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An Interim Report Identifying the Principal Constraints in the Production, Marketing, and Utilization of Grain Sorghum and Pearl Millet in Less Developed Countries

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PREFACE

This report is prepared in response to a provision in Work Order number 4, Contract No. AID/afr-C-1139. the U.S. Agency for International Development and the University of Missouri.

Central to the plan for the conduct of this project was commitment to use the judgment of scientists who are significantly involved in grain sorghum and pearl millet research in the identification of constraints. The identification of all scientists around the world so involved did not seem an achievable goal. It is believed that an adequate and representative sample was identified.

The conclusion drawn may be more meaningful if the methodology is understood. The methodology is described in Section C.

More than twenty faculty members at the University of Missouri-Columbia participated in the data gathering phase. Information was obtained directly from an estimated 150 scientists, 90 of whom completed questionnaires. To bring all of the information so gathered together and bring it to bear on the identification of constraints, a day long workshop of all the University of Missouri-Columbia participants was organized. With all of the available information at hand, these twenty-one scientists identified constraints, evaluated each on a quantitative scale of importance, and rated the level of knowledge about each. The results of that workshop are presented in table form in Section C-3 of the report. If any one section can be said to be the most important single section, then Section C-3, The Summary of Workshop Evaluations by Interviewers and the Internal Scientist Committee is the most important section. It is suggested that the reader study this table carefully as the contents of Sections A and B are interpreted. It is further suggested that Section A, B, and C-3 must be used in total to achieve proper interpretation.

The reader should know that the terms "Interviewer Ratings," (as in the C-3 table heading); "interviewer judgments," (bottom of page 4), and "workshop participants," middle of page 5) are used interchangeably, and all refer to the workshop outcome.

A. The Principal Constraints

I. FERTILITY AND PLANT NUTRITION

1. Low fertility of soils on which grain sorghum and millet are typically grown in less developed countries is a constraint to increased production. Although many of the responding scientists gave high ratings in the constraints instrument to "fertilizer response," (see Items I-1 to I-5 in Table C-2 of Section C2) the faculty members who interviewed researchers in the LDC's were repeatedly told that research in crop response to different levels of nutrients of the type typically done in the U.S. is not of high priority, nor is it likely to lead to major increases in production in the LDC's. Sufficient research has been done to know that both crops respond positively to fertilizer. Fertilizer use is not now sufficient to make research on different levels of nutrient application highly useful. Fertilizer is not available to a large segment of the typical producers of these crops, nor do they have money resources to expend in significant quantity on purchased inputs. Thus, especially in those sections of the world where production is primarily by subsistence farmers, typical fertilizer response research is not of high priority. An examination of the individual responses rating this constraint of high priority indicates that those respondents were referring to either the U.S. context or commercial production systems in LDC's.

There was a concensus among scientists interviewed overseas that the possibility of increasing soil fertility from non-market, non-monetized sources should receive

attention. Research on nitrogen fixation had a high priority in their judgment. Research to identify or develop genotypes that more effectively extract and/or utilize limited nutrients available is an example of the type of research that would seem to have merit in this connection.

Section I of Table C-3 in Section C3 summarizes the judgment of all of the workshop participants on how the various components of the fertility and plant nutrition problem relate one to the other in reference to the research project. Items 1, 2, and 3 under I in that table reflect the high priority given to developing techniques of increasing and/or maintaining fertility through non-monetized means. Fertilizer response as such, soil test calibration, secondary nutrients, chemical properties of soils, and physical properties of soils were considered relatively less important as components for this research proposal.

Two exceptions to the foregoing are recognized. In the irrigated areas, and where commercial sorghum production is important, there may be opportunity for productive research on fertilizer response. And, in some sections where irrigation is practiced, research on the salinity problem may have relatively high payoff. Thus, if a U.S. institution has or can establish a functional linkage with a research or outreach institution in an LDC where either of these two conditions prevail, and GS/PM production in such areas is economically important to the poorer segments of the population, such research may be an appropriate part of collaborative research.

II. CULTURAL PRACTICES AND MANAGEMENT

2. Water related concerns, especially less than optimum soil moisture supplies, but also water management, water storage , etc. constitute a constraint to increased production. The tabulation of responses of all scientists responding to the constraints instrument indicate a very high rating of these concerns. (See Item II-5 of Table C-2, in Section C2).) However, the combined judgment of the interviewers indicates less significance attached to research on irrigation. See Section II of Table C-3 in Section C3. This is for the same reasons as cited in the first paragraph of I above, and it relates most directly to the small, subsistence producer growing grain sorghum and pearl millet under marginal moisture conditions.

Again, U.S. institutions with functional linkages with research or outreach institutions serving LDC areas where significant production on irrigated land prevails may appropriately propose a research contribution to this collaborative program.

Breeding for low moisture tolerance is treated under Item IV of this section.

3. The difficulty of stand establishment is a constraint to increased production, to improved efficiency of production, and to expanded plantings. In the combined judgment of the interviewers, the relatively high rating given to time, rate, and depth of seeding (Item II-1 in Table C-2 of Section C2) relates primarily to the problem of getting a stand. See Item II-1 of Table C-3 in Section C3.

Another important problem in stand establishment is seedling vigor. As with low moisture tolerance, seedling vigor may be an appropriate concern in the breeding portion of Section IV, and it also may be of concern to pathology researchers.

4. Pests--rodents, animals, birds--constitute a constraint to the production of grain sorghum and pearl millet. Both the scientist response on the constraint instrument and the combined judgment of the interviewers underscore the importance of the constraint. See Item II-2 of Table C-3 in Section C3. Birds are an especially serious constraint to GS/PM production in many LDC's around the world.

5. Weeds complicate stand establishment and reduce yields. Weed control ranks in the intermediate priority category in that only 16 scientist responses indicated it of high priority, in comparison to 31 and 49 responses putting seeding and water related problems in that category. However 75 per cent of the responses on grain sorghum and all responses on millet, albeit a small total, rated weed control a high priority for research. Striga constitutes an especially significant problem in Africa, which probably can be more appropriately addressed through breeding programs than through cultural practices.

Item II-4 in Table C-3 of Section C2 indicates the combined judgment of the interviewers that weed control is important in some situations and that some major thrust in research is needed.

6. Risk constitutes a restraint to increased production of grain sorghums and pearl millet in regions where it is produced on a subsistence basis for human consumption primarily by the family producing it. Scientists in developing countries indicated that stability of yield is of greater concern to subsistence producers than is maximum yield. Double cropping and inter cropping are seen as practices that may lead to both increased yield and increased stability of yield. The desire to get a meager yield in the worst years outweighs the desire for high yields in other years if the higher yieldis accompanied by crop failures in some years. With these considerations in mind, workshop participants (as shown in Item II-3 of Table C-3 of Section C3) gave research on effective inter cropping and double cropping higher research priority than did the respondents viewing them as independent cultural practices. The significance of this problem and the manner in which it relates to the production process may vary markedly between the very small farmer and the larger commercial farmer.

III. ENGINEERING AND MECHANIZATION

7. Lack of machinery for land preparation and cultivation restricts production in some local situations. Neither the respondents to the constraints instrument nor the combined judgment of the interviewers indicate this as a high priority research area for most LDC conditions.

8. Inadequate farm and commercial grain storage constrict supplies of grain sorghum and pearl millet available for consumption. Within the engineering and mechanization

section, respondents to the constraints questionnaire gave farm storage priority as high as or higher than any other item in the section. Workshop participants rated farm storage as important in some situations and indicated that some additional research could be advantageous although not of high priority.

For commercial storage, the situation varies widely by regions and crops. It is largely irrelevant for millet in most regions. Technology transfer through development programs appears to be more appropriate than a research program.

The workshop group suggested that for those tropical regions where storage of grain is a major constraint, grain sorghum and pearl millet might well serve as a focus for the study, but any such proposal should include other crops as well.[1]

IV. BREEDING, VARIETAL IMPROVEMENT AND DEVELOPMENT

9. Risks associated with unstable production constitute a major constraint in grain sorghum and pearl millet production and utilization. Stability of production of both local varieties and any proposed new varieties needs to be addressed through plant breeding. It was the judgment of the scientists interviewed and of the workshop group that resistance to adversities to reduce risk associated with unstable yields was of major importance. The adversities include infertile soil, drought, primitive cultural practices, insects, diseases, striga, birds, and weathering of grain. The importance of the adversities varies from area to area, and by type of agriculture.

[1] The program of the Tropical Products Institute in England includes work on storage.

Quality acceptable for human consumption in LDC's must be maintained. Breeding work should be coordinated with basic research in other disciplines.

The scientists interviewed gave breeding for resistance to diseases and insects, and the introduction of new cultivars the highest priority ratings in this section. The workshop group designated breeding for productivity, resistance, and quality to be of the highest level of importance (a 4 rating) in every region except Latin America. Level of knowledge and programs underway scores vary by region. The state-of-the-arts is more advanced in breeding programs than in other of the constraint categories used in the questionnaire because of attention received in the past decade. Even so, this area of research remains a most fruitful avenue for addressing the kinds of constraints suggested above.

10. Genetic, cytological and physiological studies are generally deficient for both grain sorghum and pearl millet, and constitute a major constaint to progress in breeding. Basic research in these disciplines will contribute to efficiency and advancement of breeding programs.

Failure to collect and preserve germ plasms, particularly native strains and wild relatives not adequately represented in present collections will constitute a major restraint to future breeding activities. Many local strains and wild relatives are not adequately represented in current major collections, limiting the genetic, cytologic, physiological and breeding research.

11. Lack of seed multiplication and distribution programs is a major constraint to making improved varieties available to farmers. This constraint was rated of highest importance in Africa, Asia, and the Middle East, and only one step lower for India and Latin America, with justification for a major thrust in research indicated. The essential problem is lack of viable policies and institutional structures to assure farmers access to improved varieties. These include adequate testing of new strains in farmers fields to insure that growing the new variety does not involve greater risks, providing inputs, including credit, to acquire new seed, and educational efforts at the village level.

V. ENTOMOLOGY

12. Insect damage, both during growth and after harvest, limit the supply of grain sorghum and pearl millet available as a food source. The insect problem is less serious in millet than in sorghum. The major insect pests in sorghum are shoot fly, stem borer, and midge; in millet, the shoot fly and midge. There are many more insect pests of significance.

In the interviewer workshop, research on the biology of economically important insects and research on control through cultural, chemical and biological means were rated of greater importance in some regions than in others as indicated in Table C-3.

Although the importance of insects as vectors of diseases or as predisposers of the plant to disease was not treated specifically in the questionnaire, there is no intent to exclude this aspect from consideration for research.

VI. PLANT PATHOLOGY

13. Diseases reduce output of grain sorghum and pearl millet, and cause variation in production from year to year. Downy mildew and head molds are major diseases of sorghum; anthracnose, rusts, ergot, and smuts are important, varying somewhat by year and geographic area. Downy mildew and ergot are especially important in millet, with stalk rot and rusts of slightly less significance. Striga, mentioned under the section on weeds, is an especially serious threat to both sorghum and millet in Africa.

Introduction of new cultural practices or of new varieties may be accompanied by new disease problems. Pathology research needs to be collaborative with plant breeding research. Sources of resistance to many diseases are not now available, and do not appear to be present in local varieties, especially with millet. Chemical control is utilized by larger commercial growers, but not by the small farmer producing for subsistence purposes.

14. The limited germ plasm collection is a constraint to the most effective breeding program. A major effort is needed to assemble and preserve (1) local strains of both grain sorghum and pearl millet from all parts of the world, and (2) wild relatives which may have useful genes to a breeding program, especially aimed at building disease resistance.

VII. UTILIZATION

15. The bitter taste and reduced nutritional value associated with high tannin and the floury endosperm of some types of grain sorghums are major constraints

affecting the utilization of grain sorghum. Grain sorghum/pearl millet are superior to other cereal grains in yield stability in the semi-arid tropics. Nevertheless, utilization of grain sorghum/pearl millet for human food will not expand or even be maintained at existing levels as purchasing power in these regions of the world increases unless high quality grain types are developed that can compete with wheat and rice in consumer acceptance. Much of the reluctance to use grain sorghums as a human food, unless forced to, may be associated with palatability, digestability, and texture of the grains. If human food is a primary objective in the production of grain sorghum/pearl millet, then the development or the retention of acceptable taste in any new varieties developed through breeding programs must be given the highest priority.

The evidence indicates there is sufficient genetic variability in sorghum and millet grains to successfully develop acceptable grains with desirable characteristics that can achieve a prestige equivalent to other cereal grains. This evaluation of this constraint was supported both by the respondents to the questionnaire as well as the UMC workshop group.

VIII. SOCIAL AND INSTITUTIONAL FACTORS

16. Poor communications systems are a major constraint limiting the adoption of new technology which might increase grain sorghum and millet production. This is particularly true of those systems designed to reach small, low-income farmers who grow grain sorghum and millet. There was an

almost universal recognition by questionnaire respondents that outreach systems in most LDC's are inadequate for the task. If new technology is developed to overcome some of the technical constraints, and if communications research and experimental programs have not been completed to communicate new technology to small farmers, a high probability exists that commercial producers will utilize the improved technology and small producers will not. This may effectively reduce market price and place the small producer in a poorer position for that portion of his crop he does sell. Therefore, it is important that research be designed and conducted which has as its primary purposes the determination of present communications systems, examination of factors associated with adoption of innovations by small farmers, and conduct of experimental work on new systems of communication.

It is clearly recognized that these constraints are culture specific and it will be necessary to repeat the research in a number of places to insure adequate coverage.

17. Lack of risk-taking ability constitutes a major inhibitor in the adoption of any improved technology. Small farmers who grow grain sorghum or millet for their own use have very small amounts of risk capital, if any at all. Further, new technology frequently introduces a risk of family survival in that it carries an uncertainty of disease, insect, or weather response that may in some circumstance yield total failure. The subsistence farmer's perception of the risk involved, rather than the actual risk involved, is the determinant of whether or not he

adopts the new technology. If production is to be increased by the introduction of new technology, especially that which requires monetary investment, research into ways to reduce the amount of risk capital necessary for adoption of improved technology, and ways to reduce risk associated with its use assumes significant proportions.

18. Grain sorghum and millet are in most parts of the world regarded as "inferior" or "low status" grains. This may serve as a major constraint to the increase of production. Many of the respondents had the feeling that if small farmers could, they would prefer to grow what they regard as a superior grain such as maize, wheat or rice, and if they could increase yields of grain sorghum or millet they might cut back on total acreage and thus have the same total production, but on a smaller area. Therefore, research to establish the basis of the low image that GS/PM have may be important to addressing the problem. Is it bitter taste, longer processing time, lower quality soils on which the grain is grown, or other factors? How can this image be changed to encourage the increased use of grain sorghum or millet?

Again, this constraint likely is culture specific and would need to be addressed in various settings.

19. The exact role of grain sorghum and millet in the culture, including food production is only superficially known. Closely associated with 16, 17 and 18, as well as with the constraints listed under nutrition, social factors related to production and utilization of sorghum and millet need to be

better understood. For example, use of kafir beer throughout large portions of Africa as a social beverage is an important end use of grain sorghum. What would happen as a result of increased grain sorghum productivity in these portions of Africa? Would additional kafir beer be produced or would the grain sorghum be used as a human food, a livestock feed, or would total production not be increased?

20. If attempts are made to introduce grain sorghum or millet as new crops, a whole new series of social constraints will be developed. Social constraints described above are involved where grain sorghum and/or pearl millet are a part of the indigenous culture. However, in significant areas to which grain sorghum or millet are adapted it is not currently being grown. If current efforts to develop a cold tolerant grain sorghum in Mexico are pursued to fruition, then research on social factors of introducing a new grain into a culture need to be pursued with some diligence if social factors are not to become major constraints. Such potential constraints include those described above such as communications, risks, status of the crop, compatibility with the existing culture, etc.

21. Inadequate price policies and insufficient plans for the utilization of increased production of sorghum and millet. If production increases quickly above usual on-farm consumption levels, the marketable surplus will increase by a much larger percentage. For example, in some African countries where as little as 25 percent of the production has entered market channels, a modest production increase of 10 percent might double the amount marketed because all

of the increased production might be marketable surplus. Hence, for subsistence and small farm production systems, a potential set of "second generation" problems of significant proportions exists.

Even before "second generation" problems emerge, there exists the constraint of price policy designed to provide cheap food for consumers rather than incentives for producers. Many respondents indicated that price incentives to producers must be provided if countries are to break out of the hand labor, semi-subsistence production systems now found in much of Africa and Asia. This is of much less import in Latin America. However, incentive prices could lead to more production than needed for direct human consumption, because other food grains are preferred to sorghum and millet in almost all countries, i.e., only limited national markets exist. If economic development proceeds, however, food consumption patterns will shift to include more animal protein in the diet. In this case, sorghum and millet could shift from use primarily as a food grain to a feed grain. One of the best converters of these crops to animal protein is poultry. Poultry production and consumption is subject to few religious constraints, would be a valuable addition to many LDC diets, requires a minimum of refrigeration, and is relatively efficient in converting feed to meat. Poultry can be produced in small flocks, is a familiar enterprise for most farmers in the world, is capable of consuming sorghum and millet without grinding, and requires relatively little capital investment when produced on a small scale.

In this respect, potential for utilizing GS/PM for manufacturing processed foods should be explored. If such an alternative uses could generate demand by income groups other than the poorest segments of society, new production opportunities might result for GS/PM as a cash crop by small producers.

A strategy for agricultural development, including the increased production of GS/PM and shifting of their use from direct food to new forms of processed food or feed grains was not found in most LDC's. Suffice it to say, major constraints exist in the areas of price policy and product utilization, e.g. systems of production/nutrition improvement.

22. Poor-market information constrains efficient production and utilization of sorghum and millet. Especially among small farmers, who market infrequently and have a limited amount of information and transportation available, this is a problem. It not only limits supply response to incentive prices but also adds to problems of uncertain and uneven income flows that farmers who are attempting to break out of subsistence production must face. Likewise, consumers are at a disadvantage because supplies do not flow to areas of greatest need due to lack of market intelligence. As is true of the constraints discussed above, this is less of a problem in Latin America than in the other regions.

23. Inadequate market organization and performance serve as an obstacle to improved production and utilization of sorghum and millet. In many Asian and African countries marketing systems traditionally have been inefficient and poorly organized. Hence, governments elected to intervene. However, results seldom have realized initial expectations. In some cases, prices are not announced sufficiently far in advance to act as incentives. In other cases, the government marketing channels have not attracted enough sorghum and millet to justify their continuation. In still other cases

the government channels have not been responsive to changing situations. In almost all countries there is discontent with the way in which markets for sorghum and millet are organized and performing. This includes not only markets for the grains themselves but also for the inputs that must be purchased for these crops if their production is to be classed as anything above primitive.

IX. OTHER CONSTRAINTS

24. The shortage of trained manpower for conducting research on all aspects of food production, marketing, and utilization in LDC's and for staffing the educational institutions (including extension programs) constitutes a major constraint. The problem of limited facilities is a closely related problem, in some cases only slightly less severe. The problem assumes greater importance in Africa and Asia than in the other designated regions, but is significant in all LDC's. Surely, productive studies into the question of how best to contribute to the development of the manpower and institutional facilities needed have not been exhausted. It would seem highly in order that a total collaborative research program include components intended to contribute to the institutionalization of appropriate research in the LDC's to sustain the continuing adaptive research growing out of the program, to contribute to the pool of trained manpower in the LDC's, and to provide for improved dissemination of the results of the research to farmers and/or other individuals in a position to make use of those results.

B. Most Urgent Research Needs

The number of scientists and institutions conducting research directly related to grain sorghum and pearl millet is limited, in the U.S., at International Research Centers, and in LDC institutions. The number conducting research especially applicable to the small subsistence farmer in LDC's producing grain sorghum or pearl millet for human food is even more limited.

Throughout the preparation of this report, recognition was given to the mandate that USAID should focus on the rural poor in the LDC's. The listing of most urgent research needs is not intended to be used separate from the listing and discussion of constraints, but rather the two should be used together.

1. Plant Breeding and Genetics. Expanded work in plant breeding may be the avenue through which more constraints can be addressed than any other single category of research. The research, to be most productive, will be effectively integrated with research in plant pathology, entomology, human nutrition, animal nutrition, consumer acceptance, sociological and cultural factors, plant nutrition, and production systems, at the least, and likely with other kinds of research in particular areas or situations.

A comprehensive plant breeding research program that includes selection for increased productivity through better response to high level of nutrients, improved capacity to extract limited nutrients, more efficient use of limited nutrients, more efficient use of limited moisture, tolerance

for limited moisture, resistance to diseases, resistance to insects, and resistance to pests especially, birds, etc.; for increased nutritive value, both caloric and protein, and including digestibility; for greater consumer acceptance, with taste in the forefront but not to the exclusion of color, texture, etc.; and for adaptability to improved cultural and production systems seems indicated. Such a program could and should build on the excellent progress made to date in grain sorghum and pearl millet breeding. A major advantage of a research program of the scope envisioned is the possibility of integrating effectively into one program all of the concerns suggested by the above listing.

2. Research on Cultural Practices. Research in this area may offer the best prospect for non-monetized innovations or new technologies that require relatively little capital investment. Items that stand out in this area are those associated with stand establishment, weed control, cropping systems and/or production systems, and pest control. The different needs of the different production/consumption systems described in Appendix B, the variation in soils, rainfall, and climate; and difference in available technology (irrigation, markets, fertilizer, etc.) will need to be taken into account in planning a comprehensive program. Weed control is important especially in Africa and Asia. Practices that enhance yield stability, even with some sacrifice of high yield capability if necessary, seems to be of high priority in LDC's generally.

3. Plant Pathology Research. Integration of plant

pathology research with plant breeding research is an important part of the pathology contribution. But the reduced yields due to diseases is so important that an extensive research program directly focused on the identification of the economically important disease pathogens, and the development of disease control methods, cultural and chemical, is indicated. Again, a comprehensive program will account for the wide variation throughout the LDC's in important diseases, farming systems, available technologies, market orientations, etc.

4. Entomological Research. Production losses from insects, diseases, and pests are estimated to be as high as 60 percent in extreme cases. Integration of the entomology research with plant breeding research, especially resistance to insects, as is called for on p. 17. Research into the biology of economically important insects seems indicated. Insects that are damaging, both pre-harvest and post-harvest, should be studied. Control methods that are economically and ecologically adaptable are needed. Biological control of insects may assume greater importance in the future.

5. Research to Improve Grain Quality. If the production of grain sorghum and pearl millet for human food is a primary objective, then research to maintain or develop acceptable taste in the grain must be a high priority research objective. Utilization of grain sorghum and pearl millet for human food will not expand unless high quality grain types are developed that more nearly approach the high level of acceptance of wheat and rice. Quality

characteristics in need of research are (a) appearance, flavor, cooking quality, texture, etc.; and (b) nutritional characteristics such as digestability, caloric and protein content, toxicity, etc. For research in other areas to realize its potential in production response results, grain quality research is a necessary accompaniment.

6. Storage. Post harvest losses of all grains in LDC's is a major concern within the entire concern for improving world food supplies. Storage, per se, may seem to be, from this study at least, less important a concern for grain sorghum and pearl millet than for other grains important to LDC's. Nevertheless, post-harvest losses are of such significance that research to develop improved storage to protect the grain seems to be indicated. If in fact, the total research program leads to increased production of these grains, satisfactory storage will become even more important.

7. Development of Improved Methods of Technology Communication. If the research is to be useful, the results must be communicated to the ultimate user, largely the producer or the handler or the consumer; although frequently and to an increasing degree the government official may be the target of the communication. Ineffective modes of technology communication still prevail in much of the less developed world, although there is wide variation between countries. Imaginative research into improved methods is called for. This need is by no means commodity specific, yet a comprehensive research program on a commodity basis

will include research on this vital component, as well as a plan for disseminating the results of the major body of the research. Again, such programs should account for the wide variation in circumstances surrounding the producers and consumers in the different kinds of production/utilization systems described in Appendix B.

8. Trained Manpower. There is general agreement that the ultimate impact of research on LDC production will reach its potential only if the scientific base, in trained manpower and institutional support, is developed within the country to continue the research and education effort on an applied basis, at least. Research into procedures and modes by which external resources may be employed to impact this problem more effectively should yield valuable results. Research programs in general dealing with improved food production in LDC's might well include a component intended to contribute to the pool of scientifically trained manpower. This may well be a major advantage of a worldwide collaborative effort. The problem is not commodity specific, but a comprehensive commodity program should have such a component.

9. Market Development--Market Organization and Performance, and Market Information. Effective markets for both product and inputs are limited and limiting throughout most of the LDC's and for most food commodities. Much of the grain sorghum and pearl millet produced for direct human consumption never passes through a market. Yet, if increased production is achieved, and if it is to augment the food supply of all of the people of any country, some

kind of market system will be involved. The potential for research into market organization and structure for food grains in LDC's is great and yet to be achieved.

10. Government Policies, Especially Price policies. In most LDC's the central government performs a key role in directing and motivating both the production and marketing systems. It influences, if not controls, motivation of the principals in the system, the movement of product, the availability of inputs, the incentives for production, etc. Many governments search for ways to improve their performance in this respect to accomplish national goals. Collaborative research between U.S. and LDC scientists can be expected to serve such government officials, as well as to develop the capacity of indigenous scientists to continue to render such service to government on a sustaining basis.

11. The socio-cultural complex surrounding acceptance and Use of Grain Sorghum and Pearl Millet as Human Food. These commodities are widely known as low status commodities. Even though they have advantage in production in marginal situations, they are commodities of last resort after all others have failed. If biological breakthroughs are achieved so that the production advantage is enhanced, then these socio-cultural constraints to expanded use or to adoption in new areas assumes greater importance. Some imaginative research addressing these problems could justify investments in biological research by enhancing its usefulness.

12. Risks, per se, Constitute a Constraint to adoption of New Technology Such as to Warrant Research Attention. The

risk of unstable yield or occasional crop failure associated with adopting new technology or new varieties is important to the subsistence farmer. Both that risk and the risk of investing in purchased inputs with uncertain outcomes (both in production and in markets) is important to the market oriented producer. Most of the research cited above can be expected to contribure to decreased risks. Yet increased attention is being given to risk reduction, per se, and imaginative research in this area could have high pay off.

13. Nutrition. Although nutrition is highlighted in connection with grain quality (p. 20) and in connection with breeding (p. 17), nutrition research is of such importance that special mention is warranted. The importance of nutrition research associated with all research efforts to improve the world's food supply is recognized. Consideration is being given by AID and JRC to a general nutrition study as a priority. Certain types of nutrition research are inextricably related to the specific commodity under consideration, in this case, grain sorghum and pearl millet. No judgment as to the relative efficiency and effectiveness of nutrition research in the context of a total nutrition study as compared to commodity specific studies is being made at this time.

14. Farming Systems - Farm Management Reference is made in earlier sections to the importance of research related to how grain sorghum and pearl millet fit into the total farming system if they are to be produced at all. Research on practice and benefits of inter-cropping and

continued P. 23a

double cropping has been mentioned, and is a part of this research thrust. There is an important role for farming systems research to play in assuring that the other research output has relevance to the producer, especially the small farmer who cannot afford to test and experiment.

15. A Central or Unified Data Management System; Creation of an International Data Base. There is already underway an increase in the amount of information regarding grain sorghum and pearl millet, some in U.S. institutions, some in the International Research Centers, and some in the LDC's through both national and international research programs. Some of it is published and some is not. There should be developed a system of collection, storage and retrieval that will assure that all data is made readily available to all researchers and to extension education personnel around the world. The significant role of ICRISAT as an international center for grain sorghum and pearl millet research information is noted. The comprehensive and extensive nature of a collaborative research program such as is comtemplated in this project should offer a unique opportunity to create a truly international data base, and with either a single system or a unified management system, make that data available to all scientists throughout the world.

C. The Methodology Utilized

1. Overall Summary

The basic elements of the methodology utilized were established at the meeting of the ad hoc planning committee[1] constituted under the terms of the scope of work for developing a proposed Collaborative Research Support Program (CRSP) on Grain Sorghum/Pearl Millet (GS/PM).

The methodology involved three general steps:

(1) Survey questionnaires were administered to knowledgeable scientists for quantified information on (a) constraints to GS/PM production and utilization in less developed countries (LDC's), and (b) the present level of scientific knowledge concerning such constraints.

(2) Site visits to selected institutions with a manifest interest in GS/PM research programs to gain qualitative insights not possible from quantified questionnaire responses.

(3) A day long workshop of an institution-wide internal committee of scientists (composed of interviewer/site visitor scientists and other knowledgeable UMC scientists collaborating in the planning effort) to interpret, integrate, and summarize the results of steps (1) and (2).

(A) Selection of Scientists to be Contacted

The sample of scientists to be contacted or interviewed were selected as follows:

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[1] Made up of knowledgeable scientists from the University of Missouri, Columbia, and U.S. institutions with known strong research programs in the subject matter, plus designated liaison personnel with BIFAD, JRC, and AID, and a representative of ICRISAT.

1. A letter was sent to the directors of all experiment stations and the administrators of research in all eligible institutions listed by BIFAD inquiring of their interest in participating in the program. Of those who expressed interest, we requested the names of faculty who would represent the interest of that institution in a research program related to GS/PM production and utilization in the Less Developed Countries.

2. The ad hoc planning committee compiled a preliminary list of names of scientists which committee members felt might be missed in step 1, above.

3. In the survey questionnaire, respondents were asked to name other scientists who had an interest in and knowledge about the subject matter.

4. Contacts during site visits were not limited to scientists whose names appeared on the list; in fact interviewers were encouraged to seek out other knowledgeable persons.

(B) Selection of Sites for Visit

The selection of institutions for personal visits by scientist interviewers was based on the collective judgment of an eight-member UMC internal planning group made up of selected members of the institution-wide internal committee of scientists. To make the selection, this planning group evaluated (1) responses to the letters sent to directors and administrators of research, (2) the level of expenditures for GS/PM agricultural research by responding insti-

tutions (based on budget data from "Inventory of Agricultural Research," FY 1975, USDA, Volume II, Table II, B, pages 36-63) (3) location of selected persons from the list of scientists judged to be sufficiently knowledgeable and experienced to merit personal interview in order to gain qualitative insights not possible from mere administration of the survey instrument, and (4) time constraints to which this planning process is subject.

The institutions visited for purposes of gathering constraint questionnaire information and of learning about research underway are listed in appendix A.

Site visits first were made to an initial selection of U.S. institutions. Based on individual judgment of interviewers, the questionnaire was (1) administered by the interviewer in his visit with a particular scientist, (2) explained in some detail to the scientist and left with him for completion and return by mail, or, (3) left with one of the scientists (or administrators) contacted in the site visit to be passed on (and explained) to the scientist who was to complete it. This procedure resulted in 90 responses from scientists.

Upon completion of the first group of visits, the internal planning group made further selections of U.S. institutions for site visits and selected foreign institutions and agencies in LDC's to be visited. Interviews and site visits were completed by December 16, 1977.

(C) Workshop Procedure

As interviews and site visits were completed, the information on the constraints questionnaire was collated and summarized. Three additional kinds of information were available among the University of Missouri group, namely: (1) A great deal of information was gained from the site visits outside the constraints questionnaire; (2) several interviewers used the constraints questionnaire to summarize interviews, drawing quantitative conclusions based on their overall impressions and understanding resulting from the interviews and site visits; and (3) various members of the group studied different written materials, both published and unpublished, relevant to the subject. In addition to that, one faculty member participated in the five day world-wide conference on millet held at ICRISAT at the outset of the study, and collected report manuscripts of a similar conference on grain sorghum.

In total, twenty-one University of Missouri faculty members representing eight subject matter departments were involved in questionnaire interviews, site visits, literature review, and seminar discussions.

The day long workshop (December 20) was organized to provide a vehicle for bringing together the understandings of these faculty members and to apply their combined judgment to the relevance and significance of the constraints identified and under consideration.

This collective judgment of the workshp group is described in Section C., 3. of this interim report, entitled

"Summary of Workshop Evaluations by Interviewers and Internal Scientist Committee."

(D) Evaluation of Methodology Utilized

Experience in implementing the methodology described has resulted in some conclusions as to its strengths and weaknesses. Many of the weaknesses can (and will) be corrected in the ensuing planning period. It is the judgment of the planning institution that the results described in this interim report are, in general, an accurate representation of the problems and priorities to be addressed by a CRSP on GS/PM production and utilization in LDC's.

The substantial merit and strength of the methodology utilized is that it achieved as near complete coverage of the knowledgeable scientific community worldwide as reasonably could be expected with existing limitations of time and resources. It further permitted an extensive expert opinion weighting of all responses which can be expected to have achieved a composite which balances quantitative and qualitative data into an integrated result.

To maintain a perspective in the planning process which appropriately balanced relative emphasis on the biological aspects of GS/PM research, on the one hand, and research related to socio-economic aspects of GS/PM production/utilization, on the other, considerable effort was expended to assure joint participation of social and biological scientists in the internal planning activities, site visits and interviews. Site visits always were made by at least two scientists, one a social scientist and the other a biological

scientist. Despite these efforts, the number of biological scientists in the respondent list is considerably greater than the number of social scientists. This bias reflects, to a considerable extent, the commodity focus of the research planning involved, i.e., biological sciences research frequently is commodity-focused while social sciences research tends to be people oriented. This bias is reflected in the more precise categorization of biological constraints as compared to the socio-economic and institutional constraints.

The usefulness of the responses to the survey instrument would have been enhanced had the respondents been instructed to specify the type of production and utilization system[2] to which their responses were applicable. Since this was not done, applicability had to be imputed by the workshop group based on country or region specified by the respondent, and personal knowledge by workshop members as to the production/utilization system with which the particular respondent had experience or was otherwise familiar. An effort will be made to further overcome this weakness by categorizing questionnaire responses according to production/utilization systems and re-summarizing the data on that basis for inclusion in the final report.

The internal planning group is of the judgment that this will not significantly affect the priorities established by the workshop.[3]

[2]Three general types of systems are described in appendix B.

[3]If time had permitted, a pre-test of the survey instrument might have obviated this shortcoming.

Although the above discussion so implies, it should be expressly noted that there were cases of apparent inconsistencies in data and information that the application of the methodology described generated. These were resolved in the workshop. Where such apparent inconsistencies appeared to be significant and/or difficult to resolve, they are noted in the discussion of principal constraints and urgen research needs sections of this Interim Report.

2. Summary of Constraints Questionnaire Results

Appendix C lists the scientists who responded to the questionnaire. It also shows (a) their institutional association, (b) the countries or regions to which they indicated their responses applied, (c) whether they responded to questions related to grain sorghum or pearl millet or to both, (d) the constraint categories (Roman Numeral Headings as shown in the questionnaire in appendix E) which they addressed, and (e) the specialty or discipline of the scientist responding. The summary in appendix C suggests that GS/PM production/utilization research manpower emphasis presently is on biological sciences expertise, as compared to social sciences expertise. It also suggests that much less is known about and much less research presently is directed toward the social, economic and institutional factors constraining GS/PM production/utilization in LDC's. Further, significantly smaller numbers of scientists have knowledge of pearl millet production/utilization as compared to grain sorghum, and significantly fewer have knowledge of constraints in the Middle East, South Africa and Asia as compared to other areas of the developing world. Finally, the data suggests that many scientists have research experience that is limited to the U.S. This implies that a considerable scientific manpower resource base with specialized expertise in grain sorghum and pearl millet research is yet to be tapped for focusing on the alleviation of constraints as they are applicable to LDC conditions.

More than one alternative was tested for summarizing the data obtained from the survey questionnaire. Data from a selected set of questionnaires (40 responses) was summarized on a three-level priority scale. This was done on both a worldwide and on a regionalized (by ICRISAT regions) basis, for each constricting problem listed on the questionnaire. Priority levels were based on the sum of the response ratings given for (a) importance of the constraint and (b) level of present knowledge and programs according to the graduation scheme specified in the questionnaire (see appendix E, page 2, for a definition of the graduation scheme). Priority ratings were established as follows:

M: If the sum of the (a) and (b) ratings was 6 or more, the constricting problem was deemed to be a high priority research area requiring considerable resources.

S: If the sum of (a) and (b) ratings was 4 or 5, the constricting problem was deemed to be an intermediate priority research area requiring some resources.

I: If the sum of (a) and (b) ratings was 3 or less, the constricting problem was deemed to be a low priority research area, but one that might be important in some local cases.

Table C-2 shows a summary of data from the 40 selected questionnaires for all areas combined. (See page 38)

An examination of this summary indicates considerable diversity of opinion as to the research importance of the various constraints. Someone considered that every constraint listed was of high priority for research, while, by the same

token, nearly every constraint listed also was rated low priority by one or more persons.

Such a range of opinion is to be expected from respondents with a wide spectrum of scientific specialties and geographic interests. Nevertheless, the summary of responses can and did serve as a clear guide for focusing the deliberations of the workshop participants in developing a final list of proposed high priority research areas for a CRSP. This is especially true when the summary of ratings is viewed within the context of the accompanying comments made by respondents, both in writing on questionnaires, and verbally to the interviewers/site visitors at the time of their visits.

Based on the assumption that a relatively high number of ratings of high priority is a more reliable indicator of relative research importance than a relatively low number, all grain sorghum constraints where M equals 15 or more, and all pearl millet constraints where M equals 4 or more were selected from Table C-2. The resulting list of high priority research areas is as follows:

Constricting Problem	Grain Sorghum	Pearl Millet
I. Fertility and Plant Nutrition		
1. Fertilizer Response	X	X
2. Secondary & Micro Nutrients	X	X
3. Chemical and/or Physical Properties of Soil	X	X
4. Economics of Fertilizer Response	X	X

Constricting Problem	Grain Sorghum	Pearl Millet
II. Cultural Practices and management		
1. Seeding: Time, Rate, Depth, etc.	X	X
2. Weed Control	X	X
3. Water: Control, Storage, Quality	X	X
4. Harvest: Losses, Quality, etc.	---	X
5. Intercropping	X	X
6. Pest Control	X	---
7. Meteorological Factors: Growth & Yield	X	X
III. Engineering and Mechanization	---	---
IV. Breeding, Varietal Improvement and Development		
1. Introduction of Cultivars	X	X
2. Breeding for Resistance		
a. to diseases (pathogens)	X	X
b. to insects	X	---
c. to birds	X	---
3. Breeding for Quality (protein)	X	---
4. Breeding for Productivity		
a. yield	X	X
b. seedling vigor	X	---
c. plant characteristics	---	X
5. Seed Multiplication and Distribution	X	X
V. Entorology		
1. Identification and Damage		
a. stem boring insects	X	X
b. grain head insects	X	X
2. Control of Insects	X	X

Constricting Problem	Grain Sorghum	Pearl Millet
VI. Plant Pathology		
1. Disease Identification and Damage		
a. downy mildew	X	X
b. red stalk rot and anthracnose	X	---
c. ergot	---	X
d. smuts	---	X
e. headmolds	X	---
2. Control of Disease (combined)	X	X
VII. Utilization		
1. Constraints to Acceptance		
a. palatibility	X	X
b. tannins, lysine, etc.	X	X
c. mycotoxin problems	---	X
2. Constraints in Industrial Processing	---	X
3. Nutritional Constraints		
a. protein problems	---	X
b. digestability problems	---	X
VIII. Social and Institutional Factors		
1. Social Factors	X	X
2. Institutional Factors	X	X
3. Transportation	X	---
4. Storage	X	X
5. Marketing	X	X
IX. Other Constraints	X	X

A comparison of the above ratings with the ratings of the workshop group demonstrates a high degree of agreement.

The one constraint category where an apparent inconsistency stands out is in the Fertilizer and Plant Nutrition category. Here, the respondents to the questionnaire rate four constraining problems as high priority research areas, whereas the workshop group, based on site visits and personal interviews, did not feel that these were such high priority research areas. An examination of the individual (40 selected) questionnaires explains, at least in considerable degree, this variance. For example, 23 of the 29 responses rating fertilizer response as a high priority research area for grain sorghum were referring to the U.S., Latin America and East Africa. Twelve of the 15 high priority responses for pearl millet for the same constraint were referring to the same three regions. Thus, these respondents were undoubtedly using as a reference base the commercial production of these crops for livestock feed. Fertility and plant nutrition is, perhaps, the constraint category with most notable differences in priorities for research for the different production systems (described in appendix B). The workshop group assigned relatively less importance to research in fertility and plant nutrition, except for largely non-monetized alternatives, because of the relatively much greater importance of subsistence and small farmer GS/PM production and utilization by the poorest population sub-groups for direct consumption as compared to the mode for the U.S., most of Latin America and significant portions of East Africa.

Summary of the data by ICRISAT regions tended to reconfirm the conclusions on priority of research drawn from the data summarized for all areas combined.

Another selected set of about 30 questionnaires was collated in a different manner. The A and B ratings by respondents for each constricting problem were totalled and then averaged for each region and/or country designated by the respondent. This collation method shows (a) the number of scientists responding to each constricting problem, (b) the ICRISAT region and/or country of his response, and (c) the average rating of the constraint importance (A) and the average rating of the level of knowledge (B) for that constraint. Examination of this method of collation revealed no particular inconsistencies with the results shown in Table C-2. It did help to explain some of the variations in constraint importance depending on whether the respondent was referring to a country's specific problem or to generalized concern in several LDC's.

Because of the size of the tables summarizing questionnaire data by regions and countries, they are not reproduced in this report, but can be made available for examination on request.

TABLE C-2. Number of Responses By Constricting Problem and Priority Rating, All Areas Combined, University of Missouri Constraints Survey of Grain Sorghum/Pearl Millet Research Needs, Selected Questionnaires, December 1977.

Constricting Problem	Sorghum			Pearl Millet		
	M (1)	S (2)	I (3)	M	S	I
I. FERTILITY & PLANT NUTRITION						
1. Fertilizer Response	29	22	5	15	4	0
2. Secondary & Micro Nutrients	18	3	3	10	0	0
3. Chemical and or Physical Properties of Soil	16	5	0	6	1	1
4. Soil Test Calibration & Technique	5	7	1	2	4	1
5. Economics of Fertilizer Response	17	7	3	7	0	0
6. Toxicity	2	0	0	0	0	0
II. CULTURAL PRACTICES & MANAGEMENT						
1. Seeding: Time, Rate, Depth, etc.	31	18	13	5	4	4
2. Soil Preparation	4	2	4	2	0	2
3. Weed Control	16	5	1	8	0	0
4. Fertilizer Placement	3	1	5	1	0	2
5. Water: Control, Storage, Quality	49	19	4	6	4	2
6. Harvest: Losses, Seed Quality, Timeliness, Cost, Methods	10	7	11	6	2	4
7. Multiple Cropping:						
a. Double Cropping	4	2	3	1	0	2
b. Inter Cropping	7	5	1	4	3	0
8. Pest Control (birds, etc.)	15	3	1	1	2	0
9. Meterological factors						
a. Growth & yield	17	2	2	4	0	0
b. Effect on seed quality	6	3	2	1	0	2

(1) M= High priority research area requiring considerable resources.
(2) S= Intermediate priority research area requiring some resources.
(3) I= Low priority but may be important in some cases.

TABLE C-2. Number of Responses by Constricting Problem and Priority Rating, All Areas Combined, University of Missouri Constraints Survey of Grain Sorghum/Pearl Millet Research Needs, Selected Questionnaires, December 1977.

Constricting Problem	Sorghum			Pearl Millet		
	M	S	I	M	S	I
III. ENGINEERING AND MECHANIZATION						
1. Machinery Evaluation & Development						
a. Land Preparation, Planting & Cultivating	10	0	11	0	0	5
b. Plant Protection	3	1	3	0	0	1
c. Water Utilization	4	1	3	0	0	2
d. Harvesting	2	2	5	0	0	2
e. Transportation						
2. Storage						
a. Farm	10	0	5	0	0	2
b. Commercial	2	3	3	0	2	0
3. Crop Drying	5	0	35	0	0	2
IV. BREEDING, VARIETAL IMPROVEMENT AND DEVELOPMENT						
1. Introduction of Cultivars	20	10	6	6	1	0
2. Competition of Cultivars	11	4	1	3	1	0
3. Breeding for Resistance						
a. To Disease (pathogens)	32	8	0	6	0	0
b. To Insects	25	6	0	3	1	0
c. To Birds	20	10	3	3	2	2
d. To Other Pests	9	3	2	2	0	2
e. To Drought	3	0	1	1	0	1
4. Breeding for Quality						
a. Protein	16	2	3	2	0	1
b. Palatability	12	3	3	2	0	1
5. Breeding for Productivity						
a. Yield	23	2	1	5	2	1
b. Seedling Vigor	18	3	2	0	1	2
c. Plant Characteristics	13	8	1	4	1	1
6. Breeding Methodology	8	2	9	0	0	4
7. Cytology	1	4	5	0	1	2
8. Seed Multiplication	19	2	0	3	1	0
9. Seed Storage & Distribution	24	8	6	7	1	0

TABLE C-2. Number of Responses by Constricting Problem and Priority Rating, All Areas Combined, University of Missouri Constraints Survey of Grain Sorghum/Pearl Millet Research Needs, Selected Questionnaires, December 1977.

Constricting Problem	Sorghum			Pearl Millet		
	M	S	I	M	S	I
V. ENTOMOLOGY						
1. Identification & Damage						
a. Soil Insects	4	2	6	0	1	2
b. Seedling Insects	9	3	5	1	0	2
c. Foliage Insects	9	6	2	3	1	0
d. Stem Boring Insects	15	3	1	5	1	0
e. Grain Head Insects	16	2	0	5	1	0
f. Stored Grain Insects	12	2	1	3	1	0
2. Control of Insects	36	5	4	4	3	5
3. Economics of Control	13	0	0	3	0	0
4. Identify Beneficial Insects	6	2	2	0	0	2
VI. PLANT PATHOLOGY						
1. Disease Identification & Damage						
a. Fungi						
(1) Downy Mildew	4	3	0	0	0	0
(2) Red Stalk Rot & Anthracnose	14	7	5	5	0	0
(3) Leaf Spots & Rusts	16	5	5	0	0	2
(4) Ergot	12	7	7	0	1	2
(5) Smuts	7	4	7	4	1	0
(6) Headmolds	9	6	5	4	0	0
b. Bacteria (Stripe)	25	3	0	1	1	2
c. Viruses (MSMV)	2	6	4	0	0	2
d. Nematodes (Root Knot)	3	10	2	0	0	2
e. Phanerogamic Parasites (Witch Weed)	1	0	3	0	0	2
2. Control of Disease	12	3	4	3	0	0
a. Cultural Control	3	0	0	0	0	0
b. Chemical Control	6	1	2	2	0	0
c. Resistance to Pathogens	3	0	3	0	0	2
3. Economics of Control	11	0	1	3	0	0
	4	0	1	0	0	0

TABLE C-2. Number of Responses by Constricting Problem and Priority Rating, All Areas Combined, University of Missouri Constraints Survey of Grain Sorghum/Pearl Millet Research Needs, Selected Questionnaires, December 1977.

Constricting Problem	Sorghum			Pearl Millet		
	M	S	I	M	S	I
VII. UTILIZATION						
1. Constraints in Processing						
a. In Home	4	2	4	0	0	4
b. Industrial Processing	7	4	17	10	3	14
2. Constraints in Acceptance						
a. Palatability	21	10	12	10	5	3
b. Tannins, Lysine, etc.	25	4	8	7	2	0
c. Fortifications	4	1	4	1	1	2
d. Mycotoxin Problems	8	1	6	4	1	0
3. Nutritional Constraints						
a. Protein Problems	4	1	3	4	0	0
b. Digestability Problems	11	0	3	6	0	0
VIII. SOCIAL & INSTITUTIONAL FACTORS						
A. Social Factors	24	6	16	8	0	5
B. Institutional Factors	25	1	5	14	0	0
C. Transportation	23	2	3	3	0	0
D. Storage	31	3	8	8	0	4
E. Marketing	18	1	12	6	0	2
IX. OTHER CONSTRAINTS	75	16	16	22	2	2

3. Summary of Workshop Evaluation by Interviewers and Internal Scientist Committee.

The data base for the derivation of the constraints was collected from three general sources (1) literature of the field including CRIS project reports; (2) completed constraint questionnaires filled out by leading scientists; and (3) observations and other information collected by several teams of scientists in their visits to research institutions in this country and to selected international and national research centers in other countries.

This large, diverse, and sometimes conflicting set of information had to be brought together into a coherent body. To accomplish this, two steps were taken: (1) All appropriate data, including copies of the constraints forms, were shared with the internal scientists, for their area of responsibility, and (2) an all day workshop was attended by members of the teams and other UMC scientists collaborating in the planning effort (20 persons in total). The constraint form was used as a guide for the workshop deliberations. Countries of the world were divided into the ICRISAT regions, plus the U.S.A. Using this two way classification scheme, each of the major topical areas was discussed by first presenting the results of the constraints questionnaires and then by presenting the observations of site visit teams. Each discussion of a topical area was led by a scientist from that area. As a result of the discussions, the wording of the constraints used on the questionnaire was modified

to better describe actual problems. Then each constraint was assigned a numerical value in each of two columns for each of the major regions. The number in the A column is a code for the rating of the importance of the problem or constraint, and the number in the B column is a code for the level of present knowledge and programs underway. The key to this graduation scheme is:

A. The importance of the problem or constraint

1. Problem or constraint of little importance
2. Problem or constraint of only periodic importance
3. Problem or constraint important in some local situations
4. Problem or constaint of wide-scale importance

B. Level of present knowledge and programs underway to gain necessary knowledge

0. Problem or constraint solvable by transfer of technology, a crop production or development program required
1. Local information satisfactory, some other studies maybe advantageous
2. Strong program underway that should generate necessary knowledge, may need some refinement
3. Only preliminary information available, major thrust is required
4. No local information available, a need to initiate new or relative new research effort

For most of the constraints, unanimous agreement was reached, both for the ranking of importance and for the level of knowledge. For the remainder, agreement was substantial. The results of the workshop ratings are shown in tabular form on pages 43A to 43E.

C-3 Summary of Interviewer Ratings of: (A) Principal Constraints to Production and Utilization of Grain Sorghum and Pearl Millet as food sources, and (B) Level of Knowledge Regarding Those Constraints, by Regions Established by ICRISAT plus USA, Rated as per Graduation Scheme Attached.

Constraint Category	West Africa		East Africa		South Africa		Asia		Middle East		South America		India		US	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Fertility & Plant Nutrition																
(1) Nitrogen Fixation	4	4	4	4	4	3	4	4	4	4	4	2	4	2	4	2
(2) Long Term Fertility Maintenance																
a. Intercropping	4	3	4	3	3	3	3	3	3	3	3	2	3	2	1	2
b. Organic residue management	4	3	4	3	3	3	3	3	3	3	3	2	3	2	1	2
c. Soil erosion/water management	4	3	3	3	4	3	3	3	3	3	4	3	3	2	1	2
(3) Use of Manufactured Fertilizer																
a. Variable yields, year to year	4	3	4	3	4	3	4	3	4	3	4	2	4	2	2	1
b. Lack of market and inadequate infrastructure	4	3	4	3	3	3	3	3	3	3	2	2	2	2	1	1
(4) Fertilizer Response and Soil Test Calibration	1	1	1	1	1	1	1	1	1	1	3	2	1	1	2	2
(5) Secondary Nutrients	1	3	1	3	1	3	1	3	1	3	3	3	1	3	3	3
(6) Chemical & Physical Properties of Soil Including Salinity, Acidity, etc.	1	3	1	3	1	3	3	3	3	3	3	3	2	3	3	2

C-3 Summary of Interviewer Ratings of: (A) Principal Constraints to Production and Utilization of Grain Sorghum and Pearl Millet as food sources, and (B) Level of Knowledge Regarding Those Constraints, by Regions Established by ICRISAT plus USA, Rated as per Graduation Scheme Attached.

Constraint Category	West Africa		East Africa		South Africa		Asia		Middle East		South America		India		US	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
I. Cultural Practices & Management																
(1) Stand Establishment																
a. Rate, depth, time of seeding, water control	4	3	4	3	4	3	4	3	4	3	2	2	4	3	3	2
b. Seedling vigor	4	3	4	3	4	3	4	2	4	2	2	2	4	2	3	1
(2) Bird, Rodent, and Animal Control (planting to harvest)	4	3	4	3	4	3	4	3	3	3	3	4	3	3	2	4
(3) Multiple Cropping & Inter-cropping	3	3	3	3	3	3	3	3	3	3	3	2	3	2	2	2
(4) Weed Control	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	1
II. Engineering & Mechanization																
(1) Commercial Storage																
a. Sorghum	3	0	2	0	2	0	3	0	2	0	2	0	3	0	1	0
b. Millet	3	0	-	-	2	0	-	-	-	-	-	-	2	0	-	-
(2) Machinery Development and Availability	3	0	3	0	3	0	3	0	3	0	3	0	3	0	1	0
(3) Farm Storage																
a. Sorghum	3	1	3	1	3	1	3	1	3	1	3	1	2	1	2	0
b. Millet	3	1	3	1	3	1	3	1	3	1	3	1	2	1	-	-
(4) Drying (Sorghum)	-	-	-	-	-	-	-	-	-	-	3	0	-	-	1	0

C-3 Summary of Interviewer Ratings of: (A) Principal Constraints to Production and Utilization of Grain Sorghum and Pearl Millet as food sources, and (B) Level of Knowledge Regarding Those Constraints, by Regions Established by ICRISAT plus USA, Rated as per Graduation Scheme Attached.

Constraint Category	West Africa		East Africa		South Africa		Asia		Middle East		South America		India		US	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
IV. Breeding, Varietal Improvement, and Development																
(1) Productivity																
a. Sorghum	4	2	4	2	4	2	4	3	4	3	3	2	4	2	4	3
b. Millet	4	2	4	3	4	2	4	3	4	3	3	2	4	2	4	2
(2) For Resistance																
a. Sorghum	4	2	4	2	4	2	4	3	4	3	3	2	4	2	4	2
b. Millet	4	2	4	3	4	2	4	3	4	3	3	2	4	2	4	2
(3) For Quality (Acceptability, Nutrition)																
a. Sorghum	4	3	4	3	4	3	4	3	4	3	3	3	4	2	4	2
b. Millet	4	3	4	3	4	3	4	3	4	3	3	3	4	2	4	2
(4) Seed multiplication	4	3	4	3	4	3	4	3	4	4	3	2	3	2	1	0
V. Entomology																
(1) Biology of Economically Imported Insects:																
a. Preharvest:																
1. sorghum	4	2	4	3	4	3	4	3	4	3	4	2	4	2	4	-
2. millet	3	2	3	3	3	3	3	3	3	3	3	2	3	2	-	-
b. Postharvest	4	2	4	3	4	3	3	3	3	3	3	3	3	2	2	2
(2) Insect Control (cultural, chemical, biological)	4	2	4	3	4	3	3	3	3	3	3	2	3	2	3	

C-3 Summary of Interviewer Ratings of: (A) Principal Constraints to Production and Utilization of Grain Sorghum and Pearl Millet as food sources, and (B) Level of Knowledge Regarding Those Constraints, by Regions Established by ICRISAT plus USA, Rated as per Graduation Scheme Attached.

Constraint Category	West Africa		East Africa		South Africa		Asia		Middle East		South America		India		US	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
VI. Plant Pathology																
(1) Economically Important Disease Pathogens:																
a. Sorghum	3	3	3	3	3	3	3	3	3	3	3	2	3	2	3	2
b. Millet	3	3	3	3	3	3	3	3	3	3	-	-	4	2	-	-
(2) Control of Diseases (cultural, chemical, resistance):																
a. Sorghum	4	3	4	3	4	3	3	3	3	3	4	2	4	2	4	2
b. Millet	4	3	4	3	4	3	3	3	3	3	-	-	4	2	-	-
II. Utilization																
(1) Quality (palatability, digestibility, tannins, texture, protein, color, caloric value, mycotoxins):																
a. Human food	4	3	4	3	4	3	4	3	4	3	3	4	4	3	-	-
b. Livestock feed	-	-	4	3	3	3	3	3	3	3	3	3	3	3	3	2
(2) Forage	3	3	3	3	3	3	3	3	3	3	3	2	3	3	2	2

C-3 Summary of Interviewer Ratings of: (A) Principal Constraints to Production and Utilization of Grain Sorghum and Pearl Millet as food sources, and (B) Level of Knowledge Regarding Those Constraints, by Regions Established by ICRISAT plus USA, Rated as per Graduation Scheme Attached.

Constraint Category	West Africa		East Africa		South Africa		Asia		Middle East		South America		India		US	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
III. Social & Institutional Factors																
(1) Marketing:																
a. Price and market policy	4	3	4	3	4	3	4	3	4	3	3	1	4	3	-	-
b. Market information	4	3	4	3	4	3	4	3	4	3	2	3	3	3	-	-
c. Market organization and performance	4	3	4	3	4	3	4	3	4	3	2	3	4	3	-	-
d. Transportation	4	1	4	1	4	1	3	1	3	1	2	1	3	1	-	-
(2) Infrastructure (credit, cooperatives, etc.)	4	3	4	3	4	3	3	3	3	2	3	2	3	2	-	-
(3) Communication and Adoption																
a. Organizational structure (Extension)	4	3	4	3	4	3	4	3	4	3	4	2	4	2	-	-
b. Cultural constraints (presige of grains, differences in ethnic groups, etc.)	4	3	4	3	4	3	4	3	4	3	4	3	4	3	-	-
c. Technological compatibility	4	3	4	3	4	3	4	3	4	3	4	3	4	3	-	-
IX. Other Constraints																
(1) Shortage of Research Personnel	4	-	4	-	4	-	4	-	3	-	3	-	2	-	-	-
(2) Inadequate Educational and Research Facilities	4	-	4	-	4	-	4	-	3	-	2	-	2	-	-	-
(3) Limited Financial Resources	4	-	4	-	4	-	4	-	3	-	3	-	3	-	-	-

APPENDIX A

Institutions Visited by University of Missouri Faculty University of Missouri Constraints Survey of Grain Sorghum/Pearl Millet Research Needs, November & December, 1977

1. ICRISAT Headquarters, India
2. Indian Agricultural Research Institute, India
3. All India Sorghum Project, India
4. All India Millet Project, India
5. National Institute of Nutrition, India
6. Andhra Pradesh Agricultural University, India
7. Indian Council for Agricultural Research, India
8. USAID/India, India
9. Maharashtra Agricultural University, India
10. ICAR, New Delhi, India
11. Punjab Agricultural University, India
12. Technical Service Association, Pakistan
13. Yousafwala Maize & Millet Research Institute, Pakistan
14. Barani Project, Pakistan
16. Agricultural Research Council, Pakistan
17. Cereal Research Institute, Pakistan
18. FAO Office, Syria
19. Arab Center for Study of Arid Zones, Syria
20. USAID/Syria, Syria
21. University of Khartoum, Sudan
22. USAID/Sudan, Sudan
23. Ministry of Agriculture, Sudan
24. Katumani Branch Research Station, Kenya
25. FAO Office, Kenya
26. East Africa Agricultural and Forestry Research Organization, Kenya
27. USAID/Kenya, Kenya
28. Ministry of Agriculture, Kenya
29. USAID/Senegal, Senegal
30. Bambey Research Station, Senegal
31. ISRA, Senegal
32. ICRISAT Office, Senegal
33. EMBRAPA National Corn and Sorghum Research Center, Brazil
34. Instituto Nacional de Alimentacao e Nutricao, Brazil
35. Empresa Brasileira de Assistencia Tecnica e Extesso Rural, Brazil
36. University Federal of Brasilia, Brazil
37. EMBRAPA Headquarters, Brazil
38. Pernambuco IPA, Brazil
39. Instituto Colombiano Agropecuario, Colombia
40. CIAT Headquarters, Colombia

41. Centro Nacional de Technologia Agropecuaria, El Salvador
42. CIMMYT Headquarters, Mexico
43. National School of Agriculture, Mexico
44. University of Nebraska, USA
45. Texas A&M University, USA
46. Mississippi State University, USA
47. University of Arizona, USA
48. Purdue University, USA
49. Oklahoma State University, USA
50. Kansas State University, USA
51. Texas Tech University, USA
52. United States Department of Agriculture, USA

APPENDIX B

Current Production/Utilization Systems

In the process of identifying problems and research needs in grain sorghum and pearl millet production, marketing and utilization in LDC's, it became apparent that the importance and nature of constraints and research needs are different for different types of grain sorghum/pearl millet (GS/PM) production/utilization systems. There of course is considerable variability in such systems between regions of the world, from country to country, and from area to area within countries, as well as from farm to farm. Nevertheless, based on a review of information from knowledgeable experts 1) in GS/PM production/utilization and 2) in agricultural development in LDC's, it appears that these many systems can be broadly grouped, for identification of urgent research needs, as follows:

1. Subsistence production which is directly consumed primarily by the producing family.
2. Small farm production where a significant part of the production is fairly consistently marketed as a food grain.
3. Medium/large farm commercial production marketed primarily as a feed grain.

Examination of the distinguishing characteristics of these three GS/PM production/utilization systems rather clearly demonstrates the difference in research needs for addressing constraints related to GS/PM production/utilization within each system group.

It is estimated that nearly 75 per cent of LDC grain sorghum production worldwide falls into the first two systems listed above, whereas perhaps as much as 90 per cent of pearl millet production falls within those systems. In most countries of Africa, India, and Asia more than three-fourths of total production of grain sorghum is utilized for direct human consumption, while in Latin America, an estimated 90 per cent is utilized for livestock feed. In the case of pearl millet, the grain is produced almost entirely for direct human consumption in all LDC's, while the forage is used for livestock and other uses. Table B-1 (attached p. 53) shows the above estimates by ICRISAT region.

The following discussion summarizes the particular characteristics in each system group that surfaced as being important determinants of the urgency of research addressing constraints affecting that system.

1. Subsistence Production/Consumption System

This group is characterized by the non-monetized nature of the GS/PM production/utilization process. The objective of the producing families here is to produce sufficient GS/PM to satisfy their own basic food needs. They try to plant enough to produce for their minimum needs even in (what their experience tells them would be) a bad crop year. Thus, in a good crop year, they can expect to have a small surplus for sale; in an average year they will have adequate GS/PM for their own consumption. In a bad year they will be on short rations, and in a very bad year they face serious supply deficiencies and resulting malnutrition.

The poorest sub-group of this subsistence producer group is almost totally non-monetized, with no production of any crop for sale, while another sub-group produces, in addition to GS/PM for their own consumption, another cash crop for sale. For example, in areas of Central West Africa, groundnuts are produced as a cash crop by small farmers who raise GS/PM for home consumption, whereas in much of the more arid areas of North-West Africa, many subsistence families produce only pearl millet for their own consumption, and, if they have a surplus, trade with nomadic herdsmen for animal products.

Some characteristics of this group that are important to take into account in determining urgent research needs are:

a. The risk structure is such that to be willing to adopt a production practice dissimilar to that with which the farmer is familiar, he must perceive it as no threat to his minimum family subsistence needs. He is not readily willing to risk family survival. Thus, for him, yield stability, takes priority over higher yields per unit of land or labor used in the production process.

b. Since the production/utilization process is non-monetized, there is no transactional basis for using cash inputs such as manufactured fertilizers and purchased seed. Research oriented toward improvement in use of cash inputs would be relevant to this subsistence group only as they move into

the money economy and begin purchasing cash production inputs such as fertilizer and pesticides. Even improved seed is not relevant to a non-monetized production system unless it can be introduced periodically, permitting seed re-use for several years without destroying the beneficial characteristics of the improved seed.

c. Market structure probably is not very important to this production system, since the marketing function is a discontinuous process that does not move beyond local barter markets. This is not to say that as a producer under this sytem moves to a more market-oriented system, market structure does not become important. However, this moves the producer into another system. A similar conclusion probably can be drawn for institutional structure related to input supply and production credit. However, to the extent that constraint-alleviating production research output is relevant to this system, the institutional structure for outreach is an important problem area to be addressed by appropriate research.

d. Given the above, it is likely that research related to cultural practices is potentially the most useful production research for impacting on this system. Outreach methods and institutional structures, and other socio-cultural factors affecting change from this system to another also are important.

Finally, research designed to increase production under this system, e.g., intercropping, nitrogen fixation, etc., may have relevance.

2. Small Farmer Market-Oriented Production/Domestic Food Use System

This group produces for home consumption as in the case of the subsistence group, but a producer in this group also consistently expects to have production for sale. Such sales generally are within the local market, some being bartered for other consumption items for the producer family, but generally there are sales for cash. The production which is sold moves through domestic channels for consumption as human food for the rural non-farm and urban poor.

The actual production system for this group generally is as primitive as is that of the subsistence producer, and his risk orientation is similar. However, there is some potential for adoption by this group of producers of low-risk cash inputs in the production process, as well as cultural practices that improve labor use efficiency. In some cases, land availability may be a constraint (El Salvador, for example), but in other areas of the world, labor probably is the critical constraint at crucial periods in the production process. Likewise, moisture shortages frequently limit production.

What is of overriding importance to members of this group of producers, in terms of the production process, appears to be the effect which the introduction of a change in the way GS/PM is produced may have on the total farming

system of the individual farm/household firm. Shifts in land use or labor utilization for one crop impacts on production of other crops, non-farm labor use, consumption patterns, etc., for the farm family.

This means that production research activities aimed at resolving constraints for this group of farmers must be very closely associated with farmer adoption. Thus, such research must be closely integrated into the outreach structure of the country aimed at this group, and that outreach structure must incorporate a workable testing/feedback system from the research institution to farmers and back again to the research institution.

In addition to the characteristics described above for the production aspects of the system, the marketing/utilization aspects of this system assume considerable importance since market structure often is not well developed. Effective demand for what this group of farm families produces is constrained by the ability of the marketing/utilization system to reflect consumer demand for GS/PM as compared to substitutable products such as rice and wheat. To the extent that imperfections in the physical and institutional structure of the market dampen demand at the farm gate, to that extent, supply response is limited. Socio-cultural factors related to social status of GS/PM, as well as nutritional and related characteristics of the product, such as palatibility and digestability, may be important researchable constraints, albeit often relatively site-specific. Researchable problems related to price policy and institutional

structure usually are apparent. Again, the relationship and interchange between the research process and application to site specific situations gains considerable importance.

3. Commercial Production/Feed Grain Utilization System

The characteristics of this type of production/utilization system in LDC's most closely parallels the U.S. system, although there may be significant differences. However, in terms of present importance to LDC's, this system is significant only in Latin America and in some countries in East and South Africa. Even in Latin America, except for Mexico and Argentina, GS/PM are relatively minor crops.

Improved output efficiency in the use of cash inputs such as fertilizer, pesticides and improved seed are important constraints for this system. In some countries where this system is not yet well established, marketing structure and development may be important constraints.

This system has only limited impact on the poorer segments, (whether rural or urban), of LDC populations, whereas the other two systems described impact heavily on these poorer segments.

In terms of relative importance to GS/PM production/utilization in LDC's, research activities which are aimed at resolving constraints limited to this group generally can be expected to be of lower priority than research activities aimed at resolving constraints which obviously impact significantly on the other two groups.

Table B-1

Estimate of Production of GS/PM, by End Use and in Total, for Countries Producing 50,000 Hectares or More, Grouped by ICRISAT Regions, 1976 (in Thousands of Hectares)

	GRAIN SORGHUM						PEARL MILLET					
	Total hectare	%*	Human Food hectare	%	Livestock Feed hectare	%	Total hectare	%*	Human Food hectare	%	Livestock Feed hectare	%
W. Africa	7,830	19	7,047	90	783	10	10,608	31	9,548	90	1,060	10
E. Africa	10,150	25	7,612	75	2,538	25	3,833	11	3,450	90	383	10
S. Africa	351	1	176	50	175	50	555	2	500	90	55	10
Asia	705	2	564	80	141	20	1,047	3	942	90	105	10
Mid East	711	2	356	50	355	50	-	-	-	-	-	-
L. America	4,455	11	445	10	4,010	90	269	1	242	90	27	10
India	16,000	40	12,800	80	3,200	20	18,000	52	16,200	90	1,800	10
Totals	40,202	100	29,000	72	11,202	28	34,312	100	30,882	90	1,430	10

Source: Derived from Foreign Production, Supply and Distribution of Commodities (computer tape), National Technical Information Service, U.S. Department of Commerce, and UMC estimates.

*These percentages refer to per cent of total hectares for all LDC's listed.

APPENDIX C

Respondents to Constraint Questionnaire by Institution and by Selected Characteristics of the Responses

University of Missouri Constraints Survey of Grain Sorghum/Pearl Millet Research Needs

December, 1977

Responding Scientist by Institution	Region to Which (1) Response Applies	Subject Category (2) of Response	Crop of (3) Response	Specialty of (4) Respondent
University of Arizona				
1. Matlock, W. G.	W.A.	I,II,III,VI,	G.S.,P.M.	Ag. Engineering
2. McDaniel, R. G.	U.S.	I,II,IV	G.S.	Plant Breeding
3. Rice, R. W.		VII,VIII,IX		Animal Nutrition
4. Swingle, R . S.	U.S.	IV,VII	G.S.	Animal Nutrition
5. Theurer, C. B.		VII		Animal Nutrition
6. Webster, O. J.	W.A.	all	G.S.,P.M.	Plant Breeding
Kansas State University				
1. Chung, D.S.				Ag. Engineering
2. Edmunds, L. K.	U.S.			Plant Pathology
3. Hackerott, H. L.	U.S.	II,IV,V,VI	G.S.	Plant Breeding
4. Hoseney, R. C .	W.A.,F.A.,IA.	VII	G.S.,P.M.	Grain Science
5. Harvey, T. L.	U.S.	V	G.S.,P.M.	Entomology
6. Kanemasu, E.	U.S.	II	G.S.	Crop Physiology
7. Olson, R. V.	W.A.,F.A.	all	G.S.,P.M.	Soils
8. Pedersen, S. J.	with Chung, D.S.(q.v.)			
9. Peterson, V. H.	IA.	I,II,III,VIII,IX	G.S.	Crop Physiology
10. Pfost, H.	with Chung, D.S.(q.v.)			
11. Stegneicr, W. D.	U.S.		P.M.	Plant Breeding
12. Vanderlip, R. L.	W.A.,E.A.	all	G.S.,P.M.	Crop Physiology
13. Varreavo-Marsten, E.	U.S.	VII,VIII	P.M.	Food Science
14. Wilde, G.	U.S., L.A.	V	G.S.	Entomology
University of Michigan				
1. Ross, C.	W.A.	VIII,IX	P.M.	Agricultural Economics

Respondents to Constraint Questionnaire by Institution and by Selected Characteristics of the Responses
University of Missouri Constraints Survey of Grain Sorghum/Pearl Millet Research Needs
December, 1977

Responding Scientist by Institution	Region to Which (1) Response Applies	Subject Category (2) of Response	Crop of (3) Response	Specialty of (4) Respondent
Mississippi State Univ.				
1. Andrews, C. H.	W.A.,L.A.	II,III,IV,V,VIII	G.S.	Seed Technology
2. Delouche, J. C.	U.S.	I,II,III,IV,VII,VIII, IX	G.S.,P.M.	Agronomy
3. Ditworth, B. C.		VII,VIII,IX		Animal Nutrition
4. Gourley, L.	U.S.	I,II,IV,V,VI,IX,	G.S.	Plant Breeding
5. Jones, W. F.	U.S.	I,II	G.S.	Soils
6. King, S. B.	W.A.	II,III,V,VI,VIII,IX	G.S.,P.M.	Plant Pathology
7. Pitre, H. N.	U.S.	V	G.S.	Entomology
8. Sanford, J. O.	U.S.	II	G.S.,P.M.	Soils
9. Saunders, J.	L.A.	VIII	G.S.,P.M.	Rural Sociology
10. Whisler, F. D.	U.S.	II	G.S.	Agronomy
University of Nebraska				
1. Clark, R. B.	U.S.,L.A.	I,IV	G.S.,P.M.	Crop Physiology
2. Clegg, M.D.	U.S.,L.A.	I,II,III,IV	G.S.	Crop Physiology
3. Dunkle, L. D.	U.S.	VI	G.S.	Plant Pathology
4. Francis, C. F.	L.A.	all	G.S.	Plant Breeding & Physiology
5. Kindler, S. D.	U.S.	V	G.S.	Entomology
6. Maranville, J.	U.S.	I,II,VII	G.S.,P.M.	Plant Physiology
7. Olson, R. A.	L.D.C.	I,II,VII	G.S.	Soils
Oklahoma State University				
1. Page, R.E. Gus	E.A.	I,II,III,IV,V,VI,VII, VIII	G.S.	Marketing Economics
2. Rouk, Hugh F.	E.A.	VII,VIII	G.S.	Agronomy
3. Weibel, D. E.	AS.,L.A.	I,II,III,IV,V,VI,VII, VIII	G.S.,P.M.	Agronomy

Respondents to Constraint Questionnaire by Institution and by Selected Characteristics of the Responses

University of Missouri Constraints Survey of Grain Sorghum/Pearl Millet Research Needs

December, 1977

Responding Scientist by Institution	Region to Which (1) Response Applies	Subject Category (2) of Response	Crop of (3) Response	Specialty of (4) Respondent
Purdue University				
1. Butler, L.	L.D.C.	II,IV,VII	G.S.	
2. Contrell, R. P.	U.S.,L.A.	II,IV,V	G.S.	
3. Ejetta, G.	E.A.	all	G.S.	
4. Featherston, W. R.	U.S.	VII	G.S.	Animal Nutrition
5. Finch, E.	L.A.	III,VIII	G.S.	
6. Forsyth, D. M.	U.S.,L.D.C.	VII	G.S.	
7. Foster, G. H.	L.A.	III	G.S.	
8. Hoff, J. E.	U.S.,AS.	IV,VII,IX	G.S.	Food Science
9. Kirleis, A. W.	U.S.	IV,VII,IX	G.S.	Cereal Technology
10. Mertz, E. T.	U.S.,L.A.,IA.	IV,VII	G.S.	Biochemistry
11. Myquist, W. E.			G.S.	
12. Price, M. L.	L.D.C.	IV,VII	G.S.,P.M.	
13. Tuite, J.	U.S.,E.A.,IA.	III,IV,V,VI,VII,VIII	G.S.	Plant Pathology
14. Warren, H. L.	U.S.,E.A.,IA.	I,III,IV,V,VI,VII,VIII	G.S.	Plant Pathology
15. West, L. G.	U.S.	VII	G.S.	Nutrition & Food Toxicology
Story, J. A.				
Greger, J. L.				
16. White, T. K.	W.A.,L.A.	I,II,IV,V,VI,VII,VIII, IX	G.S.	

Respondents to Constraint Questionnaire by Institution and by Selected Characteristics of the Responses
University of Missouri Constraints Survey of Grain Sorghum/Pearl Millet Research Needs
December, 1977

Responding Scientist by Institution	Region to Which (1) Response Applies	Subject Category (2) of Response	Crop of (3) Response	Specialty of (4) Respondent
Texas A&M				
1. Frederiksen, R. A.	L.D.C.	I,IV,VI,VII,IX	G.S.,P.M.	Plant Pathology
2. Johnson, J. W.	AS.,L.A.,IA.	I,IV,V,VI	G.S.,P.M.	Entomology
3. Jordon, W. R.	U.S.	I,II,III,IV,VIII,IX	G.S.	Plant Physiology
4. Krieg, D.	W.A.,U.S.	I,II,IV,V,VI,VII,VIII, IX	G.S.,P.M.	Plant Physiology
5. Miller, F. R.	L.D.C.	I,II,III,IV,VI,VII, VIII,IX	G.S.	Plant Breeding
6. Morgan, P.	M.E.,U.S.	I,II,IV	G.S.	Plant Physiology
7. Reyes, L.	L.A.	I,II,III,IV,VI,VIII, IX	G.S.	Plant Pathology
8. Rooney, L.	AS.,IA.	VI,VII	G.S.,P.M.	Food Science
9. Rosenow, D. T.	L.D.C.	all	G.S.,P.M.	Plant Breeding
10. Shertz, K.	L.D.C.	IV,V,VI,VIII	G.S.,P.M.	Plant Breeding
11. Teetes, G. L.	L.D.C.	I,II,IV,V,VII	G.S.	Entomology
12. Wendt, C. W.	F.A.	I,II,III,VII,VIII,IX	G.S.	Plant Physiology
ICRISAT				
1. Andrews, D. J.	W.A.,IA.	IV	P.M.	Plant Breeding
2. Bidinger, F. R.	W.A.	I,II	G.S.,P.M.	Agronomy
3. Charreau, C.	W.A.	all	G.S.,P.M.	Agronomy
4. Davies, J. C.	E.A.,IA.	I,II,IV,V,VIII,IX	G.S.,P.M.	Entomology
5. Jambunathan, R.	IA.	VII	G.S.,P.M.	Biochemistry
6. Ryan, J. G.		IV,VII,VIII	G.S.,P.M.	Economics
Vanoppen				Economics
7. Williams, R. J.	Africa	IV,VI	G.S.,P.M.	Plant Pathologist
8. House, L.	E.A.,IA.	IV,VII	G.S.	

Respondents to Constraint Questionnaire by Institution and by Selected Characteristics of the Responses
University of Missouri Constraints Survey of Grain Sorghum/Pearl Millet Research Needs
December, 1977

Responding Scientist by Institution	Region to Which (1) Response Applies	Subject Category (2) of Response	Crop of (3) Response	Specialty of (4) Respondent
CNRA				
1. Beye, G.	W.A.	all	G.S.,P.M.	Agronomy
2. Denis, J. C.	W.A.	I,II,III,IV,VI	G.S.,P.M.	Plant Breeding
3. Loose, E. E.	W.A.	all	P.M.	Agricultural Economics
U.S.A.I.D.				
1. Fredrickson, C. J.	W.A.	I,II,III,IV,V,VII,VIII	G.S.,P.M.	Entomology
2. Livingston, J. H.	W.A.	all	G.S.,P.M.	Agriculture
3. Stewart, J. I.	E.A.	I,II,IV	G.S.,P.M.	Water Management
OTHERS				
1. van Arkel, H. UNDP/FAO	E.A.	all	G.S.	Plant Breeding
2. Bhardwaj, B. FAO	M.E.	all		
3. Gebrekidan, B. Ethiopia	E.A.	all	G.S.	Plant Breeding
4. Harvey, P. USDA/ARS	W.A.,E.A.,S.A.,IA.	I,II,IV	G.S.,P.M.	Agronomy
5. Muhammad-Amin Pakistan	AS.	all	G.S.,P.M.	Agronomy
6. Rao, N.G.P. India	IA.	I,II,IV,V,VI,VII,IX	G.S.	
7. Ulsaker, L. L. Pakistan	AS.	all	G.S.,P.M.	Agronomy

Footnotes are on page 58-A

FOOTNOTES--EXPLANATIONS OF ABBREVIATIONS

1. W.A. -- West Africa
   E.A. -- East Africa
   S.A. -- Southern Africa
   AS. -- Asia
   M.E. -- Middle East
   L.A. -- Latin America
   IA. -- India
   U.S. -- United States
2. I. -- Fertility and Plant Nutrition
   II. -- Cultural and Management Practices
   III. -- Engineering and Mechanization
   IV. -- Breeding, Varietal Improvement and Development
   V. -- Entomology
   VI. -- Plant Pathology
   VII. -- Utilization
   VIII. -- Social and Institutional Factors
   IX. -- Other Constraints
3. G.S. -- Grain Sorghum
   P.M. -- Pearl Millet
4. Ag. Engineering - Agricultural Engineering

APPENDIX D

Summary of Research Programs of ICRISAT

ICRISAT has a comprehensive, well planned research program on the sorghum and millet crops in areas ranging from production through utilization of the crops for human food. A considerable amount of this research is done by a network of ICRISAT staff located outside India where there is cooperation and support in the research effort given to national programs in many tropical countries.

ICRISAT research is directed toward the basic improvement of the sorghum and millet crops. Major focus is on breeding to improve stability of yield as well as production potential. The collection and exchange of germplasm, as well as programs to regenerate and improve genetic variability, are central to the effort. Pathological, entomological, physiological, microbiological, biochemical, etc., research contributes to better understanding the nature of the problems as well as backing up the breeding programs. Many alternative approaches, in view of the importance of risk to the small farmer, are being investigated, such as bacterial nitrogen fixation, "efficient use of nutrient" plant types, etc., that might help stabilize yield on the subsistence farm. Much work on the major yield reducers--diseases, birds, insects, striga, drought, etc.--is underway. Alternate means of control, such as cultural, biological, and chemical, as well as breeding, also are pursued.

Research also involves use of the crops in production systems. New genotypes are studied that might fit into

changing systems of culture, management, intercropping, multicropping, etc. New equipment is being developed that might have utility in the small farming system. Cultural and management practices to better insure the farmer of getting and maintaining stands are being explored.

Research on grain quality, including acceptability and cooking and eating quality, has high priority. This has utility in the breeding program as well as in the production research. The production and maintenance of quality both in the field and in storage is of concern. Nutritional and digestability studies hopefully can enable the production of foodstuffs that better meets overall human needs.

A well balanced social science research program directed to the human factor in the production and utilization of the sorghum and millets in the Semi Arid Tropics (SAT) is under way with plans for expansion. The staff includes at least three economists and a social anthropologist. Indepth studies involving paired villages in three areas in India are heavily directed to the diacovery and assessment of grass roots social, cultural and economic constraints on the production and utilization of these two crops. In addition, the case studies are designed to provide a continuing data base for indepth studies if and as the need arises. Plans are to expand them to other areas and regions of the world.

General thrusts of their research are to production and marketing with training components under each. More specific emphases under each are as follows:

On the production side

1. The village level studies just noted
2. History and economics of existing tank irrigation constraints
3. Systems of waterharvesting and supplementary irrigation constraints imposed by soil conditions, topography and present systems of land ownership and distribution
4. Group action and organization for improved land and water management. The present systems of land ownership and distribution are known constraints. The ultimate search is for watershed based ecological arrangements where group participation in the common good is possible and is used.
5. Collaborative planning and evaluation experiments.
6. The role of risk and uncertainty in SAT areas concerning which a great deal has already been written.
7. Improvement of animal drawn implements and mechanization in the SAT with emphasis on alleviation of labor requirements in peak seasons and better utilization of scarce water resources.

On the marketing side

1. Marketing channels and marketing efficiency.
2. Derivation of demand and supply parameters for ICRISAT crops.
3. Measurement of consumer preferences for evident quality characteristics of ICRISAT crops, including sorghum and millets.

4. Case study of rural marketing systems in a selected district.
5. Spatial allocation of crops, inter-regional trade, integrated trade and aggregate productivity.

A current list of publications issued by the ICRISAT Economics Program which also includes anthropological-sociological research, carries 62 entries, most of very recent date. The catalog classifications of these entries are:

Research Resource Allocation

Production

Marketing

General

APPENDIX E

Grain Sorghum/Pearl Millet
Identification of Constraints Interview

1. Respondent _____ Institution _____

2. Present Assignment _____

_____

3. Mailing Address _____

_____ Phone _____

4. Major Discipline(s) _____

_____

5. International Development Experience:

Countries	Type of Experience	Approx. Dates

6. Suggestions of Other Scientists to Contact for this Purpose:

_____

_____

_____

_____

7. Comments: _____

_____

_____

_____

_____

_____

8. Interviewee: _____ Date _____

DEFINITION OF GRADUATION SCHEME
Grain Sorghum/Pearl Millet Research Program Planning

In the blank space opposite "country" indicate the country or countries to which your evaluation applies.

The A column in each case is for rating the significance of the constraint by entering the number 1, 2, 3, or 4 according to the four levels given under section A below.

The B column is for recording the level of present knowledge, again by indicating one of the numbers 0 to 4 according to the definition given under item B below.

A. The importance of Problem or Constraint

1. Problem or constraint of little importance
2. Problem or constraint of only periodic importance
3. Problem or constraint important in some local situations
4. Problem or constraint of wide-scale importance

B. Level of present knowledge and programs underway to gain necessary knowledge

0. Problem or constraint solvable by transfer of technology, a crop production or development program required
1. Local information satisfactory, some other studies maybe advantageous
2. Strong program underway that should generate necessary knowledge, may need some refinement
3. Only preliminary information available, major thrust is required
4. No local information available, a need to initate new or relative new research effort

Grain Sorghum/Pearl Millet Research Program Planning
Graduation of Production and Utilization Constraints
and Level of Research and Development

Constricting Problem	Sorghum				Pearl Millet			
Country								
	A	B	A	B	A	B	A	B
I. FERTILITY & PLANT NUTRITION								
1. Fertilizer Response								
2. Secondary & Micro Nutrients								
3. Chemical and or Physical Properties of Soil								
4. Soil Test Calibration & Technique								
5. Economics of Fertilizer Response								
6. _____								
7. _____								
Comments								
II. CULTURAL PRACTICES & MANAGEMENT								
1. Seeding: Time, Rate, Depth, etc.								
2. Soil Preparation								
3. Weed Control								
4. Fertilizer Placement								
5. Water: Control, Storage, Quality								
6. Harvest: Losses, Seed Quality, Timeliness, Cost, Methods								
7. Multiple Cropping: a. Double Cropping								
b. Inter Cropping								
8. Pest Control (birds, etc.)								
9. _____								
10. _____								
Comments								

Grain Sorghum/Pearl Millet Research Program Planning
Graduation of Production and Utilization Constraints
and Level of Research and Development

Constricting Problem / Country	Sorghum				Pearl Millet			
	A	B	A	B	A	B	A	B
III. ENGINEERING AND MECHANIZATION								
1. Machinery Evaluation & Development								
a. Land Preparation, Planting & Cultivating								
b. Plant Protection								
c. Water Utilization								
d. Harvesting								
e. Transportation								
2. Storage								
a. Farm								
b. Commercial								
3. Crop Drying								
4. _____								
5. _____								
Comments								
V. ENTOMOLOGY								
1. Identification & Damage								
a. Soil Insects								
b. Seedling Insects								
c. Foliage Insects								
d. Stem Boring Insects								
e. Grain Head Insects								
f. Stored Grain Insects								
2. Control of Insects								
3. Economics of Control								
4. Identify Beneficial Insects								
5. _____								
6. _____								
Comments								

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Grain Sorghum/Pearl Millet Research Program Planning
Graduation of Production and Utilization Constraints
and Level of Research and Development

Constricting Problem / Country	Sorghum				Pearl Millet			
	A	B	A	B	A	B	A	B
IV. BREEDING, VARIETAL IMPROVEMENT AND DEVELOPMENT								
1. Introduction of Cultivars								
2. Competition of Cultivars								
3. Breeding for Resistance								
a. To Disease								
b. To Insects								
c. To Birds								
d. To Other Pests								
e. To Drought								
f. _____								
4. Breeding for Quality								
a. Protein								
b. Palatability								
c. _____								
5. Breeding for Productivity								
a. Yield								
b. Seedling Vigor								
c. Plant Characteristics								
d. _____								
6. Breeding Methodology								
7. Cytology								
8. Seed Multiplication								
9. Seed Storage & Distribution								
10. _____								

Comments

Grain Sorghum/Pearl Millet Research Program Planning
Graduation of Production and Utilization Constraints
and Level of Research and Development

Constricting Problem / Country	Sorghum				Pearl Millet			
	A	B	A	B	A	B	A	B
VI. PLANT PATHOLOGY								
1. Disease Identification & Damage								
a. Fungi								
(1) Downy Mildew								
(2) Red Stalk Rot & Anthranose								
(3) Leaf Spots & Rusts								
(4) Ergot								
(5) Smuts								
(6) Headmolds								
b. Bacteria (Stripe)								
c. Viruses (MDMV)								
d. Nematodes (Root Knot)								
e. Phanerogamic Parasites (Witch Weed)								
2. Control of Disease								
a. Cultural Control								
b. Chemical Control								
c. Resistance to Pathogens								
3. Economics of Control								
4. _____								
5. _____								

Comments

Grain Sorghum/Pearl Millet Research Program Planning
Graduation of Production and Utilization Constraints
and Level of Research and Development

Constricting Problem	Sorghum				Pearl Millet			
Country								
	A	B	A	B	A	B	A	B
VII. UTILIZATION								
1. Constraints in Processing								
a. In Home								
b. Industrial Processing								
2. Constraints in Acceptance								
a. Palatability								
b. Tannins, Lysine, etc.								
c. Fortifications								
d. New Varieties Acceptance								
e. Mycotoxin Problems								
3. Nutritional Constraints								
a. Protein Problems								
b. Digestability Problems								
c. _____								
4. Need for New Food Products								
a. Fermentation								
b. Mixed flours								
5. _____								

Comments

Grain Sorghum/Pearl Millet Research Program Planning
Graduation of Production and Utilization Constraints
and Level of Research and Development

Constricting Problem	Sorghum				Pearl Millet			
Country								
	A	B	A	B	A	B	A	B
VIII. SOCIAL & INSTITUTIONAL FACTORS								
A. Social Factors								
1. Inadequate Understanding of Social Constraints								
2. Insufficient Knowledge re Assessing & Adjusting to Existing Social Factors								
3. Orientation of Producers to Subsistence Economy--not to Market Economy								
4. Low Social Status of Sorghum/Millets								
5. Differences Between Ethnic Groups								
6. Problems of Men/Women Roles in Production/Processing								
B. Institutional Factors								
1. Unreliable Input/Supply System								
2. Availability of Inputs								
3. Cost of Purchased Inputs								
4. Credit Unavailable								
5. Inadequate Information Delivery System								
6. Restrictive Government Policies								
7. _____								
8. _____								
C. Transportation								
1. Inadequate Roads								
(a) Farm to Market								
(b) Between Major Trade & Population Centers								
2. Inadequate Means (Vehicles)								
3. Ineffective Modes								
4. _____								

Comments

Grain Sorghum/Pearl Millet Research Program Planning
Graduation of Production and Utilization Constraints
and Level of Research and Development

Constricting Problem	Sorghum				Pearl Millet			
Country								
	A	B	A	B	A	B	A	B
VIII. - Continued								
D. Storage								
1. Inadequate Home Storage								
(a) Moisture Damage								
(b) Insect & Rodent Damage								
(c) No Adequate Structure Design								
(d) _____								
2. Inadequate Commercial Storage								
(a) Moisture Damage								
(b) Insect & Rodent Damage								
(c) No Adequate Structure Design								
(d) _____								
E. Marketing								
1. Ill-defined or No Marketing Channel or System								
2. No Reliable System of Exchange								
3. No System for Moving Grain								
4. Inadequate Quality & Grading System								
5. Restrictive Government Policies								
6. _____								
7. _____								
F. Conflict of Proposed Technology W/Existing Practices								
1. New Varieties								
2. Purchased Inputs								
3. Capital/Credit Needs								

Comments

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Grain Sorghum/Pearl Millet Research Program Planning
Graduation of Production and Utilization Constraints
and Level of Research and Development

Constricting Problem	Sorghum				Pearl Millet			
Country								
	A	B	A	B	A	B	A	B
IX. OTHER CONSTRAINTS								
1. Research & Education Limitations								
a. Trained Personnel Limited								
b. Inadequate Institutions & Facilities								
c. Inadequate Financial Support								
d. Inappropriate Government Policies								
e. GS/PM Precluded from Research/ Education Program								
2.								
3.								
4.								
5.								
6.								

Comments

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