plan for a multi-purpose processing plant. In this plant a higher capacity air-screen cleaner with 4 screens and 2 air systems is specified.

Summary of Costs for Example IV

| No. | Item | Capacity | Unit Price | Total |
|---|---|---|---|---|
| 1 | Air-screen cleaner (4 screen, 2 air-systems) | 3-6 T/hr | $5500-7000 | $7000 |
| 2 | Width & thickness graders | 1-2 T/hr | 1800 | 3600 |

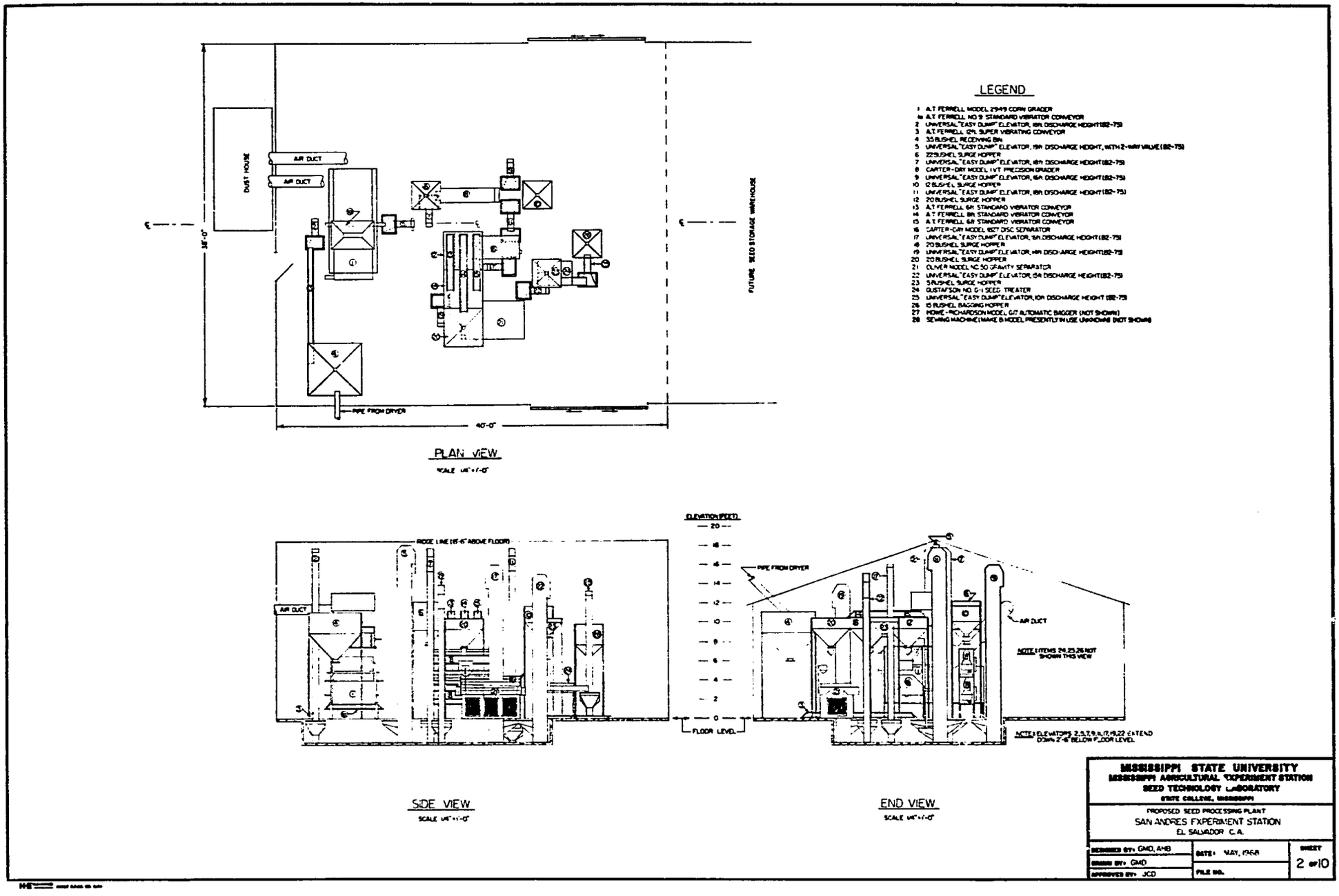

DUST HOUSE
AIR DUCT
AIR DUCT
PIPE FROM DRYER
40'-0"
FUTURE SEED STORAGE WAREHOUSE
PLAN VIEW
SCALE 1/8" = 1'-0"
LEGEND
1 A.T. FERRELL MODEL 2949 CORN GRADER
2 UNIVERSAL "EASY DUMP" ELEVATOR, 18A DISCHARGE HEIGHT (82-75)
3 A.T. FERRELL 12A SUPER VIBRATING CONVEYOR
4 35 BUSHEL RECEIVING BIN
5 UNIVERSAL "EASY DUMP" ELEVATOR, 19A DISCHARGE HEIGHT, WITH 2-WAY VALVE (82-75)
6 22 BUSHEL SURGE HOPPER
7 UNIVERSAL "EASY DUMP" ELEVATOR, 18A DISCHARGE HEIGHT (82-75)
8 CARTER-DAY MODEL 1VT PRECISION GRADER
9 UNIVERSAL "EASY DUMP" ELEVATOR, 16A DISCHARGE HEIGHT (82-75)
10 12 BUSHEL SURGE HOPPER
11 UNIVERSAL "EASY DUMP" ELEVATOR, 18A DISCHARGE HEIGHT (82-75)
12 20 BUSHEL SURGE HOPPER
13 A.T. FERRELL 6A STANDARD VIBRATOR CONVEYOR
14 A.T. FERRELL 8A STANDARD VIBRATOR CONVEYOR
15 A.T. FERRELL 6A STANDARD VIBRATOR CONVEYOR
16 CARTER-DAY MODEL 82T DISC SEPARATOR
17 UNIVERSAL "EASY DUMP" ELEVATOR, 9A DISCHARGE HEIGHT (82-75)
18 20 BUSHEL SURGE HOPPER
19 UNIVERSAL "EASY DUMP" ELEVATOR, 14A DISCHARGE HEIGHT (82-75)
20 20 BUSHEL SURGE HOPPER
21 OLIVER MODEL NC 50 GRAVITY SEPARATOR
22 UNIVERSAL "EASY DUMP" ELEVATOR, 15A DISCHARGE HEIGHT (82-75)
23 5 BUSHEL SURGE HOPPER
24 GUSTAFSON NO. G-1 SEED TREATER
25 UNIVERSAL "EASY DUMP" ELEVATOR, 10A DISCHARGE HEIGHT (82-75)
26 15 BUSHEL BAGGING HOPPER
27 HOWE-RICHARDSON MODEL G17 AUTOMATIC BAGGER (NOT SHOWN)
28 SEWING MACHINE (MAKE & MODEL PRESENTLY IN USE UNKNOWN) (NOT SHOWN)
RIDGE LINE (15'-6" ABOVE FLOOR)
AIR DUCT
SIDE VIEW
SCALE 1/8" = 1'-0"
ELEVATION (FEET)
20
18
16
14
12
10
8
6
4
2
0
FLOOR LEVEL
PIPE FROM DRYER
AIR DUCT
NOTE: ITEMS 24,25,26 NOT SHOWN THIS VIEW
NOTE: ELEVATORS 2,5,7,9,11,17,19,22 EXTEND DOWN 2'-6" BELOW FLOOR LEVEL
END VIEW
SCALE 1/8" = 1'-0"
MISSISSIPPI STATE UNIVERSITY
MISSISSIPPI AGRICULTURAL EXPERIMENT STATION
SEED TECHNOLOGY LABORATORY
STATE COLLEGE, MISSISSIPPI
PROPOSED SEED PROCESSING PLANT
SAN ANDRES EXPERIMENT STATION
EL SALVADOR C.A.
DESIGNED BY: GMD, AHB
DRAWN BY: GMD
APPROVED BY: JCD
DATE: MAY, 1968
FILE NO.
SHEET
2 of 10

Figure 34

Summary of Costs, Continued -

| | | | | |
|---|---|---|---|---|
| 1 | Gravity separator | 1-3 T/hr | 1500 | 1500 |
| 1 | Disc separator | 1-3 T/hr | 1750 | 1750 |
| 5 | Belt bucket elevators of various heights | 10 T/hr | 800 | 4000 |
| 1 | Seed treater for slurry or liquids | 10 T/hr | 1750 | 1750 |
| 1 | Semi automatic bagger weigher | | 500 | 500 |
| 1 | Portable sewing machine | | 350 | 350 |
| | | Total Equipment Costs | | $20,450 |

plus, installation, fabrication of 7 holding bins, spoutings, miscellaneous equipment - local fabrication

and, cost of building.

EXAMPLE V. Variation of Multi-Purpose Processing Plant (Figure 35 )

The plant in Figure 35 has essentially the same equipment as the one in Figure 34 but it is arranged on one floor rather than two. The single floor arrangement requires an additional 20 ft. belt-bucket elevator and holding bin to maintain the same capacity. This extra cost is offset, however, by a reduction in the cost of platform framing. In addition, the plant illustrated in Figure 35 has two 500 bushel drying bins and a 24 sack drying unit. The drying bins were constructed locally, while the two 500,000 BTU heaters are the same as the one in Example II. At this installation most incoming seed require little or no drying. The total cost of the equipment and installation, excluding the building and heater units, is approximately US $45,000. In full operation it will process an average of 10-12 tons of clean seed per 10 hour day of all major crops.

## Conditioned Seed Storage Facilities

To preserve the viability of seed that do not store well, or any seed for periods longer than 6-9 months under tropical conditions, it is necessary to reduce the temperature and/or relative humidity (of the air) inside the storage facility. In many instances existing building or rooms can be suitably converted by installing refrigeration and/or dehumidification equipment in the room after renovation and installation of insulation and/or vapor barriers (asphalt paint, aluminum or plastic film, or light weight sheet metal).

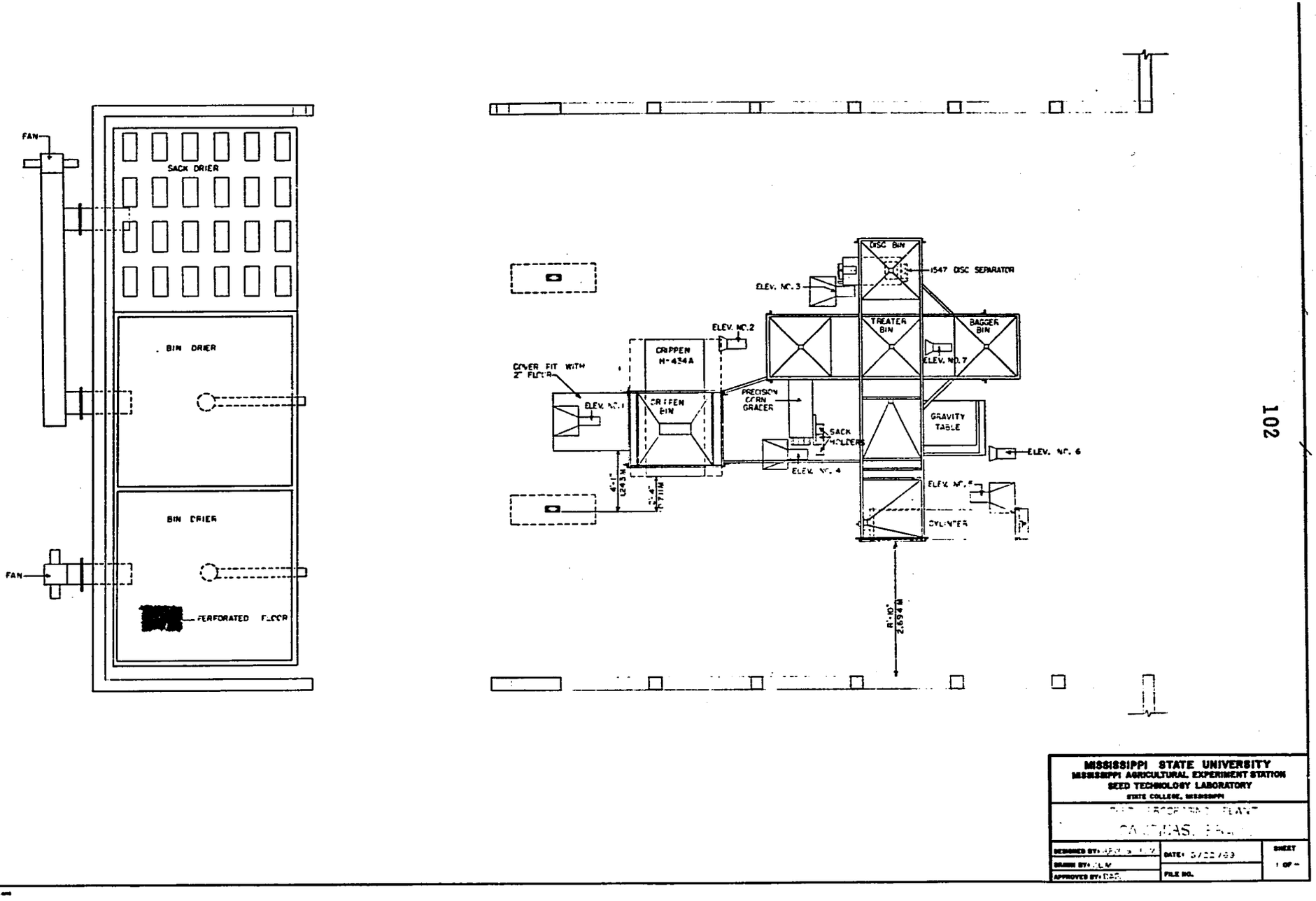

FAN
SACK DRIER
BIN DRIER
BIN DRIER
FAN
PERFORATED FLOOR
DISC BIN
1547 DISC SEPARATOR
ELEV. NO. 3
ELEV. NO. 2
TREATER BIN
BAGGER BIN
ELEV. NO. 7
CRIPPEN M-434A
COVER FIT WITH 2" FLOOR
ELEV. NO. 1
CRIPPEN BIN
PRECISION CORN GRADER
SACK HOLDERS
GRAVITY TABLE
ELEV. NO. 6
ELEV. NO. 4
ELEV. NO. 5
CYLINDER
4'-1" 1.243 M
5'-4" 1.711 M
8'-10" 2.694 M
MISSISSIPPI STATE UNIVERSITY
MISSISSIPPI AGRICULTURAL EXPERIMENT STATION
SEED TECHNOLOGY LABORATORY
STATE COLLEGE, MISSISSIPPI
DESIGNED BY:
DRAWN BY:
APPROVED BY:
DATE:
FILE NO.
SHEET
1 OF

Figure 35

Example VI. Air-Conditioned Storage Facility

Two 24,000 BTU heavy duty window air conditioners can maintain adequate conditions for storage up to 20 months in an area 100 ft. x 50 ft. x 10 ft. (height), if 2 inches of insulation and a vapor proof barrier are added to the walls, ceiling, and floors, and a heavy duty refrigeration type door is used. Two hundred tons of bagged seed can be stored in such a facility. Two air conditioners are always preferable to one because of the safety factor provided if one unit malfunctions.

In tropical areas where ambient temperatures average 80°F. or less but the relative humidity is high (70% or above), it may be preferable to install only a dehumidifier and vapor proof the storage area. To maintain 40% R.H. inside a 100 ft. x 50 ft. x 10 ft. room, two 80 lb/da. dessicant type dehumidification units are required. Because of heat liberated, dehumidifiers must have air coolers attached or a 12-18,000 BTU window air conditioner must be installed to compensate for the head added by the dehumidification process.

Summary of Equipment and Supply Costs for Air Conditioned Storage

| No. | Item | Rating | Unit Price | Total Cost |
|---|---|---|---|---|
| 2 | Heavy duty air conditioning units | 24,000 BTU | $ 600 | $1200 |
| | 13,000 sq. ft. of 2 in. styrofoam insulation | | | 4500 |
| | 65 gal. adhesive asphalt paint | | | 700 |
| 1 | 4 foot refrigerator door | | 500 | 500 |
| | | | Total Cost | $6900 |
| | OR | | | |
| 2 | Dessicant type dehumidifiers | 80 pints/day | 2200 | 4400 |
| 2 | Air conditioners | 14,000 BTU | 500 | 1000 |
| | 130 gal. asphalt base paint | | 11 | 1400 |
| | | | Total Cost | $[illegible] |

EXAMPLE VII. Seed Cold Storage Facility (Figure 36 )

Storage of seeds for more than 1 year under tropical conditions will normally require both dehumidification and refrigeration. Because these rooms are mostly required for storage of small quantities of valuable breeder and foundation seed stocks or vegetable seed, they normally are only 1500 to 2000 cu. ft. in size.

Figure 36 illustrates some of the details of a room designed for long term storage of seeds. In this example a condensor type commercial refrigeration unit both cools and dehumidifies the air. To reduce operational costs and equipment capacity requirements, the room is both moisture vapor proofed and well insulated.

Summary of Equipment and Supply Costs for Cold Storage Room

| | |
|---|---|
| Refrigeration unit with heater strip and controls | $3000 |
| 800 sq. ft. insulation (4" styrofoam equivalent) | 300 |
| 900 sq. ft. vapor barrier (6 mil polyeythelene) | 50 |
| Adhesive | 100 |
| 1 Refrigeration door | 500 |
| Total Cost | $3950 |
| plus, plaster or wood covering for insulation | local purchase |

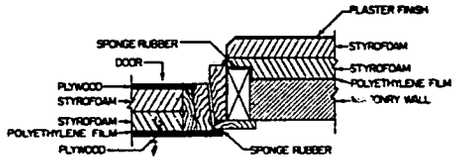
Seed Testing Laboratory

A seed testing laboratory consists of three major work areas (a) preparation area, (b) purity analysis area, and (c) germination area. Office and supply storage space must be provided and conveniently located. The specific design of the laboratory is relatively unimportant, but the spatial relationships of the principal work areas and location of equipment within these areas are important.

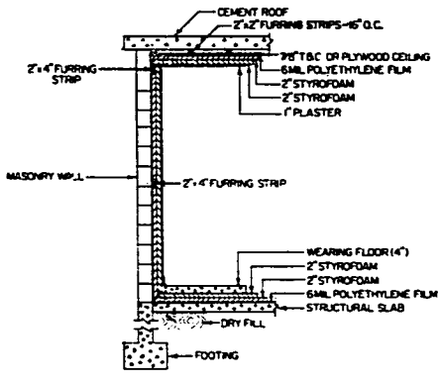
EXAMPLE VIII. Seed Testing Laboratory (Figure 37 ).

Figure 37 shows the floor plan for both a seed testing and grain grading laboratory which allows sharing of reception and preparation areas.

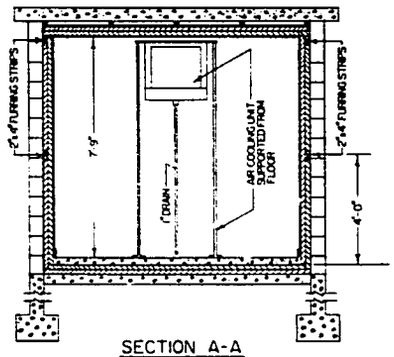
The annual capacity of a seed testing laboratory depends upon the kinds of seeds tested, number and efficiency of the personnel and the equipment available. For most of the common food grains a properly equipped laboratory should have an annual capacity of 1000-1500 samples per analyst per year.



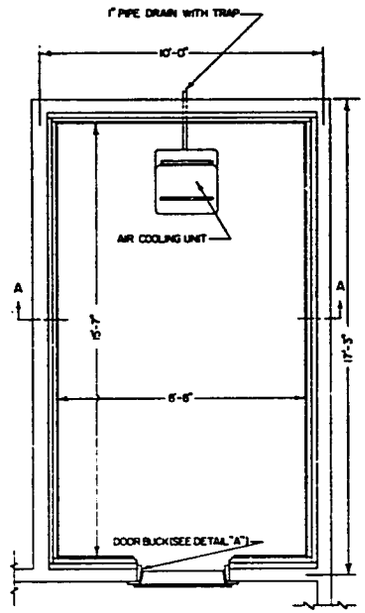

DETAIL "A"
NO SCALE




OUTSIDE WALL SECTION




SECTION A-A

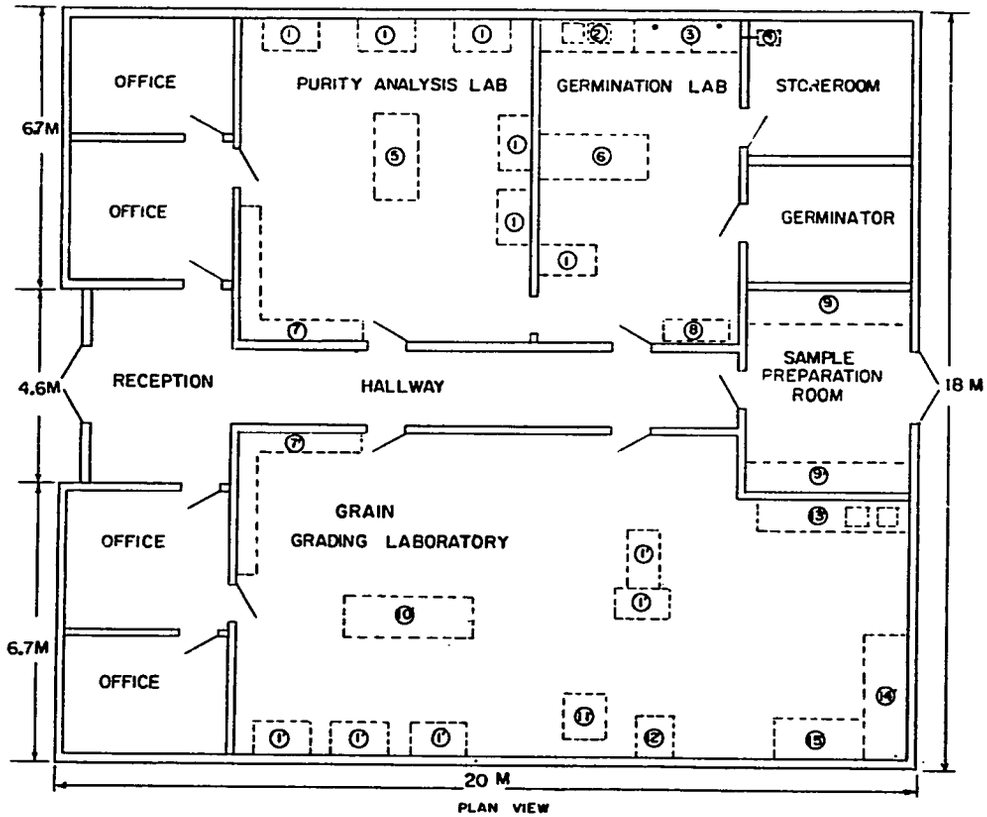



PLAN

SCALE = 1/2" = 1'-0"

| | |
|---|---|
| MISSISSIPPI STATE UNIVERSITY<br>MISSISSIPPI AGRICULTURAL EXPERIMENT STATION<br>SEED TECHNOLOGY LABORATORY<br>STATE COLLEGE, MISSISSIPPI | |
| PROPOSED COLD STORAGE ROOM<br>SAN ANDRES EXPERIMENT STATION<br>EL SALVADOR C.A. | |
| DESIGNED BY: GMD, AHB<br>DRAWN BY: GMD<br>APPROVED BY: JCD | DATE: MAY, 1968 (REVISED JUNE, 1968)<br>FILE NO. |
| SHEET 10 OF 10 | |

Figure 30




PLAN VIEW

SCALE 1:50

DESCRIPTION OF NUMBERED ITEMS

1. Laboratory work tables - purity analysis
2. Cabinet with double sink
3. Laboratory table - germination preparation
4. Vacuum power count unit
5. Laboratory table - balances and dividers
6. Laboratory table - germination evaluation
7. Book and reference materia. shelves
8. Germinator
9. Cabinet - sample preparation

MISSISSIPPI STATE UNIVERSITY
MISSISSIPPI AGRICULTURAL EXPERIMENT STATION
SEED TECHNOLOGY LABORATORY
STATE COLLEGE, MISSISSIPPI

GRAIN AND SEED LABORATORY
UNIVERSITY OF COSTA RICA

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DATE: NOV. 1970
FILE NO.
SHEET 1 OF 2

Figure 37

Summary of Equipment Costs for Seed Testing Laboratory

| | |
|---|---|
| Preparation and Purity Equipment | $4,500 |
| Germination Equipment | 8,000 |
| Miscellaneous Equipment and Initial Supplies | 1,500 |
| | $14,000 |

Plus, Furniture - tables, cabinets, shelves, benches, etc., (local purchase).

## Check-List for Planning Seed Facilities

In the foregoing discussion and examples, we have considered typical costs and layouts for several types of seed facilities. Keep in mind that the design for each installation must be specific for the conditions in which it will be located, and the capacity desired. Before determining the type and specific equipment needs of any facility consideration should be given to the following factors.

Location:

(1) Proximity of transportation arteries

(2) Convenience to production areas

(3) Physical advantages or disadvantages of the proposed site

(4) Possibility for expansion of facility

Type:

(1) Kinds of seed to be handled and processing to be completed

(2) Size of seed lots and total quantity

(3) Approximate percentages of contaminants

(4) Pre- or post-handling special requirements

Operation:

(1) Length of operational season and schedule of delivery (of seed)

(2) Working hours per day

(3) Days operation per week

(4) Size of working force

Facilities:

(1) Receiving methods and maximum quantities that need to be handled (per day)

(2) Storage facilities - existing or required for incoming seed

(3) Type, size and number of bins or containers to allow intermittant or continuous movement of seed through the facility

(4) Rapidity and method of movement of packaged seed from the facility

Consideration of these factors will establish the type and scope of the facility(s). The size and type equipment needed can then be determined.

The next phase in planning the new facility is to draw a preliminary flow diagram showing all equipment, intermediate storage (bins) and accessories within a space (building or room of building). This flow diagram need not be complicated but should be reasonably accurate as to scale. It is a simple yet positive way to visualize each step or phase of the total operation.

After the flow diagram is finalized, costs can be estimated. Quite accurate cost estimates of buildings can be made if square footage and special structural features are known. Costs of equipment can be obtained by requesting pro-forma invoices from suppliers based on specifications.

## APPENDIX II

## CHECK LISTS OF OPERATIONAL EXPENSES FOR SEED PROGRAM-INDUSTRIES

When planning the financing of the various segments of a comprehensive seed program the following factors must be kept in mind:

(a) Certain costs will re-occur every year or season

(b) These costs occur whether they are recovered or ignored.

(c) Payment of these costs is usually the responsibility of the individual, company or governmental agency involved.

(d) Provisions for paying these costs is an integral part of the planning and implementation process.

"Why do seed cost more than I receive from my grain?" and "What is meant by 'reasonably priced' seed?" are two of the most frequently asked questions by cultivators and government workers having their first contact with a seed program. The answer to both questions lies in the additional costs encountered in the production, preparation and marketing of seed as compared with grain. In a private enterprise system profit, or return on investment, must be added to the above costs.

To assist persons who have not had the opportunity to analyze the costs involved in the production, preparation and distribution of seeds the following check list of major operational costs is given in the form of a general comparison with grain production costs. The list does not include capital investment costs but does provide for replacement of equipment. In our comparison the "final products" are mechanically dryed, cleaned and graded seed of good germination and varietal purity packaged in new 50 kg. bags,and naturally dried, winnowed grain packaged in used 100 kg. bags.

## I. Production

| Cost Item | Comparative Cost | |
|---|---|---|
| | Seed | Grain |
| Salaries - permanent employees | = | = |
| Temporary labor - general | = | = |
| Equipment operation and maintenance | = | = |
| Workman's benefits | = | = |
| Depreciation on equipment | = | = |
| Insurance and taxes | = | = |
| Interest (production loan) | + 10% | = |
| Land preparation | = | = |
| Fertilizer | = | = |
| Seed | + 50% | |
| Pesticides | = | = |
| Irrigation | = | = |
| Planting | = | = |
| Rouging (labor) | +100% | 0 |
| Inspection fees | +100% | 0 |
| Harvesting | + 25% | |
| Transport to market or processor | = | = |

It is evident from the above list that the production costs of non-hybrid seeds are only slightly higher than those of grain, usually 10-20%. Additional costs, however, can be incurred in seed production due to isolation requirements (less efficient use of land), yield reductions due to breakage and removal of plants during inspection and rouging, additional labor required to clean planting and harvesting equipment to prevent contamination, etc.

In most countries grain is marketed near the area of production. Therefore, other than storage and its associated costs little additional expense is incurred before utilization or milling.

The same is not true for seed, which do require additional processing. For this reason comparisons between seed and grain cannot be made beyond the production stage. Even in countries where grain handling and marketing is highly developed, operational costs for drying, processing, storage, marketing, and distribution of seed are substantially greater than those for equal quantities of grain. This is because of the smaller volume or tonnage and the special handling required for seed.

## II. Drying, Processing and Storage of Seed

| Cost Item | Remarks |
|---|---|
| a. Salaries (permanent employees) | Need trained workers |
| b. Temporary labor | Highly seasonal |
| c. Workman's benefits | |
| d. Equipment maintenance and repair | Equipment must be maintained in an operable condition |
| e. Depreciation on equipment | |
| f. Office supplies and maintenance | |
| g. Insurance and taxes | |
| h. Interest on working capital | Slow turnover |
| i. Cost of uncleaned seed | When produced under contract |
| j. Handling, breakage, and quality losses | Can amount to 10-15% of total volume of seed handled |
| k. Processing loss | About 10%, half of which can be recovered for grain |
| l. Bags, tags, closures | New bags required |
| m. Rodent and insect control | |
| n. Inspection and testing fees | |
| o. Seed treatment materials | When applied eliminates alternative used of seed |
| p. Travel and subsistence | Salesmen |
| q. Communications and postage | Advertising |
| r. Fuel, electricity and water | |

## III. Marketing and Distribution [1]

| Cost Item | Remarks |
|---|---|
| a. Salaries (permanent employees) | |
| b. Temporary labor | Highly seasonal |
| c. Workman's benefits | |
| d. Equipment maintenance and repair | Mainly transport and storage |
| e. Office supplies and maintenance | |
| f. Insurance and taxes | |
| g. Interest on working capital | |
| h. Transportation and handling | A major cost item |
| i. Advertisement and promotion | |
| j. Analysis and testing fees | |
| k. Communications and postage | |
| l. Subsistence costs for salesmen | |
| m. Collection fees and unpaid bills | |
| n. Loss from breakage and reduced quality | |

The above listing is illustrative only and is by no means a strict cost-accounting breakdown of expenses.

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[1] Because seed are perishable and sold in small quantities to many buyers only once or twice a year, the distributional costs are usually higher than for grain, fertilizer, and farm chemicals.

# APPENDIX III

## SOME IMPEDIMENTS TO INDIGENOUS AND FOREIGN PRIVATE SECTOR PARTICIPATION IN DEVELOPMENT OF SEED PROGRAMS

### Indigenous Private Sector Participation

There are many reasons why an indigenous private sector component of the seed program-industry of the less developed countries has not or cannot develop. The impediments to participation are both technical and socio-economic in nature and often require for their elimination difficult concessions on the part of government officials trained under the authoritarian socio-political traditions common to many developing countries. Furthermore, the majority of foreign technical advisors assisting with the development of private sector agricultural enterprises have neither the training nor experience in commercial business practices to be of much help in this area.

Lack of financial incentive is perhaps the chief impediment to indigenous private sector participation in seed program development. Few individuals or firms willingly invest money in a business venture which offers a lesser opportunity for return on investment than can be achieved by alternative investments of which there are many in most developing countries.

The seed business is characterized by high investment and slow turnover and "contains" the risks of both manufacturing and farming, plus, some that are unique. Seed are also the only major agricultural input that is reproducible on the farm; thus, the cost of seed is usually the first out-of-pocket expense to be cut by farmers in a financial squeeze. Additionally, many cultivators have become so dependent upon subsidized seed prices that the prices necessarily charged by private seedsmen are considered to be too high if not outrageous.

In summary, the private sector component of the seed program does not develop because the opportunity for profit (return on money invested) falls below that offered by alternative investments. Without private investment there is no private enterprise.

Additional impediments encountered by private sector participants in seed program-industry development include:

(1) A lack of technically trained, indigenous manpower with business acumen required to develop and implement private sector operations, i.e., no managers.

(2) Poor coordination and continuity in varietal development programs and the lack of coordination and cooperation between research agencies and those responsible for the orderly multiplication and distribution of improved varieties.

(3) No effective educational program to create an awareness of the advantages of using improved seed among farmers, credit institutions, and other farm related enterprises and advisory agencies.

(4) Lack of governmental leadership and planning to assure the orderly integration of the several technical disciplines of the public sector necessary for seed program development.

(5) Direct competition and serious conflicts between the public and private sectors in the development of seed processing, marketing and distribution systems.

(6) Unrealistic price policies that fail to differentiate between seed and grain.

(7) Undue harrassment of private sector participants by government officials.

(8) Too much dependence of cultivators on government subsidies including "free" seed programs.

(9) Farmer and public sector hesitancy to accept private industry in the agricultural sector because of past abuses and dishonest business practices.

## Offshore Private Sector Participation

Private seed companies from the more developed countries constantly search for both new production and marketing opportunities. These are largely restricted to seeds of hybrids or specialty crops, i.e., vegetables, flowers, and forages, because the potential return on investments in seed of self pollinated, easily reproducible varieties is limited. Nevertheless, established private companies working in conjunction with indigenous companies could help to resolve many of the technical and financial problems of developing seed program-industries.

A survey of American seed companies who have had both seed marketing and production experiences in foreign countries identified many impediments to "normal" commercial operations in other countries. The impediments are classified according to source or cause and listed in order of frequency reported.

Developmental and Economic

(1) Money exchange and slow payment.

(2) Language and communication barriers.

(3) Lack of media for promotion and sale of products.

(4) Lack of local credit, or its high cost.

(5) Limited markets within individual countries and restrictions between countries within a region with similar market potential.

(6) Prohibitive investment risks.

Technical

(1) Plant quarantine and phytosanitary restrictions.

(2) Restrictive varietal lists and requirements for introduction of new varieties.

(3) Impractical purity and/or germination requirements.

(4) Lack of information on market locations, requirements for development, and development potential.

(5) Restrictive packaging requirements.

(6) Lack of unbiased varietal or sub-species performance data.

Educational

(1) Low educational level of potential customers.

(2) Lack of trained indigenous personnel for management and technical supervision of operations.

(3) Too much emphasis on price and not enough on quality.

Political or Governmental Policy

(1) Import and license restrictions including gratuities.

(2) Competition from local government in seed production and marketing.

(3) Governmental restraints on private businesses.

(4) Lack of legal recourse against "pirating" of privately developed varieties.

(5) Tariffs on U. S. products essential for seed operations.

(6) Trade preferences, i. e., mother countries, common markets, etc.

(7) Ever present threat of nationalization of foreign investments, capital and facilities.

## APPENDIX IV

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