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USAID/SAFGRAD/OAU-STRC/ICRISAT

West and Central Africa Sorghum Research Network
(WECASORN)

BASIC INFORMATION ON WECASORN

SECOND EDITION

REVISED AND UPDATED

International Crops Research Institute for the Semi-Arid Tropics
(ICRISAT)

West African Sorghum Improvement Program
(WASIP)

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1. BACKGROUND

The first regional sorghum workshop sponsored by SAFGRAD/USAID/ ICRISAT was held in Ouagadougou, Burkina Faso from 27-30 November, 1984. During that workshop, representatives from NARS agreed that ICRISAT should coordinate the West and Central Africa Sorghum Research Network (WECASORN). It was attended by a total of 46 participants from 16 countries. There were also representatives from ICRISAT, IRAT, INSAH/CILSS, and SADCC/ICRISAT. The idea of a regional approach to sorghum improvement was discussed and approved. WECASORN became operational in 1985 when a Steering Committee was formed. The Committee consisted of representatives from NARS as members and representatives from several regional organizations as observers.

Phase II of SAFGRAD started in September 1, 1986 and ended in August 31, 1991. However, a transitional phase was financed by USAID upto 31 December 1992. USAID, through SAFGRAD which is a component of the Scientific Technical and Research Comission (STRC) of the Organization of African Unity (OAU), provided a grant of 3.1 million dollars for phase II for both WECASORN and the Eastern Africa Sorghum and Millet Network of which WECASORN received 1.6 million dollars. This grant was sub-contracted to ICRISAT whose West African Sorghum Improvement Program in Mali (WASIP-Mali) executes the project, with the provision of a Coordinator. The execution of the project by ICRISAT was carried out from Ouagadougou upto June 1988 when ICRISAT's sorghum program was re-organized and moved to Bamako as WASIP-Mali.

2. IMPORTANCE OF SORGHUM

In the semi-arid ecology of West and Central Africa, sorghum *Sorghum bicolor (L) Moench* is an important crop in the diet of the population and can be regarded as the staple food in several countries. Most of the sorghum is grown in the Sudanian Zone (500 - 1000 mm rainfall) and the Northern Guinean Zone (1000 - 1200 mm rainfall). Some sorghum is also grown in southern Sahelian Zone (400 - 500 mm rainfall). Together with pearl millet (*Pennisetum glaucum (L) R.Br.)*, sorghum provides the main energy source for the people of the Sudanian and Northern Guinean Zones, and is probably the most important food crop in semi-arid West Africa. The 17 member countries of WECASORN, their corresponding area harvested, yield and production figures for sorghum are given in Table 1.

3. OBJECTIVES OF WECASORN

The purpose of the USAID grant was to address the sorghum improvement problems of West Africa by concentrating on constraints having regional significance, and by establishing the necessary links with national, regional and international institutes to serve the entire region effectively. The objectives of WECASORN as

outlined in the Project Document are:

a) To increase the production of sorghum thereby contributing to the stabilization of food supplies in the region and contributing to improved nutrition and income for farmers in the drier areas of the region;

b) To assist and strengthen national sorghum improvement programs, and contribute to their research needs in all agroecological semi-arid zones;

c) To develop improved varieties and hybrids and agronomic/management practices capable of giving higher and more stable economic yields in the semi-arid environments;

d) To organize and promote systematic regional testing of available and improved genetic material and technology in the semi-arid zone;

e) To facilitate the development of agricultural research manpower among West Africa nationals at all levels; and

f) To organize regional workshops and monitor uniform yield trials through field inspections.

4. NETWORK PROGRAM AND IMPLEMENTATION STRATEGY

The main activities of the Network are as follows:

- Training
- Regional trials and nurseries
- Research projects
- Monitoring tours
- Regional workshops
- Visits to NARS.
- steering committee meetings

Administrative and technical support are given by WASIP-Mali, except for hybrid production which is carried out by WASIP-Nigeria. Prior to June 1989, the Coordinator was also the Team Leader of WASIP-Mali. At present ICRISAT provides a Coordinator who is with the WASIP-Mali team. The Coordinator implements the decisions of the steering committee which meets on the average twice a year, and is the driving force of the Network. The Coordinator carries out the day-to-day activities of the Network by making use of all levels of technical and administrative staff of WASIP-Mali.

With regard to personnel, a bilingual secretary and a driver are provided by Network funds. The Coordinator is in close consultation with the Team Leader of WASIP-Mali. Direct links exist between the Coordinator and SAFGRAD Coordinating Office (SCO) in Ouagadougou.

Yearly progress reports are prepared by the Coordinator and submitted to USAID, Ouagadougou through the Executive Director of ISC. The Coordinator disburses funds for the activities of the Network and financial reports are prepared on a monthly basis by WASIP-Mali accounts section. These financial reports are sent directly to ICRISAT Center (IC) in Hyderabad, India, which has the responsibility to submit them to USAID in Ouagadougou.

Major recommendations are made by representatives from NARS at regional workshops which are held every two years. Members of the steering committee are also elected at these workshops. The present steering committee consists of representatives from six member countries and the Coordinator as follows:

- Mali (Chairman)
- Burkina Faso
- Cameroon
- Senegal
- Nigeria
- Chad
- Coordinator.

Regular observers are, INSAH, IRAT, SAFGRAD and USAID.

The steering committee recently decided that the Team Leaders of both WASIP-Mali and WASIP-Nigeria should always be invited to attend as observers. Global 2000 has recently been invited as an observer.

5. SUMMARY OF ACTIVITIES AND ACHIEVEMENTS

5.1. Research projects

5.1.1. Background and Objectives

At the fifth steering committee meeting of WECASORN held in Bamako between 5 and 11 May, 1989, it was decided that the Network should fund research projects in some of the NARS. Prior to that decision, national programs had been classified into lead, associate and technology adopting NARS (Table 2). The classification was based on the extent to which certain biotic and abiotic factors limited sorghum production in a given NARS. The availability of qualified scientists to carry out research on these stresses and on certain aspects of food technology were also taken into account. The steering committee thought that there was a need to encourage capable scientists in NARS to carry out research on problems common to sorghum production in the region. Based on the classification of NARS into lead, associate and technology adopting centers five lead NARS were requested in 1989 to submit research proposals on various constraints. These were Burkina Faso on anthracnose (pathology), Niger on long smut (pathology), Mali on head bugs (entomology), Cameroon on *Striga*, and Nigeria on

wheat-sorghum composite flour (utilization). In 1990, the steering committee agreed to fund a second project in Niger on grain quality. The titles of the projects, funding and reports received are given in Table 3.

The objectives of the project on anthracnose in Burkina Faso are to identify sources of resistance to anthracnose and to determine if local races (pathotypes) of the anthracnose fungus exist.

The objectives of the project on long smut are to develop effective inoculation techniques and to screen sorghum germplasm from the Niger national program and from other national programs in the Network for resistance to long smut.

The entomology project has as its objectives the following:

- to determine the zones in Mali with high head bug infestation in farmers' fields;
- to evaluate the economic importance of head bugs in the different zones in which sorghum is grown in Mali;
- to study the biology of the insect;
- to develop a regional nursery for the study of stable resistance to sorghum head bugs.

The project on *Striga* is on screening of sorghum germplasm from Cameroon and other countries against *Striga hermonthica* under heavily infested field conditions. The major objective of the *Striga* project is to identify suitable sources of resistance in sorghum to *Striga*. Other objectives include the identification of a suitable screening methodology and multilocational testing of resistant genotypes identified from the project.

The title of the project on wheat-sorghum composite flour is, Technology for Production of Acceptable Wheat-Sorghum Composite Bread and Confectionery. The objectives of this project are:

- to develop a technology for producing acceptable local wheat-sorghum composite bread and confectionery, aimed at increasing the sorghum component as high as possible;
- to test the developed technology for wheat-sorghum composite bread and confectionery in industrial pilot plants;
- to test the new technology in selected commercial bakeries;

- to determine the acceptability in Nigerian markets of bread and confectionery produced from wheat-sorghum composite flour.

The objectives of the grain quality project are:

- to develop and conduct laboratory tests that can be used to characterize seeds of local and improved sorghum for human consumption;

- to analyze seeds of the best varieties from the Network trials and from national programs;

- to test germination percentage after 6, 9 and 12 months of storage under traditional conditions.

5.1.2. Significant Results

Significant results from research projectS on a yearly basis are summarized in Table 4.

Anthracnose Project

The project on anthracnose used the composite spreader row technique to screen a total of 80 sorghum lines, of which 56 were local varieties and 24 were introduced genotypes. Seventy-four out of the 80 lines tested were resistant (mean score of 3 or less in a 1-6 scale) to the foliar stage of the disease. Of the six susceptible lines, four were introduced genotypes. Only one introduced genotype was susceptible to stem infection. Grains of 30 out of the 80 lines were free of the fungus. The level of grain contamination by the anthracnose fungus *C. graminicola* was higher in introduced genotypes. Nineteen local and three introduced varieties were identified as having a rate reducing-like resistance to leaf anthracnose. Also, 16 local and nine introduced varieties were resistant to the stalk phase of the disease. Thirty-six locals and seven introduced varieties had 10% or less of their grains contaminated with the anthracnose fungus.

Long Smut Project

Attempts were made to develop a suitable artificial inoculation technique to screen for the disease. Only one or two sori developed on three plants 20 days after inoculating several plants using three forms of inoculation techniques. Eleven out of 75 genotypes were highly resistant (score of 0, on a 1-4 scale) to long smut from natural inoculum. The results further showed a positive correlation between infection and the maturity cycle of the genotypes tested. Late maturing genotypes were more susceptible. In another experiment, 24 out of 57 sorghum lines tested were identified as resistant, based on infection from natural inoculum at two locations. The longevity of the teliospores of the long smut

fungus under laboratory conditions was increased when stored dry, as compared to storage under humid conditions. In preliminary pot experiments, infection (number of sori) was much higher when plants were inoculated with basidiospore (sporidia) compare to teliospore.

Head Bug Project

Results from the head bug project in Mali indicated that the population of *Eurystylus marginatus* was more abundant towards the end of September and October. Early planting resulted in no attack by *E. marginatus*, whereas two generations of the insect developed in late planted sorghums. In a screening experiment 25 out of 100 lines were resistant to *E. marginatus*. Further resistant lines were identified in an advance trial and in an international trial. A limited survey in farmers' fields revealed that in certain localities, *E. marginatus* attack was higher in introduced lines than in locals. However, the level of attack depended on the locality. Some local varieties were severely attacked in some areas. A further 21 lines out 51 were identified as resistant in a preliminary nursery. The resistance of nine sorghum varieties identified in preliminary nurseries for two years, was confirmed by artificial inoculation.

Striga Project

Based on counts 20 days after sowing, 14 lines in two separate trials had relatively low *Striga* infection ($\leq$ 10 per m^2). All 12 entries in the 1991 and 1992 *Striga* regional trial came from the *Striga* project.

Wheat-Sorghum Composite Flour Project

Major progress made after the first year included the identification of Farafara as the most suitable sorghum variety for wheat-sorghum composite bread and confectionery. In the laboratory, acceptable bread can be produced with up to 50% level of wheat substitution by sorghum. Also, acceptable confectionery can be produced with up to 60% level of sorghum substitution. In general, it would appear that composite bread was lower in volume and had a shorter shelf life than 100% wheat bread. Incorporation of a small fraction (0.50%) of cassava starch flour to the composite flour produced bread which was more spongy, closer textured and less crumbing. However, cassava shortened the shelf life of the bread. In addition, the nutritional status of the wheat-sorghum bread was lower than that of pure wheat bread. With the limited sales undertaken, wheat-sorghum composite bread appeared popular, especially among low income groups, probably because it was more filling than pure wheat bread.

5.2. Regional Trials

The Network conducted the following trials:

1. The West African Sorghum Variety Adaptation Trial, early duration (WASVAT-E).

2. The West African Sorghum Variety Adaptation Trial, medium duration (WASVAT-M)

3. The West African Sorghum Hybrid Adaptation Trial (WASHAT)

4. The West African Sorghum Disease Resistance Nursery (WASDRN)

5. The West African Sorghum *Striga* Trial (WASST).

The varietal and hybrid trials were started in 1986, the disease nursery in 1987 and the *Striga* trial in 1988. The Coordinator multiplied and dispatched seeds for all the trials except those of the hybrid trial. Hybrids for WASHAT were multiplied and dispatched by WASIP-Nigeria. Table 5 gives the percentage of results received based on the number of sets of trials dispatched per year.

Whereas in 1986 all the test varieties in WASVAT-E, WASVAT-M, and WASHAT were contributed by ICRISAT, in 1991, 73, 53 and 11% of the test varieties, respectively, were from NARS. Similarly, NARS contributed no varieties to the disease nursery and only 9% to the *Striga* trial in 1988. By 1991, 43 and 100% of the varieties for the disease and *Striga* trials, respectively, were from NARS (Table 6). Twenty scientists from 17 countries participated in conducting the regional trials, of which 75% were breeders, 17% were pathologists and 8% were agronomists. A total of 206 varieties were tested in the four trials (two WASVATs, WASDRN and WASST) between 1986 and 1992, and 89 hybrids between 1986 and 1991.

Majority of the highest yielding varieties in the two varietal trials, WASVAT early and medium duration, were ICRISAT varieties. Yields in these varieties ranged from 1.90 to 3.66 t ha^{-1}. However, varieties contributed by NARS were among the four highest yielding entries (Table 7). For example, Nagawhite from Ghana was the highest yielding variety in WASVAT-early in 1987 (2.80 t ha^{-1}) and in 1988 (3.55 t ha^{-1}. It became a "standard" control in future years. In 1990, CE 196-7-2-1 from Senegal and CS 85 from Cameroon were the highest yielding varieties in WASVAT early and medium , respectively, with yields of 2.53 and 2.09 t ha^{-1}, respectively (Table 7).

ICRISAT developed the hybrids for the regional trials (WASHAT). However, in 1989 the national program of Niger contributed two hybrids and they were also included in WASHAT for

1990 and 1991. One of the hybrids from Niger, Tx 623 A x MR 732, was among the four highest yielding entries in 1989. Yields of the four best hybrids between 1986 and 1991 ranged from 2.64 to 3.71 t ha^{-1} (Table 7).

Entries in the disease nursery (WASDRN) were considered resistant if their mean disease severity score across locations (MDSL) was ≤ 3.0, and moderately resistant if their MDSL was between 3.1 and 3.5. the scores were based on a 1-6 scale. Only leaf anthracnose and gray leaf spot occurred in sufficiently high levels of infection in all locations between 1987 and 1991. During this period a total of 15 and 35 varieties were identified as either resistant or moderately resistant to leaf anthracnose and gray leaf spot, respectively.

With respect to the *Striga* trial (WASST), the same entries were tested for three years between 1988 and 1990. Two varieties, IS 9830 and ICSV 1007 BF had relatively low *Striga* infection in 1988 and 1989. ICSV 1001 BF (Framida) was the only variety with low *Striga* counts in both 1989 and 1990. Five of the six resistant varieties for 1990 had not been identified as resistant in 1988 and 1989. A new set of entries were evaluated in 1991 and the following seven lines had low *Striga* counts: CS 54 X Djigari, CS 141, CS 95, CS 54, IS 15823, S 35, and IS 1260.

At the eighth steering committee meeting held on 3 and 4 December 1990, six promising varieties tested in WASVAT early and medium were selected for further observation in NARS. Accordingly, 50g each of ICSV 1083 BF, ICSV 111 IN, CE 180-33, ICSV 1063 BF, ICSV 1089 BF and Malisor 84-1 were sent to 11 NARS in May 1991, together with a technical information bulletin. Collaborators were requested to grow the six varieties in at least three locations in their respective countries and fill out a technical information bulletin.

The Coordinator received requests from Mauritania early in 1992 and more recently from Ghana for seeds of Nagawhite and ICSV 16-5 BF, respectively. Between 10 and 20kg of Nagawhite and 2kg of ICSV 16-5 BF were requested. Nagawhite was developed by the national program of Ghana, whereas ICSV 16-5 BF is an ICRISAT variety. The request from Mauritania for Nagawhite was transmitted to the Ghana national program through SCO.

5.3. Human Resource Development

5.3.1. Training

Striga Training Workshop

The first training workshop was on *Striga* control and was held in Ouagadougou, Burkina Faso, from 5 to 10 October, 1987. There were 12 participants from the following 11 countries: Burkina Faso,

Cameroon, Gambia, Ghana, Kenya, Mali, Niger, Nigeria, Sudan, Togo, and Uganda. Two participants came from Uganda. In addition to ICRISAT scientists, specialists from IRAT, Sudan, and Old Dominion University assisted in the training.

Training Workshop on Agronomic Research and On-Farm Testing

This workshop was held in Bamako, Mali between 9 and 29 September, 1989. Nine out of ten countries invited were represented. The representative from Central African Republic was absent. The countries invited were Central African Republic, Côte d'Ivoire, Gambia, Ghana, Guinea Bissau, Mauritania, Niger, Nigeria, Senegal, and Sierra Leone. There was a total of 11 lectures and five field visits. Lecture topics ranged from soil fertility, control approaches to *Striga*, and crop and animal interaction to principles of on-farm testing. Field visits included a trip to the Cinzana research station some 270 km from Bamako, the national program at the Sotuba station just outside Bamako, a special *Striga* field trip to Katibougou, about 70 km north of Bamako, and WASIP-Mali trials at the new site Samanko, 18km from Bamako.

Crop Protection

One participant each from Chad, Côte d'Ivoire and Senegal attended this in-service training on *Striga*, entomology and pathology, respectively, for ten days at ICRISAT in Bamako.

5.3.2. Regional Workshops

The first regional sorghum workshop was held in Ouagadougou, Burkina Faso from 27-30 November, 1984. At this workshop, the NARS requested ICRISAT to coordinate the network activities. It was attended by a total of 46 participants from 16 countries. There were also representatives from IC, IRAT, INSAH/CILSS, and SADCC/ICRISAT.

The second regional workshop was held in Bamako, Mali from 21-24 October, 1985. This workshop was attended by 47 scientists from 15 countries. Representatives from IC, IRAT, INSAH/CILSS, SAFGRAD, INTSORMIL, and TROPSOIL also attended. During this workshop, a steering committee was formed.

The third regional workshop was held in Maroua, Cameroon from 20-23 September, 1988. It was attended by 52 participants from 14 countries. It was also attended by representatives from IRAT, ICRISAT, and SAFGRAD. A total of 33 technical papers were presented.

The fourth regional workshop was held in Niamey between 7 and 14 March, 1991 as part of the Inter-Network Conference for all of SAFGRAD networks. Twenty representatives from 15 NARS participated in the sorghum section of the conference. In addition, there were

16 other participants from various regional and international organizations, including seven principal staff and five research assistants from WASIP-Mali, ICRISAT Bilateral Program in Mali and WASIP-Nigeria. During the joint session of all the networks, three scientific papers were presented from the sorghum network. In the separate sorghum network session, 10 scientific papers and 15 country reports were presented. Recommendation groups on agronomy, breeding, plant protection, and sorghum utilization were formed.

5.3.3. Monitoring Tours

1986. Six scientists from Benin, Central African Republic, Gambia, Mauritania, Nigeria and Senegal visited national programs in Cameroon, Gambia, Nigeria and Senegal from 23 September to 6 October, 1986. The visiting national scientists were able to exchange views on sorghum production problems, and the on-going research programs in the countries visited.

Five scientists from the national programs of Ghana, Guinea Bissau, Mali, Niger and Sierra Leone visited the research stations located at Kamboinsé, Saria and Farako-Ba in Burkina Faso during 13-16 October 1986 to observe breeding material, experimental varieties and hybrids.

1987. Eleven Representatives from the national programs of Benin, Burkina Faso, Cameroon, Chad, Cote d'Ivoire, Gambia, Niger, Nigeria, Senegal, Togo and Mali visited Burkina Faso. The participants monitored sorghum research activities in the national program, and the on-going ICRISAT's research work.

1989. A monitoring tour was organized between 9-18 October, 1988 in which seven representatives from Benin, Burkina Faso, Cameroon, Guinea, Mali, Chad and Togo visited Mali, Burkina Faso and Niger. They visited national, regional and international trials and nurseries at Sotuba, Samanko and Cinzana in Mali, Farako-Ba and Saria in Burkina Faso, and Lossa, Tillabery and Maradi in Niger.

1991. A "mini" monitoring tour was organized between 10 and 12 October 1991. Three scientists from Niger, Nigeria and Chad visited the national program of Mali.

5.3.4. Visits to National Programs

Steering committee members assisted the Coordinator in visiting NARS. During each of these visits, information was collected based on Terms of Reference for Visits to National Programs developed by the Network. These included information on manpower. Details are given in Table 8.

5.3.5. Working Group Meetings on Research Projects

Working group meetings were held in April 1990 for the projects on anthracnose and head bugs, in September 1990 for the project on wheat-sorghum flour, in March 1991 for the *Striga* project, and for all the projects in March 1992. The principal investigators of the projects on anthracnose and grain quality from Burkina Faso and Niger, respectively, did not attend the meeting in March 1992. During the working group meetings, results were presented followed by discussions and suggestions. Each project was evaluated by at least one expert for a given discipline from NARS, using standard evaluation forms.

5.3.6. Special Meeting on *Striga*

In accordance with the recommendation made at the tenth steering committee of WECASORN, a special meeting of selected *Striga* researchers was sponsored on 11 and 12 March, 1992 in Bamako.

The objectives of the meeting were:

- To discuss recent results obtained.
- To develop common research agendas for various aspects of *Striga*.
- To synthesize observations and results presented.

Participants included *Striga* researchers from the national programs of Senegal, Cameroon, and Burkina Faso and from FAO, ICRISAT, and IRAT-CIRAD. The Coordinators of the Pan African *Striga* Network and the West and Central Africa Cowpea Research Network were also present.

5.4. Policy - Steering Committee Meetings

A total of 11 steering committee meetings were held between 1986 and 1992. Dates and number of participants are given in Table 9.

5.4.1. Landmark Decisions

The first meeting of the steering committee of WECASORN took place in Ouagadougou between 13 and 14 January 1986. The following terms of reference for the steering committee were agreed upon :

1. the steering committee will play a key role in guiding the network activities.
2. The steering committee will monitor the execution of recommendations adopted by the general assembly during workshops.

3. The steering committee will propose for discussion at the regional workshops new themes/ideas of interest to the network and related plan of action.

4. The steering committee, through the network Coordinator, will send a report of its decisions to all the members of the network. This report will be a subject of discussion in the next workshop.

- Organization of a *Striga* training workshop and collaborative research projects with NARS (2nd meeting, March 1987).

- Number of committee members to be increased from four to six. The name of the Network changed to include Central Africa (3rd meeting, December 1987).

- Research projects identified in five NARS and funds made available. Lead NARS scientists should help the Coordinator visit weaker NARS. Promote intensive evaluation of selected promising varieties from the regional trials. Global 2000 to be invited as regular observer.
(5th meeting, May 1989)

- $ 1000 be paid to the 12 non-lead NARS in support of their research activities on sorghum. INTSORMIL and the Team Leaders of ICRISAT's regional programs in Mali and Nigeria to be invited as regular observers.
(7th meeting, May 1990)

- The Network should start regional trials in agronomy and organize an in-service training on plant protection. Financial support to non-lead NARS was increased from $ 1000 to $ 2000.
(8th meeting, December 1990)

- The Network should help organize a meeting of selected scientists from NARS working with *Striga*, and organize an in-service training course on sorghum production and experimentation for technicians.
(10th meeting, November 1991)

- The *Striga* and long smut projects should receive funding of $ 5000 each during the transition period.
(11th meeting, June 1992)

6. TECHNOLOGY TRANSFER - THE QUESTION OF IMPACT

6.1. In Research and Extension

Based on eight responses to a questionnaire sent to collaborators in the 17 member countries of WECASORN in early 1992, and considering only the varieties tested in the regional trials and nurseries, a total of 35 varieties and one hybrid are at various

levels of use in seven NARS. The 35 varieties constitute 17% of the total 206 varieties tested in the regional trials between 1986 and 1992. Seventeen or 48.5% of the 35 varieties were contributed by NARS and 18 or 51.5% were contributed by ICRISAT. Only one, or 1.1% of the total 89 hybrids tested between 1986 and 1992 is being used. This hybrid, ICSH 507, is under observation at the research station level in 0.25ha in Côte d'Ivoire. The respondent did not indicate which year this hybrid was placed under observation.

The information in Table 10 gives a primary level impact of the regional trials and nurseries. Through these regional trials NARS were able to exchange germplasm and to make use of them in their research programs. For example, considering the 35 varieties under use, the 17 from seven NARS are being used in various levels of research in six other NARS. Of the 18 varieties contributed by ICRISAT, 15 were developed by the breeding programs of ICRISAT. These 15 ICRISAT varieties with the prefix ICSV are at various levels of use in six NARS (Tables 10 and 11). It should be mentioned that ICRISAT has used Nagawhite from Ghana in crosses in its breeding program in West Africa.

The second level of impact, with respect to germplasm exchange involves the actual use of the germplasm. This information is summarized in Table 11. Based on the responses from eight collaborators in seven countries, 13 or 37.1% of the total 35 varieties under use are being tested in farmers' fields in three countries, six (17.1%) are being observed at research stations in three countries, and one variety each (2.8%) is either in demonstration plots or in multilocation tests in two separate countries. Eight varieties (22.8%) are at the pre-release stage in five countries and one variety (2.8%) has been released in one country. Furthermore, 20 varieties (57.1%) have been used in crosses in four countries (Table 11).

6.2. As Food and beverages

Responses to the questionnaire revealed that among the varieties tested in the regional trials, Framida is used by some farmers to prepare solid food and drinks in Guinea (Conakry), Togo and Ghana. In addition, CSM 388 and ICSV 111 IN are used to prepare solid food in Mali and Ghana, respectively.

7. FUTURE THRUST

The following activities are proposed for the future:

a) Expand on-going research projects with NARS and initiate new ones to be based on a revised list of constraints. Thus, it is envisaged that the Network will become more of a "research" network than a "trials" network;

b) Organize in-service training in various disciplines, but with emphasis on agronomy, food technology and utilization;

c) Share responsibility of seed multiplication and dispatch of regional trials and nurseries between ICRISAT and strong NARS with the requisite capability;

d) Degree training up to M.Sc. and Ph.D levels according to the needs of the NARS;

e) Assist the NARS in developing promising varieties and hybrids with high and stable yields;

f) Facilitate the exchange of germplasm between member states;

g) Organize annual research working groups on the collaborative research projects with active participation of NARS;

h) Organize germplasm collection and evaluation within agronomic packages for the NARS;

i) Organize once every two years scientific meetings and regional workshops as the forum for evaluating progress and planning for the future;

j) Organize monitoring tours in years when scientific meetings and regional workshops are not scheduled.

An enormous effort will be made to ensure the flow of technology developed in the Lead Centers where research projects are carried out, to the Associate Centers. In shifting the overall emphasis of the Network from a "trials Network" to a "research Network", this activity will become a priority. The role of a research associate as a Network staff will be extremely important in this regard by working closely with principal investigators in the Lead Centers, researchers in the Associate Centers, and encouraging the Technology Adopting Centers to implement the "finished" product.

8. ACRONYMS

CILSS	Comité permanent inter-Etats de lutte contre la sécheresse dans le Sahel (Burkina Faso)
CIRAD	Centre de Cooperation internationale en recherche agronomique pour le développement (France)
FAO	Food and Agriculture Organization of the United Nations (Italy)
IC	ICRISAT Center (India)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics (India)
INSAH	Institut du Sahel (Mali)
INTSORMIL	International Sorghum/Millet, Collaborative Support Program (USA)
IRAT	Institut de recherches agronomiques tropicales et des cultures vivrières (France)
ISC	ICRISAT Sahelian Center (Niger)
NARS	National agricultural research system(s)
OAU	Organization of African Unity (Ethiopia)
SADCC	Southern African Development Coordination Conference (Botswana)
SAFGRAD	Semi-Arid Food Grain Research and Development (Burkina Faso)
SCO	SAFGRAD Coordinating Office (Burkina Faso)
STRC	Scientific technical and research commission of OAU (Nigeria)
TROPSOIL	Soils Management Collaborative Research Support Program (USA)
USAID	United States Agency for International Development
WASDRN	West African sorghum disease resistance nursery
WASHAT	West African sorghum hybrid adaptation trial

WASIP-Mali	West African Sorghum Improvement Program of ICRISAT (Mali)
WASIP-Nigeria	West African Sorghum Improvement Program of ICRISAT (Nigeria)
WASST	West African sorghum *Striga* trial
WASVAT	West African sorghum variety adaptation trial
WECASORN	West and Central Africa Sorghum Research Network

Table 1. Sorghum Production in WECASORN Countries.[1]

Country	Area Harvested (1000 ha)	Yield (kg/ha)	Production (1000 MT)
Benin	150*	707	106
Burkina Faso	1295*	860	1113*
Cameroon	500 F	800	400*
Centr.Afr.Rep.	45 F	889	40 F
Chad	496	736	365
Côte d'Ivoire	47*	617	29*
Gambia	12*	855	10*
Ghana	263	919	241
Guinea	25 F	1400	35 F
Guinea Bissau	13*	870	11*
Mali	750 F	972	729*
Mauritania	100 F	590	59
Niger	2067 F	229	472
Nigeria	4600 F	1043	4800 F
Senegal	95*	893	85*
Sierra Leone	39	565	22
Togo	165 F	642	106
World	44702	1292	57763
Africa	19031	795	15130

1. Source: The FAO Production Yearbook 1991.
F = FAO estimate
* = Preliminary data

Table 2. Distribution of the more important biotic and abiotic stress factors of sorghum and classification of national programs into Lead, associate, and Technology Adapting Countries.

	Insects		Diseases					*Striga*	Grain			
Country	PAN	BOR	GM	SS	AN	GL	LS		QL	UT	DR	ST
Burkina Faso	A	A	L	A	L	A		A	A			
Cameroon				A	A	A		L			A	A
Mali	L		A	A	A	A	A	A	A		A	A
Niger		A					L		L		A	
Nigeria	A	L	A				A	A		A	A	L
Côte d'Ivoire	A											
Ghana	A		A									
Benin												
CAR												
Tchad												
Gambia											A	
Guinea												
Guinea Bissau												
Mauritania												
Senegal												
Sierra Leone												
Togo												

1. Stress factors: PAN: panicle, BOR:borers, GM: grain molds, SS: sooty stripe, AN: leaf and stem anthracnose, GL: gray Leaf spot, LS: Long smut, QL: grain quality, UT: grain utilization, DR: draught, ST: stand establishment.
Classification: L: Lead Centers, A: Associate Centers. The others are Technology Adopting Centers.

Table 3. Country, project title, amount paid so far and reports received for the six research projects of WECASORN.

Country	Project title	Amount paid and date			Reports Received	
		$	CFA	Date	Technical	Financial[4]
Burkina Faso	Identification of sources of resistance to leaf anthracnose of sorghum (*Sorghum bicolor*) caused by *Colletotrichum graminicola* (ces) Wilson in Burkina Faso	2500	877500	28/6/89	Preliminary, 1989	Complete
		2500	787238	24/11/89	First year, 1989	Complete
		2500	712500	22/6/90	Second year, 1990	Complete
		4000	1120000	7/5/91	Third year, 1991	Complete
Cameroon[1]	Screening of local germplasms of Cameroon and other countries against *Striga hermonthica* in heavily infested field conditions	2500	705000	29/6/90	First year, 1990	Complete
		2500	700000	7/5/91	Second year, 1991	Complete
Mali	Studies on head bugs of sorghum in Mali	2500	827500	26/6/89	Preliminary, 1989	Complete
		2500	790000	25/10/89	First year, 1989	Complete
		2500	712500	19/6/90	Second year, 1990	Complete
		2500	630500	26/10/90	Third year, 1991	Complete
Niger	1. Identification of resistance to long smut	2500[2]	-	-	Preliminary, 1989	Complete
		5000	1200000	5/9/92	Third year, 1991	Complete
	2. Morphologic, Chemical and Nutritive Characterization of seeds of local and improved sorghum in West and Central Africa	2500	700000	7/5/91	-	-
Nigeria	Technology for production of acceptable wheat-sorghum composite bread and confectionery	2500[3]	-	-	Preliminary, 1989	Complete
		2500[3]	-	-	First year 1989/90	Complete
		5589[3]	-	-		

1. Received $ 5000 in 1992
2. Paid through ICRISAT Sahelian Center, Niamey.
3. Paid through ICRISAT, Kano.
4. Complete = Total amount justified.

Table 4. Significant results on a yearly basis from WECASORN's research projects.

Project	Country	Year Project started	Significant results		
			Cropping season		Results
1. Anthracnose	Burkina Faso	1989	1989	1.	Identified 74 out of 80 lines screened as resistant to foliar infection.
				2.	Grain of 30 lines were free of the fungus. Grain contamination was higher in introduced varieties.
			1990	1.	The resistance to foliar infection observed in 1989 was confirmed in 70 lines.
				2.	A total of 44 lines, all local varieties, were resistant to leaf, stem and grain infection.
				3.	Disease progress more rapid in introduced varieties.
			1991	1.	Identified 19 local varieties and three introduced varieties with rate reducing-like resistance to leaf infection.
				1.	Eleven out of 75 varieties screened were highly resistant.
2. Long smut	Niger	1989	1990	2.	Late maturing varieties were more susceptible.

Table 4 continued.

Project	Country	Year project started	Significant results	
			Cropping season	Results
			1991	1. New sets of 24 varieties identified as resistant at two locations.
				2. Longevity of teliospores of the long smut fungus was increased when stored dry.
				3. Infection was higher when plants were ino-culated with sporidia than with teliospores
3. Head bugs	Mali	1989	1989	1. Population of the head bug insect was high at the end of September and October.
				2. Early planting resulted in no attack, whereas two generations developed in late planted sorghums.
				3. Twenty-five out of 100 lines were resistant.
			1990	Results obtained in 1989 were confirmed.
			1991	1. Identified 21 new sources of resistance out of 51 lines screened in a preliminary nursery.
				2. The resistance of nine varieties identified in 1989 and 1990 were confirmed by artificial inoculation.

Table 4 continued.

Project	Country	Year project started	Significant results	
			Cropping season	Results
4. *Striga*	Cameroon	1990	1990	The project multiplied eight varieties and two germplasm lines resistant to *Striga*, for entries in regional *Striga* trial.
			1991	1. Fourteen lines with low *Striga* counts identified.
				2. All 12 entries in the *Striga* regional trial came from the project.
5. Wheat-sorghum flour[a]	Nigeria	1989		1. Local Farafara variety identified as most suitable sorghum variety for the composite flour.
				2. Upto to 50% substitution of sorghum for bread and upto 60% for confectionery.
				3. Addition of 0.5% Cassava starch flour to the composite flour produced more spongy bread, closer textured and less crumbling, but shelf life was shortened.
				4. Wheat-sorghum composite flour bread more popular among low income group because it was more filling than pure wheat bread.

a. Work was not carried out according to cropping season.

Table 5. Percent response (results received) from NARS of regional trials, 1986 to 1991).

Year	Trial[1]	Dispatched	Results received	
			Number[2]	Percentage
1986	WASVAT-E	7	7	100
	WASVAT-M	8	8	100
	WASHAT	14	12	86
1987	WASVAT-E	10	9	90
	WASVAT-M	13	12	92
	WASHAT	15	15	100
	WASLDN	5	5	100
1988	WASVAT-E	14	12	86
	WASVAT-M	19	13	68
	WASHAT	12	12	100
	WASLDN	7	7	100
	WCASST	6	3	50
1989	WASVAT-E	16	12	75
	WASVAT-M	19	13	68
	WASHAT	9	8	89
	WASLDN	10	2	20
	WCASST	9	6	67
1990	WASVAT-E	15	13	87
	WASVAT-M	19	13	68
	WASHAT	10	10	100
	WASDLN	8	4	50
	WCASST	11	3	27
1991	WASVAT-E	15	11	80
	WASVAT-M	18	13	77
	WASHAT	14	13	93
	WASLDN	9	4	55
	WCASST	7	3	43

1. WASVAT-E = West African Sorghum Variety Adaptation Trial, Early Maturing Cycle. M= Medium cycle. WASHAT = West African Sorghum Hybrid Adaptation Trial. WASLDN = West African Sorghum Leaf Disease Nursery. WCASST = West and Central Africa Sorghum *Striga* Trial.

Table 6. Percentage of varieties contributed by NARS to the regional trials, 1986 to 1992.

Year	Trial[1]	Total number of test entries	Test entries from NARS	
			Number[2]	Percent
1986	WASVAT-E	18	0	0
	WASVAT-M	18	0	0
	WASHAT	30	0	0
1987	WASVAT-E	18	6	33
	WASVAT-M	18	7	39
	WASHAT	22	0	0
	WASLDN	36	0	0
1988	WASVAT-E	18	5	28
	WASVAT-M	18	7	39
	WASHAT	18	0	0
	WASLDN	36	0	0
	WCASST	11	1	9
1989	WASVAT-E	17	6	35
	WASVAT-M	17	10	59
	WASHAT	17	2	12
	WASLDN	25	0	0
	WCASST	11	1	9
1990	WASVAT-E	17	6	35
	WASVAT-M	17	10	59
	WASHAT	18	2	11
	WASDLN	25	0	0
	WCASST	11	1	9
1991	WASVAT-E	11	8	73
	WASVAT-M	15	8	53
	WASHAT	-	-	-
	WASLDN	14	6	43
	WCASST	12	12	100
1992[3]				

1. WASVAT-E = West African Sorghum Variety Adaptation Trial, Early Maturing Cycle. M= Medium cycle. WASHAT = West African Sorghum Hybrid Adaptation Trial. WASLDN = West African Sorghum Leaf Disease Nursery. WCASST = West and Central Africa Sorghum Striga Trial.

2. Rest of test entries contributed by ICRISAT. 3. As in 1991

3. As in 1991.

Table 7. The top four yielding varieties and hybrids in the regional trials of WECASORN, 1986 to 1991.

WASVAT-Early		WASVAT-Medium		WASHAT	
Variety	t ha^{-1}	Variety	t ha^{-1}	Hybrid	t ha^{-1}
		1986			
ICSV 1078 BF	3.66	ICSV 1063 BF	2.55	ICSH 230	3.36
ICSV 1054 BF	3.52	IS 915	2.40	ICSH 229	3.34
ICSV 1055 BF	3.37	ICSV 1074 BF	2.37	ICSH 208	3.26
ICSV 1065 BF	3.28	PM 11344	2.35	ICSH 134	3.24
		1987			
Nagawhite	2.80	ICSV 1063 BF	2.58	ICSH 336	2.80
ICSV 111 IN	2.57	ICSV 1089 BF	2.56	ICSH 232	2.75
ICSV 1083 BF	2.50	M 24581	2.48	ICSH 643	2.72
CE 180-33	2.38	Malisor 84-1	2.48	ICSH 642	2.64
		1988			
Nagawhite	3.53	ICSV 1063 BF	3.34	ICSH 507	3.32
ICSV 210 IN	3.41	Malisor 84-1	3.08	ICSH 330	3.09
ICSV 111 IN	3.27	ICSV 1089 BF	3.01	ICSH 88042	3.03
S-35	3.23	BF 80-7-7-2-1	2.97	ICSH 88040	2.92
		1989			
ICSV 1079 BF	2.74	ICSV 1171 BF	2.37	ICSH 507	3.66
CS 61	2.65	F2-20	2.34	ICSH 780	3.60
ICSV 111 IN	2.55	CS-95	2.32	TX623XMR 732	3.58
ICSV 1172 BF	2.47	ICSV 1089 BF	2.29	ICSH 89002	3.57
		1990			
CE 196-7-2-1	2.53	CS 85	2.09	ICSH 89002	3.71
ICSV 1174 BF	2.26	SEPON 82	1.96	ICSH 89008	3.68
ICSV 401 IN	2.22	F2-20	1.94	IS 6928	3.56
ICSV 1172 BF	2.14	IS 6928	1.90	ICSH 89007	3.54
		1991			
90 W 186	2.47	S 219	2.33	ICSH 89009 NG	3.65
SSV-2	2.37	BF 83-3/3-1-1	2.25	ICSH 780	3.53
CE 145-66 TRANS 2	2.26	BF 83-3/42-2-1	2.10	ICSH 950005	3.44
CE 314-18	2.08	Kadaga	2.09	ICSH 507	3.41

1. Values in t ha^{-1} are means from several locations. Prefixes: all ICSV, IS, PM and ICSH are from ICRISAT; nagawhite from Ghana; CE and F2 from Senegal; CS and S from Cameroon; Malisor from Mali; BF from Burkina Faso; Sepon and Tx from Niger.

Table 8. Details on members of the steering committee who assisted in visiting non-lead NARS.

Made by Country[1]	Countries visited	Year	Date	No of days
Mali	Senegal Gambia	1989	5/9-16/9	8
Nigeria	Ghana	1990	18/8-27/8	10
Burkina Faso	Benin	1990	28/9-6/10	10

1. Countries of the Steering Committee members who assisted the Coordinator in visiting the weaker NARS.

Table 9. Location, date, number of days and number of participants from NARS of WECASORN's steering committee meetings.

Location	Year	Date	No of days	Participants from NARS as	
				Member[1]	Observer[2]
1. Ouagadougou, Burkina Faso	1986	13-14 Jan	2	2	1
2. Ouagadougou, Burkina Faso	1987	10-11 March	2	3	1
3. Ouagadougou, Burkina Faso	1987	15-17 Dec	3	4*	1
4. Maroua, Cameroon	1988	24 Sept	1	6*	2
5. Bamako, Mali	1989	9-11 May	3	4*	0
6. Ouagadougou, Burkina Faso	1989	14-17 Nov	4	5*	1
7. Niamey, Niger	1990	2-4 May	3	6*	1
8. Bamako, Mali	1990	3-4 Dec	2	3*	0
9. Niamey, Niger	1991	13-14 March	2	5	0
10. Ouagadougou, Burkina Faso	1991	12-14 Nov	3	5	1
11. Bamako, Mali	1992	8-9 June	2	6	7

1. An asterik indicates members includes individuals from outside the region, but with NARS on special projects as follows: 1987 = 1; 1988 = 3; 1989, May = 2; 1989, Nov = 2; 1990, May = 2; 1990, Dec = 1.

2. Observers = individuals from NARS. Observers from International and regional organizations not included.

Table 10. Thirty-five varieties tested in the regional trials and nurseries of WECASORN between 1986 and 1992 that are at various levels in the research programs of seven NARS[1].

From NARS			From ICRISAT	
Variety	Country of origin	used by (country)	Variety	used by (country)
1. CSM 388	Mali	GC	1. ICSV 16-5 BF	GC, GH
2. Malisor 84-1	Mali	GC, CI, TO	2. 84 W 848	GC
3. Malisor 84-5	Mali	GC	3. IS 3443	GC
4. BF 83-3/48-2-1	Burkina Faso	GC	4. Framida (ICSV 1001 BF)	GC, CI,TO
5. F2-20	Senegal	SE	5. 90 W 190	GC
6. CE 180-83	Senegal	SE,TO	6. ICSV 1171 BF	SE
7. CE 196-7-2-1	Senegal	SE	7. ICSV 1089 BF	SE, MA,TO
8. CS 95	Cameroon	SE,TO	8. ICSV 1163 BF	SE
9. SEPON 82	Niger	SE,TO	9. ICSV 111 IN	SE,TO, GH
10. CS 54	Cameroon	SE,TO	10. ICSV 1063 BF	CI, MA,TO
11. Nagawhite[2]	Ghana	MU	11. ICSV 401 IN	MA
12. S 34	Cameroon	TO	12. ICSV 1079 BF	MA,TO
13. S 35	Cameroon	TO	13. ICSV 1078 BF	MA,TO
14. CS 61	Cameroon	TO	14. ICSV 1002 BF	MA,TO
15. CS 95	Cameroon	TO	15. E 35-1	TO
16. CE 315-14-1-1	Senegal	SE	16. ICSV 1049 BF	TO
17. S 219	Côte d'Ivoire	GH	17. ICSV 1007 BF	TO
			18. ICSV 1083 BF	TO

1. GC = Guinea (Conakry). GH = Ghana. CI = Côte d'Ivoire. TO = Togo. SE = Senegal. MA = Mali. MU = Mauritania.

2. Released in Ghana in 1971 before WECASORN's regional trials started.

Table 11. Utilization by NARS of germplasm tested in regional trials and nurseries of WECASORN between 1986 and 1992[1]

Country/variety	Level of use	Year	Total ha
1. Guinea (Conakry)			
ICSV 16-5 BF	FF	91-92	0.7
84 W 848	FF	91-92	0.7
IS 3443	FF	91-92	0.7
CSM 388	PR	92	55
Malisor 84-1	ST	90-92	0.2
Malisor 84-5	ST	90-92	0.2
Framida	ML	90-92	1.5
BF 83/48-2-1	FF	92	0.7
90 W 190	FF	92	0.7
2. Senegal			
F2-20	R	89	-
CE 180-33	PR	92	5
CE 196-7-2-1	FF	90	-
ICSV 1171 BF	FF	91	-
CE 315-14-1-1	FF	92	-
ICSV 1089	FF	91	-
CS 95	FF	92	-
Sepon 82	CR	91	-
ICSV 1163 BF	CR	90	-
ICSV 111 IN	CR	91	-
CS 54	CR	92	-
3. Côte d'Ivoire			
Framida	DM	88	0.25
Malisor 84-1	PR	91	0.5
ICSV 1063 BF	PR	91	0.5
ICSH 507	ST	90	0.25
4. Mali			
ICSV 401 IN	PR		-
ICSV 1063 BF	PR	-	-
ICSV 1079 BF	CR	-	-
ICSV 1089 BF	CR	-	-
ICSV 1078 BF	CR	-	-
ICSV 1002 BF	CR	-	-
		-	-
5. Mauritanie			
Nagawhite	CR	90	-

Table 11. Continued

Country/variety	Level of use	Year	Total ha
6. Togo - 1			
ICSV 1079 BF	CR	89	-
ICSV 1078 BF	CR	89	-
Sepon 82	CR	89	-
S-34	CR	90	-
S-35	CR	90	-
Framida	CR	90	-
E 35-1	CR	90	-
CS 54	CR	90	-
CS 61	CR	90	-
CS 95	CR	90	-
Malisor 84-1	CR	92	-
ICSV 1049 BF	CR	91	-
ICSV 1063 BF	CR	91	-
ICSV 1007 BF	CR	91	-
ICSV 1002 BF	CR	91	-
7. Togo - 2			
ICSV 1089 BF	ST	91-92	-
CE 180-33	ST	91-92	-
ICSV 1063 BF	ST	91-92	-
ICSV 1083 BF	FF	91-92	-
ICSV 111 BF	ST	91-92	-
Malisor 84-1	FF	91-92	-
Framida	FF	87	-
8. Ghana			
ICSV 111 IN	PR	90	60
ICSV 16-5 BF	PR	90	-
S 219	ST	91	-

1. Based on responses from a questionnaire. FF = Farmer's fields; PR = Pre-release; ST = On-Station; ML = Multilocation; R = Released; CR = in crosses; DM = Demonstration; ICRISAT varieties with prefixes ICSV 84 or 90. E 35-1' Framida; IS 3443 contributed by ICRISAT. All others from NARS.

1992-11

Basic information on WECASORN

ICRISAT

ICRISAT