

Sorghum Improvement in the Third World: Successes and Failures

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Resumen: El mejoramiento de sorgo ha sido enormemente estimulado por la disponibilidad y el uso de la colección mundial de germoplasma y al intercambio oportuno de germoplasma entre los programas de mejoramiento alrededor del mundo. El efectivo uso de nuestras fuentes de germoplasma ha sido enormemente mejorado gracias al de la Universidad de Texas A&M/USDA programa de conversión. El continuado y extensivo uso de estos germoplasmas es anticipado. El incrementado uso de los híbridos ha sido variable, pero esperamos que se expanda, particularmente en el Africa. La investigación ha sido multidisciplinaria en muchos lugares contribuyendo a obtener más altos y estables rendimientos. Aunque se han tenido muchos logros, aún quedan muchos problemas por resolver. La investigación en el área de utilización de cultivos, necesita ser aumentada prioritariamente al igual que poner un mayor énfasis para el desarrollo de cultivares con características que apoyen diferentes usos.

Uno de los mayores problemas en muchas partes del mundo es el insuficiente número de científicos e inadecuadas infraestructuras. La necesidad de una continua educación y entrenamiento es muy importante; y se requiere un mayor impulso en el desarrollo y manejo de estaciones experimentales. También los científicos no deberían conformarse únicamente con el desarrollo de nuevos cultivares, por lo que deberían continuar evaluando su comportamiento en los campos de producción.

El aumento en las oportunidades para la producción de semilla y comercialización, y el fortalecimiento de los servicios de extensión y áreas entre investigación y el productor, requieren una mayor contribución de parte de los científicos, sus instituciones y donadores.

ABSTRACT

The improvement of sorghum has been greatly stimulated by the availability and use of the germplasm collection and the ready movement of breeding stocks between programs the world over. The effective use of our germplasm resources has been greatly enhanced because of the Texas A&M/USDA Conversion Program. The continued, even expanded, use of this germplasm is anticipated. The increased use of hybrids has been variable

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and one hopes will expand, particularly in Africa. Research has been multidisciplinary in a number of places contributing to higher more stable yields. While progress has been made, many problems remain. Research in the area of crop utilization needs increased priority as well as placing greater emphasis on developing cultivars with characteristics that support different uses.

A major problem in many parts of the world is sufficient numbers of scientists and adequate infrastructure. The need for continuing education and training is important and greater input into the development and management of experiment stations is required. Also, scientists should not be satisfied with just the development of new cultivars, but should follow them to the farmer's field.

Greater input into opportunities for seed production and marketing, the strengthening of extension services and areas between research and the farmer, require a much greater contribution from scientists, their institutions, and donors.

INTRODUCTION

Sorghum is a crop of Africa having been domesticated in several different locations on the continent. Five distinct races with different geographic origin have been identified. Over the last several thousand years man has carried sorghum within and outside of Africa; it arrived in the Americas only about 100 years ago. The traditional farmer, as breeder, applied a selection pressure that basically narrowed genetic variability and evolved varieties that withstood a relatively hostile climate but were not high yielding. They had utilization and resistance traits but frequently were not very responsive to modern management inputs. They were growing food for themselves and even today, in some countries, little of the total sorghum produced reaches a market.

Sorghum is now grown world wide particularly in the hotter drier climates. Over the last 20 to 50 years sorghum has moved into traditional maize areas and maize into traditional sorghum areas. Now, at a declining pace, this process is still going on.

The improvement of sorghum in the modern sense is seldom more than 50 years old. Even today, there are some countries

where sorghum is an important crop but where little is being done towards its improvement. I have been asked to talk about sorghum improvement, its successes and failures with a focus on third world countries.

INSTITUTIONALIZATION OF RESEARCH AND DEVELOPMENT

Today, I am unaware of a country growing sorghum that does not have a Ministry of Agriculture with a Department of Research. While this basic structure exists, it is frequently resource limited, frustrated by bureaucratic procedures, and shy of adequate manpower. In the third world, private investment in sorghum--particularly in research--is rare. In fact, much of the support is based on donor funding and in some cases contribution of expatriate personnel. This represents national weakness but the importance to prioritize agricultural research as critical to national development is increasingly being recognized.

Contribution from sorghum research necessary to stimulate effective extension programs, availability of quality seed to service and support the community and rural credit, have been seldom realized. In most instances, there is still a long way to go on the road from the traditional to a more Technical Agriculture including sorghum.

MANPOWER

Staff strength to concentrate on sorghum improvement varies from good in countries like India to inadequate in many countries, particularly in disciplines other than breeding and agronomy. At an increasing rate over the last 20 years, technicians educated or trained has dramatically increased; and, with some increase, this is occurring within educational institutions in countries of the third world. Many of these people have been diverted to activities other than sorghum improvement; yet, the manpower gain has been substantial and is necessary if national capability for sorghum improvement is to become a reality. This development can only be commended and encouraged, and as we look to the future, the needs are still substantial and the priority for education and training should remain high.

I feel another very significant development in manpower has been the tremendously increased interaction between sorghum scientists nationally, regionally, and internationally. We have become a community of scientists with a common objective. This has led to greater understanding of problems hence relevance to research, to interpersonal relationships encouraging openness and appreciation, and to a more rapid mobilization of ideas and products of research. This has been encouraged on an individual basis by meetings such as this; and, institutionally by agencies such as INTSORMIL, IRAT, FAO, ICRISAT, to mention some. This is an extremely valuable development that will no doubt be continued and should be ensured.

Station Development and Management

I have been concerned about the problems of experiment station development and management. In 1981, I was able to visit many sorghum stations from Senegal to Ethiopia. I estimated that the useful information that could be realized would be 20 to 80% of what it should have been. This area of station development and management is poorly recognized. In the developed world where most education occurs, everyone takes well run stations for granted and places no priority in this area. There is no curriculum for this topic, no effort to make students aware of management procedures. Scientists from third world countries invariably return to mediocre stations without ideas of how to develop a good station operations system. Without better understanding of what is involved, there is not much hope for improvement. In spite of the loss in time and resource resulting from poor experimental conditions, few involved with sorghum improvement give this problem any reasonable priority. It is a problem of both infrastructure and manpower development.

CROP IMPROVEMENT

Germplasm

The collection, preservation, distribution, evaluation, and utilization of the world's sorghum germplasm has been a significant achievement. I do not have recent figures but there must be close to 30,000 accessions. This has been and is perceived to be a corner stone for the crop's improvement. Of tremendous significance has been the conversion program of Texas A&M and the USDA. Lines developed by this program, I

am sure, can be found in virtually all sorghum improvement programs. This availability of diversity and source of traits with its wide dissemination and use has been a singularly important contribution that deserves substantial encouragement. There is rising concern that germplasm is a national treasure not to be freely shared; but even the most cursory of observation would reveal the tremendous gain that many countries have realized from germplasm importation. This value should be clearly made known.

As germplasm and breeding stocks have moved, they have resulted in both phenotypic change and improved production. Eleven hybrids have now been released in India and these are phenotypically different from the traditional local sorghums. In over a total of twenty parents, I believe that these hybrids have only three or four traditional varieties incorporated somewhere in the breeding process. The increased per hectare yield of sorghum in India rests heavily on the use of introduced germplasm and breeding stock.

The zerazeras from central Sudan and the Gambella area of Ethiopia have contributed greatly to improved food quality and have contributed to sorghum improvement in many parts of the world. However, gains have not been universal. Improvement of the guineas found in the high to intermediate rainfall zones of West Africa eastward into Tanzania have neither been replaced or improved. It has been almost impossible to modify them without yield loss, and they are uniquely adapted to an environmental situation with severe pest problems. This remains a challenge.

In spite of substantive gains in production of sorghum in India during the monsoon season, little gain has been realized in the post monsoon season. Again, a unique climatic situation where neither modification of existing varieties nor breeding of introductions has contributed much to yield. Results from all the good research developments around the world fail to contribute significantly in these situations raising questions about possible solutions and indicating need for imaginative inputs. This may also be true for the *maicillos criollos* in this part of the world.

Crop Improvement

I believe that our objective is to assist a transition from traditional to a more Technical Agriculture. We must help lift the

farmer from his tradition and in doing this we must understand the traditional farmer (as we are often reminded) but also we must be scientists with imagination to perceive beneficial changes that the traditional farmer cannot (I feel that many policy makers also fail to perceive this).

I have long been bothered about the overwhelming concern for the poorest of the poor. This has been a headline banner in the halls of many institutions, both donor and research, including the international centers. One cannot argue with the heart felt need for these people nor can one ignore the missionary spirit with which the problem has been tackled. But, I believe one can question the wisdom of the approach. A lot of money and time has been spent with limited reward and I find the pendulum swinging toward a greater focus on producing where production has a better chance, both environmentally and because of better farmers. I strongly believe that this is the right direction--raise production where the chances to do so are best. This will generate an improved community of goods and services and I believe be the best road to the poorest of the poor.

I feel that hybridization is one of the stronger tools that we have to effect change, particularly in the more stressed environments. To me, it is important to avoid academic discussions about hybrids versus varieties, but to evaluate both properly and let the crop speak for itself.

Both varieties and hybrids of sorghum have been released in India over the last 23 years (11 hybrids, 10 varieties). The area sown to these improved cultivars is over 90% hybrid. I think that this not only says something about yield advantage, but also about a seed industry for which hybrid sorghum contributed in its development. Once we know that we have superiority in hybrids compared to varieties, the stage is set to encourage a seed industry. A development period is required but compared to the usual methods of seed increase and marketing, the hybrid seed industry provides a more solid base for quality control programs, a better organized market, and possibly a contribution to strengthening rural credit, increased fertilizer use, etc.

I would regard the increased use of hybrids in several Latin American countries, India and China, with good prospects and in the Sudan, Nigeria, and several southern Africa countries as an important accomplishment. I hope that these will stand as

example situations for those who are afraid of hybrids, frequently because of seed production problems. I feel that there is a great widespread misconception that hybrids are only used in favorable agro-ecological conditions and with inputs. A more widespread appreciation of the contribution of hybrids compared to varieties in stress conditions is required.

MULTIDISCIPLINARY INPUT

The increased focus on sorghum production and utilization by scientists from a number of relevant disciplines has been contributing. These disciplines can be broadly categorized into breeding and genetics, resistance to biotic and abiotic stresses, crop utilization for food, feed, and non-food industrial uses.

Certainly, a knowledge of the genetics of such traits as malesterility, plant height, maturity and grain characteristics, have assisted the breeder in this manipulation of the crop. An understanding of the mode of inheritance of more complex traits has also been valuable in establishing breeding objectives. It is not always; easy, such important traits as yield and resistance to moisture stress are still not completely understood and better understanding would be helpful. While much has been learned, the breeder geneticist is not running out of challenge.

There have been some notable successes managing pest problems. Resistance per se has contributed to problems of greenbug, midge, and the India strain of *Striga asiatica*. The concept of pest management is no longer new and relevant for pests such as stemborers and headbugs where heritable resistance provides only a partial solution. We have a better understanding of diseases, and progress has been made capitalizing on resistance to milo disease, downy mildew, and with good prospects for several leaf diseases. Problems of stalk rot have been more difficult. Although progress is being made empirically, a foundation for better understanding is being laid. I feel that useful procedures have been developed to evaluate component traits that contribute to stand establishment. We can measure response to moisture and temperature stress, but our understanding is largely empirical. Photoperiod sensitivity is well understood and its value in plant improvement, for some areas, better appreciated. The ability to manage these traits in multidisciplinary teams has been important to increasing yield and stability of production. I feel it is important, in third world

countries where expression of these problems is usually more severe than in temperate areas, that a concerted effort is made to have a critical mass of scientific talent on the research team. Pests are dynamic just as is the crop; with changes in cultivar and cultivar management, pests also change and have been and can be disastrous. To develop a relevant sorghum improvement capacity, a multidisciplinary input is required. I feel that this is generally recognized, but in many countries yet to be effectively implemented.

The focus of sorghum improvement research has been to increase production as a sole crop or in combination with other crops. Research on crop utilization has not received the same priority. The use of sorghum as a source of alcohol for fuel, the blending of sorghum flour into that of wheat and maize, the development of an array of traditional and new food beverage products, and development of pearling and milling techniques to place sorghum flour on the grocery store shelf are examples where research has contributed, but results have been limited. The use of sorghum as a feed has been important in a number of countries. Essentially, we have improved sorghum as sorghum and although we have learned a lot, the evaluation of traits relevant to grain quality has had limited impact.

A number of countries are now self-sufficient in food (India, China, Zimbabwe as examples) and some countries have periodic surplus (Malawi, Zambia, Nigeria as examples). Surplus has long existed in a number of developed countries. The world is not short of food--we have a distribution and economic problem. It has been demonstrated that pricing policy can be a strong impetus to production, but production toward what market opportunities. I believe that it is increasingly recognized that we need to look more at marketable products, at the market itself, and at government policy. I feel that a much greater input into post harvest research is important to maintain sustainability of agricultural production. I believe the day has arrived when we must place greater emphasis on the development of sorghum varieties and hybrids for specific end uses. I also feel that we need to carefully explore multiple crop use--the grain for food, flour, for starch, the stem for fuel and for cellulose. I believe that there are many opportunities to make sorghum a convenience food like wheat and to expand the array of marketable products. I feel that this is an important area of research that needs considerable strengthening in the future.

Our job is not finished until the products of research reach the farmer. As scientists we should be concerned about and contribute to important activities between research and the farmer--seed production, strengthening extension, credit and the availability of inputs are examples. Over the years we have seen many gains from research and many more people involved. However, with varying degrees, the needs for efficient research capability to improve sorghum is still critical. The road in front of us is still long.