



ORGANIZATION OF AFRICAN UNITY
ORGANISATION DE L'UNITE AFRICAINE



Scientific Technical and Research Commission
Commission Scientifique Technique et de la Recherche

Joint Project 31 Semi-Arid Food Grain Research and Development

N° 0534

Projet Conjoint 31 Recherche et Développement

des Cultures Vivrières dans les Zones Semi-Arides

(OAU/STRC JP 31 SAFGRAD)

(OAU/CSTR PC 31 SAFGRAD)

BIBLIOTHEQUE
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SPECIAL PUBLICATION N° 1
PUBLICATION SPECIALE N° 1

SCIENTIFIC DOCUMENTS PRESENTED
AT
THE SECOND WORKSHOP ON SORGHUM AND MILLET
GABORONE, BOTSWANA, 16-20 MARCH 1981



DOCUMENTS SCIENTIFIQUES PRESENTES
AU
DEUXIEME ATELIER SUR LE SORGHO ET LE MIL
GABERONE (BOTSWANA) 16-20 MARS 1981

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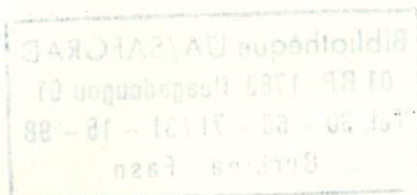
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Part I : INTRODUCTION.

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I N T R O D U C T I O N

The second OAU/STRC JP 31 SAFGRAD workshop on Sorghum and Millet was held from 16 to 20 March 1981 at the Holiday Inn, Gaborone, Botswana.

The opening ceremony was chaired by the Honourable W. MESWELE, Botswana's Minister of Agriculture. Mr. A.H. Abdel Razik, Assistant Executive Secretary and Officer-in-Charge of OAU/STRC was present.

Delegates from 13 JP 31 SAFGRAD Member Countries and one observer country (Zimbabwe) as well as representatives from international cooperating organizations such as AAASA, IDRC, FAO, GTZ, INTSORMIL, IRAT, ICRISAT, CILSS and USAID (donor agency) attended the meeting.

The following member countries were absent : Guinea, Kenya, Ivory Coast, Mauritania, Cape Verde, Sierra Leone, Ghana, Chad, Tanzania, Zambia, Somalia and Central African Republic.

The inaugural ceremony began with an introductory address by Dr. K.O. Akadiri-Soumaila, OAU/STRC International Coordinator for JP 31 SAFGRAD. After emphasizing the fact that recommendations drawn up and adopted by the 1st workshop on sorghum and millet had not been implemented, he gave a brief outline of SAFGRAD's sorghum and millet programme and proposed to participants 7 guiding principles to improve and make the workshops more efficient.

The Assistant Executive Secretary of OAU/STRC Mr. A.H. Abdel Razik who is also the Officer-in-Charge of the OAU/STRC Secretariat then took the floor to thank the Botswana authorities for hosting the workshop and for the warm welcome given to participants. On behalf of OAU, for which JP 31 SAFGRAD is the only continental project of its kind, he appealed to participants to help achieve self-sufficiency in food in Africa. He informed participants of the desire of certain countries to be covered by SAFGRAD. Mr Abdel Razik further distributed copies of the resolution adopted by the OAU Council of Ministers at its Thirty-Sixth Ordinary Session in Addis-Ababa, Ethiopia, (CM/CTEE B/RES.9 (XXX VI) Ren. 1) in respect of SAFGRAD to participants.

.../...

The opening address was delivered by the Botswana Minister of Agriculture. He stressed his country's lack of material means and agricultural research officials as well as the considerable cereal deficit with which Botswana has to cope with each year. He declared that Botswana fully subscribes to the objectives of SAFGRAD which is a project of the OAU.

National reports from Member States were presented. Delegates gave account of their national agronomic activities and submitted highlights of their programmes, problems found and solutions applied (with or without success) to the meeting. After that, renowned specialists presented important working documents for the benefit of participants. We are publishing in this document (beginning page 4) all the invited papers. Recommendations adopted by the workshop are found in Annex I.

.../...

INTRODUCTORY ADDRESS DELIVERED BY DR. K.O. AKADIRI-SOUMAILA
INTERNATIONAL COORDINATOR OF OAU/STRC FOR JP. 31 SAFGRAD
ON THE OCCASION OF THE 2ND OAU/STRC WORKING ON SORGHUM & MILLET
HELD IN HOLIDAY INN, GABORONE, BOTSWANA FROM 16 - 20 MARCH, 1981.

Honourable Minister,
Distinguished Delegates and Invited Guests,
Ladies and Gentlemen,

Before the official opening of this 2nd OAU/STRC Workshop on Sorghum and Millet, may I ask you to observe a minute's silence in memory of the late Mr. Amos ODELOLA, Executive Secretary of OAU/STRC, who died prematurely last year.

Thank you.

Honourable Minister,
Distinguished Delegates and Invited Guests,
Ladies and Gentlemen,

1981 is a highly important year for the Joint Project 31 on Semi-Arid Food Grain Research and Development in Africa (SAFGRAD). So far this year, two JP. 31 SAFGRAD Workshops have already been organized under the auspices of the Scientific, Technical and Research Commission of the Organization of African Unity (OAU/STRC). The first one which was held in Dakar, Senegal, last January dealt with farming systems in Africa while the second held last month at the International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria was on maize and cowpeas. The third one which we are opening today is the 2nd OAU/STRC Workshop on Sorghum and Millet.

JP.31 SAFGRAD has a very heavy programme. Two more meetings have been planned for this year after the current one. These are first of all the Technical Advisory Committee meeting which will not only evaluate SAFGRAD's research activities but also define major orientations for the Project in view of the Lagos Plan of Action adopted by OAU in favour of agriculture and review the activities of our Accelerated Crop Production Officers (ACPO). This Committee will draw up recommendations which in turn will be submitted to the Consultative Committee will group together all Directors of Agronomic Research in Member States as well as current and potential donors of SAFGRAD.

After this brief, general information, I would like all of us to take an objective and a critical look at SAFGRAD research results.

Indeed, it is almost three years now since JP.31 SAFGRAD got under way to achieve self-sufficiency in food on the continent. To this day, and at this hour that I have the honour to address this august assembly, we are better organized and have promising results as far as maize and cowpeas are concerned. What I find deplorable in the limited awareness of National researchers in Member States concerning on-field SAFGRAD trials.

It was for this reason that Dr. C.M. Pattanayak, ICRISAT's Team Leader in Upper Volta, was unable last year to make all the regional trials on Sorghum and Millet scheduled according to recommendations of the 1st Workshop on Sorghum and Millet held in Mombasa, Kenya. This was mainly due to negligence on the part of certain Member States and to late forwarding of promised seed to SAFGRAD headquarters in Ouagadougou, Upper Volta by some of our participants. We therefore have virtually no results at SAFGRAD for Sorghum and Millet.

.... /

Today, we have the occasion to examine results obtained in Member States last year, ACPD activities and farmer-level impact. We should draw lessons from our past experience and give our research and transfer of technology a more direct and appropriate orientation. In this regard, the Farming Systems Unit (FSU) and ACPD's will be working in unison, the former in selected sample villages representative of given areas and the latter in applying the same techniques at the individual level. Research topics should be treated from a multidisciplinary angle by a team of homogeneous researchers on each variety while putting a lot of emphasis on cultivars.

Concerning SAFGRAD Workshops, a reorganization on the following points seems necessary to make them more beneficial.

- a) Objectives of the Workshops: SAFGRAD Workshops are primarily training sessions designed as a forum for professional researchers and renowned institutes or organizations alike to exchange ideas.
- b) Intellectual Leadership for the Workshops: The SAFGRAD contracting agencies - IITA, ICRISAT, Purdue University - should provide the intellectual leadership and direction in terms of the agenda, presentation of materials, and discussion.
- c) Structure of Workshops: The contracting agency should have primary responsibility for the setting of the agenda and submit it to the Coordination Office. Each Workshop should revolve around a principal or keynote address by an internationally recognized authority to define the subject, purposes and objectives of the workshop. If necessary, two keynote address may be planned at the beginning of each session.

- d) Chairmanship of sessions: Chairpersons for the sessions should be well-versed in the area to be discussed for the obvious purposes of facilitating and adding to the discussions as well as keeping the group on the subject, summarizing results and papers at the end of each session. A preliminary private meeting will be held between the Chairman and his principal assistants before each session begins, all in the presence of SAFGRAD officials.
- e) Country reports: These should be brief and precise and limited to new activities which have taken place since the last workshop. The written reports will be distributed in the hall and authors will give an oral synopsis of the more important points which could then be discussed. The important element here is the quality.
- f) Evaluation: Each participant should be also to make a topic-by-topic evaluation and get more guidance through feedback.
- g) Forward planning: A one day analysis session among contractor and SAFGRAD representatives will be held at the close of each workshop to review the successes and failures, participant evaluations and establish the framework for the next workshop and fill gap found in the agenda.

I strongly hope that you will take these points into account to enable us to advance in the organization of our future workshops.

I shall therefore ask representatives of Member States to give us brief reports according to the time allotted on the agenda. We shall then discuss the exposes of eminent researchers among us who will be giving SAFGRAD the benefit of their knowledge.

.../...

Honourable Minister,
Distinguished Delegates and Invited Guests,
Ladies and Gentlemen,

I wish you fruitful and fraternal discussions during the workshop. Indeed all the necessary arrangements have been made to enable you to get the most out of this meeting. May I simply remind you that the object of our preoccupation is the African farmer from whom we obtain all and to whom everything should go back improved. Self-sufficiency in food by the year 2000 should not be a myth for our researchers but a reality to which we should push forward with all effort.

Honourable Minister,

May I now ask you to be our spokesman and convey to His Excellency, President Quett Masire and his Government our profound gratitude for permitting us to hold this workshop in the beautiful city of Gaborone and for the facilities put at our disposal. We are extremely grateful to them.

Thank you.

.../...

Honorable Minister,
and members of the
Indian and Canadian

I wish you to know that the
United all the necessary
get the work out of the
object of our efforts
all the more every day
in food by the year
a facility to which

Honorable Minister,

May I now ask you to
I therefore quite
particular to be
and for the facilities
to them

Thank you

ADDRESS DELIVERED BY MR. A.H.A. RAZIK
ASSISTANT EXECUTIVE SECRETARY AND OFFICER-IN-CHARGE OAU/STRC
ON THE OCCASION OF THE
2ND OAU/STRC WORKSHOP ON SORGHUM AND MILLET UNDER JP.31 SAFGRAD
HELD IN GABORONE, BOTSWANA FROM 16 - 20 MARCH, 1981.

Honourable Minister,
Distinguished Delegates and Observers,
Ladies and Gentlemen,

It is my great pleasure, on behalf of His Excellency Mr. Edem KODJO, Secretary-General of the OAU, to welcome you all to Gaborone on the occasion of the 2nd OAU/STRC Workshop on Sorghum and Millet under the Joint Project 31 SAFGRAD.

Honourable Minister,

Our meeting today is the third out of a series of five scheduled this year under the auspices of OAU/STRC to review activities carried out under the Semi-Arid Food Grain Research and Development Project (SAFGRAD) and formulate new strategies.

I recall the 1st Workshop held in Mombasa, Kenya, last year and the concrete recommendations drawn up by our eminent scientists to improve the quantity as well the quality of the two cereal crops, namely, sorghum and millet. To what extent were Member States able to implement the recommendations? What can we do, within OAU's Lagos Plan of Action, to achieve self-sufficiency in sorghum and millet production by the year 2000? This is the challenge before us.

Excellency,
Ladies and Gentlemen,

If I should once again emphasize the singular importance of self-sufficiency in food crop production, I don't think that it should be before you distinguished scientific people. You are all too well aware of the imbalance in food crop production on the continent. It has been said, and rightly so, that the right to live is the right

to eat. You will however agree with me that on the continental level, Africa's picture is rather too gloomy.

This nagging problem has not left OAU indifferent. Ever since African Heads of State and Government gave SAFGRAD the green light we have left no stone unturned, through joint and cooperative efforts to increase productivity in African agriculture. Indeed, JP 31 SAFGRAD aims at improving the staple cereal and grain legume crops (maize, sorghum, millet, cowpeas, groundnuts etc.) in semi-arid Africa.

Excellency,

Distinguished Delegates and Observers,

Although the Project currently covers 25 Member States of OAU situated in the median belt from Mauritania in the Atlantic Coast to Somalia on the Indian Ocean Coast and down to Botswana in the Southern part of the Continent, it is the wish of the OAU to expand the project to include other Member States located in the semi-arid region. Resolutions have been adopted at the just ended 36th Ordinary Session of the Council of Ministers of OAU to that effect in Addis Ababa.

The General Secretariat of OAU therefore urges Member States to double their efforts in this project through competent participation in the various technical meetings of the Project and to further give effective support in the needed administrative actions so as to give the Project a truly dynamic orientation. In this connection, may I avail myself of this opportunity to ask Member States to act on the various circular letters issued on the training component of the Project as well as on the posting of Accelerated Crop Production Officers (ACPO).

may..../...

Excellency,
Distinguished Delegates and Observers,

None is ignorant of the fact that meaningful agronomic research is an expensive and time consuming enterprise. It is for this reason that we appeal to all donors and participating Members States alike, to integrate as much as possible, their various national and sub-regional programmes with those of SAFGRAD so that we can achieve the maximum of results through truly concerted action.

Permit me once again to express Africa's profound gratitude to the United States Agency for International Development (USAID) and the French Aid and Cooperation Fund (FAC) for their financial and technical support indispensable to the success of the Project. We sincerely look forward to active collaboration from potential donor agencies such as the German Agency for Technical Cooperation (GTZ) and the Ministry of Overseas Development (ODM). We equally renew our thanks to our contracting institutes like ICRISAT, IITA and PURDUE University for their continued technical support.

In conclusion, may I ask you, Mr. Minister, to kindly convey our deepest appreciation to His Excellency Quett Masire, President of the Republic of Botswana, the Government and People of Botswana for the excellent facilities put at our disposal.

I wish you success in your proceedings.

Long live to the Republic of Botswana!

Long live International Cooperation!!

Long live the Organization of African Unity!!!

Thank you.

.../...

SPEECH BY THE HONOURABLE W. MESWELE
MINISTER FOR AGRICULTURE ON THE OCCASION OF
THE OPENING OF THE SECOND OAU/STRC SAFGRAD WORKSHOP
ON SORGHUM AND MILLET IN GABORONE, BOTSWANA
MONDAY MARCH 16TH 1981 AT 9.00 AM.

The Assistant Executive Secretary and Officer-in-Charge of OAU/STRC - Mr. A.H.A. Razik,
The International Coordinator,
Distinguished Delegates,
Invited Guests,
Ladies and Gentlemen,

I am pleased to be here today to formally open the second OAU/STRC SAFGRAD workshop on sorghum and millet, and to welcome scientists from 25 countries in Africa and elsewhere. I extend to you all a formal welcome to Botswana and hope that you will enjoy your stay with us.

The importance of sorghum and millet in Africa and particularly in the semi-arid areas of this continent is immense and it is fitting that Africa is the home of both these crops, which have been of agricultural importance for several thousand years. Although new cereal crops have been introduced in the last 2-3 hundred years, sorghum and millet will continue to play an important part in the feeding of mankind on this continent. This is not only due to the fact that human population is increasing rapidly in Africa, but also because the two crops, sorghum and millet are specially adapted to grow and produce in vast areas of the semi-arid regions of Africa to which SAFGRAD has focused its attention.

The SAFGRAD project was adopted by the OAU Council of Ministers at its 27th Ordinary Session in Mauritius in June, 1976 and finalized at a Conference in Ouagadougou in October, 1977.

The first SAFGRAD workshop on sorghum and millet was held in Kenya during February 1980. This second workshop on sorghum and millet is being held to bring together scientists involved with these two crops for discussion and liaison and to define the areas to which attention by research, development and extension workers should be directed.

We are all aware that food production is a vital issue in the world today, and also a political issue. I therefore request you to take your deliberations and discussions this week seriously, so that the procedures for stimulating enhanced food production in the OAU countries will be clearer.

It is opportune that the workshop is being held in Botswana as we are about to launch our Arable Lands Development Programme (ALDEP). ALDEP aims to increase the food production and income of small farmers in this country by encouraging the adoption of improved cultural practices, including of course improved cereal varieties.

The average farm yields of sorghum and millet in Botswana are low, and in most years we have to import cereals to make up the deficit. Our aim is to become self sufficient in cereal production, so our scientists will therefore participate fully in the workshop proceedings, because the challenge ahead of them and you is considerable. As you are all aware the solution to the problem associated with small farm production are not only the provision of improved crop varieties, but the adoption of improved cultural practices which are compatible with small farm semi-arid farming systems. It is therefore important that research scientists, development personnel and extension workers cooperate fully so that not only are new varieties and practices developed but that they are also made available to the farmers and are acceptable to them. I would also like to mention at this stage the Southern African Development Coordination Conference (SADC) which invited ICRISAT (the International Crops Research Institute for the Semi-Arid Tropics) to Botswana in November 1980 to discuss the establishment of a regional research centre for the Southern Africa countries and increased collaboration with ICRISAT and amongst the member countries. My Government will keep the OAU/STRC informed of any developments in this area.

Whilst you are in Botswana, I hope that you will find time to visit the Agricultural Research Station at Sebele where a collection of sorghum and millet entries are available for your inspection, as well as the other research activities underway out the station.

As stated earlier the task before us (of increasing food production) is immense and we are all involved. I would like at this stage to acknowledge the help and assistance given to us in this respect by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the International Institute of Tropical Agriculture (IITA) and various Institutes and Universities in the USA for provision of germplasm, training and consultants.

I also acknowledge the roles played by donors, missions and Governments, within and outside Africa, that are providing us with both financial assistance and expertise.

In conclusion, I wish you all the best in your forthcoming deliberations, trust that a substantial amount will be achieved during your workshop, extend again to you a warm welcome to Botswana, and have the honour to declare the Second OAU/STRC SAFGRAD Workshop on Sorghum and Millet here in Gaborone officially open.

.../...

Part II : INVITED PAPERS.

THE PROSPECTS OF BREEDING FOR INSECT RESISTANCE
IN SORGHUM IN TROPICAL AFRICA.

By

A. A. ADESIYUN

(Sorghum Entomologist)

Institute for Agricultural Research

Ahmadu Bello University

P.M.B. 1044

Samaru, ZARIA - NIGERIA.

INTRODUCTION.

The use of resistant plant varieties has been recognized in integrated pest management over the years. Their use involves no recurring cost and poses little or no danger to non-target organisms. Their effect is specific, persistent and cumulative. An example of the persistent nature of resistant varieties is an apple variety, Winter majetin, reported resistant to the wooly apple aphid, Ericosoma lanigerum (Hausm), in 1831 and is known to still retain its resistance. They are quite compatible with other control measures, e.g., biological, chemical, cultural, etc. They are useful even in situations where the pest attains damaging proportions only occasionally (Bakhetia and Labana, 1978). They infact represent the cheapest and safest methodes of insect pest control and serve as a built-insurance of crop against its pests. However, in spite of the numerous advantages of resistant crop varieties listed above, very little progress has been made in tropical Africa towards the production of insect resistant sorghum varieties with agronomically acceptable characters. The obvious question to ask then is, why is this so? An attempt is made in this paper to renew the progress that has been made and to highlight the constraints that have hitherto made rapid progress in the direction of producing insect resistant sorghum varieties difficult.

INSECT PESTS.

Sorghum is damaged by a number of insect pests, but the ones that can be regarded to be of major importance are only about a dozen. These are listed in Table I. It is rather difficult to rank these insects according to the magnitude of damage they cause on a continental scale, because their occurrence and importance appear to be governed by several factors, e.g. climate, altitude, cropping patterns and sequence employed in the different countries. However, in Nigeria, the stem-borer, Busseola fusca, is the most important insect pest of sorghum at present. The others inflict minor to severe losses depending on the environmental conditions and the cultural practices employed.

PROCEDURE FOR UTILIZING GENETIC VARIABILITY IN PLANTS FOR PEST CONTROL.

Breeding for insect resistance usually entails a close collaboration between entomologists, plant breeders, geneticists and at times, biochemists, agronomists and pathologists. The first step is to screen the available germ plasm of the host plant for resistance with a view to locating resistant lines. The actual process of identifying such sources of resistance is usually time-consuming in that hundreds and at times, thousands of lines are normally screened. More often than not, such screening is not possible because of the lack of uniformity in the natural populations of the insects in the field. One of the options left in such a case is the supplementary infestation in the field from laboratory reared insects. This, in itself, requires several provisions, e.g.,

1. The development of an artificial diet or method of rearing large numbers of the insect in the laboratory.
2. The provision of facilities for large scale laboratory rearing.
3. The provision of facilities for field screening, e.g. screen houses.
4. The development of techniques for consistently effective field screening.

.../...

All these are time-consuming and more importantly, require a lot of fund, which in most cases are not available. Unless and until adequate funds are provided for these basic things, our march towards the development of sorghum varieties resistant to some of its important pests will be very slow.

Once the source(s) of resistance has been located, the next step is the incorporation of the resistant factor(s) into plants possessing better agronomic qualities. This phase of the work is essentially that of the breeder, but a close collaboration between the breeder and the entomologist is also desirable.

WORK DONE ON BREEDING FOR RESISTANCE TO THE SORGHUM SHOOT-FLY.

No doubt, the most extensively studied insect pest of sorghum from the point of view of locating the source of resistance and incorporating this resistance into agronomically acceptable varieties, is the sorghum shooty-fly, Atherigona soccata. This has been reviewed by Young (1980), so reference will be made here to the findings of only a few of the workers. The first attempt at screening for shoot-fly resistance in sorghum was conducted by Ponnaiya in 1944. In his pioneering work, Dr. Ponnaiya recognized the presence of host plant resistance in sorghum and suggested its possible value as a means of reducing shoot-fly injury. His subsequent studies led him to the conclusion that the presence of silica bodies in the 3rd and 4th leaf sheaths of some varieties conferred resistance on them, whereas such silica bodies were not present in the susceptible varieties until in later growth stages, by which time the shoot-fly must have taken its toll (Ponnaiya, 1951).

This important research finding marked the start of a long series of efforts to identify and use resistance in sorghum for shoot-fly control.

Recent workers have confirmed that non-preference for oviposition is also a major mechanism contributing resistance to the shoot-fly (Jotwani et al, 1974; Wongton, S., and Patanakamjorn, S., 1975).

.../...

The presence of trichomes on the abaxial surface of leaves and/or colouration of the leaves have been suggested as being responsible for the non-preference of some varieties for oviposition.

Various other workers have found evidence for antibiosis in some varieties. Langham (1968) and Blum (1968) have found that the leaf sheaths of resistant varieties have small prickly hairs on the abaxial epidermis of the 1st, 2nd and 3rd leaf sheaths that may deter penetration of shoot-fly larvae. A third resistance mechanism, high tillering or recovery resistance of infested seedlings was first reported in Uganda by Doggett and Majisu (1966).

The search for sources of resistance to A. soccata continued through field screening of thousands of lines in the world collection by All India Co-Ordinated Sorghum Project in the sixties (Young, 1972), by the scientists in the OAU/STRC JP-26 based in Samaru in the early seventies and by ICRISAT scientists during the mid- to late seventies (Seshu Reddy and Davies, 1978). Techniques have been developed for consistently effective field screening (Seshu Reddy and Davies, 1978) and for laboratory rearing of the fly and screening of varieties for resistance to it (Soto and Laxminarayana, 1971; Soto, 1972).

A number of sources for resistance have been identified, many of them the same types first noted by Ponnaiya (1951). Many of these have now been evaluated in international nurseries in Africa, Israel, India and Thailand and their resistance has been stable over the area of distribution of the fly (Young, 1972; ICRISAT, 1978). In a detailed study of stability of 15 varieties over environments; Singh et. al. (1978) determined that most of them were consistently resistant over six environments representing 3 crop growing seasons and 2 locations. The varieties IS 1054, IS 5469 and IS 5490 provided the most stable source in this study, where it was also concluded that non-preference for oviposition was a stable mechanism over all the environments.

Selected resistant varieties have been included in breeding programmes to incorporate resistance in more agronomically acceptable higher yielding sorghums. Early breeding work indicated that hybrids between resistant and susceptible parents tended to be intermediate or more like the susceptible parent in shoot-fly reaction. Research to date on the inheritance of non-preference resistance has indicated that resistance is quantitatively inherited and mainly governed by additive genes (Rao *et al.*, 1974; Sharma *et al.*, 1977). These authors have suggested that selections from resistant families of agronomically superior X resistant lines would be effective in developing resistant varieties combining dwarf to semi-dwarf stature, earliness and high yield, qualities that are not present in the resistant sources.

It now seems that as far as the shoot-fly is concerned, the sources of resistance have been identified and the techniques that should speed progress in the development of resistant high yielding varieties that can be recommended to the farmers have been worked out. Breeders and entomologists in national research programmes are now in a position to start incorporating these resistant lines into their national breeding programmes.

WORK DONE ON OTHER INSECT PESTS OF SORGHUM.

Unlike the shoot-fly, relatively little progress has been made in terms of screening and breeding sorghum varieties resistant to the other insect pests of sorghum. The major constraint appears to be inadequate research funds. Fund to employ qualified staff, fund to build, equip and maintain laboratories and fund to meet other research needs. However, in spite of all these financial constraints, some advances on grasshopper locust made in Europe recently can be of relevance in the search for sorghum varieties resistant to these insects. In this connection, the works of Bernays *et al.* (1974) and Woodhead and Bernays (1977) in which they showed that leaves of some young sorghum plants are rejected by some grasshoppers and locusts at the first bite, i.e., before causing significant damage because of HCN production, is particularly relevant. Different amounts of successes have been recorded in the case

of stem-borers. With Busseola fusca, the screening of sorghum varieties to it had to be suspended at Samaru until such a time that adequate laboratory facilities can be provided for research on artificial diet, rearing methods, etc., so that large numbers of insects can be reared in the laboratory to supplement the usually ununiformly distributed natural population in the field. Similarly, initial attempt to rely only on the naturally occurring field populations of Chilo partellus for the screening had to be discarded at ICRISAT, India because of the lack of uniformity of infestation. Efforts were intensified on the development of artificial diet in the laboratory with the result that a very effective diet which gives recoveries of up to 74% adults has now been developed (Seshu Reddy and Davies, 1979). A technique for releasing the young larvae into the whorls of the sorghum plants has also been devised. The diet and the technique for releasing the larvae now make it possible to screen several hundred lines for Chilo resistance at ICRISAT.

CONCLUDING REMARKS.

It is apparent from the foregoing discussion that very little progress has been made so far in the direction of breeding for insect resistance in sorghum, except with the sorghum shoot-fly. There is an urgent need to remove the constraints enumerated, which hitherto have hindered progress. Scientists (plant breeders, geneticists, entomologists and biochemists) in national and international research programmes must co-operate, exchange ideas and materials. But above all, adequate funds should be provided for research. Breeding for high yield has to go on simultaneously with screening and breeding for insect and disease resistance, if any lesson is to be learnt from the initial setbacks of the "Green Revolution" in Asia and South America.

ACKNOWLEDGEMENT.

I wish to sincerely thank SAFGRAD for agreeing to bear my transportation and per diem costs. I am also grateful to the Director of the Institute for Agricultural Research, Samaru and the Vice-Chancellor of Ahmadu Bello University for the permission granted to attend the workshop.

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Table 1. List of major insect pests of sorghum.

Common Name	Scientific Name	Nature of damage.
Shoot-fly	<u>Atherigona soccata</u>	injure growing point of young plants cause 'dead heart'.
Stem-borer	<u>Busseola fusca</u> <u>Sesamia</u> spp. <u>Chilo partellus</u> <u>Eldana saccharina</u>	some leaf damage boring in stalk may injure growing point and kill plant or cause lodging.
Armyworm	<u>Spodoptera exempta</u>	Voracious feeder on foliage, young plants may be stripped of leaves completely thus destroying the plants.
Grasshoppers	<u>Zonocerus variegatus</u> <u>Oedaleus senegalensis</u> <u>Schistocerca gregaria</u> <u>Locusta migratoria</u>	Nymphs and adults eat plant foliage, stem and grain, thereby causing defoliation and death of seedlings and reduced yield of older plants.
Sorghum midge	<u>Contarinia sorghicola</u>	Destroy developing seed.

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THE ROLE OF HOSTPLANT RESISTANCE IN INTEGRATED
PEST MANAGEMENT TECHNOLOGY AND ITS RELANCE TO PESTS OF PEARL MILLET
IN THE WEST AFRICAN SAHEL.

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INTRODUCTION.

The concept of Integrated Pest Management (IPM) is not new although emphasis on the development of ecologically oriented pest control did not begin until the impact of insecticides in the environment became increasingly disturbing. By definition, integrated pest control is a pest management system that in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods-cultural practices, host-plant resistance, chemical insecticides, biological control and legislation-in as compatible a manner as possible and maintains the pest populations at levels below those causing economic injury (Brader, 1980).

The history of cotton production in post World War II USA adequately describes the fate of organic insecticides in that country and most of the world over. The surge in production/acre due to the extensive use of DDT, followed by BHC and organophosphates was followed by the development of pesticide resistance in insects and of secondary pests. With the subsequenat concern over the impact of chemical insecticides on the environment an urgent research for alternative methods of pest control became imminent.

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In any profit oriented society, the best form of insurance sells the most. Therefore, as long as governments support farmers, consumer preferences become cosmetic and farmers receive less money for produce of poor grade, the indiscriminate use of insecticides will continue for years to come. IPM is more complex to establish and is harder to sell but is more ecologically sound with long term benefits. It does not abolish the use of insecticides but encourages the judicious and intelligent use of these chemicals at lower dosage levels and frequencies in an attempt to maintain an ecologically balanced environment.

The development of a pest management program requires the inputs of several disciplines. It stipulates the involvement of plant breeders, agronomists, soil scientists, weed scientists, pathologists, agricultural engineers, economists and entomologists.

The key element in an IPM program is a knowledge of the economic injury levels of the pests involved. Most important in this concept is the economic threshold which is the point at which an artificial control measure must be administered to prevent the pest population from reaching a level that will cause economic crop loss. Therefore, accurate measurements of pest populations and seasonal fluctuations are an integral part of establishing an IPM program. Adequate assessment of pest damage and crop losses and the tolerance level of the crop (or varieties) will facilitate successful implementation of such programs. Tolerance levels exist in several crops in the form of resistant varieties and constitute a major component in a IPM system.

Among the various alternatives to chemical insecticides the use of insect resistant plants, in combination with good cultural practices is perhaps the most effective, convenient, economical and environmentally acceptable method of insect control. Although the first significant economic contribution by host-plant resistance (HPR) to agriculture occurred in 1890 (the development of grape vine resistant varieties to save the French wine industry from Phylloxera vitifolia, Fitch), the potential of HPR as an insect control method was not fully appreciated until the mid 1960s due in part, to the then successful push for the use of chemical control methods.

Today, the successful use of resistant varieties abound in many crops: tobacco, cotton, rice, sorghum, wheat, maize, soybeans, cowpeas, phaseolus beans, cassava, potatoes, etc etc.

In practical agriculture, HPR represents the ability of a certain variety to produce a larger crop of good quality than would other varieties under the same insect population (Painter, 1951). In a broad sense, host-plant resistances includes the exceptional abilities of certain plants to avoid, repel, retard, restrict or localize insect infestation and damage or to tolerate it by fast regrowth and recovery from injury (Horber, 1980).

Resistance may be classified into 3 broad categories: Immunity, resistance and susceptibility (Painter, 1951). An immune variety is a non-host. Resistant varieties possess characteristics, chemical or mechanical, that affect insect populations in one way or other thus there are levels of resistance depending on the "concentration" (quantitative difference) of the causative factor. Based on the causative factors, three main categories of resistance proper are recognized, namely: non preference for oviposition, food or shelter; antibiosis against the survival, development and reproduction of the pest and tolerance-plant response abilities to support pest populations that are damaging to susceptible plants.

Resistant varieties have advantages of being economical, leave no harmful residues in food or the environment, do not interfere with beneficial insects, minimally interfere with nature's balance between destructive insects and their control enemies and are compatible with biological, chemical and cultural control methods (Horber, 1972). Thus, the greatest use of resistant varieties is as one component of a pest management system, in this type of management system, the value of low levels of resistance is magnified because the resistance works as just one of possibly many suppressant factors integrated to prevent the target species from exceeding the economic threshold.

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When viewed therefore as a component of an IPM system it has several desirable implications: (1) it may influence the pest's ability to attain economic injury level (2) it may increase damage tolerance levels (3) create a situation for increased efficiency of biocontrol agents due to slower rates of pest increase (4) it may improve the effectiveness of insecticides or make it possible to omit or reduce treatments and (5) by keeping the pest below damaging levels, a resistant variety may even permit the growing of high-yielding susceptible varieties (Teetes, 1975).

The successful use of resistant varieties is well documented. The factors range from mechanical or physical interference to chemical antibiosis. But the crux of the matter however is the initial search for resistance. Screening for resistance requires detailed knowledge of the biology, ecology, population dynamics and its relationship with the host plant. Such studies are needed for determining methods and times for artificial infestation or for planting in order to maximize insect numbers and damage levels for a uniform field screening of the host material. It is essential that breeder's materials are subjected during early generations to entomological tests in order to eliminate "double travail" after a variety must have long been selected and recommended, based only on its agronomic performance.

The successful transfer of resistance genes of a selected line into an agronomically improved line can today be accomplished in a few generations. Successes utilizing mass selection, backcrossing, random mating populations (population improvement) and recurrent selection programmes have been used in developing insect resistant sorghum lines to major pests. Much information has been collected on the pests of sorghum and millet at the ICRISAT center in Hyderabad, India.

Further to the development of such a program, ICRISAT has strong center and cooperative breeding programs and as an obvious element in an IPM system, materials that are resistant or relatively less susceptible to the complex of insects are available and can be provided for testing in each region.

While emphasis in hostplant resistance centers on the development of genetically inheritable resistant genes, early maturing varieties have a role to play in IPM programs. An early maturing variety could be harvested early thus evading peak pest populations, short falls in rainfall and may withstand a high-density pattern since the period of plant growth is shortened. Such a variety may also induce premature entry into diapause of pest species thus reducing numbers of carry-over populations.

IPM AND HPR IN MILLETS IN THE WEST AFRICAN SAHEL.

The classical implementation of IPM in Africa on a large scale is limited to Egypt where it was developed as a consequence of the recognition of the limitations of the use of insecticides as the ultimate solution for the control of pests attacking major crops viz: cotton, maize, rice and sugar cane (Brader, 1980). Basically this recognition arose from problems involving insecticide resistance, high costs of chemical pest control and environmental pollution of the densely populated Nile Valley.

Even with the so-called "environmentally safer" chemicals, given the current yield levels in West African peasant agriculture, the use of insecticides by farmers on food crops it was observed that the product was diverted from a cash crop onto a food crop. Moreover, the predominant chemical was either DDT or BHC. The recommended use of "less-polluting products" was not followed because usually the alternative product was unavailable. It is obvious therefore that we must focus our efforts in building management practices that require the very minimum use of insecticides.

There are two major insect pests of millet in the Sahel, namely: the earhead caterpillar, Raghuva albipunctella and the stem borer, Acigona ignefusalis. Progress in the development of millet resistant varieties or pest control measures in general is not as advanced as in sorghum. This is primarily due to the fact that for a long time millet was considered a less important crop and is less widely grown. Furthermore, in countries

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where advance in cereal research is considerable the problems on millet are less severe and as such receive minimal attention. However, in the Sahel, both R. albipunctella and A. ignefusalis pose severe problems to millet.

A. ignefusalis is the predominant borer in millet. Other borers of minor importance are Sesamia calamistis and Eloana sachatina. The control of Acigona in millet can be viewed within the frame work of an IPM system in the application of cultural practices, use of resistant varieties and biocontrol agents. Early planted millets sustain less damage than the late planted crop. This is linked to the fact that usually 3 generations of pest occur during the crop season. While attack by the first generation larvae cause insignificant damage, severe losses are inflicted on the late planted crop by the second and third generation larvae. This trend has been confirmed at Kamboinsé in 1980 (Table 1). Both stem infestation (13.7%) and severity of attack (9.6%) measured by internode damage, were low in the

Table 1. Effect of planting date and A. ignefusalis infestation on millet.

Planting date	% infested stems	% bored internodes	No larvae stem.
8 June	13.7	9.6	0.3
7 July	49.1	15.1	0.7
24 July	72.5	37.8	4.4

first planting date of 8 June. For the late crop of 24 July, these rates increased to 72,5% and 37,8% respectively.

Apart from manipulating planting dates, the destruction of crop residues and volunteer sorghum before onset of the rains would considerably reduce the initial population of first generation borers. This is particularly important since larvae diapause within out stalks and stubble. Adesiyun and Ajayi (1980) have shown that partially burning of sorghum stalks after harvest can reduce Busseola fusca larvae within stalks by 95%.

Local varieties of millet have a high tillering ability. Initial borer attack may kill the growing point and produce dead hearts and in some varieties it may induce tillering. Tillering is an aspect of varietal tolerance and at low/borer infestation the overall head production may be related to tillering ability. This is the case with the local variety at Kamboinse (Table 2). This phenomenon may also be linked to the rapid.

Table 2. Observations on A. ignefusalis attack on stems of four millet varieties at Kamboinsé.

	% dead hearts at 45 days	% infested tillers at harvest	% infested internodes	Mean number heads/plant.
Local	5	52.3	18.5	2.3
Souna III	35	72.9	26.5	1.0
Ex-Bornu	30	95.0	62.5	1.4
Saria Synthetic	15	98.0	55.5	1.8

Vegetative development of a variety thus permitting the host to rapidly pass through a sensitive growth stage to insect attack and minimize damage.

Harris (1962) listed 14 primary parasites, one predator and four diseases that attack different stages of borers including A. ignefusalis at Samaru, Nigeria. Although the overall rate of parasitism was low and only increases towards the end of the growing season, his study indicates the scope of biocontrol in an IPM program.

Raghuva albipunctella. This insect which occurs primarily within the southern Sahel and the Sudan Bioclimatic zones (precisely between latitude 12°N and 15°N where the rainfall is between 400-700) was practically of no importance before the Sahelian drought years of 1972-1974. Only one generation occurs annually and larvae diapause in the soil (Vercamble, 1978). The most critical period of crop growth is at head emergence when adults lay their eggs on recently exposed heads. Thus early planted or early maturing varieties are more predisposed to infestation as adult emergence from the soil is synchronised with the period of head emergence of such varieties. Two cultural control measures are therefore evident:

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(1) Planting date : By manipulating date, it is possible to evade infestation by shifting the host/pest relationship in favor of the host. This mechanism will permit the crop to pass through peak adult emergence at a stage that is not conducive as site for oviposition. This is particularly important especially in Niger where most millet varieties are non-photosensitive (Dr. B.B. Singh, per. com.).

(2) Early plowing : By early plowing at the end of the crop season in October/November after harvest, this practice has the advantage of exposing diapausing larvae to dessication and natural enemies during the long dry season.

The use of resistant varieties was indicated by Vercambre but it appears the varieties identified were early maturing. It is now known that Raghuva infestation is negatively correlated with the number of days to maturity ($r = 0.83$) (Nwanze, unpublished). But similarly we have identified less infested varieties with the head emergence occurring during the critical period of adult Raghuva emergence from the soil. Therefore resistance in this case may be due to two factors (1) non-preference for oviposition and/or (2) antibiosis of earheads against larval penetration and/or feeding.

Non-preference for oviposition may be related to density and the variation in their length and orientation at head emergence. Bristles and hairs are known in several crops to affect insect oviposition. In Raghuva, they may also deter feeding of the early instars before penetration into the rachis of millet heads.

Antibiosis of earheads is presently being linked with head compactness in some varieties. Although no definite data is now available to support this, this character may deter larval penetration thereby (a) causing death by starvation (b) inducing premature entry into diapause with reduced chances of survival (c) prolonging larval exposure to natural enemies. Since only a limited collection of millets have been tested, a larger germplasm, in particular of the West African collection, reveal greater chances of identifying resistant varieties. Host-evasion as seen in late maturing varieties should also be examined within the frame work of overall resistance, taking into consideration the short duration of the crop season and the erratic rainfall pattern in the Sahel.

CONCLUSIONS.

In concluding this paper, certain aspects of pest management which are usually side-stepped by proponents of this system from technologically advanced countries should be mentioned here. It is consistently emphasized that planting time should be synchronized in order to maximise success. But to ensure the maximum proportion of land sown in good time, which of itself is an eminently desirable objective, the primary requirement is to reduce the dependence of the peasant farmer on hand cultivation and speed up animal-drawn equipment. The cultural control of several pests in Africa thus becomes the facet of the general problem of the need to improve the efficiency of the peasant farmer in Africa (Bowden 1965).

Moreover, given the nature, size, distribution and pattern of farms in West Africa, there is an urgent need for strengthening extension services in the different countries. The successful implementation of any IPM program will depend largely on the education and collaboration of the farmers in a particular area. The different regional and subregional programs in Africa should address themselves to this problem taking primarily into consideration the past failures in the implementation of research findings and recommendations in these regions due to a lack of trained personnel and weak-to-non-existent extension services.

All components of pest management involve demonstration to farmers through cooperation in pilot programs. But they must be routed through, and carried out by national programs if any impact is to be achieved. There is enough evidence to show that synchronized sowing dates, intercropping and crop spacing, destruction of crop residues, use of tolerant or resistant varieties and improved agronomic practices etc. etc. contribute to higher yields. The implementation of these practices is within the scope of national programs and should both be encouraged and emphasized.

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INTERESTING CASE

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STRIGA PROGRAM IN AFRICA

By

K.V. RAMAIAH

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1980 is the second year of ICRISAT Striga program in Africa based in Upper Volta. The objectives of the program are (a) identification of Striga resistant sorghum and pearl millet cultivars (b) transfer of resistance into elite agronomic background and (c) studies on physiological stains of S. hermonthica.

Identification of resistant sorghum cultivars. A few cultivars of sorghum which have been identified as resistant during 1979 were tested over a large number of locations in Africa to assess their stability of resistance across an array of physiological strains and crop growing conditions. The results (means over 15 locations) are presented in Fig. 1.

N 13 a local sorghum cultivar from India is by far the best source of resistance available. It was found to be resistant in several African countries like Ethiopia, Kenya, Sudan, Upper Volta, Mali, Niger, and Cameroon when tested during the last four years. However, its grain yield potential is rather low. Another improved cultivar, SPV 103, again from India, was tested less extensively but has very useful level of resistance in an agronomically good background. This crosses well with other sorghum cultivars, so its improvement through breeding is feasible. Similarly IS 8686 which is of African origin has very good yield potential but its resistance is less stable across locations. Therefore, attempts have been made to cross N 13 and IS 8686 to improve yielding ability of N 13. Several progenies are in advanced stages of testing.

Several new cultivars like Najjadh, IS 9830, IS 2862, etc. have been identified as resistant. They were advanced to multilocation testing the next season.

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Identification of Striga resistant pearl millets. Several West African local pearl millets have been tested in northern Upper Volta. Eleven lines have been identified for further testing and use in breeding program (Table 1). The most promising ones are P 2671 and P 2950. In another trial Souna was also resistant.

Physiological strains of Striga hermonthica. A detailed analysis of physiological strains was carried out by field trials, microplots and pot experiments. The synthesis of 1979 and 1980 data enabled to divide.

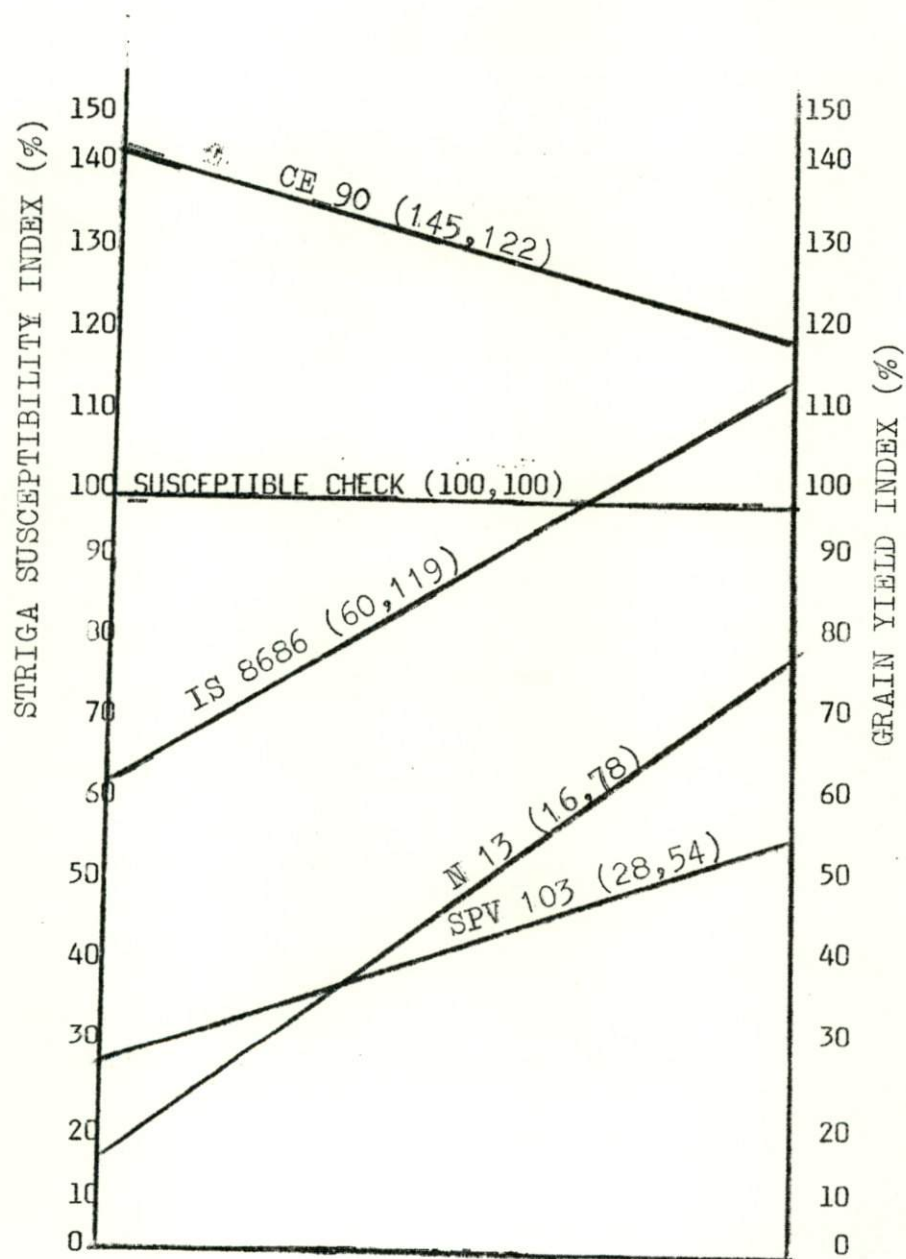


Fig. 1. Performance of a few resistant cultivars of sorghum in a multilocation trial.

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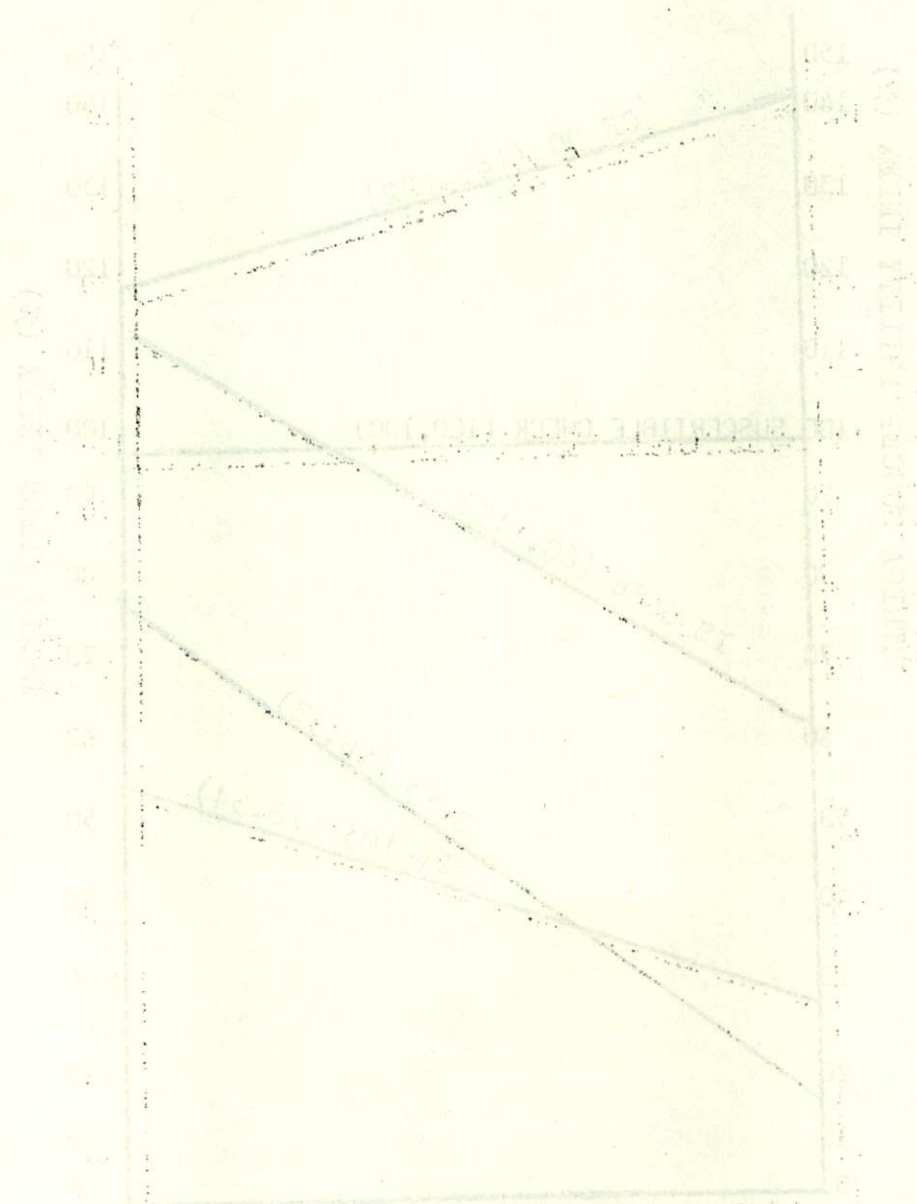


Fig. 1. Performance of a few treatment units over time.

Table 1. Performance of selected pearl millet cultivars in northern Upper Volta.

Entry	Pedigree	Mean <u>Striga</u> * score	Mean agronomic* score
805224	Sel from Thiou	1.0	2.7
805228	"	1.0	3.0
SDN 347-1	SDN 347-1	1.0	3.0
805239	Tenkodogo local	1.0	5.0
805226	Sel from Thiou	1.3	3.0
805210	Bitou local	1.3	5.0
P 2671	P 2671	1.7	2.0
Serere A 2A-9	Serere 2A-9	1.7	4.0
P 2950	P 2950	2.0	2.5
P 1525	P 1524	2.0	3.0
805238	Zandkom local	2.0	5.0

* (1-5 scale) 1 = Superior 5 = Inferior.

West Africa into four Striga (Fig. 2): Zone I above 13°N latitude with 350 to 500 mm rainfall belongs to pearl millet Striga; Zone II around 13°N consists of a Striga strain capable of attacking both sorghum and millet; Zone III between 12 and 13°N belongs to sorghum specific strain, and Zone IV between 11-12°N consists of a mixture of two strains, one specific to sorghum and another to pearl millet.

Significance of physiological strains.

(a) In Zone I it is not necessary to breed Striga resistant sorghums. On the other hand pearl millets without Striga resistance would be eliminated. Similarly in Zone III Striga resistant sorghums are required but not millets.

(b) The resistant cultivars identified in a particular zone in Upper Volta would theoretically be resistant in corresponding zone in neighbouring countries in West Africa.

(c) Striga free millets in Zone III would be useful as direct introduction into Zone I provided they are resistant there. But Striga free millets from Zone IV cannot be introduced into Zone I directly because they are photoperiod sensitive.

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Table 1. Performance of various test and field activities in North Africa

Activity	Test	Field
1. 1000 yds	1.0	1.0
2. 500 yds	1.0	1.0
3. 250 yds	1.0	1.0
4. 100 yds	1.0	1.0
5. 50 yds	1.0	1.0
6. 25 yds	1.0	1.0
7. 10 yds	1.0	1.0
8. 5 yds	1.0	1.0
9. 2.5 yds	1.0	1.0
10. 1 yd	1.0	1.0
11. 0.5 yd	1.0	1.0
12. 0.25 yd	1.0	1.0
13. 0.125 yd	1.0	1.0
14. 0.0625 yd	1.0	1.0
15. 0.03125 yd	1.0	1.0
16. 0.015625 yd	1.0	1.0
17. 0.0078125 yd	1.0	1.0
18. 0.00390625 yd	1.0	1.0
19. 0.001953125 yd	1.0	1.0
20. 0.0009765625 yd	1.0	1.0

1-10 (approx) = 1000 yds; 11-20 = 500 yds; 21-30 = 250 yds; 31-40 = 100 yds; 41-50 = 50 yds; 51-60 = 25 yds; 61-70 = 10 yds; 71-80 = 5 yds; 81-90 = 2.5 yds; 91-100 = 1 yd; 101-110 = 0.5 yd; 111-120 = 0.25 yd; 121-130 = 0.125 yd; 131-140 = 0.0625 yd; 141-150 = 0.03125 yd; 151-160 = 0.015625 yd; 161-170 = 0.0078125 yd; 171-180 = 0.00390625 yd; 181-190 = 0.001953125 yd; 191-200 = 0.0009765625 yd.

West Africa and East Africa. The test results show that the performance of the test activities in North Africa was generally better than in West Africa and East Africa. This is probably due to the fact that the test activities were performed in a more controlled environment in North Africa than in West Africa and East Africa. The test results also show that the performance of the test activities in North Africa was generally better than in West Africa and East Africa. This is probably due to the fact that the test activities were performed in a more controlled environment in North Africa than in West Africa and East Africa.

3.1.1.1. Test results in North Africa

- (a) The test results in North Africa show that the performance of the test activities was generally better than in West Africa and East Africa. This is probably due to the fact that the test activities were performed in a more controlled environment in North Africa than in West Africa and East Africa.
- (b) The test results in North Africa show that the performance of the test activities was generally better than in West Africa and East Africa. This is probably due to the fact that the test activities were performed in a more controlled environment in North Africa than in West Africa and East Africa.
- (c) The test results in North Africa show that the performance of the test activities was generally better than in West Africa and East Africa. This is probably due to the fact that the test activities were performed in a more controlled environment in North Africa than in West Africa and East Africa.
- (d) The test results in North Africa show that the performance of the test activities was generally better than in West Africa and East Africa. This is probably due to the fact that the test activities were performed in a more controlled environment in North Africa than in West Africa and East Africa.
- (e) The test results in North Africa show that the performance of the test activities was generally better than in West Africa and East Africa. This is probably due to the fact that the test activities were performed in a more controlled environment in North Africa than in West Africa and East Africa.

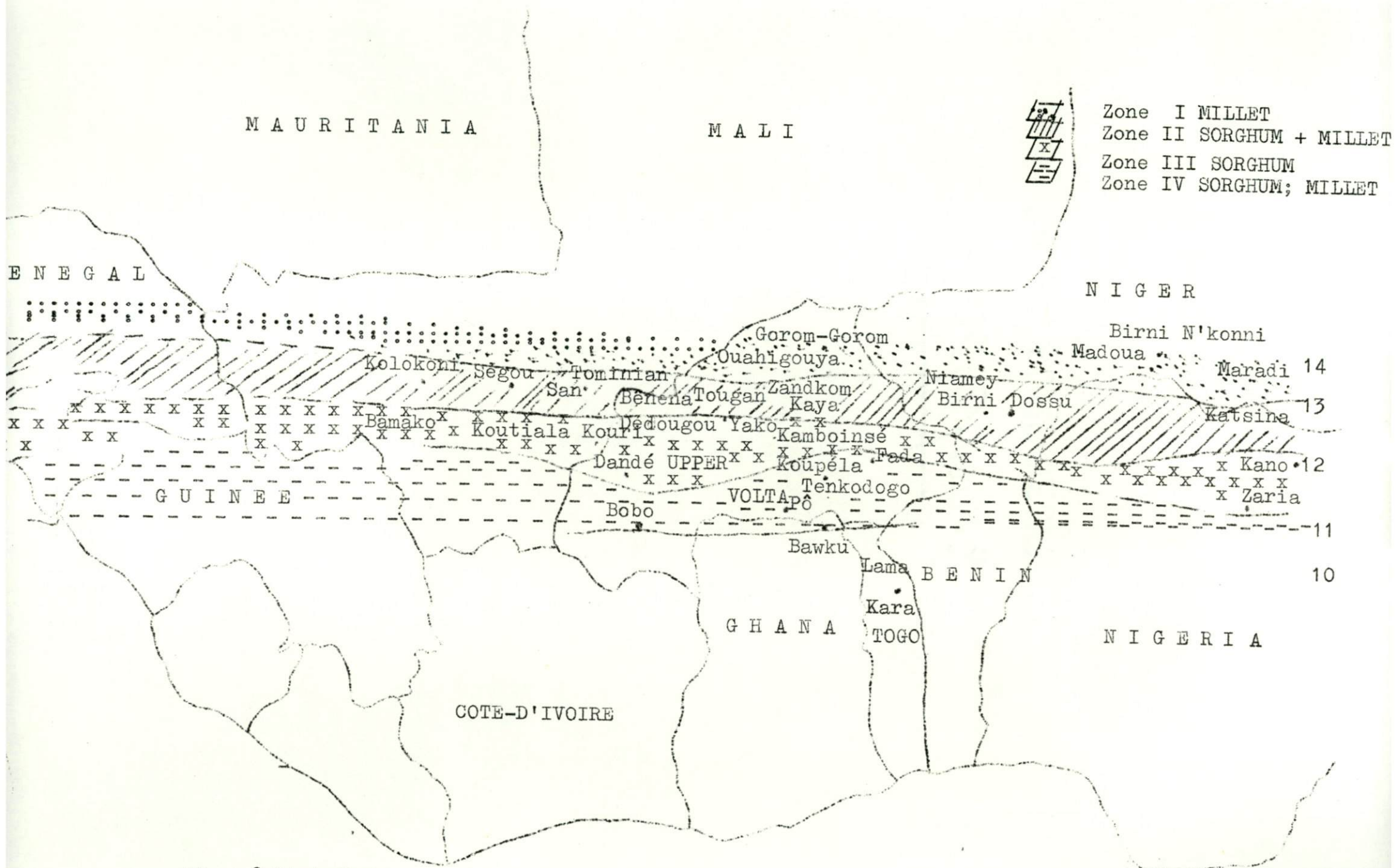


Fig. 2 Distribution of crop specific *Striga hermonthica* strains in West Africa.

They have to undergo a breeding process. A test location in Zone IV like Farako-Bâ will be useful. Testing in two locations one in Zone I and another in Zone IV and intercrossing the selected ones should result in wider adaptation and stability of resistance across the zones.

Breeding program. A systematic breeding program has been initiated to (a) strengthen the resistance source by bringing resistance genes from different sources. This needs to understand the sources of resistance by detailed studies on their morphological traits and breeding behavior. (b) improve the resistance source for agronomically desirable traits like grain yield, quality, etc, and (c) understand the inheritance of field resistance.

Training. As discussed in the breeding program there are several interesting topics which can form the subject of research for students of plant breeding leading to MSc or Ph.D. A detailed agronomic research is also planned for future which also offers an excellent scope for graduate students' training.

International Striga trials. We have been organising international Striga trials since 1977. We have identified several resistant sorghum cultivars and can be supplied to interested parties on request either in the form of a trial, observation nursery, or early generation segregating material. Those who are interested can send their requests to

K.V. Ramaiah
ICRISAT/PNUOD
B.P. 1165
Ouagadougou
Upper Volta (via Paris)

not later than mid-April.

International Striga workshop. ICRISAT is organizing an international Striga workshop from 5-7 October 1981 in Ouagadougou, Upper Volta. The objectives are to discuss the present situation on Striga control methods and draw some guidelines for future Striga control strategy in Africa. Those who are interested can contact K.V. Ramaiah. The participants should find their own travel grants to attend the workshop.

They have to undergo a breeding process. A fast forward in time IV like
parents will be useful. In fact, in two locations and in time IV like
another in time IV like the selected ones result result
in wider adaptation and selection of resistance across the range.

Breeding program. A breeding program has been initiated
to (a) strengthen the resistance by bringing resistance genes from
different sources and (b) to understand the sources of resistance by
detailed studies on their molecular traits and breeding behavior.
(c) Improve the resistance against the economically desirable traits
like grain yield, quality, etc. and (d) understand the inheritance of
field resistance.

Training. Assistance in the breeding program has been several
interesting topics were discussed. The subject of research for students
of plant breeding research, ICRISAT, detailed agronomic research
is also planned for future students also offers an excellent scope for
graduate students' training.

International symposium. It has been planned to have an international
symposium on plant breeding in 1985. The symposium will be held in
Madras and will be attended by scientists from various countries
and will be a great opportunity for scientists to exchange views
and to discuss the present situation on plant breeding and other
related matters. These will be invited to attend this symposium to
discuss the present situation on plant breeding and other related matters.

K. V. Reddy
ICRISAT/Pune
P. M. Rao
ICRISAT/Pune

Dr. V. V. Rao (via Paris)

not later than 15th April 1985.

International symposium workshop. ICRISAT is organizing an international
symposium on plant breeding in 1985. The symposium will be held in
Madras and will be attended by scientists from various countries
and will be a great opportunity for scientists to exchange views
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ROLE OF HOST PLANT RESISTANCE
MILLET RESISTANCES TO INSECTS AND STRIGA.

Discussant; Dr. B.B. SINGH.

Following significant points in the presentation of Dr. Nwanze need to be emphasised and are self explanatory while considering the role of host plant resistance in an integrated pest management programme:

1. Ecologically based integrated pest management is most appropriate approach for pest management.
2. Integrated pest management in a joint effort of entomologist, ecologist, breeder, economist, soil scientists etc..
3. Host plant resistance is most important aspect of integrated pest management.
4. Development of varieties and populations of pearl millet and increase of level of host plant resistances may be achieved with very active cooperation between breeders, entomologist and other pest specialists.
5. Overall success depends upon active cooperation between international center, regional and national programs.

As regards my view related to breeding pearl millet against insects and striga, following aspects need to be considered:

- (a) Pearl millet being a cross pollinated crop favours out crossing and inbreeding, leads to inbreeding depression, reduction of vigor, heterosis and susceptibility to major insects, pests and diseases.
- (b) Available information, indicate additive gene action for most of these characters, and hence level of resistances in an appropriate millet population may be increased by recurrent selection procedure.

.../...

(c) The appropriate population - local or resulting from cross breeding program can be improved by recurrent selection following steps:

- Identification or creation of a good population - considering ecological zone in question and major pest problem.
- Selection of agronomically desirable and pest resistant genotypes.
- Evaluation of selections in appropriate ecological zone and pest sick plots.
- Recombination of selected genotypes.
- Repeat the selection.

(d) Success of this recurrent selection program depends upon testing the material in pest sick plots which may be created by alternative planting dates or growing infector rows. ICRISAT center and established testing procedure and screening technique for some of the problems. For insects and striga, screening technique for millet need to be standardised.

(e) Multilocation testing of base populations and selections in appropriate ecological zone is necessary.

(f) Plant breeder and entomologist need to work jointly in this kind of population improvement program.

Proceedure described above may also be useful in breeding pearl millet against diseases, striga and drought.

I have prepared a short paper on this aspect and if it is cyclostyled, I may circulate the same to the participants for their thought and consideration.

.../...

QUESTIONS, REMARKS AND ANSWERS ON PRECEDING DOCUMENTS.

QUESTION, ANSWERS AND COMMENTS.

Chairman (comment)

The best approach to the pest management of these pest may be the prevention of their occurrence in large numbers. Shootfly and midge occur in high numbers when there are late plant crops or two cropping seasons.

Delegate from Nigeria (question):

DIMBOA has been implicated in some references as a source of resistance to sorghum stem borers. Is there any work in this area in Africa, and could it be used as a more effective method for screening for resistance ?

ICRISAT, Upper Volta (answer):

No work has been done on this chemical but ICIPE, Nairobi, is currently studying the chemical aspects of stem borer resistance.

ICRISAT, Upper Volta (comment):

It was interesting to know from Dr. Rao that the local sorghum varieties in India have high levels of resistance compared to temperate varieties. However, our observations in Upper Volta indicate that the local varieties are more susceptible to shootfly than good temperate varieties.

Delegate from Gambia: (question):

Sometimes we may look too far out for answers to our questions. As such we may be breeding for resistance whereas all that is necessary is merely sanitary methods that presently could be effective in the field. Examples that could be cited are looking into vegetative remains in the field, such as, stubble and fencing materials which may carry over larvae, etc, from one generation to another. Have sanitary methods been looked into, therefore, to solve some of these insect problems ?

.../...

Delegate from Nigeria: (answer)

Yes, sanitary methods of control have been looked at, as well as whole cultural practices for insect pest control on sorghum. In Nigeria the by-products of sorghum are used by the farmer for fencing, building and firewood. It has been recommended in Nigeria for stubble and stalk management, which are a main source of carry over population of stem borers, that stalks be burned. The farmers hesitate to do this because of the other uses for the stalk. Now it is recommended that farmers partial burn stalks immediately after grain harvest when leaves are dry and stems still moist and green. The leaves are burnt off and the resulting heat kills any borer larvae in the stems without destroying the stalk. It has been found that these partially burnt stalks makes better fencing material and firewood.

Chairman (question):

This is a good example of pest management through cultural practices. How much success has been had in carrying out this practice?

Delegate from Nigeria.

It has been shown that this procedure works very well and has been pushed very hard to be adapted by the farmers. Initial general survey have shown that the practices is wide spread in Nigeria but we have no accurate data.

FAO, Kenya (comment)

In Kenya shootfly, stem borers and midge are important pests. Over 2000 entries have been screened for shootfly resistance including over 600 locals. Those with dead heart counts below 40% are relatively resistant. Some 10% of local entries were in this category. ICIPE is collaborating with the project in screening varieties for shootfly and stem borer (*Chilo*) resistance. They have developed the methodology for greenhouse screening using reared larvae and also a standard method for field evaluation of variety and agronomy trials which may be useful to other co-operators.

.../...

Midge can cause 95% losses if sowings are delayed by 2 weeks. Introduction of early varieties can lead to midge problem on the local later maturing varieties.

Chairman (question).

The discussions have all been concerned with pest problems on sole crop sorghum and millet. Can the pest management experts say what work has been done in the control of pests in the mixed-or inter-cropping systems ?

Delegate from Nigeria (answer).

Most pest control work has been done in sole cropping systems but in most cases are applicable to intercropped sorghum. The chemical control of stem borers using the pistol sprayer is applicable under both sole and intercropped sorghum. Problems do occur when ULV is used because intercropping the other crops forms barriers which make it less effective.

Stem borer infestation under millet and sorghum intercropping to determine what plant population levels should be to obtain best results. It has been shown so far that millet intercropped with sorghum could reduce stem borer populations on sorghum on both per plant and unit area basis. Busseola appears not to like millet and a few plants therefore will reduce populations of stem borer on sorghum. More eggs are laid on sole crop sorghum than on intercropped sorghum.

Delegate from Botswana (question)

Could the delegates please inform us how they assess pest damage so that one can put a figure on yield losses due to pest infestation ? One can do this by chemical means, artificial infestation or natural infestation by tagging plants. We have attempted in Botswana to do this by tagging naturally infested plants but have found that due to selective composition, infestations may enhance yields, e.g., Chilo on sorghum, because small non infested plants may yield less than the larger infested plants, this is accentuated by the tillering capacity of the plant.

.../...

ICRISAT, Upper Volta (answer)

Chemicals to assess pest damage is applicable to research station but is not relevant to the situation in farmers fields. In this situation to assess losses to stem-borer on sorghum and millet needs 500 plants where the initial infestation, dead hearts and number of tillers are known and when combined with date of planting and date of infestation yield losses in early millet is 9-15% while on late millet it can be as high as 90%. Losses can be related to loss in grain formed by classifying stem according to the percentage of bored internodes. Therefore, we need yield loss methods in research station conditions that can be easily transferred to farmers fields.

Ethiopia (comment and question).

Under the Ethiopian situation the most important sorghum insect is Busseola fusca as has been pointed out in the case in Nigeria. Such insects as shootfly and midge currently are not of major importance.

With respect to Busseola we find this species in higher altitudes (above 1500 m) predominantly but Chilo is found at lower altitudes. Can the delegate from Nigeria comment on the environmental factors influencing the distribution of Busseola and Chilo in Nigeria ?

Delegate from Nigeria (answer).

There is no relation between distribution of Busseola and altitudes in Nigeria. It is found throughout all the sorghum area in the drier northern region. It is the predominant pest on sorghum at Samaru which has an altitude of 686 m.

Chairman : (comment)

The genotype environment studies carried out in Nigeria shows no relation between distribution and altitude.

ICRISAT, Upper Volta (comment)

The distribution of stem borers on millet and sorghum in Upper Volta, Niger, Northern Nigeria shows a direct relation to rainfall. *Busseola* is predominant in Upper Volta at 11°30' with rainfall above 900 mm, further north at 13° *Eldana* and *Sesamia* are found. In Niger stem borer infestation on sorghum is very low where *acigona* is the main borer on millets. In Nigeria north of *Mara Mara* *Busseola* is replaced in *Eldana* and *Sesamia* which are then replaced by *acigona* at Nigeria/Niger border.

IDRC, Senegal (comment).

The main pest problems on sorghum in Senegal are shootfly and midge. All the materials that we have tested so far have only been resistant to one insect. Many problems could be solved if we could combine sorghum midge and shootfly resistance in the same cultivar.

Delegate from Nigeria (comment).

It may be easier to find varieties resistant to shootfly and stem borer rather than shootfly and midge. The only way it could be achieved is to combine the individual resistance in separate varieties into a single variety by crossing.

Chairman : (comment).

I now call upon Dr. Nwasike to comment on the papers by presented by Mr. Nwanze and Mr Zangre.

Dr. Nwasike, Nigeria (comment).

In the area of host plant resistance the stem borer is the most important on millet. So far very little success has been made in identifying lines of resistance. There is no literature or data on reaction of germplasm to this insect. In Nigeria the borer attacks the *mewas* while the photoinensitive *geras* are not attacked. The resistance in the *geras* may be of antibiosis types.

A major pest on millets was not mentioned by the speakers, birds. The gene for bristle head in millet can reduce damage up to 25% in Nigeria. Birds are probably the greatest problem in the production of millet in West Africa.

Breeding for resistance is simple process by recurrent selection when the sources of resistance are known. The major problem is that these sources of resistance in the germplasm have not been identified.

Delegate from Cameroon (comment).

Concerning millet eating birds (*quelea*) farmers along the border with Nigeria have difficulties to protect their crop. In fact birds in these two countries caused a lot of damage to harvest.

I am of the opinion that it would be desirable to organize a common and adequate control effort to check this problem.

Delegate from Senegal (question).

Atherigona is an insect common to both sorghum and millet. For millet, has it been possible to identify morphological resistance criteria that can be used by breeders as in the case with sorghum?

Delegate from Gambia.

Birds are important pests in the Gambia but when breeding for resistance to breeds also make millet unpalatable to humans. The bristle head only give protection when other foods are present, when no other millet is available birds remove the bristles to get at the millet. The same occurs in sorghum with heads, the birds still manage to eat the grain when there is no other food. From observations on millet, it would appear that close compact heads where seeds set deep in the head makes it difficult for birds to get at the seeds.

Delegate from Ethiopia (comment).

Bird problem, particularly Quelea are limiting sorghum production in Ethiopia. We consider this one of the most important problems of sorghum. At the experimental stations we have found the bird repellent chemical mesural effective. However, the prohibitive costs of this chemical do not appear to allow its large scale use large scale production. In the long run, the most effective way to control Quelea appears to be the eradication of the birds themselves. The existing regional projects on Quelea should be strengthened.

Delegate from Nigeria (comment).

Suggestion to controlling birds, at least limiting the damage done. How a large number of farmers plant about the same time. This way, damage even total damage done might be about the same, ears to individual farmers will be less.

SAFGRAD/ICRISAT, Nigeria (comment).

This comment pertains to the observation of the delegate from Nigeria that the geros are relatively more resistant to stem borer compared to the mewas. The question is, whether the resistance in geros is real or whether they escape damage since they are elongating and culm formation have taken place and are at a different stage of growth while the mewas are at the tender roseth stage. Hence, the relative difference for resistance within geros and mewas need to be studied and once the differentials are established, breeding programs could be initiated, toughness of the stalk may be a useful criteria in assessing resistance to stalk borer.

.../...

Delegate from Nigeria (answer).

In answer to the SAFGRAD/ICRISAT delegate it is not known for sure if the resistance in gero type is escape mechanism or not. In August and September when mewas types are just flowering the geros are already mature and being harvested. There is some evidence that gero types are less susceptible than mewas type when planted late in the season and could be related to tougheners of the stem.

FAO, Kenya (comment).

The bird problem is important enough in Eastern Africa to warrant greater attention and increasing support to the organization involved. The UNDP/FAO quelea control project covers some 6-7 countries in E. Africa. Their work on direct and indirect control is of great relevance to the success of production programmes on sorghum and millets. On direct control, work done by the Denver Wild Life Research Organization and at Bowling Green in USA are of interest. The use of mesural spraying at two rates in combination with tannin extracts and costs below \$US 26 per hectare could be economical as now 35 man days labour is needed for bird scaring. The selection of varieties with high tannin at milk stage and very low levels at maturity due to polymerisation rendering tannins insoluble are of great significance to future breeding for resistance to bird damage. Organizations like ICRISAT are urged to consider giving priority to work in this field. Escape mechanisms using long glumes, bright orange grain color and ratooning to enhance maturity are proving effective under low bird pressures. With millets, long stiff bristles on compact heads are also quite effective.

SAFGRAD Coordination Office. (comment).

This is a reminder that I consider very important for all of our speakers this morning.

We are all aware that research in isolation is a thing of the past and that activities in research should be handled by a multidisciplinary team on any given plant other than that results will only be partial.

This compels me to ask the following questions:

- (1) Have soils on which we carry out all of our activities been analyzed?
- (2) Have soils in farmers fields where you make your demonstrations also been analyzed? Indeed there can be no real plant resistance unless the plant is healthy and rightly corrected.

Delegate from Senegal (comment and question).

For future workshops, it would be good to call on all specialists likely to be interested in questions to be discussed so as to benefit from their experience and ~~lose~~ less time.

Question: I've observed certain failures in insect releasing which might be due to meteorological (temperature) reasons. I'd like to ask if this is not an obstacle to biological control.

ICRISAT, Upper Volta. (answer).

The biological control agents parasites and predators reported on cereal stem borers have been recorded in most parts of Africa. However, populations of parasites only increase after damage to crops is complete and towards the end of the season. Furthermore failures reported in Senegal may be related to poor timing of release.

OAU/STRC Secretariat, Nigeria (comment).

The Inter-African Council of the OAU has on the agenda for its next meeting

- control of rodents
- control of birds
- control of locust

Your concerns and recommendation will be forwarded to the Council.

.../...

STATUS OF SORGHUM RESEARCH IN ETHIOPIA IN 1980

By

Brhane GEBREKIDAN, Leader
Ethiopian Sorghum Improvement Project.
Nazareth, Ethiopia.

BRIEF REPORT ON SORGHUM RESEARCH IN ETHIOPIA, 1980.

The 1980 crop season was the first year in which all research activities in the country in sorghum were planned and executed collectively by the National Sorghum Research Team. It was not possible to get data and results from all the projects which were planned to be carried out in the 1980 season. The major reasons for lack of data and the failure of some of the trials were theft, drought, projects not carried out as planned, and failure to collect data in time. However, most of the planned projects were carried out and promising results were obtained. The results presented in this report reflect the joint efforts of the members of the National Sorghum Research Team and all cooperators in various trials. The six major disciplines in which sorghum research was done in the year were breeding, agronomy, soil fertility, entomology, pathology, and weed control. The major findings of each area are presented below:

A. Breeding.

The bulk of the national work in breeding was the responsibility of the Ethiopian Sorghum Improvement Project (ESIP). The sorghum breeding activities of the ESIP in 1980 were varied and comprehensive and they included the following:

- a) Yield trials for highlands, lowlands, and high rainfall - intermediate altitude. These yield trials involved varieties as well as hybrids. There were 14 different sets of yield trials in 1980 most of which were preliminary yield trials tracing to ESIP's breeding nurseries. All these yield trials were multilocal.
- b) Breeding nurseries containing about 1600 populations and advanced lines ranging from F₂ to F₇. These breeding nurseries covered all of the sorghum ecological zones of the country and had multilocal testing.
- c) Initial screening of 182 Hybrids in lowland areas.
- d) Introduced trials from ICRISAT.
- e) Crossing block in which

Table 1. Grain Yield, in kg/ha, of 18 varieties and 2 hybrids in the lowland National Yield Trials at 7 locations, 1980.

Identification	Melkassa	Kobo	Miese	Ogolcho	Cheffo	Abomsa	Setit	Mean
					Jilla		Humera	
1 Bulk Y-3	2556	1132	2588	2814	1556	1000	1964	1944
2 Kobomash 76	2277	780	1818	4593	2335	1500	2745	2293
3 NES 8841	3056	2071	1968	3407	2963	1333	2420	2460
4 W.A. x Nigerian	778	1449	1762	4667	2815	1056	2437	2138
5 Gambella 1107	2667	702	1818	3852	2889	1833	1308	2153
6 Melkamash 79	3444	1271	2520	4889	2444	1778	2971	2760
7 Bulk Y-377-1043	2500	884	2638	2740	2667	1444	2021	2128
8 FLR/53-1695	2444	1547	1975	3778	2667	1278	1811	2214
9 Bulk Y-351-990	2611	909	1300	2296	1482	1444	1637	1668
10 2KX x 17	3000	707	1638	3556	2593	1278	1431	2029
11 80K-5044	3611	1547	2060	3778	1778	1166	1701	2234
12 80K-5095	4000	—	630	3333	1482	389	—	1967
13 80K-5109	3111	1076	2105	3333	1260	1056	1653	1947
14 80K-6044	2612	756	1562	5111*	652	1287	1171	1879
15 80K-6047	3444	578	1520	3482	1333	722	1900	1854
16 80K-6056	2722	1487	2090	4074	2074	1166	2724	2334
17 80K-6085	3388	1733	1405	3260	2593	1222	2467	2295
18 80K-6088	2000	951	2232	3556	1556	1222	2440	1994
19 IS 10360A x YE 121	2944	2387	2295	4074**	3260	1723	2839	2789
20 IS 10560A x YE 137	2944	1338	2978	3407	2518	1889	2460	2505
Mean	2805	1226	1945	3700	2146	1289	2374	
LSD	1372			1375			853	
C.V.%	34			23			28	
Rainfall (mm)	890	651				454	608	
Altitude (m)	1650	1500		1670	1640	1536		
Planting Date	June 18	July 6		June 15	June 14	June 26		

* 80K6043, ** IS 10360A x YE 96

about 900 crosses were completed both for the pedigree breeding program and the backcross for anthracnose resistance. f) New collections.

Since time and space will not allow detailed coverage of results of each area, only the findings from the National Yield Trials will be presented here. The results of all the other areas of sorghum breeding activities will be presented in detail in the ESIP's annual report of 1980.

Four sets of Sorghum National Yield Trials were carried out in 1980. These were the Lowland National Yield Trials, Elite Sorghum Hybrids Trials, High Rainfall - Intermediate Altitude Sorghums Yield Trials, and the Highlands National Yield Trials. The major results from each of these are given below:

1. The Lowland National Yield Trials.(LNYT) - There were 20 entries in this trial. The first 10 were advanced from trials of previous years and the others were new entries from the breeding nursery except the last two (Table 1) which were included as hybrid checks. Plot size used at each location was 5 rows x 4 m x 3/4 m with only the centre three rows used for all data recording. Randomized Complete Block Design with four replications was used at each site.

Table 1 gives mean grain yield data for the 20 entries and for each of the seven locations which submitted results to the coordinator. These seven locations were Melkasa, Kobo, Mieso, Ogolcho, Cheffe Jilla, Abomsa, and Setit Humera. The best mean location yield of 37 q/ha in this trial was received from the Ogolcho station of ARDU. At Ogolcho, four varieties gave yields which were over 45 q/ha and these entries in decreasing order of yield were 80K6043 (51 q), Melkamash 79 (49 q), W.A. x Nigerian (47 q/ha), Kobomash 76 (46 q). Melkasa with a location mean of 28 q/ha was the second best location. The best yielding entries were 80K5095 (40 q), 80K5044 (36 q), Melkamash 79 (34 q), 80K6047 (34 q), and 80K6085 (34 q). The third best station for grain yield with an overall mean of 24 q/ha was Setit Humera where the best varieties were Melkamash 79, Kobomash 76, and 80K6056. The yields from the rest of the stations were too low and do not allow meaningful identification of most promising varieties. The two hybrids which were included as checks did not prove to be sufficiently better than the best varieties at any location. The two varieties which are being grown in relatively large scale in lowland zones of the country, Kobomash 76 and Gambella 1107, were just about average in yield at most locations.

The mean number of days to flowering across all locations and entries was 78. W.A. x Nigerian with an overall mean of 66 days was the earliest entry. Some entries flowered in less than 50 days at some locations. As a group, the new entries of the 80K series from the breeding nurseries were the latest.

The overall mean plant height for all entries and locations was only 124 cm. At Ogolcho, the best yield station, most entries were tallest of all other locations. The location mean plant height for Ogolcho was 147 cm. The highest yielding entry at Ogolcho, 80K6043, with 125 cm was one of the shortest entries.

2. The Elite Sorghum Hybrids (ESH) Yield Trial - Four locations, Melkasa, Kobo, Mieso, and Setit Humera, planted the 1980 ESH. Twenty four entries, three of which were the best available varieties for the lowland areas, were included in the trial. The trial design and plot size at each location were the same as those given for the L-NYT. All the hybrid seeds used in this trial were obtained from ESIP's 1980 off-season nursery at Melkasa.

The results of grain yield from the four locations are given in Table 2. The yield figures from Kobo were too low and erratic and were not statistically analysed in detail. The Mieso figures were also relatively low. The low yields at these two locations were due to the severe droughts encountered at these two areas in the 1980 crop season. The yields obtained at Melkasa were good where the location mean was 44 q/ha. The yields of the three check varieties were 35, 34, and 23 q/ha for Gambella 1107, Melkamash 79, and Kobomash 76, respectively. Four hybrids out-yielded the best of the three varietal check entries. The grain yields of these four top yielding hybrids in q per ha were 63, 59, 56, and 54 for IS 10360A x YE 65, IS 10360A x Tx430, IS 10360A x YE 294, IS 10360A x Bulk Y-3, respectively. At all locations, other than Melkasa, the advantages of hybrids over varieties was not evident. Such hybrids of YE 96 and YE 121 with IS 10360A which have yielded well in past seasons gave yields essentially the same as the variety checks.

The mean number of days needed for all entries was 73, 73, 64, 62 for Melkasa, Kobo, Mieso and Humera, respectively. The best yielding hybrids were earlier than Gambella 1107 by about a week but had flowered about the same time as Melkamash 79.

Table 2. Grain Yield in Kg/ha, of 21 hybrids and 3 varieties in the 1980 Elite Sorghum Hybrid Yield Trial (ESH-YT) planted at 4 locations.

Entry No.	Identification	Melkasa	Kobo	Mieso	Setit Humera	Mean
201	IS 10360A x YE 96	3778	1316	3111	1760	2491
202	" " x YE 121	3037	948	1804	2476	2066
203	" " x YE 137	4518	1487	2332	2248	2646
204	" " x YE 36	4444	362	1517	1063	1846
205	" " x YE 62	4889	747	1206	873	1929
206	" " x YE 65	6296	815	1908	1212	2558
207	" " x YE 83	4518	714	1917	1579	2182
208	" " x YE 85	4444	1120	1398	1698	2165
209	" " x YE 90	4074	978	776	2503	2083
210	" " x YE 294	5629	913	1816	2012	2592
211	" " x Tx 430	5852	530	1853	1422	2414
212	" " x Bulk Y-3	5407	455	2560	1581	2501
213	IS 10468A x YE 58	4815	948	2252	2481	2624
214	" " x YE 159	5037	1431	2323	1788	2645
215	" " x YE 276	4296	1547	2598	2953	2848
216	" " x YE 294	3556	1227	2300	3028	2528
217	" " x Bulk Y-3	5037	1739	2305	3188	3067
218	Tx 622A x YE 129	4000	1340	1914	2961	2554
219	" " x YE 294	4444	1873	2020	3170	2877
220	" " x YE 435	5037	1227	1547	2729	2635
221	" " x Tx 430	4371	1310	960	3095	2434
222	Gambella 1107	3482	1724	797	1915	1980
223	Melkamash 79	3407	948	1369	2488	2053
224	Kobomash 76	2296	1200	1164	1976	1659
Mean		4444	1156	1823	2174	2400
LSD		1965		996	1009	
C.V.%		27		33	28	
Rainfall (mm)		890	651		608	

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In plant height, the overall mean was 114 cm for all entries and locations. The location mean for Melkasa was 123 cm. Among the highest yielding hybrids, IS 10360A x Bulk Y-3 and IS 10360A x YE 294 with about 145 cm height each were among the tallest. Gambella 1107 with 153 cm was the tallest entry. The mean plant heights for all entries at Kobo and Mieso was only 106 and 112 cm. Shortage of moisture was the main reason for the relatively short plant heights at Kobo and Mieso.

3. High Rainfall Intermediate Altitude Sorghums (HRIAS)

Yield Trial - This year was the first time for organizing a special yield trial for the high rainfall and intermediate altitude sorghum zone. The six stations which returned completed data were Arsi Negelie, Bako, Didessa, Ambo, Jimma, and Birr. Twenty one entries most of which were Southern African Kafirs were included in the trial. Seven of the entries were advanced lines from the ESIP breeding program. The HRIAS trial planted at Alemaya failed completely because of drought.

The data for grain yield for each of the seven reporting stations are given in Table 3. The highest location mean yields were obtained from Bako, Arsi Negelie, and Birr and they were, respectively, in q/ha, 50, 43, and 51.

At Bako, several entries gave yields of 60 q/ha or better. These were in decreasing order of yield, in q/ha, IS 9302 or 80 ESIP 11 (78), IS 9465(68), IS 9294 (66), IS 9415 (65), IS 9439 (65), and IS 9323 (61), IS 9466 (60). Out of these high yielding varieties, considering overall agronomic desirability and disease reaction, the best three varieties for Bako were IS 9302 or 80 ESIP 11, IS 9294, and IS 9323.

Arsi Negelie with the second best location mean yield had seven varieties with mean yield of 50 q/ha or better. Considering overall agronomic desirability along with grain yield, the best entries for Arsi Negelie were IS 9439 (63), IS 9293 (54), IS 9323 (53), and IS 9302 (51).

The grain yields recorded at Birr were also quite good. The best entries, taking overall agronomic desirability into account also, were IS 9302 (60), IS 9323 (56), IS 9294 (53). Considering the grain yields and overall agronomic desirability visual score at the three best yield locations (Arsi Negelie, Bako, Birr) for this trial, the following entries appear most promising: IS 9293, IS 9294, IS 9302 (80 ESIP 11), IS 9323, IS 9379, IS 9415, IS 9439 (Table 3).

For Jimma the best three varieties were IS 9439 (55), IS 9415 (49), and IS 9323 (43). These are also varieties which have done well at the high yield stations. The yields recorded at Didessa and Ambo were very low compared to the other locations.

Table 3. Grain Yield, in kg/ha, of 21 entries in the 1980 high rainfall intermediate altitude Sorghum National Yield Trials planted at 6 locations.

Entry No.	Variety	Arusi	Dako	Dicesa	Ambo	Jimma	Birr	Location mean
1	ALAD 502 x WS 1763	4557	4090	600	1224	1805	4766	2597
2	ALAD 691 x Asfaw white	4444	5020	1030	1125	2338	4000	3002
3	ALAD 502 x LTS 2270	3945	4130	730	1725	3489	3566	2932
4	ALAD 502 x WS 1763	2834	4520	1850	1142	3091	2133	2612
5	ALAD 502 x Asfaw white	4512	1690	1190	1324	3328	--	2429
6	ALAD 691 x LTS 2113	3833	2330	650	1866	3139	1089	2151
7	ALAD 502 x WS 1763	2834	4580	470	941	3051	1100	2161
8	IS 9293	5444	5400	2860	1396	4156	4967	4037
9	IS 9294	4389	6560	3180	1621	3687	5323	4160
10	IS 9302	2222	2820	1940	1876	--	1689	2109
11	IS 9302	5111	7820	1280	2061	3345	5989	4371
12	IS 9323	5278	6090	3470	1335	4308	5628	4351
13	IS 9325	4277	5000	3200	1561	3693	4212	3690
14	IS 9327	5166	5760	2900	1456	4867	4366	4086
15	IS 9335	1833	4530	2330	1248	1550	3622	2602
16	IS 9379	5000	6440	930	2665	3311	5268	3936
17	IS 9415	5166	6530	4120	1907	4859	5433	4669
18	IS 9439	6277	6530	3540	2048	5472	4978	4808
19	IS 9465	4389	6800	2230	2587	3389	4133	3921
20	IS 9466	4889	5980	3240	1936	3694	5178	4153
21	Local Check	3778	2670	2100	1408	2039	5222	3016
	Mean	4312	5027	2130	1677	3481	4143	
	LSD (5%)	1458	1500	590	--	1293	853	
	C.V.	24	22	21	--	23	14	
	Rainfall				1368	1470	877	

* Instead of ALAD 502 x WS 1763, Gambella 1107 was planted at Birr.

It appears that the general trend of varietal performance is that those varieties identified as best for Bako, Birr, and Arsi Negelie seem to be doing relatively better at Ambo and Dedessa.

Compared to the L-NYT varieties this group of varieties was late. Bako and Didessa with 98 and 94 reported the earliest days to flowering. On the other hand, at Ambo the mean number of days to flowering for the HRIAS varieties was 148.

In plant height the HRIAS varieties were generally taller than the L-NYT entries. However, the varieties as a group were substantially shorter than the traditional sorghums grown in these areas. The overall mean plant height was about 180 cm. The varieties indicated as best yielding above for the different locations were generally shorter or same as the overall mean. This height appears satisfactory for the needs of the state farms in these areas.

4. Highland National Yield Trials (HNYT) - The highland sorghum national yield trials of 1980 were planted at five different locations. However, data were received from three of the locations only. Those returning data were Arsi Negelie, Ambo, and the Kokate station of WADU. The trial planted at Alemaya failed completely because of the unprecedented drought in the Alemaya area. All the entries in this trial have yielded well in the past and all of them trace to past Ethiopian sorghum collections as their source.

The only reasonable grain yields obtained in this trial were those of Arsi Negelie only and they are given in Table 4. The location mean for the H-NYT for grain yield was about 39 q/ha compared to 43 q/ha for the HRIAS trial at Arsi Negelie. The best yielders were Alemaya 70 and ETS 4946 with 51 and 47 q/ha, respectively. Both of these varieties have been released for the Arsi Negelie area. Another released variety ETS 2752 gave only 34 q/ha in this trial.

Compared to the L-NYT and the HRIAS the entries in the H-NYT were much earlier and taller. The mean number of days to flowering at Arsi Negelie for this trial was 137 and the mean plant height at the same location was 279 cm.

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Table 4. Grain Yield, in Kg/ha, of 10 sorghum varieties in the 1980 highland National Yield Trials planted at Arsi N.

Entry No.	Identification	Arsi Negelie
1	ETS 2752	3444
2	ETS 3235	3778
3	ETS 4940	3166
4	ETS 4942	4055
5	Alemaya 70	5111
6	ETS 4946	4667
7	ETS 4947	3166
8	ETS 4948	4011
9	Muyra	3556
10	Local Check	3611
Mean		3856.

B. Agronomy.

Several agronomical trials were run by members of the National Sorghum Research Team during the 1980 crop season. Selected trials on plant population, land preparation methods, and planting dates will be reported here.

1. Variety x Population Density Trial - This experiment was run at Melkasa, Kobo, and Mieso using three varieties and one hybrid. Five population levels 50,000 to 150,000 plants per ha with a difference of 25,000 plants per ha between successive levels were planned to be reached. At each site the row spacing was uniformly 75 cm. All cultural and fertilization practices used at each location were the standard ones for each location. The trial at Mieso failed completely because of drought.

Tables 5 & 6 give the effects of varieties and plant population levels on grain yield of sorghum at Melkasa and Kobo. At Melkasa, even though the expected number of plants per ha was from 50,000 to 150,000, as seen in Table 5 for all the varieties it was not possible to attain these population levels. For each of the cultivars used the final population levels attained were all far below the expected. The main reason for not achieving the desired population level was poor stand establishment even though planting was done by hand in excess and seedlings thinned down. For each cultivar, the grain yield data obtained at the different population levels were not significantly different. This is understandable because of the little difference in plant population levels actually attained. The grain yields obtained for Kobomash 76, Gambella 1107, IS 10468A x R-1750, and Melkamash 79 were 37, 42, 43, and 57 q/ha, respectively (Table 5). These yield levels are consistent with the normal expected yields of each cultivar at Melkasa.

The final population level actually achieved and the associated grain yields obtained at Kobo are presented in Table 6. At this location even though the expected population levels were realized there was no consistent trend in grain yield with changing population levels. The main reason for lack of trend was the low rainfall and the resulting drought. In this trial it was also not possible to tell difference between cultivars.

2. Experiments on Land Preparation Methods - In the Kobo area, the most important factor limiting sorghum grain yield is shortage of moisture. In the 1980 crop season, several experiments on different methods of land preparation and water conservation were underway. Data from two such experiments done at Kobo in 1980 are

Table 5. Effects of varieties and plant population on grain yield of sorghum grown at Melkasa, 1980.

Expected no. of plant ha ⁻¹	Grain Yield (kg/ha)				Mean.
	<u>Gambella 1107</u>	<u>Kobomash 76</u>	<u>Melkamash 79</u>	<u>IS 10468A x R-1750</u>	
50,000	4963	2963	4963	3852	4185
75,000	3926	3926	5407	3185	4111
100,000	4296	4148	5111	4222	4444
125,000	3852	3481	5630	5556	4630
150,000	4148	4222	7185	4815	5092
Mean	4237	3748	5659	4326	4492

	Stand Count/ha ('000)				Mean.
	<u>Gambella 1107</u>	<u>Kobomash 76</u>	<u>Melkamash 79</u>	<u>IS 10468A x R-1750</u>	
50,000	44.7	52.7	50.1	51.3	49.7
75,000	61.6	58.4	54.5	67.6	60.7
100,000	62.5	70.5	73.5	71.7	69.6
125,000	64.3	73.2	77.6	85.9	75.3
150,000	61.3	78.0	82.4	78.8	75.1
Mean	58.9	66.6	67.6	71.1	66.0

presented in Tables 7 and 8 where L_1 , L_2 , L_3 , L_4 , and L_5 represent, respectively, planting on the flat, open ridge with planting in the furrow, open ridge with planting in the furrow, and tied ridge with planting on the ridge.

The data in Table 7 are grain yield results for different combinations of plant spacings within the row and land preparation methods. The land preparation methods which gave the best grain yields were tied ridge with planting on the ridge and tied ridge with planting in the furrow where the respective yields obtained were 29 and 26 q/ha. The grain yields obtained with the other land preparation methods were just about 50% of the tied ridge results. The difference in grain yield obtained with the different spacing used were not significant.

Table 8 gives the grain yield results for different combinations of planting date and land preparation. It can be observed in Table 8 that later plantings resulted in progressively lower yields where mid-June planting on the average gave 19 q/ha and mid-July plantings gave about 9 q/ha yield across all land preparation methods. For the land preparation methods, the trend observed in Table 7 was also repeated here where the two tied ridges treatments gave again the highest yields. Tied ridges with planting in the furrow gave 21 q/ha and tied ridges with planting on the ridge gave 20 q/ha. The mean yields from the other three land preparation methods were again about 50% of the yield of the tied ridges.

The superiority of tied ridges were also confirmed at other substations in the Kobo area. In general, when moisture is so limiting as in the Kobo area and when the infiltration rate of water into the soil is very low as in the Kobo area, tied ridges can increase sorghum grain yield significantly.

C. Soil Fertility.

Nitrogen and phosphorus are known to be deficient in most Ethiopian soils. In the 1980 crop season a number of NP trials on sorghum were underway in different stations representing the major sorghum ecological zones of the country - highland (Alemaya), high rainfall and low altitude (Kobo, Mieso, Nazareth). In general, since the trials in the highland and lowland stations either failed completely because of drought or gave too low and erratic grain yields it was not possible to draw any general conclusions about fertilizer response on these trials. The trial at Kobo showed that there was no significant response to the fertilizer treatments except that there was general trend of yield increase from about 16 to 33 q/ha as the level of N increased.

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Table 6. Effects of varieties and plant population on grain yield of sorghum planted at Kobo, 1980.

<u>Expected no. of plant ha⁻¹</u>	<u>Grain Yield (kg/ha)</u>				<u>Mean.</u>
	<u>Gambella 1107</u>	<u>Kobomash 76</u>	<u>Melkamash 79</u>	<u>IS 10468 A x R-1750</u>	
50,000	2841	2055	1085	1510	1873
75,000	2744	2518	1349	564	1794
100,000	2899	2354	2148	1504	2226
125,000	2681	3095	1198	1832	2202
150,000	3377	1968	1588	2351	2321
Mean	2908	2398	1474	1552	2083

	<u>Stand Count/ha ('000).</u>				<u>Mean</u>
	<u>Gambella 1107</u>	<u>Kobomash 76</u>	<u>Melkamash 79</u>	<u>IS 10468A x R-1750</u>	
50,000	50.7	53.9	53.9	52.7	52.8
75,000	80.0	79.1	80.3	79.1	79.6
100,000	82.7	105.5	104.3	101.6	98.5
125,000	118.2	123.8	100.7	115.3	114.5
150,000	145.3	149.6	141.3	138.7	143.7
Mean	95.4	102.4	96.1	97.5	97.8

Table 7. Effects of land preparation methods and spacing on grain yield of sorghum, Kobo, 1980.

(Grain Yield (Kg/ha)).						
	<u>L₁</u>	<u>L₂</u>	<u>L₃</u>	<u>L₄</u>	<u>L₅</u>	<u>Mean</u>
10 cm	1781	757	1197	2853	2905	1899
15 cm	1426	777	1552	2669	3083	1901
20 cm	1011	1566	1190	2463	3163	1879
25 cm	1011	1197	615	2557	2520	1580
30 cm	1339	1433	1279	2309	2869	1846
Mean	1314	1147	1167	2571	2909	1821

Table 8. Effects of planting date and land preparation methods on grain yield of sorghum, Kobo, 1980.

	<u>June 18</u>	<u>July 3</u>	<u>July 18</u>	<u>Mean.</u>
L ₁	695	1397	224	771
L ₂	1616	867	760	1081
L ₃	2057	819	875	1251
L ₄	2809	2181	1447	2145
L ₅	2480	2353	1189	2007
Mean	1931	1523	899	1451

Grain yield results of the NP trials conducted at the high rainfall and intermediate altitude stations are presented in Tables 9-13. In all of these trials, the variety used was either Didessa 1057 or IS 9521. The N and P_2O_5 levels were each 0, 50, 75, and 100 with all possible factorial combinations of the NP levels used in the experiment at the four sites (Bako, Didessa, Wamma, and Anger).

Table 9 gives the grain yields of the NP trial at Bako for the variety IS 9521. Relatively good yields were obtained at Bako with an overall trial mean of about 58 q/ha. However, the response to both N and P or their combinations were not significant.

Results from Wamma for the same trial with the variety Didessa 1057 are presented in Table 10. The overall trial mean here was about 46 q/ha. Some indication of response to nitrogen at lower rates could be seen in the results. On the other hand, there was no response to P at any level at Wamma.

Table 11 and 12 give the results of grain yield for the same NP trials at Didessa for the varieties Didessa 1057 and IS 9521. At Didessa, the overall trial mean for Didessa 1057 was only about 28 q/ha and that for IS 9521 was 29 q/ha. These yields are very low compared to past results from this station for these varieties. The main reasons for the low yields were reported to be the severe hail storm and the associated lodging. There was no trend of response to N and P either with Didessa 1057 or IS 9521.

The grain yield results from Anger for the same NP trial with the variety Didessa 1057 are presented in Table 13. The overall mean grain yield for this trial at Anger was about 66 q/ha which was quite good. Again the lack of response both to N and P has repeated at Anger also.

D. Crop Protection.

Even though the Sorghum Research Team has members representing the three major areas of crop protection (entomology, pathology and weed science) the data obtained in 1980 in the area of sorghum crop protection research were not very many.

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Table 9. Sorghum NP rate trial, Bako, grain yield in q/ha, 1980 (Variety.. IS 9521).

N. level kg/ha	P ₂ O ₅ kg/ha				Mean N.
	0	50	75	100	
0	57.4	61.9	62.2	50.0	57.9
50	60.0	62.9	59.3	59.7	60.5
75	46.7	57.7	62.3	62.3	57.2
100	57.0	58.0	58.4	61.1	58.6
Mean P	55.3	60.1	60.5	58.3	

Table 10. Effect of NP fertilizer on sorghum, Wamma, grain yield in q/ha, 1980 (Variety - Didessa 1057).

N. level kg/ha	P ₂ O ₅ kg/ha				Mean N.
	0	50	75	100	
0	32.2	29.3	37.7	31.6	32.7
50	38.2	50.4	48.2	45.7	45.6
75	54.1	49.4	49.2	54.4	51.8
100	50.0	53.4	52.7	52.4	52.1
Mean P	43.6	45.6	46.9	46.0	

Table 11. Sorghum NP rate trial, grain yield in q/ha, Didessa 1980 (Variety - Didessa 1057).

N. level kg/ha	P ₂ O ₅ kg/ha				Mean N.
	0	50	75	100	
0	22.0	25.1	31.2	29.4	26.9
50	21.8	30.3	31.2	34.8	29.5
75	31.2	26.4	28.7	30.3	28.9
100	24.6	31.1	31.5	25.7	28.2
Mean P	24.6	28.2	30.6	30.1	

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Table 12. Sorghum NP rate trial, Didessa, 1980, grain yield in q/ha (Variety - IS 9521).

N. level kg/ha	P ₂ O ₅ kg/ha				Mean N.
	0	50	75	100	
0	26.0	30.3	29.2	26.0	27.9
50	27.8	31.5	33.3	34.7	31.8
75	24.0	28.6	31.4	30.2	28.6
100	28.0	30.6	30.1	27.5	29.1
Mean	26.5	30.3	31.0	29.6	

Table 13. Effect of NP fertilizer on sorghum grain yield in q/ha, Anger, 1980 (Variety Didessa 1057).

N. level kg/ha	P ₂ O ₅ kg/ha				Mean N.
	0	50	75	100	
0	65.3	58.2	63.2	62.6	62.3
50	60.3	63.7	58.8	66.8	62.4
75	75.8	73.2	75.7	63.8	72.1
100	67.5	64.0	69.5	64.5	66.4
Mean	67.2	64.8	66.8	64.4	

The only 1980 crop protection experiment on which data worth reporting have been received was on variety screening of sorghum against loose and covered smut. Out of 52 varieties screened for loose and covered smut at Bako, the following seven were found to be completely resistant to loose and covered smut: ETS 4948, 80 ESIP 1, 80 ESIP 2, 80 ESIP 6, 80 ESIP 7, 80 ESIP 15, and 80 ESIP 17.

Summary.

In the 1980 crop season, in the area of breeding, about 3000 lines, populations, and hybrids were tested in preliminary yield trials and observations. The most promising entries of these were selected and advanced for further testing. In the lowland national yield trials the best yield locations were the Ogolcho station of ARDU and Melkasa. The best yielding varieties were 80K6034, Melkamash 79, and 80K5095. In the elite hybrids yield trial for the lowlands, the best four hybrids has IS 10360A as female parent and the pollinators of these hybrids were YE 65, Tx 430, YE 294, and Bulk Y-3. In the high rainfall and intermediate altitude trial, the most promising and highest yielding varieties were IS 9302, IS 9323, IS 9415, and IS 9439. The highland national yield trial at Alemaya failed because of drought and the highest yielders in the same trial at Arsi Negelie were Alemaya 70 and ETS 4946.

In the agronomic trials, compared to planting on the flat and open ridges, tied ridges increased grain yield significantly.

The soil fertility trials showed that there was essentially no response to nitrogen and phosphorus fertilization in Bako, Didessa, Wamma, and Anger.

The smut screening nursery identified ETS 4948, three advanced lines from the breeding nursery and two SA kafir introductions from ICRISAT as completely resistant to loose and covered smut.

Participation in OAU JP 31 SAFGRAD Organized Sorghum Trials.

As agreed in the OAU/STRC JP 31 First Workshop on Sorghum and Millet, Mombassa, Kenya, 26 February to March 1980, Ethiopia contributed four entries, 5 kg seed for each, to the OAU/STRC JP 31 SAFGRAD organized 1980 regional yield trials of sorghum. The seeds were sent to the International Coordinator of SAFGRAD at Ouagadougou on March 15, 1980. For the Early Sorghums SAFGRAD Regional Trial the entries contributed by Ethiopia were 76 T1-21 and Kobomash 76 and for the Late Sorghums SAFGRAD Regional Trial the entries contributed were Melkamash 79 and Gambella 1107.

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In the Mombassa workshop, Ethiopia had also agreed to receive two sets of the SAFGRAD early sorghums trial and one of the SAFGRAD late sorghums trial for 1980 planting and evaluation in Ethiopia. However, since the seeds were received from the SAFGRAD office in late-July it was too late for our normal mid-June plantings and therefore the seeds are still being held for possible 1981 planting in Ethiopia.

BREEDING FOR DISEASE RESISTANCE IN SORGHUM

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I. INTRODUCTION.

One of the yield reducing factors in sorghum is diseases affecting roots, leaves and inflorescence. In Africa yield losses due to diseases are difficult to estimate. Presently the sorghum growing areas are typified by subsistence level of farming and low production. However, in future as a more intensive method of farming is used, the disease problems will likely increase unless high levels of resistance are bred into the varieties. This may be true for leaf diseases which are intensified by monocropping and high population densities. Efforts to breed short duration varieties matching the short rainy season may lead to problems of grain molds due to late rains after grain formation, and charcoal rot due to low soil moisture accompanied by high temperatures during seed development.

2. Some common diseases of sorghum in Africa.

There is a range of fungi and virus that cause damage to the sorghum plants in Africa. An attempt will be made to refer to some common diseases in sorghum and their causal organisms, favorable environment for infection and symptoms.

2.1. Stalk rots.

2.1.1. Charcoal rot. It is caused by Macrophomina phaseoli (Manubl.) Ashy. It is widely distributed throughout the warmer areas of the world. The fungus enters through the roots and then the crown and stalk. The rot is caused by the destruction of the middle lamella of pith cells. In the final stages the pith cells dry and sclereotia are formed on the vascular tissue and subsequently the stalk lodges. The stalk rot is completely dependent on stress conditions such as low soil moisture accompanied by high temperatures during seed development.

2.1.2. Red rot. It is caused by Collectotrichum graminicola (ces.) G.W. Wilson. This fungus is more commonly associated with the leaf anthracnose. Hot and humid conditions are favorable for infection.

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Initial infection is noticed at or near the nodes. Infection eventually encircles the entire stalk. The extent of damage depends on time of initial infection; if infection is early in the growth stage, the damage is more. This results in stalk lodging, reduced weight per grain and grain yield.

2.2. Leaf diseases.

2.2.1. Downy mildew, Several downy mildew fungi are reported but the most important is Sclerospora sorghi Weston and Uppal. It is confined to tropical and sub-tropical Africa and Asia and its occurrence has been noted in Texas.

The source of primary infection is soil-borne oospores which germinate and invade roots of seedlings. Plants become chlorotic as a result of systemic infection. A white "downy" growth consisting of conidia and conidiophores of S. Sorghi appears generally on the lower surface of infected leaves. Oospores remain viable in the soil for several years. Seed-borne transmission of this disease is also reported. In central Nigeria heavy infection pressure of downy mildew is reported.

2.2.2. Anthracnose. The leaf anthracnose is caused by the same fungus Collectotricum graminicola (Ces.) G.W. Wilson that causes red rot of stalks.

This diseases is generally found where warm, wet climatic conditions prevail.

In early stages the symptoms are characterized by the formation of small circular or elliptical well-defined lesions. These may vary in color from tan, orange, or red to blackish purple depending on host variety. Under very humid conditions pink masses of spores occur and can be splashed to adjacent leaves for further infection. The pathogen remains dormant in dead host tissues and this can be a source of inoculum for infection in the next year's crop.s

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2.2.3. Helminthosporium leaf blight. The most common causal organism of leaf blight is Helminthosporium turcicum Pass. The disease development is favored by mild humid weather. Epiphytotics generally occur later in plant development.

Leaf lesions elongate and generally do not exceed 2 to 3 cm in width; but may elongate up to 10 cm or more. Lesions generally have pigmented margins with tan colored centers which become dark grey or olive in color due to the presence of conidia.

2.2.4. Sooty stripe. It is caused by the fungus Ramulispora sorghi (Ellis and Everhart) Olive and Lefebvre. The disease is found wherever sorghum is grown but is most severe in areas of high humidity.

The symptoms start with water-soaked spots which become colored by plant pigments. The spots rapidly elongate several centimeters into lesions. The disease can be easily distinguished from leaf blight by its characteristic sooty appearance of sclerotia on the lower surface of leaves.

2.2.5. Leaf rust. It is caused by Puccinia purpurea Cooke. The disease is generally noticeable at a later stage of crop growth particularly on lower leaves.

2.2.6. Gray leaf spot. The causal organism is the fungus Cercospora sorghi Ell. Everh. The disease develops well in warm and wet climates.

The symptoms are narrow lesions restricted by veins. The spores on the lesions give a greyish velvety appearance. Infections may extend to leaf sheaths and upper part of stems.

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2.2.7. Zonate leaf spot. It occurs in all major sorghum growing areas. The causal organism is Gleocercospora sorghi. Lesions are formed in zonate pattern of pigmented and non-pigmented bands. The fungus is seed borne.

2.3. Inflorescence diseases.

2.3.1. Covered smut (kernel smut). It is caused by the fungus Spacelotheca sorghi (Link) Clint. Fungicidal seed treatment gives excellent control.

Each infected floret develops into a sorus. Infection may involve all or a few spikelets. Considerable amount of physiological specialization has been demonstrated in S. sorghi.

2.3.2. Loose smut. The disease is caused by Spacelotheca cruenta (Kunh) Potter. Pathologists suspect that physiologic races exist in this species. Loose smut is seed-borne and can be controlled by fungicidal seed treatment.

2.3.3. Head smut. Head smut is caused by Spacelotheca reiliana (Kunh) Clint. Usually the entire panicle of infected plants becomes incorporated into a single sorus. The sorus is characterized by a thick, whitish peridium which begins to rupture during exertion, exposing numerous teliospores. Dark filament representing remnants of vascular tissues remain after teliospores have been shed. Physiological races exist in the pathogen. Fungicidal seed treatment can not control head smut.

2.3.4. Long smut. It is caused by Tolyposporium ehrenbergii (Kunh) Pot. Infected individual spikelets are transferred into elongated, whitish yellow sori. In West Africa, long smut is seen in the drier areas of sorghum production. The occurrence of scattered smut infection in a panicle suggests that the disease is caused by air-borne spores. There are indications that the pathogen may be seed or soil borne.

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2.3.5. - Ergot, also known as "sugary disease", is caused by Sphacelia sorghi. Usually the disease is a problem in cool moist weather in high-lands and during the post-rainy season of plains.

The symptom of the disease appears as turbid drops of honeydew dropping from infected spikelets. In the affected spikelets the grains are replaced by soft masses of mycelium. In severe infection conditions yield reductions may be quite significant.

2.3.6. - Grain mold. Grain molds are caused by a complex of parasitic and saprophytic fungi. The fungi commonly associated with grain mold are Alternaria, Curvularia, Fusarium, Cladosporium, Penicillium, Oidium, Nigrospora and Phoma.

One of the objectives in present-day sorghum breeding programs is to develop early maturing varieties which can complete the life cycle before the cessation of rain to avoid drought late in the season and minimize the risk of yield reduction. Under this situation occasional rains after the grain formation may lead to grain mold and consequent poor acceptance by consumers and in extreme cases seriously lowered grain quality.

3. - Need and availability of resistant varieties

Some diseases can be suitably controlled through the application of chemicals. However, there are limitations of cost and residual toxicity for use of fungicide and chemicals. Control of covered smut and loose smut is possible through seed dressing. Cost may be minimum and the fear of residual toxicity will be less. For many other diseases the assured way of control will be through the use of resistant varieties.

Coleman and Stocks (1954) found that resistance to red rot (stalk rot) caused by Collectotrichum graminicola is available. Resistance in sorghum to drought stress shows some promise of control (Malm and HSi 1965).

Resistance to downy mildew is the most practical method of control although removing crop residues before planting and crop rotations have some good effect. The best sources of resistance were found to exist in the Cafororum race (Sundaram et al. 1966, Nagarajan et al., 1970, Futrell and Webster, 1966).

Some control of leaf anthracnose has been obtained through the use of resistant varieties. Harris and Johnson (1967) have identified several sorghum lines including Wiley, MN960, Dwarf Lahose, Dobbs, Mugabash, Framinola, PI16447, and PI267340 which had good resistance to leaf anthracnose.

Leukel et al. (1951) reported finding most resistance to leaf blight in kafirs and kafir crosses. Inheritance of resistance appears to be governed by several genes (Drolsom 1954).

Resistant varieties are the only assured method of controlling sooty stripe. Futrell and Webster (1966) screened over 2700 entries of a sorghum collection under natural epiphytotic conditions in Nigeria and found that about 5 % of these are resistant. The highest proportion of resistant types were found in West African cultivars.

Coleman and Dea, (1971) have identified resistant selections against rust within milos, shallus and sorgos. Soumini (1949) reported that selections within Cafororum, Nigricans and caudatum showed excellent resistance in southern India.

Luttrel (1950) reported that the variety Martin showed good resistance against gray leaf spot and kafirs as a rule were most susceptible.

4. - Development of resistant varieties

Two steps are involved to develop a disease resistant variety : (a) finding a source of resistance and (b) combining resistance with other desirable crop characteristics.

For insects, Painter (1951,1958) listed three categories of resistance (1) preference or non-preference (2) antibiosis and (3) tolerance. These correspond roughly to the categories describing resistance to fungus, bacterial and viral diseases : (1) exclusion or avoidance of the causal organism (2) high resistance and (3) intermediate resistance or tolerance. Generally, we are concerned with the last two categories.

4.1. - Identification of source of resistance

Sources of resistance may be difficult to identify in natural infection conditions because of possibility of escapes and lack of uniform and high pressure of the disease. However "hot spots" can be identified for each disease where disease pressure is high from year to year and is uniform in that location. For instance, Cinzana in Mali is considered a "hot spot" for sooty stripe, Samaru

in Nigeria for downy mildw. Shallow soils in Kamboinsé (Upper-Volta) gave consistently high infection of charcoal rot. Artificial epidemics can be established in the field by interplanting susceptible checks.

Multi-locational testing is vital for screening for disease resistance as it is unlikely that all diseases or all races of a disease will occur in the same location. Through this process of exposure of resistant sources to many and varied populations of pathogens under a wide range of environmental conditions, it is possible to identify stable and durable resistance.

Following efficient screening techniques in field and laboratory and multilocal testing, ICRISAT has made rapid progress in identifying resistance to grain mold and charcoal rot (Sorghum Pathology Progress report June 1978 - May 1979).

Although high resistance to grain mold is unavailable till now, 8 lines have been identified as less susceptible. They are IS14332, IS9225, E35-1, IS2327, IS2328, JP2579, M36284 and M36285. The two M lines are derivatives from SC 108-3 and E35-1. In 1980 crop season three of these entries viz., IS9225, IS2327 and E35-1, have shown very little susceptibility to grain mold at Farako-Bâ (Upper Volta). In the same location, the low susceptibility of the lines M6065, M6125 and IS8272 since 1977, is note-worthy.

Promising lines tolerant to charcoal rot have been identified. These are (SC108-4-8xCS3541)-64, (SC108-3xCS3541)-30, CS3541, 20-87, 1-30, (SC108-4-8xCS3541)-11, 8-55, IS121 and CS120-14. Based on the observations at Samé (Mali) and Kamboinsé (Upper Volta) in 1980 several promising lines offering resistance were identified. They are A12747, BJ112, E35-1 and IS3443. These results need further confirmation.

The first multilocal ergot trial was organised in 1980 and the results are awaited.

Based on the results of 1979 and 1980 sooty stripe trials at Cinzana, several lines appear promising. These are, E35-1, SPV9, IS4150, IS7322 and IS4150.

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4.2. - Combining resistance with other desirable plant characteristics

If the resistant variety identified through the procedures described in section 4.1. has all desirable agronomic characters, the variety in question can be considered directly for cultivation by farmers. However, frequently this is not the case i.e., the resistant source materials do not possess the desirable agronomic characters. Under the situation, a breeding program is called for to transfer the resistant genes from the source line to an otherwise agronomically desirable variety. The success of such a breeding program depends on a) mode of inheritance of the resistant trait b) the ease of identifying the trait being selected for and c) the intensity of selection pressure that can be applied.

The mode of inheritance of some diseases are available in the literature. For example, three races are known to occur in Kernel smut (Sphacelotheca sorghi) and resistance to each race is controlled by an incomplete dominant allele -S1s&, S2s&, S3s&. For head smut (Sphacelotheca reiliana) resistance is dominant and susceptibility is recessive. For anthracnose (Collectotricum graminicola) leaf disease susceptibility is controlled by a simple recessive gene (l). Susceptibility to stalk rot (red rot) phase of this organism is controlled by this simple recessive allele (ls). For rust (Puccinia purpurea) susceptibility is controlled by a simple recessive gene (pu). For leaf blight (Heminthosporium turcicum) most grain sorghums are resistant. Susceptibility in sudangrass is inherited as a simple dominant.

4.2.1. - Mode of inheritance and breeding procedure

The mode of inheritance refers as to how the character is inherited - single gene, two genes, or a few genes with minor effects. In the latter case progress in selection would depend on the proportion of genetic variation that is due to additive gene action.

If the resistant trait is controlled by a single gene the backcross method of breeding is most appropriate. An agronomically desirable variety will be the recurrent parent and a resistant source variety will be the non-recurrent parent. A resistant variety can be bred through this breeding procedure without changing the genetic structure of the agronomically desirable variety.

The availability of simply inherited factors for resistance is convenient for breeding purposes ; however, as in the case of wheat rust, the resistance may break down with a new race of this disease. Horizontal resistance is controlled by many genes and complete resistance may not be expressed but it generally remains stable over period of time than does the highly specific relationship as expressed by the wheat-rust situation. From a crop production point of view, horizontal resistance is valuable.

When many genes control the resistance trait and it is quantitative in nature, a population breeding program involving recurrent selection is desirable. Recurrent selection involves an evaluation and recombination phase. The evaluation in yield trials and in separate screening nurseries for one or more of the disease problem of concern. Only the best selections from each evaluation test are included in the recombination phase.

4.2.2. The case of identifying the trait being selected for.

The expression of a character may be influenced by both the genetic background and by the environment. A major gene for resistance may express itself well in variety A and poorly in variety B. That is, variety B may carry one or more modifying factors reducing the resistance effects of the gene in the B compared to the A background. Choice of parents in a backcrossing program is very important as expression of the trait in question might vary according to the genetic background.

4.2.3. Intensity of selection.

Any method that could develop severe epiphytotics will be very useful in a selection program for disease resistance. In the early generations of the program lower intensity of selection pressure is desirable as compared to the advanced generation where high selection pressure can be given with useful result.

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If the epiphytotic is too severe all plants may be affected and the selection differential is lost.

5. Summary and Conclusions.

Several diseases occur in the sorghum growing areas in Africa.

Any one or more of the diseases can become serious as new high yielding cultivars are recommended for farmers' cultivation and intensive cropping practices are followed. While some diseases can be controlled by seed-dressing with fungicides, which may be less expensive and less risky so far as residual toxicity is concerned, breeding resistant varieties will be effective in the control of other diseases.

Resistance sources for several diseases are known but further efforts should be made to identify diverse sources of resistance. Screening efforts to identify resistance sources for other diseases are needed.

Field screening techniques for some diseases are known and for others it needs to be worked out. Laboratory verification of resistance is useful. Multi-locational testing of resistant lines offers an opportunity for identifying stable and durable resistance.

The rate of progress to introduce resistance trait to an agronomically desirable variety depends on the mode of inheritance, ease of identifying the trait being selected for, and intensity of selection. Horizontal resistance is desirable to avoid risks involved in the break-down of vertical resistance.

Much work remains to be done in the development of high yielding varieties of sorghum having stable and durable resistance. While work has started for systematic screening of world germplasm for resistance sources at ICRISAT and other institutes, concerted efforts are needed between breeders and pathologists to combine resistance traits with agronomically desirable varieties.

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RESEARCH FOR RESISTANCE TO THE MAIN MILLET DISEASES.

By

J.A. FROW & P. SEREME.

Introduction.

Ever since ICRISAT got established in Upper Volta, research in plant pathology has essentially dealt with the identification of sources of varietal resistance to the main sorghum and millet diseases on the one hand, and the distribution of these sources to breeders on the other. ICRISAT chose varietal resistance as a means of control because of the high cost of fungicides usable by farmers and the non-compliance on the part of farmers with recommended cultural practices. In spite of the fact that some rare fungicides for seed processing are subsidized and that these could be profitable in economic terms for farmers, the problem of large-scale distribution of these products always comes up.

Genetic control has a double advantage : it is less onerous and more practical for users.

Because of the serious damage that they do to millets in West Africa, three principal diseases have been the object of research by ICRISAT/Upper Volta. These are :

- Mildew which attacks the vegetal and floral parts of the plant ;
- Smut and Ergot which are ear diseases.

I MILDEW (causal agent = Sclerospora graminicola).

A) Research objectives.

This is the most serious of cereal crop diseases in West Africa with a frequent rate of attack of 50%.

In its research efforts for resistance to this disease, ICRISAT in the first instance introduced several millet lines into Upper Volta. In their original zones, these are resistant to the disease, but under the new environment, they rapidly proved sensitive an example of this is the NHB-3 under extension in India. Since the direct transfer of these varieties proved a failure, it was felt that new sources of resistance should be found in West Africa. Similar research made previously by other research organizations in Senegal and Nigeria had identified less sensitive varieties in these countries. However, the level of attack on the improved local varieties in these countries remained high (an example is the Souma-3 in Senegal on which an attack rate of 15% was recorded). These observations which are related to the existence of several fungi populations call for stable and durable resistance to this disease in the sub-region. We give special emphasis to the identification of millet varieties having horizontal resistance to the disease.

To achieve this objective, several plots were infested and maintained at different localities. The biggest of these plots is in Ouagadougou. The others are in Ouahigouya (Northern Upper Volta), Baramandougou, Cinzana, Bamako and Koporokenié-Pe in Mali.

The infested plots are old millet fields with a high percentage of mildew attack. Leftover straw is ploughed into the land the next year. Highly sensitive varieties are planted between the rows of varieties to be tested. Disease evaluation is carried out during the physiological maturity of millet grains.

B) Results.

1. Identification of sources of resistance.

Four lines of the Ex-Bornu type from Northern Nigeria were retained as mildew resistant after five consecutive years of trial at Kamboinse (Ouagadougou). The infection rates of these varieties are given in Table 1 below.

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Table 1 : Infection rates of 4 millet varieties over five consecutive years of trials.

Varieties	1976	1977	1978	1979	1980
P-7	5	11	5	7	0
700251	5	8	3	5	1
700516	2	4	2	6	1
700651	2	2	2	3	1

Similar results have been obtained with these very varieties in Kano (Nigeria) and Bamako (Mali). In spite of the fact that these four varieties have already been identified, research still continues on other sources of resistance.

On the germplasm collections, the following lines performed quite well : cmm 73 and CMM 210 form the Kolokani area in Mali as well lines form a germplasm collection form Northern Togo. It was possible to obtain mildew resistance from materials of various origins after two cycles of breeding. These are : a local variety from the neighbourhood of Kamboinse (Parentaga Foulogo) ; four varieties bred by IRAT (P-1, P-4, P-15, P-16) of which three originate form Niger ; D-316 collections (Agadez region in Niger), D-332 and D-1163 (North Eastern Upper Volta), and some varieties from certain isolated localities like Dourou in Mali.

2. Study of mildew resistance heredity.

12 millet lines among which were P-7 and 700251 with a range of sensitivity other than mildew were reciprocally crossed using all the possible combinations among them. It appears from results obtained that P-7 and 700251 evidently contribute to the reduction of the rate of the disease even among the most sensitive varieties such as 7042 of Chadian origin. Some interesting results of this trial are given in Table 2.

Table 2. Mean infection rates (%) of crossings using P-7 and 700251 as parents (male + female) and infection rates of the same lines as check.

Variety	Used as Parent	Check (uncrossed parent).
P-7	8	0
7636-P-4	1	20
700251	7	0

These results indicate that there is the possibility of using P-7 and 700251 lines as source of resistance in crossings with non-mildew resistant varieties that are of agronomic interest. The probability of hybrids from these crossings being resistant to the disease is quite high in as much as these two lines have dominant genes.

In this regard, promising results have already been obtained with ICH 165 and ICMS 7818 incorporating P-7 and 7818 elements.

3. Need for integrated control.

The use of varietal resistance as the sole means of control entails a number of problems, especially that of probable appearance of other parasite stocks. It therefore becomes necessary to strengthen the sensitivity reduced through the use of fungicides while taking into account the financial means of farmers.

The use of certain products such as "Ridomil" (Metaxyl) to treat seed could be envisaged if convincing results were obtained considering the relatively lower cost price of these products. In recent years, Ridomil has given contradictory results and in this connection, it is envisaged to make ALIETTE (Aluminium Ethyl Phosphite) trials on the processing of millet seed.

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II ERGOT (causal agent : Claviceps fusiformis).

The Ergot problem is two-fold :

- 1) Consumer toxicity when parasite sclerotia mixed with good grains are consumed.
- 2) Increased development of the disease brought about by the need to shorten millet varietal cycle through the introduction of foreign material because of the drought in recent years. In actual fact, these varieties flower at a time when rains are frequent, thus exposing them to high populations of parasite conidium.

Ergot varietal resistance research has not made it possible to identify absolute resistance sources to this disease. It has however been possible to obtain some promising results (progressive reduction of sensitivity) in recent years through cumulated breeding. Screening is done under artificial inoculation conditions. The method used is the following : Cover emerging ears, temporary removal of cover at 75% stigma emergence, ear pulverization by freshly prepared conidium suspension followed by immediate bagging of ears. Upon ear maturity, parasite sclerote development is observed. Ears are selected individually, with sclerote grain transformation not exceeding 5%.

In 1980, Malian, Senegalese and Nigerian millet collections as well as F3... from crossings including sources less sensitive to ergot (eg Serere composite 1 and 2 and J 2238) were carefully tested. The best lines are given in the following table.

Identification.	Attack rate	State of breeding
700490 x 3/4 HK 31-1-1-13-6	1.4	EF-E
700708-1 x 3/4 EB 165-2-2-2-2	2.0	
SC1 x 700158-5	2.0	EF-3
SC2 x 700158-2	2.1	
700741 x 3/4 Seno 217-2-3-2-8	2.2	EF-4
700490 x 3/4 HK 31-1-1-13-5	2.3	
Germplasm P-449-3 from Mali.	2.9	

EF-3 = 3rd generation

EF-4 = 4th generation.

The existence of several lines of some individual plants bearing relatively sound ears in spite of a high mean of the rate of sclerotium in such lines (>5%) is probably indicative of the recessive nature of genetic resistance to ergot. Several observations indicate that to obtain material that is quite resistant to ergot, it is necessary to make a certain minimum of several generations of breeding (F4 in India).

III SMUT.

This disease is particularly considerable in the northernmost areas of the millet belt where rain cessations are very frequent during the flowering period repeated drought during the flowering period is an important factor for fungi development (Tolyposporium penicillaria). It is therefore necessary to identify for this zone sources that are genetically resistant to the disease with a view to incorporating them into new materials (hybrid and improved varieties) that do not have appropriate gene resistance. But then this identification entails a number of problems. Indeed, the few varieties identified as smut-resistant have unacceptable sensitivity to mildew and ergot. Studies are continuing to find millet varieties adapted to this zone and having an acceptable resistance to smut and the other diseases.

CONCLUSION.

Out of the three diseases discussed above and which are being studied by the Plant Pathology Millet Department of ICRISAT in Upper Volta, the results of mildew research are quite satisfactory. This satisfaction is further enhanced considering that the disease is the most serious in Upper Volta and throughout almost all of the millet belt. It is to be noted that a special effort has been made for ergot studies despite the second place importance of the disease compared with smut which causes most of millet damage in Upper Volta after mildew. The importance given to ergot studies is related to one of ICRISAT's objectives, namely, the creation of short-cycle drought adapted varieties. To achieve this objective, it was only logical to seek to minimize the impact of ergot which does considerable damage to short cycle millet varieties meant to replace the long cycle ones in the combat against drought.

CONCLUSION

Out of the three diseases discussed above and which are being
studied by the Plant Pathology Division, the most serious is the
one which is caused by the fungus *Ascochyta blight*. This
disease is further characterized by the fact that it is the
most serious in Upper Volta and throughout almost all of the Sahel.
It is to be noted that a specific agent has been isolated for this disease
and the second phase of the disease is characterized by a
which causes most of the blight damage in Upper Volta and in the
the importance given to the study of this disease is evident in one of the
objectives, namely, the creation of short-cycle drought resistant
varieties. To achieve this objective, it was only logical to seek to
minimize the impact of ergot which does considerable damage to short
cycle millet varieties meant to replace the long cycle ones in the
combat against drought.

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MILLET IMPROVEMENT AND PRODUCTION IN NIGERIA

By

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Introduction.

Pearl millet is an important food crop for the Savanna areas of Nigeria. It is second to sorghum in importance in the Sudan Savanna areas but supersedes sorghum in the Sahel because of the ability to withstand drought. Millet is normally the first grain crop grown by the farmers in most of the Savannas. This early planting coupled with early maturing-ability ensures provision of grain for consumption when all grain reserves are exhausted.

There are three types of millet grown in Nigeria; these are "Gero, Maiwa" and "Dauro". The gero millet is by far the most widely grown, accounting for about 94% of the total cultivated area. Gero millet is photoinensitive and is grown mainly in the northern fringes of Northern Guinea Savanna, the Sudan Savanna and Sahel Savanna. Gero millet is sown with the first few rains, and grows to 2.8 meters tall and matures between 80-90 days. Maiwa accounts for about 3% of the total area devoted to millet. Its cultivation is restricted to the wetter areas of the Savanna ecological zones. Unlike the gero, it is photosensitive. It is sown about the same time as sorghum after the rains have established. It grows to about 3 meters tall and attains maturity between 125-150 days. Dauro is similar to gero in morphological characteristics except that it is first sown in nursery beds before transplanting to the field.

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PRODUCTION MANAGEMENT.

A large proportion of millet grown in Nigeria is grown mixed with crop like sorghum, cowpea and cotton. Production management would depend on the number and types of crops with which millet is mixed. Generally, regardless of the combination, millet is normally sown first with the first few rains of the season. Plant population, row spacing and fertilization would depend on the crops to be sown with the millet. For example, in a millet/sorghum mixture, optimum row width is 75 cm whereas in a millet/cowpea mixture optimum row width is 60 cm. Crops in the mixture could be arranged in such a way that a row of millet alternates with a row of sorghum or both millet and sorghum could be on the same row but staggered.

Only about 30 percent of millet grown in Nigeria is grown sole. Most of this 30 percent is in the Sudan and Sahel zones. The predominance of sole crop millet in these areas is due to the scanty rainfall which is probably not able to support other crops.

Whether grown mixed or sole, the ultimate aim of any production practice is to achieve maximum yield. In millet production the choice of site, source of seeds, plant population, fertilization and the control of weeds, pests and diseases are very important.

Millet does best when it is grown on well drained light loamy soil. It does poorly under water-logged conditions. Clean viable seeds are very necessary for good germination, and a source of clean viable seeds is the Seed Foundation Unit of the Nigerian Federal Department of Agriculture.

Probably the most important requirements for optimum yield in millet are optimum plant population and sowing date. Grain yield has been found to increase up to the level of 60,000 plants in Samaru whereas in Kano the optimum is about 40,000 plants per hectare (Table 1). Samaru is representative of Northern Guinea Savanna and Kano is representative of the Sudan Savanna (Fig.1). In Bama, a location in the Sahel Savanna, optimum plant population is about 20,000 plants per hectare. In these different zones the amount of water available is important in defining the upper limit of plant population.

Table 1. Effect of plant Population on Grain Yield of Millet grown at Different Locations.

Plant Population per hectare	Grain Yield kg/ha		
	Samaru	Kano	Bama
20,000	1818	1564	1386
40,000	2290	2118	1805
60,000	2645	1927	1327
80,000	2645	1927	1327
100,000	1781	1203	1004

Optimum sowing date follows the pattern of the rains with planting earliest in the Southern Guinea Savanna and latest in the Sudan/Sahel Savannas. While the last two weeks of May, depending on the onset of rains, is the most appropriate time for sowing in Samaru, the middle of June is the ideal time in Kano. In Samaru, sowings made before and long after the rains became steady resulted in significant reduction in yield (Table 2). Each fortnight delay in date of sowing after the rain became constant, reduced grain yield by about 294 kg per hectare.

Even though millet does well on marginal land where other crops will normally not do well, millet still responds to fertilizers. Egharevba (1978) showed a 40 percent increase in the yield of millet from fertilized plots as against unfertilized plots.

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Fig. 1. Map of Nigeria showing the ecological zones of the Savanna Areas

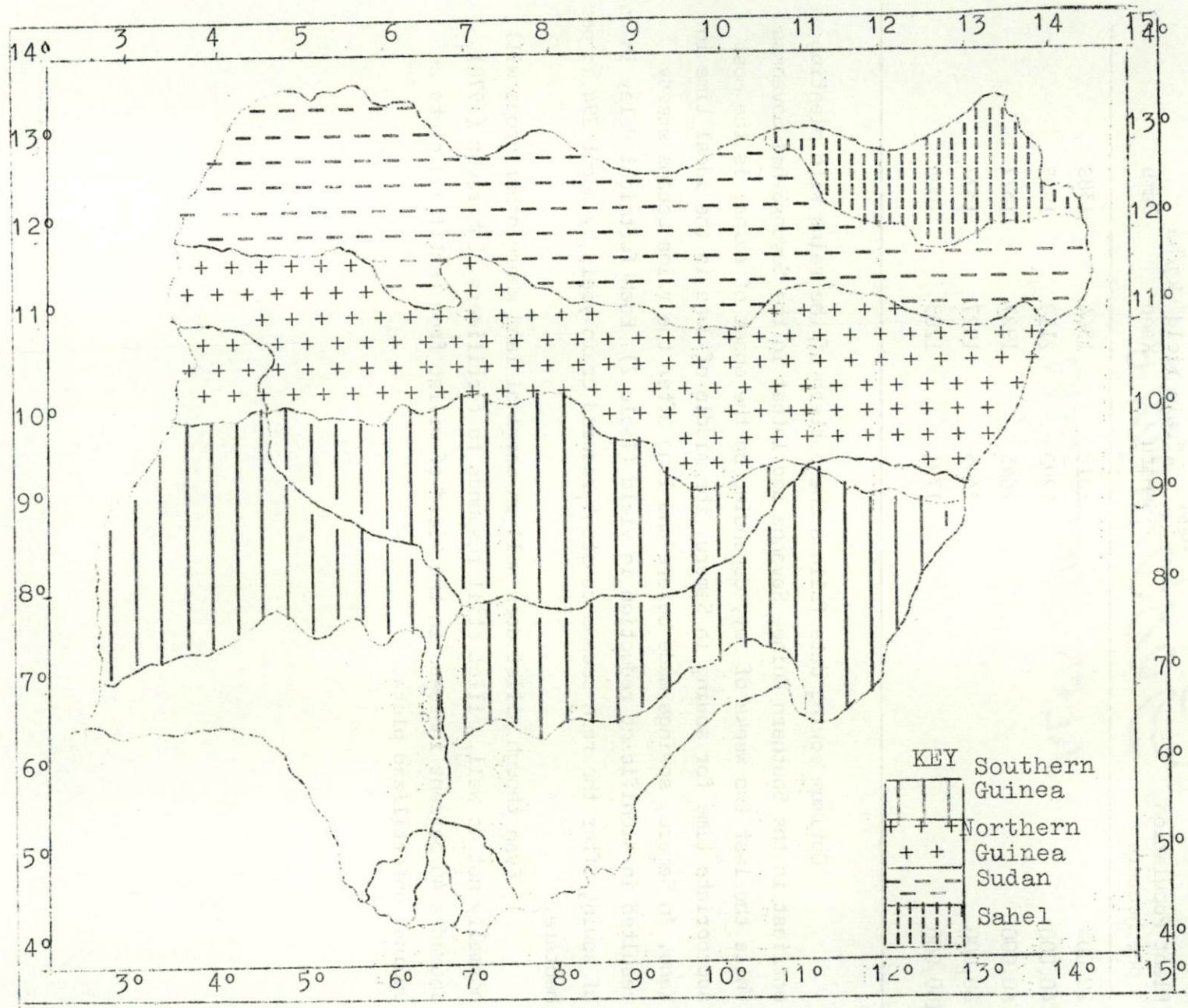


Table 2. The effect of Sowing Date on Grain Yield and 1000 Kernel Weight of Millet.

Sowing Date	1976	1977	1978	All 3 Years Combined (1976, 77 & 78)	
	Grain Yield kg/ha	Grain Yield kg/ha	Grain Yield kg/ha	Sowing Date	Grain Yield kg/ha
12 Apr. d ₁	550	-	523	12 Apr. (d ₁ +)	536
26 Apr. d ₂	850	-	749	26 Apr. (d ₂ +)	800
10 May d ₃	1320	525	1320	10 May (d ₃)	1055
24 May d ₄	1580	840	1640	24 May (d ₄)	1353
7 June d ₅	1190	1022	1279	7 June (d ₅)	1164
21 June d ₆	719	780	872	21 July (d ₆)	790
5 July d ₇	450	500	542	5 July (d ₇)	497
Mean	951.3*	733.4	989.3	G. Mean	908.0
S.E.	81.04**	57.16**	79.3**	S.E. (n=9)	43.42**
L.S.D. (.05)	250.0	189.0	244.0	S.E. (n=6)	53.17

** Significant at .01

+ d₁ and d₂ are based on 6 observations.
d₃ to d₇ are based on 9 observations.

.../...

If weeds are not timely controlled in millet it could result in total loss of crop. Generally one hand and two hoeweedings would eliminate weed competition. A few herbicides like linuron and propazine, if properly and timely applied, will give reasonable weed control.

A combination of these optimum management practices will bring about optimum millet production. Non-adherence of course brings about very low production (Table 3).

Table 3. Effect of Management Practices on Millet Production.

Treatment.	Grain Yield kg/ha
Improved var.+ Optimum Pop.+ Fert.+ Good Mgt.	1945
Improved var.+ sub-optimum pop.+ Fert.+ Poor Mgt.	348
Local var.+ Optimum Pop.+ Fert.+ Poor Mgt.	563
Local var.+ sub-optimum Pop.+ Fert.+ Good Mgt.	1009
Improved var.+ Optimum Pop.+ Fert.+ Poor Mgt.	210
Improved var.+ sub-optimum Pop. - Fert.+ Good Mgt.	468
Local var.+ Optimum Pop. - Fert.+ Good Mgt.	606
Local var.+ sub-optimum Pop. - Fert. + Poor Mgt.	103

Good Management involves seed dressing, timely sowing, timely weedings and spraying against pests and diseases.

.../...

Poor Management on the other hand means use of seeds with poor viability, late sowing, late weeding and no attempt to control pest and disease attack.

Optimum Population in this instance is 55,000 plants per hectare.

MILLET IMPROVEMENT.

The millet breeding work in Nigeria was started in Kano after a survey and collection of plant materials was carried throughout northern Nigeria. Before this time, much of the work was confined to growing National Yield Trials.

The main aims of the present programme are to develop varieties that will be :

- a) Early maturing, and high yielding with acceptable grain qualities.
- b) Resistant to lodging so that the plant remains erect until maturity.
- c) Resistant to major diseases, like downey mildew, ergot and smut that adversely affect yield.
- d) Have bristles to prevent bird damage.

DISEASE PROBLEM.

Downey mildew (Sclerospora graminicola) is most prevalent disease of millet in Nigeria. Environmental conditions influence the type of symptoms expressed. Under very high humid conditions, foliar phase development of the disease is favoured, while dry conditions during seedling and stem elongation increase the expression of green ear symptoms. Most foreign introductions tend to have low resistance to this disease. However, considerable diversity exists in millet germplasm collected from Nigeria for reactions to downey mildew and future attention is being focused on identifying sources of resistance in these Nigerian collections.

Ergot (claviceps microcephale) another disease of millet, is common in the wetter millet producing areas. Latest information is that the disease is spreading to the drier northern part of millet growing areas. The primary infection is through the Sclerotia carried along the grain while secondary infection is through conidia carried by insects, ants and rain drops. Dependable resistant sources are rare; however, work is going on at Institute for Agricultural Research in screening reactions to this disease by local collections.

Smut disease (*Tolyosporium penicillariae*), the least in terms of economic importance, is a problem in years of high atmospheric humidity. Screening national and foreign introductions for resistance to this disease is also in progress.

PEST PROBLEM.

Millet stem borer (*Acigono ignefusalis*) is found in all millet growing areas of Savanna. The bulk of the damage of this insect is however on maiwa (photosensitive types) because they grow and mature in the months of greatest incidents of this insect. Natural resistant populations to this insects have not been identified because it is a relatively new area of research at Samaru.

The greatest threat to the successful expansion and improvement in millet production in Nigeria especially in the Sudan Savanna, Northern and Southern Guinea Savannas is the damage by birds. Grain losses due to bird have been estimated as up to 30-50 percent. Breeding millet varieties with bristles have been known to reduce loss due due to bird by about 10-20 percent. We are now incorporating these bristle genes in all our varieties. The initial breeding programme on millet was based on introductions from Borno province (1960 and 1964), Nigerian collections, sixty-four exotic collections from Bombay, Senegal, six collections from India. These introductions were tested for various hybrid combinations and based on the results of the trials the following varieties and composites were formulated.

<u>Variety</u>	<u>Source Material</u>
1. Ex-Borno	Selected from collections from Borno Province
2. Ex-Benue	Selected from collections from Benue.
<u>Composite</u>	
1. Nigerian Composite	Nigerian "Gero" Millet Populations.
2. World Composite	Exotic collections.

Various breeding schemes have been used to improve these varieties and composites, namely; mass selection and recurrent selections. The average yield of improved Ex-Borno, Nigerian composite and World composite over the original ones is listed in Table 4.

.../...

Table 4. Average Yield Improvement using Recurrent Selection.

Materials	Grain Yield (kg/ha)	
Ex-Borno C_0	2065	15
Ex-Borno $(S_1) C_2$	2410	
Nigeria Composite C_0	2193	7
Nigerian Composite $(S_1) C_2$	2353	
World Composite C_0	2149	9
World Composite $(S_1) C_1$	2348	

The increases recorded ranging from 7 - 15 percent show that there is potential for yield increases within these existing varieties and composites. We think that if the present trend continues we might be able to achieve grain yields of 3 - 4 ton per hectare in the near future.

A more comprehensive breeding programme that we are now using involves the use of wide range divergent populations (composites) as outlined in figure 2.

...../.....

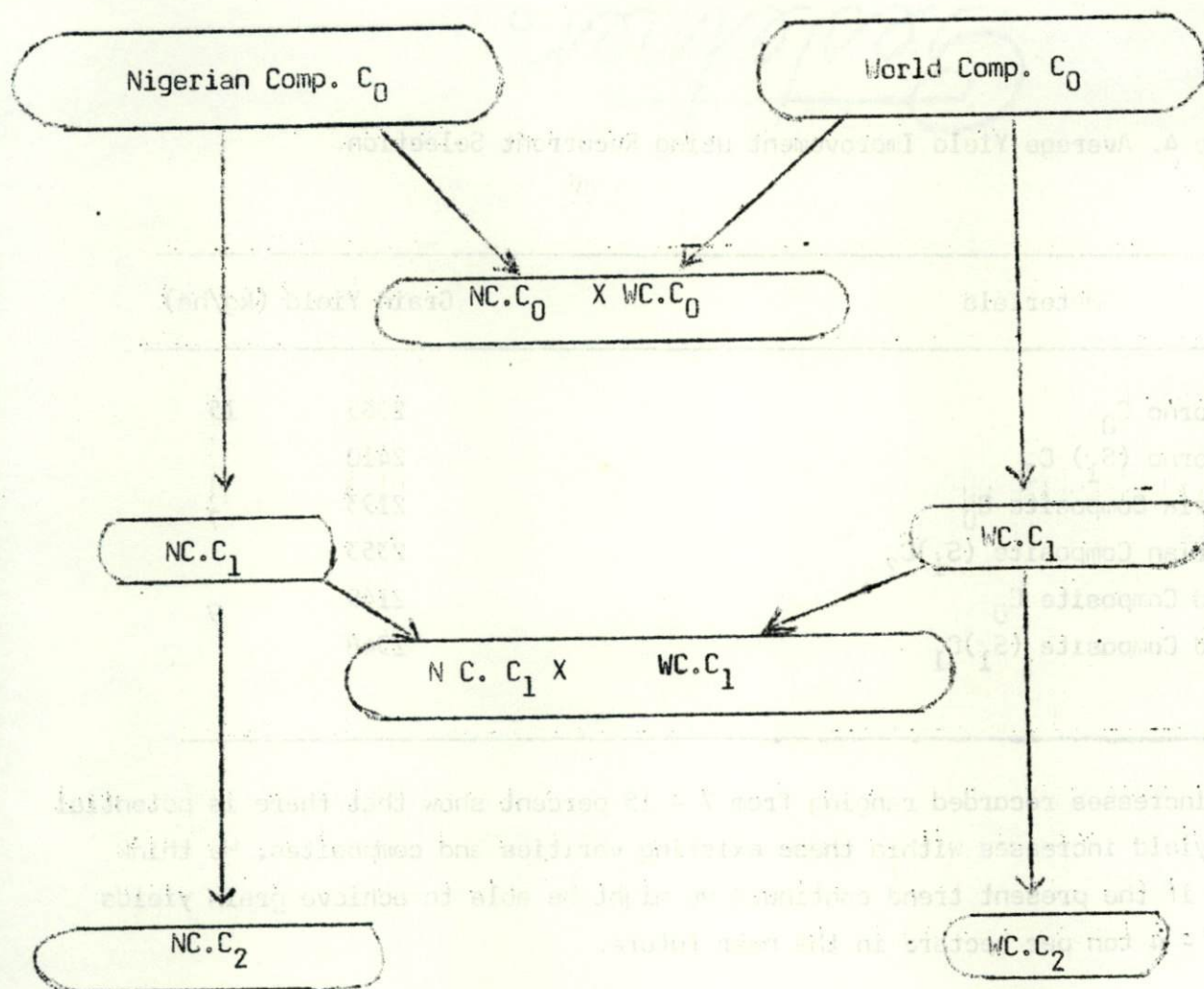


Figure 2. An outline of the comprehensive breeding system with recurrent selection in two random mating composite varieties.

These composites are then improved by recurrent selections. The latest cycle of selection of the composites can be used to produce variety-cross hybrid, composites or open pollinated varieties within parental populations.

.../...

This procedure has been outlined by Eberhart et. al. (1967) and Doget and Eberhart (1968) for maize and sorghum improvement respectively.

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SORGHUM AND MILLET BREEDING FOR DISEASE RESISTANCE.

Introduction to discussions: Mrs AMINATA THIAM N'DOYE.

Generally, in all the millet improvement programmes designed in Africa or in India, a lot of importance is given to mildew to the detriment of other cryptogamic diseases such as smut and ergot. Oftentimes, no serious studies on the biology of the former are undertaken.

Mildew is certainly the disease most visibly remarkable because of its spectacular transformation of millet ears in the event of late attacks and complete elimination of the plant in certain cases of early attacks. It is also the most remarkable disease in terms of traditional varieties.

For some years now, the tendency has been towards an intensification of millet cropping and a shortening of the cycle in those areas of the continent where rainfall is low. This shortening has brought about outbreaks, from year to year of ergot and smut, depending on the physiognomy of the rainfall season, namely the beginning and distribution of rainfall.

The importance of these three diseases depends on the ecological zone. On the case of Senegal, mildew effects is considerable in southern limit of the souma millet cropping zone where rainfall is between 500 and 800 mm, while smut damage is mostly felt in the mid-north with 400-600 mm rainfall. Ergot damage over the last two years has been enormous in the 300-600 mm.

With the current orientation of programmes towards the creation of early material therefore the three diseases become outstanding and the important work to be undertaken if not already done is the precise evaluation of losses attributable to each of the diseases in the areas under consideration.

.../...

The breeder is often caught up in a problem of choice : a material can perform well against a disease and prove unacceptable because of its sensitivity to the diseases, a material can equally have good yield and high sensitivity to these diseases. What is the rate of attack on severity to be used that a material is tolerant and what is the role of chemical control for the last type of material mentioned above ?

- Screening techniques of lines having a good level of horizontal resistance to mildew and smut.

- If results exist , it would be interesting to have further details on the heredity of resistance, the number of genes, the various gene effects in making the diagram of recurrent breeding used to transfer resisting genes.

QUESTIONS, ANSWERS AND COMMENTS ON PRECEDING DOCUMENTS.

Delegate from Botswana. (question).

The speaker from Ethiopia has talked about natural sick-plot situation. I would like to know what method he uses to determine that a sick plot has uniform infestation?

Another delegate from Botswana (question).

Does the resistance found in sorghum in Ethiopia to charcoal not stand up to conditions of high plant populations and low moisture regimes?

Delegate from Ethiopia (answer).

For developing sick plot situation for most of the diseases, we depend on hot spots and natural occurrence of the disease. We, in Ethiopia, have certain locations which give us consistent high level occurrence of the disease for screening purposes. In the case of Striga we manually seed striga seeds along the rows of a sick plot.

Charcoal plot.

The variety Kobomash 76 has shown relative resistance to charcoal rot even under high population and moisture stress situations during grain filling.

ICRISAT from West African millet collections have isolated some downy mildew resistance sources mainly from Nigeria. Materials from Niger Mali and Senegal are also having good level of resistance. These material need to be inter crossed with Ex-Bornu, Nigerian composite etc. ICRISAT has got good results by making crosses between (Souma IV X Ex-Bornu), (CIVT X Ex-Bornu). (CIVT X Souma III).

.../...

Dr. Nwasike pointed out that his major emphasis will be inheritance study on downy mildew and ergot resistance and proposes reciprocal recurrent selection to study these inheritances. Available literature and experience indicate polygenic inheritance of these characters. To increase the level of resistance, recurrent selection in appropriate population and selection under disease nursery may be more effective. To study inheritance, generation mean and variance analysis or diallel crosses involving resistant and susceptible parents may be more appropriate.

ICRISAT, Upper Volta. (comment).

The principal (fungi) involved in grain mold are phoma fusarium, and curularia at the Farako-Bâ Agricultural Station.

Delegate from Nigeria (comment).

Millet stem borer (Acigona Ignefusalis) is found in all millet growing areas of the savanna. However, major damage of the pest is on "maiwa" (photosensitive types) because their growing periods are the times of greatest incidence of the pest.

The greatest pest that will determine to what direction millet production reaches is the bishop birds it is agreed that the bristle genes have helped tremendously in reducing this damage but when the non bristled millet are around for the birds to eat. They eat up everything including the bristles.

We now think that the bird are territorial and polygamous and that if identical mimics to these males are placed in fields, the birds will be scared.

Another delegate from Nigeria (comment).

Under prevailing weather condition in many African countries it may be difficult to harvest sorghum just at physiological maturity because of moisture problem.

.../...

ICRISAT, Upper Volta (comment and question).

Based on some comments we have experienced in Upper Volta and some adjoining countries, what is the management condition we should follow in the evaluation of breeding material within and outside the station? The management conditions in question may be in the land preparation, fertilizer and other cultural techniques. The point is whether the results from high management and high input conditions are transferable to the farmers' field in the near future. I would like to invite comments on this.

SAFGRAD/ICRISAT Nigeria (answer and comment).

The ICRISAT/Upper Volta delegate has raised the issue of the level of management under which varieties or hybrids should be developed and tested so that the research station performance may reflect on-farm performance.

Data from multilocation trials conducted over several years in India indicated that as long as a variety or hybrid is really superior with respect to performance per se, the correlation between its performance under low and high management levels is nearly one to one.

Observer from Zimbabwe (comment).

Plant height either in sorghum or millet should not be a major problem. We as plant breeders and agronomists have a duty to develop both tall and dwarf materials to the liking of the farmer. The more different statured variety on the better for the farmer.

ICRISAT, Upper Volta (comment and question).

ICRISAT, Upper Volta (comment and question).

Based on some comments we have experienced in Upper Volta and some adjoining countries, and in the management of cotton and some other crops, the evaluation of breeding material with regard to the management conditions in question may be in the range of 10-20% for the different cultural techniques. The point is whether the results from high management and high input conditions are transferable to the farmers' field in the next future. I would like to invite comments on this.

SABO/ICRISAT Nigeria (comment and question).

SABO/ICRISAT Nigeria (comment and question).

The ICRISAT/Upper Volta delegate has raised the question of the level of management under which variation of hybrid vigor is observed and tested as to the research station performance may reflect on farmer performance.

Data from multilocation trials conducted over several years in India indicated that as long as a variety on hybrid vigor is maintained with respect to performance, but as the correlation between the results of the trials and the farmer's field is nearly one to one.

Observer from Zimbabwe (comment).

Observer from Zimbabwe (comment).

Plant heightening in sorghum or millet for the farmer's field is a major problem. We as plant breeders and agronomists have to be aware of the fact that the yield and overall material is the key to the farmer's field. The same different material varies in the farmer's field.

ALFA SUPERIOR

BREEDING AND IMPROVEMENT STATUS OF SORGHUM,
Sorghum Bicolor L. Moench, in Nigeria.

By

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SUMMARY.

Status of the improvement of sorghum via breeding was described. Objectives in the breeding program were defined and trends in the development of the crop were presented and discussed along the sequence of previous work done, present research activities and future research outlook.

Trends in the development of sorghum by breeding was broadly delimited into four phases, namely: 1. Collection, assessment and improvement of indigenous varieties. 2. Breeding dwarf and semi-dwarf varieties and hybrids. 3. Era of problem solving approach to varietal development and 4. Population improvement and recurrent selection among random-mating populations. Comparative progress made within these phases were highlighted.

INTRODUCTION.

Sorghum (guinea corn) is the main staple food in northern Nigeria providing the main source of carbohydrates to the inhabitants of the savanna areas. It is the most important cereal grown in Nigeria accounting for about 50% of the total cereal production (including rice, maize, millet and wheat) and occupying about 46% (in 6 million hectares) of the total land area devoted to cereal production in the country. Its production extends as far south as latitude 6° 30'N and as far north as latitude 14°N.

In Nigeria, grain sorghum is used mainly, at present for human consumption. Up to 90% of the total grain production is used for human food preparation most important of which are the thick paste (porridge) 'Tuwo' and the thin porridge 'Kamu' (Hausa) or 'Ogi' (Yoruba). Mostly, white grains are preferred for these foods although yellow or red (to a very small extent) can also be used. Most of the red grains are used for winemaking ('Burukutu') and this use forms the remaining 10% of the total production. Apart from the grains the sorghum plant has a lot of uses as the by products. The long durable stalks of the local varieties are used for fencing compounds and in making thatch roofs. After harvesting the heads, the dried leaves are left in the field for random grazing by cattle, sheep and goats. In the wetter parts of the southern guinea savanna where yams are cultivated, the harvested stems are bent or tied in upright bundles and used for support for the growing yam vines. The dried stalks are also used as mulch on yam mounds or ridges in the northern guinea savanna.

Several agronomic reports on the production and performance of local sorghum varieties have been available since 1924 when the Institute was initiated. However, planned research activities for improvement of the crop through breeding did not start actively until 1956.

My aim in this presentation is to define objectives in the sorghum improvement program and to present and discuss trends in the development of the crop in the line of past work, present research undertaking and future emphasis on research activities.

.../...

OBJECTIVES.

The objectives of the improvement program is to develop grain sorghum with high yield, disease and insect pest resistance, acceptable grain colour and quality, and with tolerance/resistance to Striga. The varieties or hybrids should be adapted to its ecological zone and have good response to intensive management.

The research activities cover four ecological zones (Table 1) recognised within the sorghum growing areas. In Nigeria, sorghum is very zone specific with different varieties bred for specific zones. In most of the zones, white-grained varieties are preferred although there are some areas important for yellow grain cultivation; all produced for solid food which is mainly 'Tuwo', and porridge 'Kamu' or 'Ogi'. However, few areas in the southern guinea zone especially around the plateau and in the derived savanna to the south of the country, sorghum is extensively grown for wine making ('Burukutu').

TRENDS IN DEVELOPMENT OF THE CROP.

A. Eras of Development.

The improvement program of sorghum grain yields could be delimited into four phases:

- (I) The collection, assessment and improvement of indigenous varieties.
- (II) Breeding dwarf and semi-dwarf varieties, and hybrids.
- (III) Problem solving approach to development of varieties.
- (IV) Population Improvement.

The different phases of the improvement program constitute major periods involving several years in the developmental stages of higher yielding varieties spanning all the four zones. Except for phase one, the three other phases overlap and are continuous for continued breeding and release of improved cultivars.

Isolated cases of assessment of few collected indigenous cultivars from the southern guinea savanna and sudan savanna, are, however, still being done.

.../...

B. Discussion of progress made: 1 PREVIOUS WORK DONE.

(I) The initial phase of sorghum breeding in Nigeria mainly involved, between 1956 and 1961, collection, classification and evaluation of indigenous sorghum cultivars. Surveys were made in all the four ecologic zones namely: Northern Sudan Savanna (NSS) which is the Sahel region in Nigeria, Sudan Savanna (SS), Northern Guinea Savanna (NGS) and Southern Guinea Savanna (SGS). Classification of the samples collected (Curtis 1967), show a representation of the four economically important races of sorghum in addition to three less important races. The relative importance of the four races in the different ecologic zones of the Nigerian Savanna is shown in Table 1. These races include:

1. The Guinea race which have typically very tall (up to 4 and 5 m) and late-maturing plants/varieties with loose and pendulous panicles and flattened grains. All the varieties indigenously cultivated in the Southern Guinea Savanna fall into this group. It also forms the most important race in the northern Guinea and Sudan Savanna regions. It is the most common race grown indigenously, being widely adaptable.
2. The Kaura race. This group is characterised by plants having semi-compact to compact heads with large round grains. All the yellow endosperm varieties belong to this race which is the most important in the Northern Sudan and Sudan Savannas. Some of the varieties grown locally in Northern guinea savanna also fall into this group.
3. The Farafara race. This race is mainly found in the Northern Sudan Savanna (Sahel zone). It resembles the Kaura race, except that the panicle is loose. The race might have arisen from a long-term natural hybridization of Guinea and Kaura races.
4. The Chad race. Compries earliest sorghum type in Nigeria common in the Sahel and Sudan Savanna, only. It is characterised by compact panicles and grains with dark sub-coat (testa).

The three other less important races into which locally grown sorghum in Nigeria are classified include: the Sokoto Umbellate and Tunicate races.

Table 1. Description of Ecologic Zones and Type of Race Cultivated (indigenous) for Sorghum Adaptation.

Ecologic zone	Crop maturity period (days)	Annual mean rainfall (total in mm)	Percent (initial) of each sorghum race in each zone			
			G	K	F	C*
Northern Sudan Savanna (NSS)	90-110	600	18	51	19	12
Sudan Savanna (SS)	120-150	750	65	11	-	15
Northern Guinea Savanna (NGS)	150-180	1000	83	17	-	-
Southerne Guinea Savanna (SGS)	OVER 180	1100	100	-	-	-

* G = Guinea race; K = Kaura race; F = Farafara race; C = Chad race.

It is noted that all the four important sorghum races are represented in the Northern Sudan Savanna (Sahel) Table 1, and to some extent in the Sudan Savanna. However observations show that with the improvement of the local sorghums via selection and hybridization, the early recorded relative occurrence of the different races in the different zones, is changing. There is a constant drift in the cultivars being cultivated by the farmers during their constant movements from village to village and region to region; thereby interchanging and adapting the different races to different zones. This process is more common in the interzones of the Northern Sudan - Sudan and Northern Guinea Savanna zones, and least common in the Southern Guinea zone where rainfall period is long and cultivars are very late maturing, ripening after the rains. These processes in addition to some natural hybridization among the local cultivars have resulted in the occurrence and presence of many different hybrid types between the main races giving rise to a very acceptable grain form and colour called "Mori". Such genetic intermixing are more common among the Guinea, Farafara and Kaura races.

The breeding program within the first phase involved the evaluation of all the collected local varieties in replicated yield tests at Kano, Samaru and Mokwa; followed by selection within the best local cultivar. The best performing local varieties were found to be: 1. Gwoza local and Ex-Bauchi (Northern Sudan Savanna zone) 2. Yar Gunki, Rano zana innua and Kaura-Baz (Sudan Savanna zone) 3. Farafara and Gaffra ex Biye (Northern Guinea Savanna) 4. Mokwa varieties (Southern Guinea Savanna). Both the Mokwa varieties and Farafara variety are from the Guinea race, Gaffa ex Biye is Farafara race, Yar Gunki, Rano zana innua and Kaura-Baz are in Kaura race, while Gwoza local and ex-Bauchi are from the Chad race.

Pedigree selection and single progeny testing were then practised within these best local varieties. This selection phase within the local varieties culminated in the development and release of improved strains between 1962 and 1968. The continuous assessment of local collections continued for sometime and the improved selections from later collected locals were released between 1970 and 1978.

The improved selections from local varieties, released in the era 1962-1968, showed an average yield increase of 62% (experimental yields) over unimproved local cultivars (farmers' varieties) (Table 2.). Similarly, later released improved local selections between 1970 and 1978 gave an average of 70% yield increase over the farmers' varieties. These average gains in yield were calculated across all four four ecologic zones.

(II) The second phase in the improvement of sorghum in Nigeria was started consequent to the realisation that the improved selections from local varieties were unresponsive to intensive management. This was because of their excessive height and low grain yield resulting in low harvest index. Thus the objective of this phase was to develop dwarf, and semi-dwarf varieties and hybrids for different zones, towards moving off the low performance level.

Developing Dwarf and Semi-dwarf varieties:

The first group of short-statured, medium-maturing sorghum pure lines and hybrids were bred and released between 1967 and 1969. Their development was described by D.J. Andrews (1970).

.../...

Work to breed adapted dwarf and semi-dwarf varieties was initially centred around Samaru mainly for the NGS. Later from 1970 such research activities extended to Kano for developing varieties and hybrids adapted to the NSS and the SS

Table 2. Average performance of sorghum varieties from different eras developed for four ecologic Savanna zones.

Variety Description	Era developed	NSS		SS		NGS		SGS	
		Yield	Local %	Yield	Local %	Yield	Local %	Yield	Local %
Unimproved Local (821)	collected before 1960	0.8	-	0.7	-	0.8	-	0.6	-
Improved selections from local (9)	1962-1968	1.1	38	1.4	100	1.4	75	0.8	33
	(5) 1970-1978	-	-	1.1	57	-	-	1.1	83
Selection from hybridization (32)	1967-1969	-	-	-	-	2.5	213	-	-
	(10) 1970-1978	3.0	275	2.1	200	2.8	250	-	-
F ₁ Hybrids (10)	1967-1969	-	-	-	-	2.8	250	-	-
	(40) 1970-1978	-	-	-	-	4.3	438	-	-
						4.3	((25-75))		

() - Figures in parenthesis are number of entries tested.

* - Yields are in tons/ha and are average for all entries in the specific groups.

(()) - Values in double paranthesis are precent increases over cross-bred varieties.

Exotic germplasm were imported into Nigeria and used in crosses with Nigerian varieties. The introductions included widely differing groups of sorghum representing the Kafir, milo, hegari, shallu, kaoliang, feterita and dura. In the early early crosses, two main Nigerian varieties were involved; these included gamma shott Kaura (g SK), a mutant obtained by irradiating a Kaura variety with cobalt 60; and short Kaura (SK 5912) a natural mutant from another kaura variety. A characteristic of SK 5912 is that it tends to mutate slowly back to the tall condition of its local parent. Later crosses in the development of the short-statured sorghum involved such crosses as: Exotic (unadapted) x local (adapted), Improved local (adapted) x local (adapted) and exotic (adapted) x exotic (adapted). Other local varieties used as parents include Farafara (SFF 60), Shambol and Yar Gunki.

Following the identification of local and exotic parents which were later used in crosses, two main breeding methods were used to isolate pure line variety from the resulting crosses. These are 1. Head-to-row pedigree selection system and bulk population breeding. Selections from the hybridization program yielded several semi-dwarf varieties for the NSS, SS, and NGS zones and none for the SGS zone. The performances of these selections shown in Table 2 indicate a range of yield increase from 200 - 250% over the unimproved farmers varieties. However, grain yield performances have not been the best criterion for selection and acceptability of the semi-dwarf varieties. Breeding objectives have been to provide sorghum that will be acceptable by the farmers for human consumption. As a result selection have been based on a form of index selection using grain yield, grain colour and quality as economic traits. Such methods have resulted in the development and recommendation of high yielding varieties shown in Table 3. The highest yielding pure line varieties are of the types exotic (adapted) x local (adapted) and the adapted exotic per se. These observations support in part, the expected better average yield performance of adapted x adapted crosses, (Frey 1964 and Weber 1966). However pure lines derived from such crosses are not better, on the average, than the selected local varieties. The almost similar yield performances between the improved local selections and crossbred varieties and other socio-economic factors affecting acceptability (e.g. sorghum stalk for fencing and roofing, acceptable food texture and colour prepared from varieties) make the indigenous tall sorghum varieties best suited and still most preferred in the sorghum growing areas.

The developed dwarf varieties introduced to the farmers are still not fully accepted (as was earlier indicated by Andrews, 1973) because of the socio-economic (including high input requirement and labour constraint for the recommendations) and cultural factors governing transfer of such agricultural technology. The rate of acceptance of the semi-dwarf varieties is still in the range of 5-10%.

Table 3. Description of Improved pure line varieties of Sorghum developed for the four different ecologic zones.

Zone	Variety	Pedigree	Type	Grain Yield t/ha ^a	Plant* height (M)	Grain** Colour
NSS	H.P.3	Tx3927-4	adapted exotic	2.5	1.3D	CSC
	H.P.8	Tx3925-2	" "	2.2	1.4D	SCS
	BES	Local	selected local	2.6.	1.6.SD	Y
	L.2257	E7A3143	adapted exotic	2.8	1.4 D	W
	L.2250	137/63	" "	2.6	1.9 SD	C
SS	KBL	CK60BxLocal	exotic x local	11.4	2.0 SD	W
	L.538	IS1224/1	adapted exotic	1.4	2.1 SD	C
	L.408	IS1224/2	" "	1.3	2.0 SD	C
	RZI	Local	selected local	1.9	1.9 SD	Y
	YG5760	"	" "	1.3	3.6 T	Y
	A-9025	S-21-14-4	adapted exotic	2.0	3.1 T	W
NGS	L.187	KurgiBxSK	exotic x local	2.9	1.8 SD	Y
	L.181	WX60xSK	" "	2.5	1.9 SD	C
	L.1499	MSBx284/1	" "	2.7	2.0 SD	W
	SK5912	local mutant	Selected local	2.8	2.5 ST	Y
	FFBL	local	" "	2.3	4.0 VT	W
	L.243	L.181xRZI	exotic x local x local	300	1.9 SD	M
	L.533	L.187xL.1499	exotic x local x exotic	2.8	1.7 SD	C
SGS	C-7-4	Local	selected local	1.2	4.0 VT	W
	ML-4	"	" "	1.1	4.0 VT	W
	FDI	"	" "	1.1	4.0 VT	Y

* D = dwarf; SD = semi-dwarf; ST = semi-tall; T - tall;
VT = very tall

** W = white; Y = yellow; C = cream; M = mori; CSC = cream
with dark seed coat

^a yield figures are based on two years' data.

.../...

Developing Hybrid Varieties:

Before and upto 1970, several attempts were made at utilising hybrid vigour among pure lines to increase grain yield in sorghum. Some sterile A and maintainer B lines were introduced, adapted and used in crosses with elite local selections and cross-bred strains.

In 1963, the first attempt were made by introducing and evaluation a collection of exotic hybrids from United States and India. Yields of these hybrids (2.6 t/ha) were found to be comparable with and non-significant from that of the improved local selection SFF60 and FFBL (2.2 t/ha). These initial exotic hybrids were also unadapted to the northern guinea savanna being too early, flowering in 57 to 60 days. These hybrids were tested in the drier sudan savannas where rain falls for only three to four months, and were found not significantly better than the improved pure line selections.

Consequent to these early failures dwarf male sterile lines were later imported to use per se or used in crosses to develop other adapted male sterile lines. This procedure was highly successful and has yielded all the male sterile lines used presently in the hybrid development program in Nigeria. Male sterile lines and their respective restorer-lines imported included CK60A and B, CK612A and B and T.P 8A and B; ISNIA and B. All these A-lines excepting ISNIA were early maturing and were crossed with best early pure lines. The resulting F1 hybrids were not promising for yield (highest with 2.3 t/ha) although they were dwarf and semi-dwarf in height, (Table 4). Lately three ATX male steriles were brought in from Texas (ATX 622, 623 and 624) and none of them is showing much promise in hybrid combinations. Work is continuing towards developing new and adapted long season and early male sterile lines for F1 hybrid development for the northern guinea and sudan savannas.

However, more progress has been recorded in the northern guinea savanna. The dwarf male fertile CK 60 B was crossed with very tall local selection Farafara (FF 60) as male. The resulting line 2121, with genotype CKFF, was backcrossed to the male sterile CK 60 A to produce an adapted long season, male sterile line RCFA.

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The semi dwarf sterile line, in addition to ISNIA and KURGIA were used as female seed parents in the hybrid program at Samaru.

Several F1 hybrids (30 in all) were developed and tested before 1977. These long season hybrids were high yielding with a range of 2.9 to 3.5 t/ha grain yield, but were tall about 3 metres in height (Table 4) and were found to be very susceptible to Striga. ISNIA had produced the highest yielding hybrids (average of 3.5 t/ha) but these were the tallest (over 3 metres) and the most susceptible to Striga. In addition, the male sterile line has been unstable in Samaru environments.

Table 4. Performance of early and long season F1 hybrids developed for two ecologic zones in Nigeria between 1967 and 1977.

Type	Male sterile seed parent	No. of hybrids	Average yield t/ha	Average plant ht.	a cm.
Early	CK 60 A	3	2.3	170	SD
	CK 612 A	1	2.0	160	SD
	T.P. 8 (all dwarf to SD)	16	1.9	155	D
Long season	RCFA	12	3.2	290	T
	ISNIA	9	3.5	330	T
	KURGIA (all semi dwarf)	9	2.9	285	T

a SD = Semi-dwarf; D = dwarf; T = tall; ST = Semi tall.

The best recommended pure line varieties are listed in Table 5 with their average performances in respective zones. A total of 19 elite pure line varieties have been released: 5 each for the NSS and SS, 6 for the NGS and 3 for the SGS. Their descriptions are shown in Table 3. It is observed from Tables 3 and 5 that the average yields of the varieties are lower in SS (1.53 t/ha) and SGS (1.28 t/ha) than in NSS (2.54 t/ha) and NGS (2.71 t/ha). The reasons for these are not far fetched. Research activities to develop cross bred varieties was intensified for the SGS only in 1978. The varieties presently recommended for the zone are selections from indigenous varieties. In the case of the SS, it is a drought prone environment with the result that in some years rainfall reaches up to 800 mm while some years record less than 600 mm. This makes it difficult to develop a genetically stable high yielding variety for this zone. Another reason could be management in terms of fertilizer application. The question is when is the best time to apply fertilizer under the condition of fluctuating rainfall pattern. This is a problem even if potentially high yielding varieties are grown.

The Hybrid Program: From 1977, the development of F1 hybrids became intensified. The three male steriles (RCFA, ISNIA and KURGIA) developed earlier are still being used as female parents; however new elite pure lines were used as male parents to achieve the very high yields with average yields (3.00 t/ha in drought years) better than the earlier hybrids. Another advantage for these new F1 hybrids is their shorter heights compared to earlier ones, plus the fact that some of them are tolerant (SSH1 and SSH2) while the others (SSH3, SSH4 and SSH5) are moderately resistant to Striga. The new long season hybrids are adapted to the NGS and they are described in Table 6.

Population Improvement and Recurrent Selection:

Six random mating populations were developed as shown in Table 7 with their descriptions. Only three of these (B composite, Y composite and YZC) are used as base populations for yield improvement, while a fourth composite MSRC (modified Striga Resistant composite) is being used in recurrent selection for striga resistance. The populations are being improved by two recurrent selection methods: mass selection and S1 Progeny testing. These methods combined with pure line development in Nigeria have been described by Obilana and El-Rouby (1980a).

Three cycles of mass selection have been completed on two of the composites, B composite and Y composite. The results showed significant improvement for yield (Obilana and El-Rouby, 1980b). After three cycles of selection, a gain of 38.4% and 40.4% for yield were observed in B composite and Y composite, respectively. This meant an average of 12.8% and 13.5% yield gain per cycle, respectively. Also selection differentials computed from S1 evaluation indicated an expected increase for yield in the two composites, (Obilana and El-Rouby, 1980a).

Table 5. (contd.)

- a. Sorghum types are described in terms of maturity
- b. Yields (for 3 to 4 years) are evaluated at populations of 37,000 pl/ha and fertilization level of 251 kg/ha superphosphate and 376 kg/ha Nitrochalk, Ammonium Sulphate or Urea.
- c. These F1 Hybrids are newly developed and newly introduced. Their acceptability for productions is not yet known.

Table 6. Description of single cross hybrids developed and recommended for production in the long season Northern Guinea Savanna (after 1977).

F1 Hybrid	Pedigree	Plant Height (m)	Head shape and seed colour	Grain yield t/ha.
S.S.H.1	RCFA x L.187	2.0 (SD)	Open loose branches. Cream	2.84
S.S.H.2	RCFA x SK5912	2.5 (ST)	Open stiff branches. Yellow	3.06
S.S.H.3	KURGIA x L.1499	2.2 (ST)	Compact 'Mori'	3.03
S.S.H.4	ISNIA x SK5912	2.3 (ST)	Compact Yellow	3.07
S.S.H.5	KURGIA x SK5912	2.4 (ST)	Compact Yellow	2.98.

.../...

The population improvement program is continuing towards developing improved populations by cycles of recurrent selection and systematic and continuous development of elite pure line varieties and hybrids.

Table 7. Description of Sorghum composites developed in I.A.R. between 1963 and 1978.

Population	Pedigree	Brief Description.
Y Composite	SK; (SK x (CKA x FF) x FF) SK x DWARF HEGARI (x FF) SK x FETERITA: 2123 (CK x FF) BULK(Z x I.S.511) J.S.511 1898 (CK x GALB-EL-JAKUS) x 2347 CK x MAKAJO DA WAYO: SHALLU/KAFIR x MDW: 2743 (CK x SK) x SK	A WELL-MIXED COLLECTION OF LOCALLY ADAPTED GERmplasm AND EXOTIC CULTIVARS FROM CHAD, SUDAN, ETHIOPIA SEMI-DWARF (1.96 m)
W.A.B.C.	U.S. CONV. PROGRAM BULK 7, 20, 25, 27 and 34 THAILAND NURSERY L.1284, L.1378, L.4015, L.6213 I.S.N. 4 LINES	A BULK OF EXOTIC CULTIVARS FROM TEXAS, THAILAND AND INDIA
B Composite		A MIXTURE OF EXOTIC B LINES AND LOCALLY ADAPTED GERmplasm SEMI-DWARF (2.00 m)
Z Composite	Y comp. x B comp.	A COMBINATION OF TRAITS FROM TWO COMPOSITES
YZ Composite	Z comp. x Y comp.	A COMBINATION OF TRAITS FROM TWO COMPOSITES SEMI-TALL POPULATION (2.41 m)
MSRC	STRIGA RESISTANT COMP.	SEMI-DWARF COMPOSITE (2.00 m) WITH GOOD FIELD STANDABILITY.

In order to remove the danger of genetic vulnerability of our hybrids, because only three male steriles are used as sources of seed parents, the breeding program has embarked on the development of more adapted long season A-lines and their restorer B parents. The B composite cycle 3 population (C3) is being used as source.

Striga Studies:

These studies are being carried out as one of our problem solving approaches to the improvement of sorghum in Nigeria. Striga (Striga hermonthica Benth) called 'Wutawuta' in Hausa, is a deadly parasitic weed on sorghums in all the savanna ecologic zones of Nigeria. Its devastating effects can be total. Between 15% and 53% yield loss has been reported for pure line varieties (Ogborn, 1979a) and up to 95% loss in yield has been observed in F1 hybrids (Obilana, 1980). Incidences of 100% loss in form of killed plants that do not head are common in densely infested fields of susceptible cultivars.

Three approaches are used in the search for control methods through breeding for resistance (Obilana, 1979). These approaches include 1. The classical breeding method of collection of local cultivars, introduction of exotic cultivars, hybridization followed by selection among segregating populations. This is the long-term approach. 2. Population improvement and recurrent selection within a modified striga resistant composite (MSRC). This cyclic method is also a long-term approach. 3. Varietal testing of elite pure lines and hybrids for their reaction to striga infestation in striga-sick plots.

The earlier observations of Andrews (1970), coupled with line screening of King (1975) and line breeding tests have shown that there is differential reaction of lines (resistance/tolerance) to striga infestation; this resistance can be selected for. Evaluation of elite lines and hybrids have also shown that materials can be selected that combine both striga resistance with high yield. Some high yielding varieties that have resistance and are high yielding have been tested, identified and recommended for farmers use. These include: the early maturing types HP3, HP8 and B.E.S.; medium maturing varieties YG 5760 and RZ1, the long season varieties L.187 and SK 5912 (Farafara - FFBL is tolerant). The long season hybrids SSH1 and SSH2 are moderately tolerant.

Evaluation for striga resistance and identification of resistant lines in sorghum is very complex and has been found to be extremely confounded with the environment. Highly significant genotype x environment interaction has been recorded for striga resistance in pure lines and hybrids (Obilana, 1980). Genetic studies have added more information to these complications while elucidating pattern of reaction of sorghum to striga. The mode of inheritance of resistance to striga was found to be controlled by at least two genes. Susceptibility in sorghum was dominant over resistance (Obilana, 1980b). This condition would explain why most of the hybrids developed so far are susceptible to striga. No hybrid has been found to be as resistant as the most resistant pure line L.187.

Adaptation in Nigerian Sorghum.

Genotype x Environment studies have shown the specificity of sorghum to different ecologic zones in Nigeria. The effect of environment on sorghum is very large and highly significant (Obilana and El-Rouby, 1980c). The most stable pure line varieties were not the highest nor the lowest yielders in each zone; they were also not necessarily indigenous adapted varieties. However, the most dependable in terms of level of management and technology are the indigenous varieties. Therefore there are distinct differences between and among adapted varieties, stable varieties and dependable varieties.

From computations (Obilana and El-Rouby, 1980c) differences among years in Nigeria are highly significant and higher than differences among locations. In addition the combined genotype x location x year interactions were highly significant and higher than either of genotype x location or genotype x year interactions. It is therefore pertinent to conclude that in order to obtain a true performance of any new developed variety, it must be tested for several years (at least three years) and several locations (at least eight locations) within the adaptive ecologic zone.

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III. PLANNED AND FUTURE RESEARCH OUTLINE.

All previous and most of present breeding activities have been geared towards developing sorghum varieties for human consumption. This is obvious considering the fact that 90% of all sorghum produced is used for human food, mainly the thick, firm porridge ('Tuwo') and the thin porridge ('Kamu' or 'Ogi'). In addition, up till present, 85% to 90% of all sorghum produced are cultivated by small scale farmers owning from 0.5 to 5 hectares. This trend is expected to continue for some years.

However with the increase in the number of medium scale (with up to 15 hectares) and large scale mechanised (Government or Privated Owned) farms (more than 20 hectares) the breeding strategy is being modified. Sorghum varieties would be developed mostly for human consumption and in the rest of the time for agro-allied industries. Acceptable (in terms of colour, taste and height in this case semi-dwarf and semi-tall) and high yielding varieties and hybrids would continue to be developed for human food. On the other hand, the rejected varieties (due to bad human preferred food qualities) in addition to hybrids, made available for mechanical harvesting and improved for poultry feed, fodder and forage and high protein. In addition efforts would also be made to improve and develop the few varieties that could be utilised in the brewing, tanning and starch industries.

Pest resistance would be looked into more directly and effectively in a multidisciplinary approach. This futuristic approach has already started. Stem borer resistance would be bred into our sorghum varieties to cut down on the expensive and hazardous task of insecticide use.

Striga resistance would continue to be incorporated into our improved varieties. The problems encountered in: non-uniform and non-intense infestation of sick-fields by striga under natural conditions, and inadequate evaluation techniques for striga reaction in sorghum plants make it necessary to study best artificial infestation and evaluation techniques for striga studies. Better pathogeneticity techniques and rating scales need to be worked out.

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Although the ideal situation is to develop different ideotypes for different crop mixtures, particular varieties of sorghum need not be developed for mixtures, at present in Nigeria. It is known that under our mixture patterns, sorghum yield is effectively increased, irrespective of variety used. There is, although, some observed varietal differences in mixture performance.

It is very important to indicate here that Nigeria has one of the largest and most extensive variability of indigenous sorghum cultivars. This variability exists both across and within the four distinct ecologic savanna zones. It is therefore urgently imperative to organise a planned, intensive and extensive collection program of our natural germplasm for preservation and utilisation. The previously collected germplasm in the present world sorghum collections is only a very small portion (about 10 - 20%) of available variability.

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WORLD WIDE GERMPLASM COLLECTIONS OF SORGHUM & MILLET

Summary Paper

By

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Introduction.

The importance of germplasm in all crop improvement programs is something that cannot be over emphasized for it is the basic raw material. Unfortunately however, the world is being robbed of its unique natural resources due to many natural and unnatural factors. The majors natural factors are for example, flood, drought etc., the man made factors being fire, urban and rural development, deforestation and the like. So far , crop improvement scientists have been able to gather their raw material from the farmers' fields. But this too is changing. The farmer is gradually yielding his broad based cultivars and is replacing them with the newly developed, relatively more uniform but high yielding varieties. The advantages and disadvantages of this situation are obvious. While the farmer is being supplied with seeds that would satisfy his immediate needs for higher production production, he is rendered defenceless in an event of an epidemy of a new pest, disease or stress. His capability to withstand such a likely crisis is therefore limited, hence the need for the timely collection and conservation of the farmer's landraces.

The collection and conservation of germplasm is, in my opinion, as old as agriculture itself. The very first thing that the settled farmer did is probably the identification and gathering of seed for food followed by seed for sowing further followed by selections for better seeds. The present predicament we are in, is that neither the farmer is keeping his precious seeds nor are the landraces found abundantly as they used to. The realization of this dilemma leads a few far sighted individuals, institutions and foundations to alleviate the farmers difficulty and at the same time conserve the vanishing germplasm in man made world collections and gene banks. In this connection, the role and impact of the Rockefeller foundation of New York and IRAT and ORSTOM of France in the early

assembly and conservations of the "world collection" of sorghum and millets in particular is of paramount importance. In the general world of genetic resources, no paper could be considered complete without the mention of institutes and gene banks like (1) The Vanilov Institute of USSR, Leningrad, (2) The German Gene Bank at Brounswieg, FRG, (3) The National Seeds Storage Laboratory, Fort Collins, Colorado, USA, (4) The Canadian Gene Bank at Ottawa, Canada.

Nowadays, the thrust in germplasm collection and conservation is further strengthened by a number of national organizations that are well known to all of you in your areas of concern. At the international level, the sorghum and millet germplasm collections and conservation effort is being undertaken by ICRISAT in close collaboration with national programs and the International Board of Plant Genetic Resources, FAO. It is also most gratifying to note that SAFGRAD has recognized germplasm collection and conservation as one of its important objectives.

Objective :

The work of germplasm collection has to be followed by a set of important activities or objectives namely-systematic evaluation, physical and biological maintainance, documentation, distribution, medium and long-term conservation for immediate and future utilization. The failure or lagging in anyone of these objectives is bound to affect the whole process. It must also be stressed that one of the major objectives of germplasm collection and conservation is the assembly of the mild relatives of the crops.

Priority Areas of Collection:

Several individuals, institutions, organizations and foundations have made substantial contribution in identifying priority areas of sorghum and millet germplasm collection throughout the world. Priority areas are identified mainly on the extent of genetic erosion of the area rather than the abundance of diversity. Accordingly the following regions have been considered as priority regions for the collection of sorghum and millets.

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<u>Region</u>	<u>Current collection status.</u>
1. South Asia	partly covered
2. Eastern Africa	" "
3. Western Africa	" "
4. Southern Central Africa	" "
5. Far East	To be explored.

More specific areas of collection and their present status is shown in table 1. (on the next page).

As stated, the list of areas of collection is tentative and will be modified as and when fresh informations come to light. All sorghum and millet scientists in Africa are invited to contribute towards the refinement and finalization of the list.

Types of Germplasm Collections:

A collection data sheet has been developed at ICRISAT in consultation with various scientists and organizations including the IBPGR. Interested collectors may feel free to contact the Genetic Resources Unit of ICRISAT for getting sample data sheets.

The various types of collections are briefly described below:

1. Accessions collection - The available world collection;
2. Spontaneous collection - The mild and weedy races maintained separately;
3. Named cultivar collection - Assembly of named cultivars released by private and public institutions;

.../...

Table 1. Tentative list of identified areas for Sorghum and Millet collection in Africa.

Area	Status of Collection	Remark
Algeria	Partly collected	mostly for parliament
Angola	not collected	unknown type
Benin	partly collected	need more work
Botswana	collected in 1980	good kofer types
Burundi	partly collected	not much known
Cape Verde	not explored	explore in 1981/82
Cameroon	fairly well collected	needs recheck
Central Afr. Republic	not collected	explore in 1981/82
Chad	not well collected	very important and
Congo	not well collected	enpire - 1982
Egypt	partly collected	to be checked
Ethiopia	well collected except packets	efforts continuing
Gambia	collected in 1980	less variable
Ghana	partly collected	to be collected in 1981
Guinea	partly collected	explore 1981
Guinea Bissau	partly collected	explore in 1981
Ivory Coast	to be explored again	some collections
Kenya	fairly well collected	check lake areas
Mali	collected	recheck
Mauritania	partly explored	further work
Mozambique	not collected	in 1981
Niger	partly collected	needs coverage
Nigeria (N)	good types observed	needs coverage
Rwanda	fairly well collected	to be explored
Sierra Leone	to be explored	few collections
Somalia	collected in 1980	desert types
S. West Africa	not collected	to be explored
Sudan (SE)	collected in 1980	excellent source
Tanzania (SE)	collected in 1978/79	excellent source
Togo	to be explored	good P. millets
Ugana	partly collected	needs more work
Upper Volta	some collection exists	needs recollection
Zaire	some collection exists	needs recollection
Zambia	collected in 1980	less variable
Zimbabwe	isolated collections	for 1982.

4. Genetic stock collection - germplasm with known genetic traits of resistance, special marker genes, genic and cytoplasmic male sterile lines, etc.
5. Conversion collection - converted lines from tall to short, photo-period sensitive to non-sensitive and etc.
6. Other collections such as pools, basic, bulks and population.

Assignment of IS of IP numbers:

As per the 1978 recommendation of the IBPGR Advisory Committee on sorghum and millets, ICRISAT has been charged with the responsibility of assigning IS (International Sorghum) and IP (Inter-pearl millet numbers to the entire "World Collection" of the two crops as well as its other mandate crops. This important task is being well implemented in broad consultation and without losing sight of the need to record the original pedigree references.

Systematic Evaluation:

The evaluation and characterization of the germplasm is continuing. In the future, however, it is planned to evaluate the germplasm at or close to its original habitat to start with in a regional fashion. The collaboration of all sorghum scientists in Africa is vital to this program. The list of descriptors required for the evaluation exercise has been developed jointly by ICRISAT and the IBPGR. The one for sorghum has already been published and released. Interested scientists may contact either the Genetic Resources Unit of ICRISAT or the IBPGR, Rome. The pearl millet descriptors list is being finalized for publication.

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Present Size of the World Collection:

The World collection of sorghum and pearl millet being maintained at ICRISAT is growing daily. The country wise collection is shown in the special bulletin of ICRISAT's Genetic Resources Unit which is presented as annex to this paper. Active program of seed exchange and collection of germplasm is going on at an accelerated pace. However, the task is still huge.

The following table 2 shows the numbers collected and conserved at the ICRISAT gene bank.

Table 2. Sorghum and Pearl Millet Germplasm Resources at ICRISAT.

	Sorghum	Pearl Millet
<u>No. of Accession:</u>		
Actual	16,587	12,431
Transit	5,386	2,193
<u>No. of Countries Represented:</u>	61	25
<u>No. of Wild Relative SP/Access.</u>	12/141	17/33
<u>No. Distributed 1977-79</u>	38,879	17,184

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Range of variability in sorghum and pearl millet:

A wide range of variability is already in our gene bank. Some of the major characters and their range of variability is presently being prepared for publication and wide distribution. Wide range has been observed in maturity, plant height, head length and width, grain size, shape and color, leaf size, midrib colour and other important characteristics.

General concluding Remark:

Germplasm collection is man's most important resource. The effort should be made at both the international and national level. That is why for example that whenever ICRISAT collects any germplasm in any country it prefers a joint mission and also delivers a complete duplicate of the collected material to the national program. The international centers can probably be in a unique situation to hold and conserve the medium and long-term world collection. National programs can and must collect and conserve their own germplasm resources.

In this regard, it would be desirable to promote a simplified germplasm exchange system. The material collected and conserved at ICRISAT belongs to all scientists who wish and could utilize it. As many have already known, all the genetic material conserved at ICRISAT is distributed free of charge anywhere in the world.

Range of variability in acidophobes and acidophiles

A wide range of variability is already in our bank. Some of the major characteristics of variability is presently being reported for publication and will be published. This range has been observed in morphology, plant height, leaf shape, and within certain taxa, shape and color. Leaf size, within certain and other laboratory characteristics.

General concluding remarks

Genetic collection is man's most important resource. The effort should be made at both the international and national level. That is why for example that whenever ICBP collects any germplasm in any country it gathers a joint mission and also collects a complete duplicate of the collected material to the national program. The international centers can possibly be in a unique situation to hold and conserve the medium and long-term world collection. National programs can and must collect and conserve their own germplasm.

References

In this regard, it would be desirable to promote a simplified germplasm exchange system. The material collected and conserved at ICBP should be available to all scientists who wish and could utilize it. No many have already known, all the genetic material conserved at ICBP is distributed free of charge wherever in the world.

SOCIO-ECONOMIC ASPECTS OF SORGHUM AND MILLET
PRODUCTION IN NIGERIA.

By

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1. Sorghum and Millet Production.

The importance of sorghum and millet in the Nigerian agriculture may be seen from the large number of farmers engaged in the production of the two grains and the land areas devoted to them as would be seen in Table 1. In terms of food and drink these two grains hold very vital positions and from the observations of the people of Northern Nigeria most farmers ensure that they store away enough quantities of these crops for family subsistence. In fact, some observers suggest that no head of household is worthy of his position if his barn (rhumbu) is not full of sorghum or millet at harvest.

Local beer is also produced extensively with these grains and it is observed that on market days most of the young men make it a point to visit the place where local beer is sold partly to quench thirst and partly to meet friends both male and female.

It is also known that the droppings from the bottom of the barns help feed the local chickens which are produced in millions and transported to all parts of Nigeria for local consumption. Of the 123 million* local chickens in Nigeria at least 80 per cent are produced in the north of the country. It is argued that if local chickens were to be unavailable, the meat supply situation and prices would be chaotic. We must also remember that cattle, sheep and goats also feed on the stalks and grain droppings after harvesting must have been completed.

In terms of self-sufficiency in certain food items these two grains seems to satisfy the Nigerian domestic demand to the extent that they are not yet on the list of our imported items. But the general decline and deterioration of agriculture being witnessed in Nigeria now may soon cause their importation.

* Poultry production in Nigeria. A survey carried out by
Department of Agricultural Economics, University of Ibadan.
1980.

Table 1: Area Planted, Yields and Total Production of Four Major Grains in Nigeria
Except Yields, All figures in thousands 1974/75 - 1978/79.

Crop		1964/75	1975/76	1976/77	1977/78	1978/79	Units
Millet	Area Ha.	4,787	5,476	3,930	3,039	2,377	Hectares
	Output	5,554	2,550	2,893	2,579	2,386	Tonnes
	Yield	1,160	465	736	835	1,004	Kg./hectares
Guinea corn (sorghum)	Area	4,653	5,721	4,842	3,479	3,008	Hectares
	Output	4,738	2,920	2,950	3,286	2,409	Tonnes
	Yield	1,013	511	609	945	813	Kg/hectares
Maize	Area	579	971	892	610	631	Hectares
	Output	528	1,332	1,068	651	659	Tonnes
	Yield	912	1,372	1,197	1,067	1,044	Kg/hectares
Riceé	Area	269	261	193	244	152	Hectares
	Output	525	515	218	411	280	Tonnes
	Yield	1,952	1,973	1,130	1,684	1,842	Kg/hectares.

Source: Federal Office of Statistics, Crop Estimates 1978/79,
Lagos, February, 1980.

.../...

Table 2: Percentage Hectarage Under Each Crop, 1974/75 - 1978/79.

Crop	Hectares	%									
Millet	4,787	46.53	5,476	44.06	3,930	39.87	3,039	41.22	2,377	38.54	
Guinea corn (Sorghum)	4,653	45.23	5,721	46.03	4,842	49.12	3,479	47.19	3,008	48.77	
Maize	579	5.63	971	7.81	892	9.05	610	8.28	631	10.23	
Rice	269	2.62	261	2.10	193	1.96	244	3.31	152	2.46	
Total	10,288	100	12,429	100	9,857	100	7,372	100	6,168	100	

Source: Derived from Table 1.

.../...

Tables 1 and 2 show the position of sorghum and millet in Nigerian agriculture. They are the two most important grains in terms of land areas devoted to them and the output when compared to the other grains in the tables. One is worried, however, that while the total human population in Nigeria continues to rise it is observed from the two tables both the hectareage and the output of the two grains continue to decline. This observation is made while taking into account the proportion of the population using these two as their basic subsistence crops for both food stuffs and production of local beer. One is worried about the impact of this decline in output on the poultry industry, particularly the north-south livestock trade that appears to be decreasing and causing food prices to rise higher and higher. It therefore becomes necessary to examine the constraints to their production, storage and distribution in a socio-economic perspective.

2. Socio-economic constraints.

It is recognised that there are two kinds of constraints in the production, storage and distribution of sorghum and millet in the same manner as they affect all other agricultural activities. These constraints are (a) technical and (b) socio-economic. The technical constraint is mainly in the use of static and stagnant technology. The farm tools, the quality of seeds, the farming practices, the storage techniques and the processing methods have not changed significantly for centuries. Farmers of today appear to be doing things in the way their ancestors did them with each generation passing the same technology to posterity.

The socio-economic constraints are many and varied but they present problems that must be solved if the well-being of the farmer-producer is to improve.

2.1. Rural-urban migration. The presence of better employment opportunities outside agriculture has caused the migration into the cities of able-bodied rural young people. This has left the rural areas with very old farmers who have neither the strength nor the financial means to migrate. And because of the high wages paid in the cities the few itinerant labourers found in the rural areas demand higher wages than the farmers can pay thereby putting a limit to farm land expansion of further investment. The old farmers have to depend on the labour supply within the households whose children are already in the cities for either education or job.

The population in the rural areas has been declining rapidly since the drilling and exporting of oil and the country has become more and more food deficit. Farmers are gradually becoming discouraged and are abandoning the farms.

2.2. High marketing and distribution cost. The small and scattered nature of production units has contributed greatly to the transportation, assembling and distribution of the grains when produced. For example, the farmers, because of poor road and foot path conditions, have to depend on headloading and donkeys to transport their surplus produce to the nearby small markets where individuals engage themselves in small volumes of trade and are constantly faced with poor price communication and very little capital or credit facilities. These high marketing and distribution costs are added to the normal production costs when being passed to the consumers who, in turn, sell to the farmers their non-farm goods at prices higher than what the farmers can pay. As a consequence the farmers become poorer every succeeding year. Sometimes the farmers may have to buy back what they have sold out earlier, especially when they run out of stock for either planting or feeding. One can just imagine the hardship suffered in terms of the prices received when selling and the prices the farmers pay when buying.

2.3 Problems of agricultural extension. The extension officer has difficulty in reaching the farmers on their small and scattered units. This is why these farmers are caused to lose hours and sometimes a whole day when they are summoned to attend village meetings for the demonstration of research results or the introduction of new farming practices. But sometimes the extension officer may not have such adequate and relevant technical knowledge as may be necessary for advising the farmers. This is very common in the sorghum/millet production process because not much basic agronomic research has been done to permit the extension officer to use in advising the farmers. There is definitely an inadequacy of research effort relevant to prevailing farming systems with respect to many aspects of production, storage, processing and distribution of these two grain crops.

.../...

2.4. Deteriorating farm base. As older farmers are dying off and very few, if any young ones, are joining the picture of farming for one's living becomes pessimistic and highly unpredictable. Farm sizes become smaller and yield per hectare decreases. A number of artisans doing such work as wood carving, weaving, tie and dye, etc. and who used to make life worthwhile in the villages are gradually being replaced by industry's plastics, chemical dyes, etc. in the cities. Such artisans are being forced to change occupation and quit the villages. Some villages are becoming fully deserted, especially those ones near big urban areas where farm lands continuously give way to the development of airports, recreational and housing land requirements, schools, hospitals, etc.

3. Recommendations and Conclusions.

The problems raised so far can be tackled in a number of ways either simultaneously or one after the other.

3.1. Working within current farming practices. There is a need to evolve a wide-spectrum technology package that tackled problems without calling for drastic changes in farming practices. This is an assignment for researchers in agricultural engineering and agronomy. There is need for a thorough knowledge of the farmers' current practices before recommending improved ones.

3.2. Freeing farmers from tyranny of nature. It has been established that farmers experience a lot of hardship in the course of their jobs because of poor technology, socio-economic constraints, fluctuations in weather, pest infestation, locust invasion and high labour costs arising from fewness of rural labourers. To free these farmers from further drudgery and frustration it is necessary to provide facilities for land clearing, spraying equipment and chemical sprays, irrigation, roads, markets and possibly guaranteed minimum prices for crops produced. All these would serve as incentives for the old farmers to stay longer and encourage new ones to engage in farming. This recommendation is for governments to implement.

.../...

3.3. Training of new sets of farmers. It is necessary to train new sets of farmers to replace the old ones. Technical education in dry farming as well as the use of irrigation must form a very important part of the training. Courses in farm management especially in the areas of record keeping, storage, marketing, etc. would also be very useful. These new farmers must be provided with land, tools and money to work on the land. They must be seen as providing services that would have other-wise been at highly exorbitant costs in form of foreign exchange for food importation.

3.4. Conclusion. It has been made clear in this paper that sorghum and millet are the two most important grains in Nigeria both in terms of land areas devoted to them and the output derived from them. The socio-economic constraints to the production, storage, marketing and distribution have also been spelt out and some recommendations made. There is however need for further research into the problems raised in order to fully appreciate the current farming systems and advise farmers appropriately.

3.2. Training of new sets of farmers. It is necessary to train new sets of

farmers to replace the old ones, technical education in the training of well-

as the up-to-date information must form a very important part of the training. Courses

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etc. would also be very useful. These new farmers must be provided with land, tools

and money to work on the land. They must be given as many services as possible.

have other-wise been at highly exorbitant costs in form of foreign exchange for

food importation.

3.4. Conclusion. It has been made clear in this paper that surplus and deficit

are the two most important aspects in the study of land use and land

in the and the output derived from them. The socio-economic constraints in the

production, storage, marketing, etc. have also been brought out and some

recommendations made. It is hoped that the present research into the problems

raised in order to fully appreciate the current farming systems and related factors

appreciably.

QUESTIONS, ANSWERS AND COMMENTS ON THE PRECEDING DOCUMENTS.

Delegate from Nigeria (questions).

1. What period in the life cycle of sorghum corresponds to the third period of grain fill?
2. What is the relationship between the time potential number of seeds in sorghum is determined, and the third period of grain fill?
3. What is the mechanism responsible for the non formation or decrease in the number of seeds formed during the third period of grain fill?

INTSORMIL (answer).

Question 1 and 2 can be combined. My growth stage description was too hurried. The third period in GS₃ corresponds to the entire grain fill stage rather than to some portion of grain fill. The other two periods over the vegetative stage (GS₁ - plantening to panicle initiation) and panicle development (GS₂) which extends to anthesis.

Question two was regarding the relationship between the time when potential seed number is developed and grain fill. If conditions during GS₂ are limiting such that only a modest seed number potential in set, the result of that is felt through reduced efficiency of photosynthesis and other associated grain fill synthetic activities.

Slated differently, an inadequate Sink Size (seed number) during grain fill reduces grain production efficiency. The plants synthetic capacities will sometimes not be fully utilized if seed number is too low.

Question 3. I do not know the mechanism responsible during GS₂ for reduction of seed number potential when plants are subjected to less than favorable environmental stresses.

.../...

SAFGRAD/ICRISAT Nigeria. (comment).

Dr Eastens presentation is extremely useful in understanding plant reactions to drought and other forms of stress. In the light of this, we need to understand the drought problem of sorghum in the tropics.

Tropical sorghums are late and tall and frequently the duration of the crop is much longer than the duration of the rainy season. They have a single peak for the rate of growth coinciding with the period of flowering. The dry matter distribution is usually 70:30 between stalk and ear when late rains fail, as frequently it happens, crop failures are common. Longer grain filling period would then lose its advantage.

Delegate from Ethiopia. (comment).

Hybrid varieties. The successful use of hybrids in a country needs a good seed industry. The advantages of hybrids compared to varieties under both stress and optimal conditions are well documented.

Delegate from Senegal (comment).

No mechanism underlies "escape". The early variety, a hybrid for instance, escapes drought because it matures early.

Avoidance on the other hand is the ability of a genotype to retard its development in a way that once the drought period is over, it can complete its cycle. Thus through its elasticity it's able to avoid stress.

If the end of the rains is uncertain, the beginning is equally uncertain. In Senegal, we planted at the beginning of June for the 1979 season, but for 1980 we planted on 7th August. A variety recommended for planting in June will it do the same in August? The very basic reason for breeding is doubted. Wider or specific adaptation?

.../...

Drought is relative. Some complain when they have 600 mm or 500 mm but we think real drought is when one has 250 mm to 350 mm.

Delegate from the Gambia (question).

You mentioned that in many instances sorghum is grown in association with other crops and regardless of variety, sorghum yields are effectively increased under mixed cropping. Do you include adaptability to crop mixtures in your sorghum breeding programme or do you assume or are convinced that varieties that do well under sole cropping perform equally well under mixtures?

Delegate from Nigeria (answer).

It is probably important that such a project should be undertaken but a workable approach at the moment is to mix in adequate proportion using appropriate geometry of planting high yielding and acceptable variety of sorghum with a high yielding and acceptable variety of millet.

Another Delegate from Nigeria (comment).

I agree completely with you in your paper where you said: "National programs can and must collect and conserve their own germplasm resources". However, because of the expense and staff requirement in establishing and maintaining such collection and conservation centres it is necessary for the International Centre at ICRISAT to aid in this verifiable venture.

This aid could be in establishment and maintenance of Regional Center and where possible National Centres in special areas.

.../...

Delegate from Senegal (comment).

I recall that Senegal has been prospected sufficiently from North to South and the South West in 1976 by ORSTOM. The greater part of this material has been given to ICRISAT for keeping. My colleague who is responsible for the tripode programme whose objective is to recuperate all the genetic variability of the Pennisetum typhoides species in East and West Africa and India has already worked on the portion of the collection left in Senegal. We are aware that we can't financially support the programme that's why we should try to defend the programme on the international level. I personally work on this same material in the architecture programme for the last two years and concurrently with the use I wish to put the material, I envisage publishing a catalogue of it. The problem is that the material begins to run out while the trials are meant to be conducted over 2 or 3 more years.

Delegate from Sudan (comment).

Among the difficulties encountered in germplasm collection are:

- (1) Wide variability of sorghum both wild and cultivated. This makes it difficult for collection.
- (2) Bad roads in the places of sorghum diversity.

Suggestions.

- (1) Making Regional Collection by the breeders in their regions.
- (2) Group those collections in one international centre.

ICRISAT, Upper Volta (comment).

Prof. Adegboye has brought up a very important point on bringing the research results to the farmers field. We researchers are responsible for developing varieties and associated technologies and these are supposed to be used by the farmers profitably. If the farmers are not able to use these profitably because of socio-economic constraints, our research results remain in the experiment stations and reports.

.../...

It may be necessary for us (researchers) to look back and modify the recommended technology to make it more acceptable to the farmer. By doing so we may not be expecting highest yields, never the less if the yields are significantly higher than the yields he gets in traditional practices it will be a step in the right direction.

.../...

It was the necessity for an investigation of the
the responsibility for the accident to the
of which we may not be responsible, even the
It is the duty of the State to
to the State to the right of the State.

A N N E X E S

RECOMMENDATIONS.

VOTE OF THANKS TO THE HOST GOVERNMENT.

The OAU/STRC JP 31 SAFGRAD Second Sorghum and Millet wishes to express its sincere thanks to the Government of Botswana, the Ministry of Agriculture, and to the people of Botswana for the excellent facilities provided for the meeting at Gaborone, and for the hospitality and friendliness shown to participants.

VOTE OF THANKS TO THE DONORS AGENCIES.

The workshop also wishes to express its gratitude to the Donor agencies which have supported the SAFGRAD project, particularly the United States Agency for International Development and the French Fund for Cooperation.

VOTE OF THANKS TO OAU.

The workshop notes with great pleasure the endorsement the OAU, at its 36th Ordinary Session of the Council of Ministers held in Addis-Ababa, February 23 March, 1981, gave to the work to continue, expand and reach other OAU Member States not now fully being covered. The workshop will appreciate more and fuller support in the future.

COLLABORATION WITH OTHER ORGANIZATIONS.

The workshop, noting the activities and programs of the different national, (IAR-ABU, University of Ibadan) sub-regional (C.I.L.S.S.), regional (SAFGRAD) and International Organizations such as ICRISAT, INTSORMIL etc., working on sorghum and millet improvement, recommend

1. That agreed research programs be mutually supportive and complementary and the cooperation between SAFGRAD and these organizations be expended and intensified.

.../...

2. - Well defined objectives for research and production programmes ;
3. - Regional Sorghum and Millet trials in the respective ecological zones ;
4. - Regional genotype x Fertilizers x population study in interested States ;
5. - That seed material for regional trials be obtained from the States concerned and other international agencies which promised to send seeds to Ouagadougou before April 10, 1981 ;
6. - That the state cooperators be responsible for regional trials at identified states in respective member countries ;
7. - That an appropriate format be developed for future annual country reports ;
8. - That facilities for germplasm availability to national programmes be developed in collaboration with ICRISAT, IBPGR, etc. ;
9. - That cooperative efforts on regional basis be fostered, national research programmes strengthened and training facilities at various levels promoted ;
10. - That invitations to SAFGRAD workshops be sent well in advance to member countries with direct intimation to relevant research workers ;
11. - That in future participants be advised to bring 3-5 kg. of seeds of each entry for regional trials and attempts also be made to create a central seed multiplication facility at a suitable location ;
12. - That SAFGRAD programme be extended to Eastern and Southern African regions and that SAFGRAD employ African research scientists ;
13. - In order to effect a better coordination of research activities in member countries that the position of director of research be created ;

14. - That a suitable research strategy for the improvement of Sorghum and Millet for the 1982-1985 period be developed to meet the needs of member states and be discussed at the next meeting ;
15. - That a Pan African approach on control of birds be intensified and encouraged ;
16. - That effective documentation on the workshops and other findings be properly done either by way of special SAFGRAD Bulletins or publications ;
17. - That the facilities available in some African Universities and Institutes be utilized in the training of potential staff of member countries and SAFGRAD ;
18. - That nitrogen fixing lines be initiated and encouraged ;
19. - That recommendations made at workshops be reviewed at the following ones as a means of evaluation progress or shortcomings of SAFGRAD ;
20. - That quarantine regulations be slightly relaxed, whenever possible for the mobilization of germplasm.

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