Strategies for Sorghum Disease Control

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Most sorghum diseases are amenable to some degree of control through the application of one or more appropriate control measures. These measures fall under the general disease control methods of host resistance, chemical control, cultural control and integrated control. The decision as to which method to apply in any disease situation would depend upon whether the method met the criteria of agronomic effectiveness, environmental effectiveness, economic feasibility, social acceptability, and implementability (Bailey and Waddel 1980). These criteria are necessary in ,der to tailor control measures to the worldwide quirements of diverse environments, agricultural systems and socioeconomic conditions under which sorghum is grown.

In the 70s, research activity in sorghum disease control was small. A survey of the *Review of Applied Mycology* and the *Review of Plant Pathology* from 1970 to 1980 revealed that in the 1970s, only 67 papers out of a total of 487 papers on sorghum diseases were on disease control. Of these 67 papers, the majority were on host resistance (31 papers) followed by chemical control (29 papers) and only 7 papers were on cultural control. Most of the papers on disease control were from India and the USA and there was none from Africa. The lack of papers from Africa where sorghum is an important crop is a reflection of the skilled manpower bottleneck that is at the root of the present low level of sorghum improvement research in that continent. It also shows that --thing has changed since the call by King (1972) the Sorghum in Seventies Symposium for indigenous trained pathologists to work on sorghum diseases.

This paper reviews progress in sorghum disease control in the 1970s and presents control strategies for the 1980s. A discussion of the control of individual diseases will not be undertaken as this was adequately covered at the 1978 International Workshop on Sorghum Diseases (Williams et al. 1980).

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Host Resistance

Cultivation of disease resistant varieties is the most valuable and practical solution to disease problems. Host resistance is cheap (to the farmer), simple and effective, and also meets the requirements of broad applicability over a wide range of environmental and socioeconomic conditions. The four essential requirements for development of stable, disease-resistant varieties are:

1. Availability of a large, variable germplasm which can be intensively screened for resistance sources. Diverse germplasm increases the chances of selecting material with resistance to many pathogens and their variants.
2. Development of sound and effective resistance screening techniques.
3. Multilocational testing for stability of resistance under different environments and races of pathogens.
4. Methods for combining resistance(s) with other desirable plant traits.

Rosenow (these Proceedings) provides a more comprehensive review of breeding for disease resistance. This discussion will therefore be limited to the first three requirements.

Germplasm

A very large, variable sorghum germplasm has been assembled and is being maintained at ICRISAT Center (Mengesha and Rao, these Proceedings). Additions are made to it every year. This germplasm is available on request to any scientist wishing to screen or evaluate it for particular traits including disease resistance. Un-

International Crops Research Institute for the Semi-Arid Tropics. 1982. Sorghum in the Eighties: Proceedings of the International Symposium on Sorghum, 2-7 Nov 81, Patancheru, A.P., India. Patancheru, A.P. India: ICRISAT.

fortunately adaptation problems preclude the evaluation of most of the germplasm at any one location At ICRISAT Center, for example, more than half the collection does not flower or set seed in the rainy season and cannot therefore be screened for resistance to grain molds, smuts and ergot

Resistance Screening Techniques

The key to the identification of sources of stable resistance is the development of reliable, efficient and epidemiologically sound screening techniques which allow discrimination between resistant and susceptible genotypes (Williams 1976) The material to be screened should be exposed to optimum levels of pathogen inoculum under conditions conducive for infection and disease development in order to avoid disease escape Also important is the exposure of the material to graded levels of disease pressure to allow for the expression by the plants of different degrees of resistance which may be important in the stability of resistance

The biological basis for the development of effective screening techniques is a clear understanding of the basic biology of the pathogens and the epidemiology of the diseases they cause

In the 1970s substantial progress was made in the development of effective field screening techniques for grain molds, sorghum downy mildew and some leaf diseases (Frederiksen and Rosenow 1979, Williams et al 1980) The use of these techniques has led to the identification of sources of resistance for use in breeding programs There are, however, still a number of diseases for which no effective resistance screening techniques are available These include some economically important diseases such as charcoal rot (*Macrophomina phaseolina* [Tassi] Goid), sooty stripe (*Ramulispora sorghi* [Ellis and Everhart] Olive and Lefebvre), and grey leaf spot (*Cercospora sorghi* Ellis and Everhart)

The continual refinement of existing screening techniques and the development of new ones is a major challenge for the 1980s if host resistance is to continue to play a major part in the control of sorghum diseases

Multilocational Testing

The final phase in the identification of stable resistance is the exposure of the material, identified as resistant at one location, to many populations of the pathogen under a wide range of environmental conditions The necessary requirements for a multilocational testing program are twofold the availability of locations where disease occurs regularly under consistently high pressure, and the presence of interested and capable scientists who can effectively cooperate with the screening

In the 1970s a significant development in multilocational testing was the establishment of international sorghum disease nurseries by ICRISAT and Texas A&M University in the USA These nurseries serve three purposes (a) they identify genotypes with stable resistance for use as parents in breeding programs, (b) they detect the occurrence of races of the pathogens, and also signal changes in pathogen virulence over time, (c) they promote international communication and cooperation on sorghum disease research

There are currently six international sorgh disease nurseries Texas A&M University coordinates the International Disease and Insect Nursery (IDIN) and the Anthracnose Virulence Nursery (AVN), while ICRISAT coordinates four nurseries the International Sorghum Grain Mold Nursery (ISGMN), the International Sorghum Downy Mildew Nursery (ISDMN), the International Sorghum Leaf Disease Nursery (ISLDN) and the *Peronosclerospora sorghi* Host Differential Nursery (PSHDN) The cooperation of national program scientists in growing these nurseries is crucial for the success of this program

The results of the international disease nurseries have so far been very encouraging Texas disease-resistant material is used in many breeding programs In the ICRISAT ISGMN, the line E-35-1, a zera zera from Ethiopia, has been found resistant to several diseases in the semi-arid tropics and in demonstration trials in West Africa where it is being used as a direct introd tion Also from the ISGMN the line IS-9521 fr South Africa was selected in Ethiopia and released as a variety in a high rainfall zone of Ethiopia In the ISDMN the Australian variety QL-3 bred for resistance to sugarcane mosaic virus, has shown absolute resistance to downy mildew (*Peronosclerospora sorghi*) at several locations in India, Africa and Latin America over 5 years of testing This variety has stable resistance to sorghum downy mildew and is now used in breeding programs where the disease is important

In the operation of the international nurseries, national program scientists are encouraged to submit their local resistant material for inclusion in the nurseries. One advantage of this is that diseases not occurring in one location or country are screened against in another location/country so that such diseases can be prevented from becoming important even if introduced. To this end, national sorghum programs should develop close links with cooperators elsewhere in the international nurseries so that their material can be screened for "exotic" diseases.

Potential Genetic Vulnerability

Genetic vulnerability to new diseases or new races of pathogens due to extensive use of certain resistance genes is difficult to predict. owever, measures designed to increase genetic iriability in the varieties grown help reduce the risk of epidemics. The multiline strategy (Browning and Frey 1981) is advocated as one method of preventing epidemics. This strategy of growing a mixture of genotypes is not new to traditional sorghum farmers. In Africa and in India genetically pure stands of sorghum are rare; plantings are in patches or small fields, and a mosaic of local varieties (landraces) are grown. Diseases are always present but such crop production conditions do not readily favor epidemics.

In efforts to transform traditional agriculture the tendency is to introduce and recommend the cultivation of a limited number of varieties (often a single, "best" variety). The risk of epidemics under such conditions is real, and serious epidemics would be particularly damaging to poor farmers and poor societies.

The 1970s were the years of major concern of netic vulnerability in crops. It was triggered by e maize leaf blight (*Helminthosporium maydis* ..ce T) epidemic in the USA (Tatum 1971). This helped stimulate research for the genetic diversification of crop varieties. In sorghum most of this work was done in the USA where the converted sorghums have provided useful and diverse resistance sources to essentially all economically important diseases in that country (Frederiksen and Rosenow 1979).

The potential problem of genetic vulnerability in sorghum is likely to receive greater attention in the 1980s as the area covered by improved sorghum cultivars expands and as the crop is introduced into new areas. Three areas which are cause for immediate concern are outlined below:

1. Varietal Diversity on the Farm

As already stated, varietal uniformity over large production areas is an invitation to disease epidemics. Even where different varieties are grown these varieties may have been developed using identical parents.

The old adage not to put one's eggs in one basket is particularly apt when choosing varieties. Farmers should be encouraged to grow a selection of genetically diverse cultivars with different sources of resistance to the prevalent diseases in the area. Such varietal diversity within and between farms should substantially reduce the risk of epidemics (Priestley 1981). The adoption of such a strategy would depend on the availability of a number of equally high yield potential varieties and a seed production program capable of rapidly spreading the varieties. This strategy may perhaps not bear fruit in the 1980s but a start should be made in this direction.

2. Cytoplasmic Male Sterility

Wide-scale sorghum hybrid seed production is not feasible without cytoplasmic male sterility, and there is only one satisfactory type of cytoplasm (milo) that is used worldwide. Although cytoplasmic susceptibility to disease appears to be rare (Hooker 1974), the USA experience with the maize leaf blight epidemic of 1970 (Tatum 1971) is a warning of the danger of reliance on a single source of cytoplasmic male sterility in sorghum. Current research in the USA, in the All India Coordinated Sorghum Improvement Project and at ICRISAT to diversify cytoplasmic male sterility should be encouraged and supported.

3. International Distribution and Exchange of Material

In his presidential address to the British Mycological Society, Macer (1975), while extolling the benefits of international exchange of breeding material, also warned of the danger of spreading material of limited genetic diversity in the following words:

> "National breeding programs rely increasingly on international aggregations of source material for parents. Breeders and their pathological

colleagues tend to draw heavily on this material and to select similar, if not identical sources of resistance. Indeed, the practice of submitting resistant parents and selections to international nurseries tends to encourage breeders to use these and to concentrate efforts within even limited ranges of resistance. This restricts further the genetic base and makes many breeding programs, often encompassing a wide geographical area, vulnerable to a single change of virulence of the pathogen. The free exchage of resistant material has advantages in encouraging international cooperation and allowing the widespread testing of the "resistant material" but these advantages may be more than offset if too great a use is made of a restricted range of material."

The solution to the problem raised by Macer lies in the continual search, testing, exchange and utilization of genetically diverse sources of resistance in breeding programs. The germplasm collection at ICRISAT is so large and diverse that it is quite conceivable that genetically diverse sources of resistance to one or more diseases can be located.

The history of breeding for disease resistant sorghums, especially in the tropics, is a very short one, and in the developing countries only an insignificant proportion of the sorghum area is covered by improved varieties. It is therefore too early to discover all the pitfalls that may have been built into the new varieties, but the extreme susceptibility of the hybrid CSH-6 to charcoal rot (*Macrophomina phaseolina* [Tassi] Goid) in India provides a timely signal of the problem. Constant vigilance is therefore necessary to monitor weaknesses in these varieties as their adoption and areas of cultivation expand.

Chemical Control

Two aspects of chemical control will be discussed: protective chemical application to an established crop, and chemical treatment of seed before sowing.

Chemical Protection of an Established Crop

Chemical application to control diseases in an established crop is not a common practice in sorghum production. In the 1970s results of research, particularly in India, showed that some important diseases could be effectively controlled by applications of a broad range of fungicides (Gangadharan et al. 1976; Singh and Pavgi 1977; Pawar and Patil 1978). However, at the farm level, chemical disease control in an established crop is uneconomic because sorghum yields a low cash return per hectare. Even in the highly productive systems of the USA or Argentina, the low profit margin in sorghum production is a barrier to the use of chemicals against diseases in a standing crop. This situation is likely to prevail throughout the 1980s as costs of chemicals continue to rise faster than the market price of sorghum.

Chemical Seed Treatment

The economic argument—despite the well-known phoblems of phytotoxic side effects, human and environmental hazards, iatrogenic diseases (Griffiths 1981) and development of resistance to chemicals—does not apply to the use of the relatively inexpensive seed treatment chemicals to destroy or control seed-borne pathogens and soil-borne pathogens adjacent to the seed at sowing. Seed treatments, applied as dusts or slurries, are inexpensive because, unlike chemicals applied to a standing crop, they are applied only once and in very small quantities per hectare, no expensive equipment is required and labor and water costs are minimal. Their uniform distribution below the soil surface, and the time interval from sowing to harvest also suggest that chemical seed treatment is not as hazardous to human food and the environment as other methods of chemical disease control.

Another advantage of seed treatment is that where seed for planting is commercially produced, chemical treatment can be done at the source at very little extra cost.

During the most critical growth period from germination to the establishment of the young seedling, the young succulent tissues of sorghum are susceptible to a variety of unspecialized, soil-inhabiting fungi. These are chiefly species of *Fusarium* and *Pythium* which cause seed rots, damping off and seedling blights, and are an important factor in poor crop establishment (Tarr 1962). Control of these diseases by host resistance has proved difficult because the pathogens are relatively nonspecific in their host requirements. Chemical seed treatments have proved to be most effective means of controlling these diseases.

An essential requirement of seed for planting is freedom from seed-borne pathogens which often adversely affect germination, crop establishment and further plant growth. Infected seed is also an important means of pathogen dissemination over long distances, and the introduction of diseases into new areas. Chemical seed treatment has essentially eliminated covered grain smut, caused by *Sphacelotheca sorghi* (Link) Clinton and loose smut caused by *S. cruenta* (Kuhn) Potter in the USA (Edmunds 1975). In Africa sorghum grain losses due to these smuts could be similarly prevented through the use of chemically treated seed. The problem appears to be the unavailability of the chemicals, or of chemically-treated seed, the lack of education of the farmer and the lack of ension advisors on diseases and their control.

n the 1970s a variety of chemicals including ..avax, Thiram, Benlate, Dithane M-45, Dithane Z-78 and Ceresan were reported as effective seed treatments against seed rots, seedling blights and seed-borne diseases of sorghum (Hansing 1970; Mishra and Siradhana 1978; Agrawal and Khare 1978; and Bidari et al. 1978). Perhaps the most significant event was the development of the CIBA-GEIGY systemic fungicide metalaxyl [N-(2, 6-dimethyl phenyl)-N-(methoxyacetyl)-alanine methyl ester, CGA 48988, Ciba-Geigy Corporation] which, as a seed dressing, significantly reduced the incidence of sorghum downy mildew caused by *Peronosclerospora sorghi* (Weston and Uppal) Shaw (Venugopal and Safeeulla 1978) at rates as low as 0.1 g a.i./kg of seed (Frederiksen and Odvody 1979). This new development means that the resistance levels of some sorghum varieties and hybrids can be enhanced by chemical seed treatment. The ective control of oosporic and conidial inoculum metalaxyl seed treatment (Frederiksen and Odvoidy 1979) would minimize the introduction and spread of the disease through seed. The use of metalaxyl needs careful monitoring for possible phytotoxic effects and the capacity of the sorghum downy mildew pathogen to develop strains resistant to it as has already occurred in the downy mildew of cucurbits caused by *Pseudoperonospora cubensis* (Berk. & Curt.) Rostow (Reuven et al. 1980).

The experience of the 70s of the soaring cost of energy-based chemicals precludes any possibility of the use of chemicals for disease control in an established crop. Research in this area would also be a waste of resources, both human and financial. There is, however, tremendous scope for chemical seed treatment to control seed-borne diseases. This would facilitate seed movement and exchange, so important for sorghum improvement, by greatly reducing the risk of introducing pathogens. It is the fear of introducing diseases through seed that restricted the exchange and distribution of sorghum germplasm and breeding materials in certain countries in the 1970s.

In the developing countries, the development of seed companies which would routinely treat all seed at source would promote seed treatment as an effective measure of disease control. Chemical companies should be encouraged to continue to develop cheaper systemic compounds that act specifically against seed-borne pathogens.

Cultural Control

Cultural control may be defined as the tactical use of regular farm operations or crop husbandry practices to delay or reduce disease incidence and spread. It includes all practices which modify the environment to favor crop growth and minimize or avoid conditions which favor disease development.

Two problems need consideration in the use of cultural practices for disease control. First, most cultural practices effective in disease control tend to be location-specific, i.e., they are effective in particular soils, locations and climates where they have been developed. Consequently they are of limited application over diverse environments. Second, the development of cultural control methods requires adequate knowledge of the basic biology and epidemiology of the disease. For most sorghum diseases, this information is not available and would require a considerable research effort to obtain it. The question for the 1980s is whether this area should receive priority attention.

Some cultural practices which have been implicated in sorghum disease control are discussed below.

Tillage

Generally tillage promotes biological control of diseases through reduction in inoculum density and replacement of pathogens by saprophytes in crop residues (Baker and Cook 1974). Tillage also accelerates soil drying which helps reduce populations of certain soil-borne fungal pathogens and nematodes.

Deep burial of infected crop residue is known to have beneficial effects by reducing the seasonal carry-over of inoculum. Tuleen et al. (1980) reported that deep plowing to bury oospores reduced the incidence of sorghum downy mildew and increased yield in a susceptible sorghum cultivar when compared with conventional plowing. Conservation tillage or no-tillage systems where crop residues on the soil surface are subjected to minimum or no tillage may affect plant diseases by providing a habitat for pathogens and thereby serving as foci of inoculum (Summer et al. 1981). Disease incidence can be expected to be high for trash-borne diseases, e.g., anthracnose, leaf blight, sorghum downy mildew and bacterial diseases.

In the tropics most small farmers practice minimum tillage since they do not have the implements and power for deep plowing. Under such conditions the risk of seasonal carry-over of inoculum on plant debris is high. However, in some regions, such as in India, the removal of the stalk for fodder at grain harvest minimizes this danger.

An indirect beneficial influence of crop residues was the reduction in the incidence of stalk rot of sorghum in a reduced tillage system (ecofallow) in Nebraska (Doupnick and Boosalis 1975). This was because ecofallow increased soil moisture storage and thereby made plants less predisposed to infection.

Time of Sowing

Adjustments to time of sowing often make it possible for crops to escape from disease by ensuring that the crop is not in the most disease-susceptible stage when pathogen inoculum is abundant and the weather favorable for infection and disease spread. This strategy has, however, received little attention in sorghum disease control. The advantage of early planting to avoid significant grain losses caused by sorghum downy mildew at Dharwar, India was reported by Balasubramanian (1974). On the other hand Tuleen et al. (1980) reported that delayed planting reduced the incidence of the same disease in Texas. These two contrasting reports emphasize the location specificity of cultural control measures.

In areas of variable and unpredictable rainfall, such as the semi-arid tropics where most of the sorghum is grown, the physiological and ecological advantages are nearly always with the early planted and established crop. In such areas delayed or late sowing is not desirable since yields of late sown crops are low even if free from a particular disease.

Avoidance of disease through adjustments in time of sowing should simultaneously avoid the period of activity of insect pests. It would be futile to protect a crop from diseases when pests would damage it.

Mineral Nutrition

Mineral nutrition is an important factor which determines in large measure a plant's resistance or susceptibility to disease. Different types, levels, and balance of nutrients, or their unavailability influence the reaction of a plant to pathogen challenge depending upon particular host-pathogen combinations. Even different forms of the same nutrient may affect host susceptibility or pathogen virulence (Huber 1980).

Reports from India indicated that high levels of nitrogen increased the susceptibility of sorghum to ergot disease (*Sphacelia sorghi* McRae) (Chinnadurai 1971), leaf disease (Naik et al. 1976) and stalk rot (Anahosur et al. 1977). Susceptibility of sorghum to downy mildew was unaffected by increases of nitrogen, but was increased by increases in phosphorus (Balasubramanian 1973).

Nutrition appears to be an important factor in the predisposition of sorghum to stalk rots and lodging. Murphy (1975) reported that excessive nitrogen and deficiencies in potassium, when combined with moisture stress, favored stalk rots and lodging. Recently at ICRISAT Center, Seetharama (personal communication) observed that in the CSH-6 hybrid, charcoal rot was more severe when grown under high (120 kg N/ha) than under low (40 kg N/ha) fertility conditions. Although other factors are involved, it is clear that nutrient imbalances play a role in the susceptibility of sorghum to charcoal rot.

Cropping Systems

Sorghum is produced under a variety of cropping systems (Willey, These Proceedings). Intercropping is the most widespread system in the traditional sorghum areas of India and Africa, and also in Central America. There is no published information on disease problems in the intercrop situation, and most research on sorghum disease control continues to be done on sole crops. Disease control methods devised under sole crops may not be satisfactory for intercrops.

In intercropping, the modification of the crop micro-environment (humidity, light, free moisture, temperature, air movement, etc.) and differences in nutrient uptake by the intercrops are likely to influence plant infection, diseases development and spread. Research on disease problems and control in intercrops deserves attention in the 1980s.

Crop rotation is a classical cultural practice that helps to control soil-borne diseases caused by fungi, nematodes and other organisms. Diseases usually become a problem where the rotational cycle is reduced through intensive cultivation and onocropping. In sorghum, there is a dearth of ormation on crop rotation as a means of disease control. As with other cultural practices, knowledge of the basic biology and epidemiology of the pathogens is a prerequisite for nonempirical application of crop rotation in disease control. In the intercrop systems of the tropics a sound rotational practice could be difficult to implement because of the diversity of crop components.

Some sorghum cropping systems are not sound for disease control. One such system is ratoon cropping which has the advantages of providing more than one harvest from a single sowing, and ensuring the maximum use of a growing season that may be too short for two sown crops in succession (Plucknett et al. 1970). The disadvantage is that systemic diseases such as sorghum downy mildew, smuts, bacterial and viral diseases tend to increase in severity on ratoon crops. Unless resistant varieties are used, on cropping cannot be recommended.

....egrated Control

We have discussed how different strategies of host resistance, chemical treatment and crop husbandry practices can be successfully used in sorghum disease control. In practice, a single control strategy often does not provide a permanent solution to a disease problem. For example, host resistance may "break down" due to the development of new races of the pathogen, or the pathogen may develop new races resistant to a fungicide. Cultural practices too are subject to the variability of the weather, and sometimes are heavily dependent on the cooperation of neighboring farmers. In view of this, the application of several control methods becomes necessary. In other words, the diversification of disease control methods can help maintain disease levels below economic injury.

Sorghum downy mildew is a disease which lends itself easily to control through the use of several methods in Texas, USA. Resistant varieties are available, several cultural practices have reduced the incidence of the disease, and seed dressing with metalaxyl also has controlled the incidence of the disease (Frederiksen 1979). The paucity of research on various methods for the control of specific diseases does not make it possible to come up with recommendations for other diseases elsewhere.

In future, multiple measures will be required for successful disease control. Again, the need is for more research.

Problems and Challenges in the Eighties

In looking ahead to the 1980s it is not unrealistic to foresee a decade of increasing importance of disease problems as improved varieties and crop management systems developed in the 1970s are adopted by farmers on an extensive scale. Previously insignificant or unknown diseases, or new races of known pathogens are likely to come to prominence and cause economic crop losses. The breeding successes of the last decade will pale into insignificance unless innovative approaches to disease control are undertaken. The problems and challenges of the eighties need to be attacked from several angles:

1. Resistance Screening Techniques

As host resistance is likely to be the favored method of disease control, particularly among the resource-poor farmers of the developing countries, an expanded and intensive effort should be made to the refinement and/or development of methods for creating artificial epidemics at desired intensities for rapid screening of germplasm and breeding lines. In spite of the successes of the 1970 s there are still a number of diseases for which no sound screening techniques are available. We must learn how to manage the diseases in the field.

2. Genetic Diversity

Genetic diversity must receive increased attention in breeding programs to reduce the risks of epidemics in genetically uniform material. Research in nonnuclear inheritance needs to be expanded and accelerated.

3. International Cooperation

The value and fruits of international cooperation in plant disease research were emphasized 20 years ago by Rodenhizer (1962). In the 70s international disease nurseries contributed to progress in the identification, exchange and utilization of stable disease resistant material. However, there is room for substantial expansion in this activity. There is need for (a) more cooperators in national programs, (b) improvement in the management of the nurseries and the recording of data, and (c) the inclusion in the test entries of material submitted by national programs.

Another area of international cooperation is the development of cooperative research projects. In many countries, limited resources, lack of trained manpower or lack of a screening opportunity due to environmental factors or quarantine regulations prevent the execution of a comprehensive research program. Scientists in such countries should cooperate with scientists in other countries in order to find solutions to mutual problems.

4. Interdisciplinary Team Effort

Disease control is inseparable from the total production system of a crop. Many of the measures of disease control represent a relatively small proportion of the many factors involved in growing a crop. Disease control alone will not increase and stabilize yield; other yield limiting factors need to be considered simultaneously. Accordingly a sound research program on disease control should be a team effort of pathologists, entomologists, breeders, geneticists, physiologists, soil scientists, and socioeconomists. A working relationship with farmers who are ultimately responsible for the implementation of disease control measures is also essential.

5. Training

The skilled manpower bottleneck is a major constraint to the development and adoption of modern agricultural technology in the developing countries. This point was driven home in a more sensational way by Paddock (1967) when he said, "Do not expect an agricultural revolution in the hungry world—there is no one to lead the revolution." At the "Sorghum in Seventies" symposium King (1972) urged that more indigenous plant pathologists be trained to conduct research which was at that time neglected or done by expatriates on a temporary basis. At the beginning of the 1980s the situation is certainly not better and is perhaps worse than in 1971. With the exception of India and the USA, there is a critical shortage of sorghum pathologists. The increase in the number and activities of national sorghum improvement programs has meant that the ·· trained pathologists are not sufficient. In the { training of national research and technical staπ ın sorghum pathology should receive top priority.

Conclusion

Over 10 years ago, Paddock (1967) made a plea for "new, more imaginative disease control methods specifically for the needs of the developing world" where the greatest need exists for increased and stable food production. This plea is still valid today. The 1980s will require a critical evaluation of disease problems and innovative strategies for their control.

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