WEST AND CENTRAL AFRICA MAIZE COLLABORATIVE RESEARCH NETWORK (WECAMAN)

SYNTHESIS REPORT ON WECAMAN FOR THE PERIOD 1997 TO 2002

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Acronyms and Abbreviations

AMS	African Maize Stress
CID	Crop Improvement Division
CIDT	Compagnie Ivoirienne de Développement des Textiles
CIMMYT	Centro International de Mejoramiento de Maiz y Trigo
CNRA	Centre National de Recherche Agronomique
CORAF	Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricoles
CRI	Crops Research Institute
IARC	International Agricultural Research Center
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IER	Institut d'Economie Rurale
IFAD	International Fund for Agricultural Development
IITA	International Institute of Tropical Agriculture
INERA	Institut d'Etudes et de Recherches Agricoles
INRAB	Institut National de Recherches Agricoles du Benin
IRAD	Institut de Recherche Agricole pour le Développement
ITRA	Institut Togolais de Recherches Agricoles
ITRAD	Institut Tchadien de Recherche Agronomique pour le Développement
NARS	National Agricultural Research Systems
OAU	Organization of African Unity
RRPMC	Regional Research Project for Maize and Cassava
SAFGRAD	Semi-Arid Food Grains Research and Development
SARI	Savanna Agricultural Research Institute
STRC	Scientific, Technical and Research Commission
UNDP	United Nations Development Program
USAID	United States Agency for International Development
WARDA	West Africa Rice Development Association
WECAMAN	West and Central Africa Maize Collaborative Research Network
WECARD	West and Central African Council for Agricultural Research and Development

Executive Summary

Maize is the number-one staple food crop for rural and urban consumers in sub-Saharan Africa, and its importance in the food basket in West and Central Africa (WCA) has been increasing steadily during the last few decades. Since 1970, maize has spread rapidly into the savannas of WCA, replacing traditional cereals such as sorghum and millet (CIMMYT, 1990). Therefore, improvement of the productivity potential of maize will play a critical role in feeding the African population which is expected to double during the next two decades (Abalu, 1997). However the crop is plagued by several crosscutting production constraints in the sub-region. The most important among these constraints are drought, inherently low soil fertility, *Striga hermonthica* infestation, stem borers, and the maize streak virus.

In an effort to tackle the production constraints and boost maize production in West and Central Africa, the Semi-arid Food Grain Research and Development (SAFGRAD) project was established in 1979 with funding support from USAID. In March 1987, the West and Central Africa Maize Collaborative Research Network (WECAMAN) was created under the SAFGRAD Phase 2. The objective of WECAMAN is to strengthen the capacity and capability of NARS of WCA to conduct high quality research and to harness their resources together in order to tackle regional constraints to maize production through the development and transfer of appropriate and sustainable technologies. WECAMAN became autonomous in 1994. Since its establishment, WECAMAN has been funded by USAID with IITA as the executing agency. Following the evaluation of the West Africa Commodity Networks funded by USAID in 1996, USAID approved funding for a five-year strategic plan of WECAMAN, which started on 1 October 1998 and is expected to end on 30 September 2003. From 1998 to 2001, IFAD and UNDP provided funds to WECAMAN in support of some key activities through the African Maize Stress (AMS) project.

The partners of WECAMAN include the National Agricultural Research and Extension Systems (NARES) of WCA, OAU/STRC SAFGRAD, INSAH, SG 2000, Sahel Solidarite, Premier Seed of Nigeria, and agro-industries in some member countries. The present member countries of the Network are Nigeria, Cote d'Ivoire, Ghana, Togo, Benin, Cameroon, Burkina Faso, Tchad, Senegal, Mali and Guinea. The clients of WECAMAN include small, medium and large scale farmers and other actors of the national economies.

The management entities of WECAMAN are the Steering Committee (SC), the Ad hoc Research Committee (ARC) and IITA. The SC is made up of eight active national scientists and is responsible for reviewing and approving the annual work plans and budgets in conformity with Network objectives. It also monitors the implementation of Network activities and management of funds. The ARC is appointed by the Steering Committee and is made up of three agricultural research experts from non-member countries of WECAMAN. It reviews collaborative research proposals, allocates research funds based on criteria established by the SC and appraises progress reports on collaborative projects. As the executing agency, IITA provides administrative, managerial and technical support to the Network. The Network Coordinator is responsible for the day to day administration of the Network and implements the decisions of the SC.

To achieve its objectives, the Network has employed the following strategy-components (i) collaborative research projects; (ii) regionally oriented resident research, (iii) exchange of scientific information and technologies, (iv) impact assessment, and (v) human resource development.

As a strategy to strengthen the regional capacity to address the key production constraints of maize in WCA and improve its nutritional quality, research responsibilities for breeding new varieties with tolerance/resistance to the major stresses have been assigned to lead countries of WECAMAN. In furtherance of this objective six regional stress and testing sites have been developed in Burkina Faso, Senegal, Ghana, Cameroon, Benin, and Nigeria. The screening sites are fully operational and have enabled the NARS scientists to conduct stress-breeding research themselves. Using these sites, the lead countries, the WECAMAN Coordinator and IITA maize scientists have screened and identified promising drought tolerant germplasm and have incorporated these into existing maize populations or initiated the development of new drought tolerant populations to serve as sources of future drought tolerant varieties. Also, promising extra-early germplasm and varieties have been developed and sources of *Striga* resistance have been introgressed into existing early and extra-early populations as well as elite varieties. The populations are presently being improved using recurrent selection methods. Efforts also continue at screening maize varieties and populations for nitrogen use efficiency and to develop stem borer resistant varieties. The lead countries in the sub-region have also conducted research to develop crop management practices for soil fertility improvement and *Striga* control.

WECAMAN has been very successful in stimulating the capability and initiatives of national scientists to solve maize production problems and to generate and/or identify and transfer appropriate technologies to end-users. The sustainable technologies emanating from research efforts of the Network include open-pollinated maize varieties with resistance/tolerance to *Striga*, drought and streak, including early and extra-early varieties for drought prone areas; post-harvest methods; and crop management practices.

The extra-early variety TZEE-W SR BC_5 has been released in seven countries while the early and drought tolerant variety Pool 16 DT has been released in six countries through on-farm tests and demonstrations funded in WECAMAN member countries since 1994. To date, a total of 20 extra-early and 30 early varieties are available to farmers in WCA through WECAMAN. Obatanpa, a quality protein maize (QPM) variety with good nitrogen use efficiency that was developed in Ghana, is being vigorously promoted by WECAMAN in the sub-region. This variety has been released or slated for release in all the member countries.

WECAMAN has consistently supported the development of community-based seed production schemes to make seed of improved varieties available to farmers. Approximately 300 tons of seed of the released early and extra-early maize varieties are produced annually in Cameroon, Togo, Benin, Burkina Faso, Mali and Ghana. More than 1,500 farmers have been trained in the techniques of seed production and maintenance of large quantities of foundation and commercial seed of the released varieties.

WECAMAN has organized several workshops, training courses and scientific monitoring tours in an effort to improve the research capacity and capability of NARS scientists and to promote technology exchange and transfer in member countries. About 50 technicians and 150 scientists have benefited from the Network's training courses and workshops. Preliminary assessment of

WECAMAN activities have shown that the technicians and scientists have greatly improved their skills to effectively develop and transfer new technologies to farmers in the sub-region.

Through the competitive grants system instituted by WECAMAN, technologies developed by lead member countries such as appropriate plant density, earlier date of fertilizer application, and the use of maize-legume rotation to improve soil fertility and maize grain yield have been tested and adopted in other countries. The availability of early and extra-early varieties developed and promoted by WECAMAN has created niches for maize production, consumption, and improved food security in WCA. The Network activities have also contributed to increased maize production and productivity through movement of maize into new areas.

There is a need to understand the maize distribution and marketing systems as well as its utilization in various foods in order to promote production, utilization and effective marketing of the crop in WCA. Toward this end, WECAMAN has funded marketing studies in Nigeria, Ghana and Togo while utilization studies have been funded in Mali and Tchad. The results of the maize utilization studies in Tchad have shown that wheat flour could be composited with maize flour at 30% for the preparation of biscuits or 50% for "beignet" that are consumer acceptable. An infant food has been prepared from 60% fermented maize flour, 20% soybean, 8% dehulled maize flour and 12% sugar. In Mali, comparison of the normal endosperm maize variety, Sotubaka and the QPM variety, Obatanpa showed that biscuits prepared from the latter were superior in terms of quality protein. Also, consumer acceptable "beignet" has been prepared from composite flour of 15% maize and 85% wheat.

Despite the significant progress made by WECAMAN in enhancing the research capacity and capability of NARS, and in contributing to increased maize production and productivity in WCA, much remains to be done and there is great potential for further progress.

Several extra-early, early and intermediate open-pollinated and hybrid varieties with moderate levels of resistance/tolerance under *S. hermonthica* infestation have been developed through the collaborative efforts of WECAMAN and IITA. During the past two years, Regional *Striga* Trials have been offered to selected WECAMAN member countries for evaluation. Through these trials, farmers of member countries have identified several promising *Striga* tolerant varieties for on-farm adaptive trials and for adoption. There is need for the on-farm testing of these varieties to be intensified so that the NARS and farmers could derive the full benefits from them.

It is necessary to combine host plant resistance with other control methods such as maize-legume rotation to improve soil fertility and progressive reduction of the *Striga* seed bank. This is because of the current moderate level of *Striga* resistance of the available maize varieties, and the inherently low fertility status of the soils of the savannas of WCA. Through studies funded by WECAMAN in Nigeria, Benin, and Togo, varieties of soybean (Samsoy), cowpea (TVX 1850-OIF) and groundnut (RMP 91) have been identified that have high germination stimulant effects on *Striga* seeds. These legumes when used in rotation with *Striga* tolerant maize varieties could cause suicidal germination of *Striga* seeds, thus reducing the damage caused by S. *hermonthica* and leading to increased maize yield (WECAMAN 2000). Such legumes need to be extensively evaluated on-farm in rotation with the *Striga* tolerant maize varieties.

The moderate level of resistance to *Striga* identified to date and incorporated into maize in WCA by IITA and WECAMAN is quantitatively inherited and no cases of immunity have been reported (Kim, 1994, Kling *et* al. 1996). The available resistance therefore allows significant reproduction of the parasite. IITA scientists have identified an accession of perennial teosinte (*Zea diploperennis*) that supports little or no emergence of *S. hermonthica*. Also, a program initiated to identify molecular markers tightly linked to *Striga* resistance genes is almost completed. The markers would facilitate the transfer of these genes to a wide array of germplasm adapted to the major maize agro-ecologies in Africa through marker-assisted backcrossing. WECAMAN has to take advantage of these novel sources of genes to develop and disseminate maize varieties with enhanced *Striga* resistance in the sub-region.

The seed industry in WCA faces a myriad of problems. The community seed production schemes of WECAMAN need to be supported and expanded to promote the production and distribution of the stress tolerant QPM and other maize varieties in order to ensure high adoption of released varieties that will increase production and productivity of the crop in the sub-region. An area of immediate interest is the transformation of successful community based seed production schemes of WECAMAN into micro-enterprises with participating farmers as shareholders for sustainability

Although some promising drought tolerant maize varieties have been released to farmers in WCA and are presently in production, WECAMAN and IITA have made rather limited progress in developing drought tolerant germplasm for WCA. Preliminary results of studies at CIMMYT show that marker-assisted selection based on a strategy combining quantitative trait loci (QTL) identified under drought for anthesis-silking interval (ASI) and grain weight of tropical maize inbred lines, and open-pollinated populations should be a powerful tool to improve drought tolerance (Ribaut *et* al. 1996). WECAMAN would take advantage of such new advances in biotechnology to develop and disseminate maize varieties with enhanced drought tolerance for farmers of WCA.

Most of the widely adopted maize varieties in WCA are not endowed with the quality protein trait available in QPM germplasm. On the other hand many highly productive QPM germplasm are yet to be improved for resistance to the maize streak virus, *Striga*, drought, storage pests and stem borers. There is therefore a need to intensify the effort at developing and disseminating high yielding, *Striga*, streak and drought resistant extra-early, early and intermediate QPM varieties for the production conditions of WCA. There is also a need to support sustainable seed production of QPM seed.

To ensure increased and sustained maize production and productivity in WCA that will lead to increased food security, improved nutrition and incomes of the people of WCA, WECAMAN and IITA propose a new phase of the USAID project of WECAMAN. The project will build on the achievements made by the Network and bring the results to a larger proportion of the target beneficiaries for whom maize is a major staple and source of income.

1.0. BACKGROUND INFORMATION ON WECAMAN

Maize is the number-one staple food crop for rural and urban consumers in sub-Saharan Africa. Its importance in the food basket in West and Central Africa (WCA) has been increasing steadily during the last few decades. Since 1970, maize has spread rapidly into the savannas of WCA, replacing traditional cereals such as sorghum and millet (CIMMYT, 1990). Therefore, improvement of the productivity potential of maize will play a critical role in feeding the African population that is expected to double during the next two decades (Abalu, 1997).

Despite the high production potential of the maize crop in the savannas it is plagued by several production constraints that cut across countries in WCA. Of primary importance among these constraints are drought, inherently low soil fertility, *Striga hermonthica* infestation, stem borers, and the maize streak virus (MSV). *Striga hermonthica* and *Striga asiatica* cause yield losses of up to 100%. The levels of infestation are often so high that farmers may be compelled to abandon their fields. Compounding the *S. hermonthica* problem in WCA savannas is the recurrent drought. Annual yield losses of maize grain due to drought in sub-Saharan Africa are estimated at 15%. However, localized losses may be much higher in the marginal areas where the annual rainfall is below 500 mm, or where the soils are sandy or shallow (Edmeades et al, 1995). The maize streak virus (MSV) affects an estimated 60% of total maize area in sub-Saharan Africa. Early infection of maize plants by MSV can lead to over 80% yield loss through poor grain-filling and barrenness, while plants attacked thereafter suffered only 20% yield loss (Ampong Nyako et al, 1998). Sternborers are also a serious threat to maize production in the humid forest and mid-altitude ecologies. Even though maize is well adapted to the climate of the moist savannas of WCA, the soils are inherently low in fertility and organic matter content. With the intensification of maize production, a complex of problems may develop, including soil erosion, low fertility, low water holding capacity leading to increased *Striga* infestations. The development of appropriate management practices and improved varieties with resistance/tolerance to drought, *Striga hermonthica*, MSV, stemborers and low-N use efficiency are, therefore, very important in mitigating the effects of these stresses and increasing maize production in WCA.

The bulk of maize in WCA is used directly for human food. Also, maize is widely used as a weaning food for young children without any protein supplement such as eggs, meat, or milk, which are relatively more expensive. Maize is also a major source of feed ingredients for the poultry and livestock industries. Even though the normal maize has about 10% protein, the protein is deficient in two essential amino acids, lysine and tryptophan. The result is that, infants fed on normal maize without any balanced protein supplements suffer from malnutrition and develop diseases such as kwashiorkor or pellagra. High yielding quality protein maize (QPM) with nearly twice the lysine and tryptophan of normal maize, as well as a more balanced amino acid distribution are now available.

In an effort to achieve food self-sufficiency in West and Central Africa, the Semi-arid Food Grain Research and Development (SAFGRAD) project was established in 1979 with funding support from USAID. In March 1987, the West and Central Africa Maize Collaborative Research Network (WECAMAN) was created under the SAFGRAD Phase 2. The objective of WECAMAN is to strengthen the capacity and capability of NARS of WCA to conduct high quality research and to harness their resources together in order to tackle regional constraints to maize production through the development and transfer of appropriate and sustainable technologies. WECAMAN became

autonomous in 1994. Since its establishment, WECAMAN has been funded by USAID with IITA as the executing agency. In 1996, USAID approved funding for a five-year strategic plan of WECAMAN, which started on 1 October 1998 and is expected to end on 30 September 2003. From 1998 to 2001, IFAD and UNDP provided funds to WECAMAN in support of some key activities through the African Maize Stress (AMS) project. The present membership of WECAMAN includes Nigeria, Côte d'Ivoire, Ghana, Togo, Benin, Cameroon, Burkina Faso, Tchad, Senegal, Mali and Guinea.

1.1. Structure and Management of WECAMAN

WECAMAN operates under the umbrella of CORAF/WECARD and has the following structure and management entities:

(i) The Steering Committee

The Steering Committee is made up of eight active scientists of the participating member countries and the Network Coordinator. It is elected in such a manner as to ensure representation of a mix of disciplines. The Steering Committee performs the following functions:

- reviews and approves annual workplans and budgets in conformity with Network objectives;
- appoints a Research Committee to review all workplans and budgets and allocate resources to different collaborative projects;
- prepares the agenda for biennial workshops and monitoring tours;
- reviews annual technical progress report of the Network and propose necessary modifications or termination of activities; and
- monitors the implementation of Network activities and management of funds.

The SC meets twice a year and may co-opt persons with required expertise to assist in carrying out its functions. Membership of the Steering Committee is for a period of two years, renewable once for half of its members to ensure continuity. The Chairman and two Secretaries (French and English speaking) of the Committee are elected by their peers for a period of two years.

(ii) Executing Agency

IITA, with its long experience in the management of Networks of various crops across the continent, provides:

- a Network coordinator,
- administrative, managerial and technical support;
- funds from its core program to cover expenses of the resident research of the Network Coordinator;
- backstopping for Network activities
- support for review and editing of research findings for publication;
- assistance in identification and acquisition of potentially useful maize germplasm;
- assistance in the procurement and shipment of office and field supplies.

(iii) Network Coordinator

The Network Coordinator is based in Côte d'Ivoire at WARDA and is supported by a research assistant, a secretary, an accounting assistant and a driver. The Network Coordinator is responsible for:

- preparing, in consultation with the Steering Committee, the Network annual workplan and budget,
- making necessary arrangements for the Network meetings: Steering Committee, workshops, monitoring tours, etc.,
- implementing decisions made by SC including collaborative research activities, training and regional trials,
- providing working documents on planning, analyzing and reporting on Network activities,
- serving as a link between IITA and Network member countries and for arranging backstopping when necessary, and
- preparing quarterly and annual reports for the donors,
- regionally-oriented resident research in an area of his expertise. At present, the WECAMAN Coordinator spends 25-30% of his time in breeding for early and extra-early varieties using the facilities of the CNRA research station at Ferkessédougou, Côte d'Ivoire.

(iv) Ad hoc Research Committee

The SC appoints an Ad hoc Research Committee (ARC) comprising three agricultural research scientists from non-member countries. Membership of the Committee is for two years. The ARC has the following functions:

- reviews all collaborative research proposals,
- selects lead centers for specific collaborative research projects on competitive basis
- allocates research funds based on criteria established by the Steering Committee and
- appraises progress reports on collaborative projects.

The decisions of the Research Committee are subject to the approval of the Steering Committee.

At present, the Research Committee is composed of a representative each from the IITA Maize Program, OAU-STRC SAFGRAD and CORAF.

(v) Partners

The partners of WECAMAN include the National Agricultural Research and Extension Systems (NARES) of WCA, OAU/STRC SAFGRAD, INSAH, SG 2000, Sahel Solidarite, Premier Seed of Nigeria, Agro-industries in some WECAMAN member countries. The clients include small, medium and large scale farmers and other actors of the national economies.

1.2. Strategy adopted by WECAMAN to implement its research and development agenda

The project's overall objective is to increase maize productivity, production, and income of farmers through the use of appropriate technologies identified by the Network and extended to farmers by extension services and NGOs in the respective member countries. The specific objectives are to:

1. develop maize varieties which possess resistance/tolerance to the major biotic and abiotic stresses that limit maize production in the sub-region,

2. develop suitable agronomic practices to enhance increased productivity and production,

3. develop sustainable seed production and distribution system in the sub-region

4. develop and promote alternative uses of maize,

5. enhance the capacity within the Network to carry out collaborative research program with minimum outside support, and

6. promote the adoption of improved maize varieties and crop management practices.

To achieve these objectives, the Network employed the following strategy-components (i) collaborative research projects; (ii) regionally oriented resident research, (iii) exchange of scientific information and technologies, (iv) impact assessment, and (v) human resource development.

1.2.1. Collaborative research projects

The strategy of optimizing the research strength and comparative advantage of strong NARS (lead Centers) by assigning them specific research problems identified as principal constraints to maize production in West Africa has been adopted. It is understood that the lead Centers would share germplasm and other technologies with the technology adapting NARS (weak NARS) so that they could all take advantage of gains made in other NARS as well as in the IARCs. This strategy enables the technology-adapting countries to concentrate their efforts on adaptive research and verification of technologies under farmers' conditions.

To ensure accountability and maximum returns from the Network's research funds, criteria for allocation of funds for collaborative project support have been established by the Steering Committee. The idea of competitive research grants has been introduced for all collaborative project support so as to motivate NARS scientists to increase research output and to be creative. Funds are allocated to prospective lead NARS based on the submission of well-conceived research proposals. Countries assigned collaborative research responsibilities are evaluated during each planting season in order to ensure that the allocated funds are properly utilized for the designated purpose and also to monitor research progress.

1.2.2. Regionally-oriented resident research

The Coordinator of the maize Network spends 25-30% of his time on developing and promoting early and extra-early maturing maize varieties that combine drought tolerance with resistance to *Striga*. The resident research is an integral part of the Network's program and is carried out at Ferkessédougou, Sinématiali in Cote d'Ivoire and Kamboinse, in Burkina Faso. The following research activities approved by the Steering Committee have been carried out:

- Breeding for early and extra-early varieties with resistance/tolerance to drought, *Striga* and streak virus.
- Seed multiplication of maize varieties nominated for regional trials.
- Establishment of nurseries for training purposes.
- Germplasm conservation and maintenance.

1.2.3. Regional trials

Germplasm of interest to the Network are included in the regional trials designed by the Network Steering Committee for evaluation by member-countries. The regional trials constitute an important vehicle for germplasm exchange within the Network. The regional trials approved by the Steering Committee and dispatched yearly to NARS upon request are the following:

(i) Regional Uniform Early Variety Trial (RUVT-EARLY), composed of early cultivars of 90 to 95 days to maturity,
(ii) Regional Uniform Extra-Early Variety Trial (RUVT-EXTRA-EARLY), composed of extra-early cultivars with about 80-85 days to maturity,
(iii) Regional *Striga* Early Variety Trial (RSVT-Early), composed of early *Striga* resistant varieties with about 90-95 days to maturity and
(iv) Regional *Striga* Extra-early Variety Trial (RSVT-Extra early) composed of extra-early varieties that mature in about 80-85 days.

The coordinator packages the trials and dispatches sets to both member and non-member countries. The entries include seed of varieties from the Network Coordinator's resident research program as well as varieties contributed by the NARS scientists and the International Centers.

1.2.4. Exchange of scientific information and technologies

Workshops serve as the fora for exchange of scientific information and new technologies. These allow presentation and review of the results from the previous year's regional trials and other relevant research conducted by lead and technology adapting centers, IITA and other international centers. A monitoring tour involving participants from the member countries of the Network is conducted in alternate years. The Coordinator and selected members of the Steering Committee pay consultation visits to national maize programs to assess the progress being made in the implementation of the approved plan of work. The visits also allow exchange of disciplinary expertise. Other mechanisms to ensure exchange of scientific information among Network

members include publication and distribution of Network Steering Committee reports, Network annual technical reports and proceedings of workshops.

1.2.5. Human Resource Development

In order to enhance the professional and scientific capacity of national research systems, training is an important activity of the Network. The Network organizes annual in-service training and special purpose seminars with the assistance of the IITA Training Unit. These focus on particular production problems or research methodologies identified by the Steering Committee. Participants at the different training sessions include scientists and technicians from the Network member countries. Some of the topics covered in the courses include: breeding for *Striga* resistance, methodologies for on-farm demonstrations, technology adoption and agricultural policy changes; seed production, variety maintenance, data collection, processing and interpretation.

1.2.6. Impact assessment.

One of the major objectives of WECAMAN is to constantly monitor the adaptation and release of technologies developed by the Network, the area under cultivation and the production levels in member countries. This is in an effort to determine the impact of the research effort of the Network in order to demonstrate good returns to investments in maize research in Network member countries and thereby influence policy on agricultural research.

2.0. ACHIEVEMENTS/PROGRESS OF WECAMAN

2.1. Development of maize varieties that possess resistance/tolerance to the major biotic and abiotic stresses that limit maize production in West and Central Africa

As a strategy to strengthen the regional capacity to combat *Striga*, drought, stemborers, the declining soil fertility of the soils in WCA and improve nutritional quality of maize, research responsibilities for breeding maize varieties with tolerance/resistance to the major stresses have been assigned to WECAMAN member countries as follows:

- Drought tolerance - Burkina Faso, Senegal, Ghana and Cameroon
- *Striga* resistance – Cameroon, Benin and Côte d'Ivoire
- Low nitrogen use efficiency – Nigeria and Ghana
- Quality Protein Maize – Ghana and Togo.

In an effort to improve the capability and capacity of NARS to develop stress tolerant maize varieties, six regional stress screening and testing sites have been developed in selected national maize programs with funding support from the AMS Project (Table 1). The screening sites are fully operational and have enabled the NARS scientists to conduct stress breeding research themselves.

Table 1. Regional stress screening sites developed in WECAMAN member countries

Stress	Country	Names of sités
Drought	Senegal	Nioro
	Burkina Faso	Valee dekou
Low-N	Ghana	Nyankpala
	Nigeria	Zaria
Striga	Cameroon	Garoua
	Benin	Ina

Using the screening and testing sites the lead countries and the WECAMAN Coordinator have screened and identified promising drought tolerant germplasm and have incorporated these into existing maize populations or initiated the development of new drought tolerant populations to serve as the sources of future drought tolerant varieties. Also, promising extra-early germplasm and varieties have been developed from crosses between the materials. Furthermore, introgression of sources of *Striga* resistance into existing early and extra-early populations and elite varieties have been carried out by the WECAMAN Coordinator and the lead centers for *Striga* resistant/tolerant varieties in Ghana, Benin Cameroon and Côte d'Ivoire. The populations are presently being improved using recurrent selection methods. Efforts also continue at screening maize varieties and populations for low-N use efficiency and to develop stemborer resistant varieties.

The highlights of the achievements/progress in developing varieties with tolerance/resistance to the major stresses by the lead centers and WECAMAN Coordinator since 1997 are as follows:

Achievements/Progress made in the resident research of the WECAMAN Coordinator:

a) *Striga hermonthica* tolerant early varieties (EV DT-W 99 STR C0, TZEW-Pop x 1368 STR C0, EV DT 97 STR C_1) which have shown superior performance in the regional trials have been made available for more extensive testing by NARS in the Regional *Striga* Trials since 1999. Based on the trials, EV DT 97 STR C1 has been identified as promising and is being promoted for adoption on-farm in Benin and Togo.

b) Six *Striga* tolerant extra-early varieties developed in the resident research program and designated as Sine TZEE-W STR, Ferke TZEE-W STR, 98 TZEE-W STR, 99 Syn EE-W, 2000 Syn EE-W and 99 TZEF-Y STR have been nominated for evaluation in the Regional *Striga* extra-early variety trial offered since 2000.

c) Several early and extra-early *Striga* tolerant S4 and S6 inbred lines have been developed and made available to NARS of WCA as sources of resistance for the development of synthetic varieties.

d) Two drought tolerant early varieties (EV DT-Y 98 and EV DT-W 98 C0) and seven streak resistant extra-early varieties (98 TZEE-W C2, EV 98 TZEE-Y, 97 TZEE-W, 97 TZEE-W2, 97 TZEE-Y1 and 97 TZEE-Y2 and TZEF-Y) developed in the resident research program have been included in the Regional Uniform Variety Trials since 1999.

e) Two early drought and *Striga hermonthica* populations, TZE-W Pop DT STR (white) and TZE-Y Pop STR STR (Yellow) and two extra-early populations, TZEE-W Pop STR (white) and TZEE-Y Pop STR (yellow) have been developed and taken through three cycles of improvement using the S_1 selection scheme. Also, *Striga* tolerant S_6 inbred lines and synthetic varieties have been extracted from each population. Bulks of the early white and yellow populations have been made available to the national programs of Burkina Faso and Côte d'Ivoire for use in the breeding programs.

f) Results of the 2001 Regional Extra-early *Striga* Trial conducted in Ferke showed that 2000 Syn EE-W, an extra-early maturing *Striga* tolerant variety developed in the resident research program outyielded the non-STR reference entry, TZEE-W SR BC_5 by 28% and 45% under *Striga*-free conditions and artificial *Striga* infestation, respectively.

g) In the Regional Early *Striga* Trial conducted in Ferkessedougou in 2001, EV DT-W 2000 STR had the lowest *Striga* emergence count while TZE-W Pop x 1368 STR was the best in terms of *Striga* damage rating.

h) Seventeen early maturing maize varieties were evaluated under non-stressed versus *Striga* and drought stress conditions for two years at Ferkessedougou, Cote d'Ivoire. Results showed that the varieties, 98 Syn WEC, Kamb 88 Pool 16 DT and EV DT W 99 STR Co were the top-yielding entries under *Striga* infestation. EV DT-W 99 STR Co, TZE-W Pop x 1368 STR C1, AC 95 TZE Comp 4 C_3F_3, AC 92 Pool16 DT and Kamb Pool 16 DT were the best varieties under drought stress. Across the three environments, AC 92 Pool 16 DT, EV DT-W 99 STR Co, TZE-W Pop x 1368 STR, 98 Syn WEC and Kamb 88 Pool 16 DT were the top-yielding varieties.

Progress made in lead member countries of WECAMAN

Côte d'Ivoire

- Results of on-station tests in Côte d'Ivoire revealed that the early *Striga* tolerant varieties, IWD STR , AC 97 TZL COMP 1-W, EV DT 97 STR C_1, AC 94 TZE Comp 5-Y, AC TZE Comp5-W and TZE-Comp 5 C_6 had high grain yield and good levels of *Striga* tolerance. Also, the intermediate varieties, TZL Comp 1 C_4, IWF STR C_0, STR EV IWF and Z. Diplo BC_4 C_2 were promising. The varieties are presently being tested on-farm.

- S_5 *Striga* resistant inbred lines extracted from TZE-W Pop DT STR and TZE-Y Pop DT STR were classified into 3 groups based on plant height and diallel crosses were made within each group. Based on the results of the diallel studies, 8-10 S_5 lines of each group were recombined to form synthetics for each group. The varieties are presently undergoing preliminary evaluations.

- Six *Striga* resistant intermediate maturing varieties identified through the IITA *Striga* Trials have been used in diallel crosses. The lines with good general combining ability have been recombined to form a synthetic.

Ghana

- Two white endosperm extra-early and one yellow endosperm intermediate maturing QPM varieties have been developed by the national maize program of Ghana and are undergoing testing.

- Results of preliminary evaluations showed that the QPM extra-early variety, GH 99-80 DWDQPM-S yielded 5.22 t/ha compared to 4.5 t/ha for the improved normal extra-early variety, Dodzi, across six sites in year 2000. GH 99-80 DWDQPM-S was therefore nominated for evaluation in the RUVT Extra-early in 2001 and its undergoing the second year of testing in 2002.

- Results of trials conducted in 10 drought stressed and non-stressed environments in Ghana showed that two experimental varieties developed in Ghana, EV EJ 9190 DWDP and EV Fu 9190 DWDP yielded 20% higher than the recommended early variety Dorke SR under drought stress but in favourable environments the yields were similar. EV Fu 9190 DWDP was nominated for the 2001 Regional Uniform Variety Trials coordinated by WECAMAN.

- The national maize program of Ghana has made an excellent progress in developing the following early and extra-early drought tolerant varieties:

  i) Fu 20 - 80 DWFDP - an extra-early white flint variety
  ii) GH 20 - 80DYFP - an extra-early yellow flint variety
  iii) Fu 20 - 90DWDP - an early white dent variety
  iv) GH 90 - DYFDP - an early white flint variety.

- Four drought tolerant source populations in the Ghana Program have been taken through several cycles of improvement for grain yield and drought tolerance.

Togo

- Based on test cross performance, 8 S_1 and 10 S_1 inbreds extracted in Togo from the QPM populations, AC 8762 and Pozarica 8673 respectively, have been recombined to form a synthetic variety for each population.
- S_5 QPM inbred lines have been extracted from the two source populations (AC 8762 and Pozarica 8763) and would be advanced to the S6 stage for the development of synthetic varieties after lysine analysis in the QPM laboratory in Ghana in 2002

Cameroon

- Two drought tolerant varieties developed by Cameroon, CMS 9810 and CMS 9817 were nominated for the 2001 Regional Uniform Variety Trials.

- Two *Striga* tolerant heterotic pools designated Pool 1 and Pool 2 have been developed based on the superior performance of the hybrids evaluated under *Striga* infestation in 2000.

- 18 families selected from Drought Pool 25,16 from Drought Pool x Obatanpa, 14 from BSR x Drought 11 and 13 S1 from BSR x Drought Pool 2 were advanced to the S_2 stage in 2001. The S_2 of each material was bulk-sibbed to obtain the F_1 which is presently being advanced to the F_2 stage

- Six varieties, 9011-30, A 9803-15, A 980310, STR EV IWF, CMS 9817 and A9802-2 were identified as promising in the IITA drought tolerant trial evaluated in Garoua and Maroua during the 2001 cropping season. The promising varieties are presently undergoing further evaluation on-farm.

Burkina Faso

- Four drought tolerant varieties designated FBDR 1, FBDR 2, FBDR 3 and FBDR 4 have been developed from S_1 lines extracted from FBC 6, Pool 16 DT, DTE-W SR BC_3 C_0 and DTE-Y SR BC_3 C_0.

- Results of field evaluations conducted in 2001 have identified the following varieties as promising for further evaluation:2000 Syn WEC, EV DT-99 STR C_0, 98 Syn WEC, EV DT-W 2000 STR, EV DT-Y 2000 STR, 2000 Syn EE-W, EV 99 QPM, ACR 94 TZE Comp5-W, ACR TZE Comp5-Y, EV DT-W 2000 STR, TZL Comp4 C_2, ACR 97 TZE Comp4 C_2, EV-IWD STR C_1, EV-IWF STR C_1.

Nigeria

- Results of studies to evaluate the progress from selection following three cycles of selection in the Low Nitrogen Population - Yellow (LNTP-Y) under stress (30 kg N ha^{-1}) and non-stress (90 kg N ha^{-1}) conditions revealed good progress from selection under low N for most of the traits measured. Grain yield increased with cycles of selection. An average grain yield of 0.13 t ha^{-1} or 4.1% per cycle was obtained. Five yield components, stay green, days to silking, anthesis, N-uptake efficiency and N-utilization efficiency were significantly associated with grain yield.

- Four maize genotypes (DTSR-W, LNPC3, AC 8328 BN C7, and LNTP) have been identified as nitrogen use efficient in Nigeria. The genotypes produced higher grain yield than the widely grown OP variety, TZB-SR at 30 Kg/ha N. However, they did not differ from other varieties at 90 Kg/ha N. These genotypes are potential N tolerant varieties that could be grown under low N stress. About 40 genotypes from the low N tolerant population, LNTP-Y Pool C1FS produced grain yield of more than 2500 kg/ha at 30 kg/ha N and have been selected for use in developing N-tolerant composites, synthetics and hybrids.

Benin

- The superior performance of 5 *Striga* tolerant composites, TZEE-W Pop C_0, EV DT 97 STR C_1, TZE Pop C_0, IWD STR and 95 TZEE-Y_1 was confirmed in 1998 and 1999 in Benin. Seed increase of the varieties was carried out for more extensive testing on-farm in 2000 and 2001. Also, crosses were made between the 5 composites and 5 *Striga* resistant lines (Tzmi 407, Tzi MMB 9, Tzmi 103, Tzi 1368 STR and Tzi Ku 1414) in an effort to improve the *Striga* resistance.

- Based on the results of the screening for *Striga hermonthica* resistance in Benin four IITA inbred lines (TZMi 407, TZMi 103, 1368 STR and KUI 414) were identified as resistant sources for use in the breeding program. Also EV DT 97 STR C_1, and STR EV IWT were selected based on tolerance to *Striga* and high grain yield for on farm trials in 1999.

- The *Striga* tolerant varieties, EV DT 97 STR C_1, IWD STR, 2000 Syn EE-W and 99 Syn EE-W confirmed the outstanding performance under artificial *Striga* infestation in trials conducted in 2000 in Benin. Seed multiplication of EV DT 97 STR C_1 and IWD STR has been initiated to ensure the availability of seed of the varieties for promotion for adoption in Benin.

2.2. Development of sustainable agronomic practices to enhance maize productivity and production

Despite the high potential for maize production in the savanna of WCA, yields are presently low due to *Striga* damage and inherently poor and fragile soils which rapidly degrade under intensive cropping. The increased importance of *Striga* in the sub-region is associated with intensification of land use resulting in reduction of fallow periods, rotations and intercropping which were common practices that kept *Striga* infestations at acceptable levels in the semi-arid WCA. To reverse this trend, the emphasis of WECAMAN for the past decade has been the development of early maize varieties with moderate levels of *Striga* tolerance and a combination of agronomic practices that break the continuous maize cropping cycles through the use of selected non-host legume cultivars. The non-host legumes when used in rotation with the *Striga* tolerant maize can cause suicidal germination of *Striga* seed in the soil and hence reduce the *Striga* seed bank for the succeeding maize crop. Biological control is also a potential technology that could reduce *Striga* infestation in the sub-region and is being actively pursued.

Benin, Burkina Faso, Cameroon, Côte d'Ivoire and Togo have been assigned on competitive basis research responsibilities for developing sustainable agronomic technologies that could enhance maize production and productivity in the savanna of WCA.

Recognizing the fact that agronomic recommendations are variety and location specific, WECAMAN encourages and supports through competitive grants, the conduct of agronomic trials to maximize maize yields on-farm. Agronomic trials supported in-country include optimal planting time, density and time of fertilizer application. WECAMAN has also supported the conduct of maize-legume rotation or inter-cropping trials for *Striga* control and improved soil fertility management. Results from such trials that address cross-cutting problems are shared and used in the formulation of on-farm research themes for the strategic deployment of improved varieties and complementary crop management options in the sub-region.

Maize responds favorably to high soil fertility. Full realization of the yield potential of maize varieties is possible only under high soil fertility. Low soil fertility, especially N and P deficiency, is a major factor limiting maize production and productivity in WCA. To complicate the problem, inorganic fertilizers are not easily available in the sub-region and where they are, the costs are usually prohibitive and beyond the reach of the majority of maize growers, the resource poor subsistence farmers.

An indirect negative impact of non-availability of fertilizers on increased maize production in WCA is that farmers are not adopting the improved varieties as rapidly as desirable. Farmers involved in impact assessment surveys in all member countries consistently indicated non-availability and / or prohibitive cost of fertilizer as the first reason they are not adopting the improved varieties (Enyong

et al., 1999; Onyibe *et al.*, 2001) . For this reason, many maize farmers are not planting maize. Some in fact shift to the cultivation of sorghum and millet that are less demanding on fertilizer application in years when fertilizer is not available.

In order to alleviate this constraint and encourage the adoption of improved maize technologies, the Network initiated and funded a series of studies on alternative methods of soil fertility management in member countries. Subject-matter areas covered by the studies included management of crop residues, incorporation of manure and organic matter into the soil, cover crops, and legume-maize rotations. Studies were also conducted on the sources and efficacy of locally available inorganic fertilizers such as rock phosphate. The major findings of the agronomic studies are summarized in the following section:

- Maize-groundnut and maize-cowpea associations have been studied in Benin. One row of maize alternated with two of groundnut produced the best yields. In another study, yield of maize increased by about 30% after one year of rotation with cowpea variety TVX 1850-01F. An added value of this combination is that *S. hermonthica* infestation was practically nil after one year of rotation.

- In Ghana, a two-year rotation of maize following groundnut gave significantly higher maize yield than maize following maize. Economic analysis showed that the returns to land were higher when maize was rotated with groundnut. From similar studies conducted in Ghana with *Mucuna* and *Calopogonium* as cover crops, it may be concluded that the use of leguminous cover crops is a better system of fallow than the traditional bush fallow. This conclusion was corroborated by the higher returns to both land and labor for the improved fallow systems with *Mucuna* and *Calopogonium*. *Mucuna* fallow was, however, found to be superior to that of *Calopogonium*

- The results of studies conducted in 1997 and 1998 confirmed the findings that in the Guinea savanna zone of Ghana addition of inorganic fertilizer or manure to maize following groundnut or soybean gave significantly higher maize grain yields than continuous cropping of maize with the addition of inorganic fertilizer or manure.

  Studies in Ghana aimed at identifying alternative sources of fertilizer showed that *Calopogonium* cover crop provided biologically fixed N equivalent to 35 kg/ha and 30 kg/ha of fertilizer N to succeeding maize crops in 1997 and 1998, respectively. *Calopogonium* also produced substantial increases in maize yields when used as a cover crop. The ability of *Calopogonium* to fix N and increase maize grain yields coupled with its capacity to produce adequate seed renders it as a suitable cover crop in maize production systems. *Calopogonium* is therefore currently being tested on farmers field in Ghana.

A study in Ghana to estimate the N fertilizer equivalency of selected cover crops has revealed that a significant linear relationship between maize grain yield and N rate. Based on the yield response curves, the fertilizer N equivalency was estimated to be 35, 16, 18 and 3 kg N/ha for the cover crops *Calopogonium, Mucuna, Pueraria*, and *Vigna unguiculata*, respectively.

- The results of a two-year study in Côte d'Ivoire on maize-legume intercropping have established that the effect of different legumes (groundnut, cowpea, soybean) on maize was similar and that maize performed equally well with any of the legumes. The best time to plant either crop depends on the interest of the farmer. When production of more maize is the objective, the maize and legume could be sown together or the maize sown as from about two weeks before the legume. On the contrary, if the interest is in the legume, it is advisable to plant the legume first. Planting the legume about two weeks before maize was better than planting the maize four weeks after the legume.

- Results of on-farm trials conducted in the Kara Region of Togo since 1995 have established that maize-pigeon pea rotation would ameliorate soil fertility, increase maize grain yield, and provide pigeon pea for human consumption. Similarly, better growing conditions were observed for the maize crop in Cameroon when pigeon pea was tested in rotation with maize for three years in each of three locations. At all three locations, higher maize yields were observed after pigeon pea than after the traditional fallow system. Use of pigeon pea in the rotation saved up to 130 kg N/ha, depending on the location.

- In Nigeria, intercropping an extra-early maize with four legumes, *Centrosema pascuorum*, *Lablab pompeureus*, soybean var TGX 1448, and cowpea var IT 94 K- 4403 significantly increased maize yield.

- In Nigeria, agronomic studies showed that ground Sokoto phosphate rock (SPR) produced yields which were comparable to those from 50% partially acidulated phosphate rock (PAPR) and single super phosphate.

- Studies on the response of extra-early, early and intermediate maize varieties to locally available fertilization material in Burkina Faso have established the best formulation to be 300 kg/ha of Burkina phosphate, 75 t/ha of organic matter, and 50 kg/ha of urea. This is equivalent to 100 kg/ha of NPK and 50 kg/ha of urea.

- Thirteen trials were conducted in the Sudan savanna zone of Benin (Guéné and Birni Lafia) in 1997 to determine the dose of farm manure and the optimal combination of farm manure and inorganic fertilizer for maize production. The results of the study revealed that of the three rates of farm manure (0, 5, 7 t/ha) and two rates of mineral fertilizer (0 and 50%) of the recommended dose of fertilizer (100 kg/ha of ammonium phosphate and 100 kg/ha of urea) evaluated in factorial combination, 7 t/ha of manure gave the highest yield.

The partial budget analysis revealed that the application of 7 t/ha of organic manure and half dose mineral gave the highest net benefit (159 235 FCFA). Nevertheless, 7 t/ha of the farm manure without the application of mineral fertilizer could be recommended to farmers for lower revenue (113 440 FCFA).

Highlights of other agronomic studies funded by WECAMAN in the respective member countries are as follows:

Cameroon

- The results of studies conducted in 1999 and 2000 in Cameroon to determine the effect of insecticides, fungicides and aromatic plant powder on the germination of seed borne fungi of maize have concluded that seed-borne fungi infection had negative effect on maize grain yield by reducing the emergence of seedlings, the plant stand, density at harvest and grain yield.

- Of the 14 different seed treatments evaluated, the best treatment was Benlate + Marshall.

- Combination of Marshall and the aromatic plant powder, *Thymus vulgaris* was the most cost effective.

- Seed treatment cost can be reduced by substituting a fraction of the synthetic chemical with the crude powder of *T. vulgaris*.

Burkina Faso

- Studies by Togo and Burkina Faso on the use of *Parkia biglobosa* pods for *Striga* control in 1996 led to the following conclusions:

  a) There exists germination inhibitors for *Striga* seeds in macerations obtained from *Parkia biglobosa* pods.
  b) Concentrated macerations fully inhibit *Striga* seed germination.
  c) In some field trials, use of macerations for *Striga* control in a maize crop was detrimental to maize growth and grain yield apparently because of phyto-toxicity.

  Research responsibility was therefore given by WECAMAN to Burkina Faso to refine field applications in respect of timing and amount of *Parkia* seed extract to be applied in the field for effective control of *Striga*.

- Studies conducted in 1996 and 1997 in Burkina Faso have confirmed that Nere powder had active components which inhibited *S. hermonthica* seed germination. The dose 750 g/m2 was comparable to 500 g/m2 even though its efficacy varied depending on the biological and physiological conditions of the soil. The Nere powder when incorporated into the soil at the rate of 750 g/m2 allowed the reduction of *Striga hermonthica* population at the flower initiation stage by more than 50% and resulted in a yield increase of 40% compared to the nontreated control.

- On-farm tests carried out in Burkina Faso in 1999 and 2000 showed that the nere extract when applied to the soil did not inhibit *S. hermonthica* germination. However, the nere extract affected the days to flowering and maturity as well as the nitrate nitrogen and the potassium available for flowering. The date of application and doses of the extract did not have any significant effect on the grain yield.

Benin

- Studies in 1998 in Benin have confirmed that the best date of planting maize in the savanna zone of Benin is between 25 June and 15 July. Also, the best plant spacings are 0.75 x 0.40 m, 0.80 x 0.30 m and 0.80 x .20 m.

- Screening of trap crops *in vitro* for *Striga* control by Benin scientists has revealed that in vitro stimulation of *Striga* seed germination was better with peanut varieties RMP 12, RMP 91 and 69-101. The cowpea variety 90-K-56 has been found to be effective as a trap crop under artificial infestation.

- Results of field studies in Benin have established the effectiveness of the cowpea varieties TVX 1850-01F, IT 90 K-56, soybean varieties TG x 536-02 D and Jupiter, and the groundnut varieties RPM 91, 69-101 and Moto as false hosts for the control of S. *hermonthica*. The cowpea varieties are particularly recommended as false hosts for S. *hermonthica* as they highly stimulated in vitro S. *hermonthica* seed germination specific to millet in contrast to the other hosts. A two-year rotation with the false hosts was found to be more effective compared to a one-year rotation while planting of two plants per hill gave better results than one plant per hill.

- Maize-groundnut association study in Benin has established that the highest grain yields were obtained when a maize row was associated with 2 rows of groundnut.

- Studies on time of N application on early and extra-early maize varieties in Benin have established that N should be applied at planting time and 15-22 days after planting for the extra-early varieties and 28-30 days after planting for early varieties in order to maximise grain yield.

Nigeria

- The project on enhancing maize production through the improvement of *Striga* and soil management capabilities of farmers was extended to three new sites/villages in the northern Guinea savanna in year 2001. The sole maize cropping system for using the Striga tolerant variety AC 97 TZL Comp1-W performed significantly higher in terms of ear height, cob weight and grain yield than the intercrop of AC 97 TZL comp1-W with cowpea at Sakarau. However, in two of the villages, the difference was not significant. Also, the sole crop supported lower *Striga* shoot and exhibited lower host damage severity. Similarly, sole cowpea produced significantly higher pod weight and seed yield than the inter-cropped cowpea. Soybean did not differ significantly in these parameters. The cost-benefit analysis of the rotation systems showed that sole OPV maize rotated with sole cowpea had the highest profit for the farmers.

- Results of studies in Nigeria to identify trap crops for the control of *Striga* in the Giunea and Sudan savanna zones of WCA have established the effectiveness of the following crop varieties:

  Cotton-SAMCOT 9 and SAMCOT 10
  Cowpea-IT 89 KD - 245-1 and IT 93K - 596 Groundnut - RMP 12 and RMP 91
  Soybean - TGX 1681 - 3F and SAMSOY 2.

- Results of the studies aimed at developing complementary crop management practices that will severely reduce the stem-borer population in endemic areas of Nigeria showed that

intercropping the stem-borer tolerant maize varieties, TZBR-Eldana-3C2 and DMR-LSR-W with cassava significantly reduced stem-borer infestation in maize population at 8 weeks after planting and at maturity. This is explained by the fact that stem-borers do lay eggs on non-host plants in a complex intercropping system thereby reducing the number of eggs laid on the maize crop. Of the two maize varieties evaluated, TZBR-Eldana-3C2 appeared superior to DMR-LSR-W in terms of the maize population at 4, 8 weeks and at maturity as well as the number of plants with cobs. Stalk damage was also less in TZBR-Eldana-3C2.

- Results of studies conducted in Nigeria in 1998 and 1999 to identify complementary crop management practices that would increase maize yields as a result of decreased stem-borer damage confirmed that maize cassava intercrop significantly enhanced maize establishment 3 and 8 WAP and was superior in grain yield than sole maize.

2.3. Promotion of the adoption of improved maize varieties and crop management practices

The major thrust of WECAMAN has been on the development of early and extra-early maize varieties and associated agronomic practices. Adoption of these varieties and, to some extent, the complementary agronomic practices by farmers has led to the expansion of maize production in the sub-region. However, the rate of adoption of the technologies has been constrained by several factors, including high price and non-availability of inputs, poor seed production and distribution, inadequate on-farm testing of available technologies, inadequate number of extension workers and poor researcher-extension farmer linkages.

There are several pieces of evidence supporting the importance that WECAMAN attaches to promoting the adoption of improved technologies. First is the allocation of funds to the different Project themes from 1994 to 2002. During the SAFGRAD era, the Network allocated the largest proportion of the available research funds to technology generation, particularly genetic enhancement (GE) and agronomic research (AR). This trend continued into the initial years of the 1994-2002 period (Fig. 1). In 1994 and 1995, for example, technology transfer (TT) was allocated only about 14 and 18% whereas GE received about 32 and 26% of the funds for the two years, respectively.

During the two years, marketing and utilization (M&U) projects were not funded at all. From 1996, however, the largest proportion of the funds was allocated to TT and M&U projects were also funded, although this aspect got the lowest allocation. Summed across the 1994-2002 period, nearly 30% of the funds was allocated to TT (Fig. 2). The combination of TT and community seed production (CSP) was allocated 46-55% (47% on average) from 1996 to 2002 (Figs 3 and 4). Corresponding allocations were 17-27% (about 23% on average) for GE and 14-20% (17% on average) for AR.

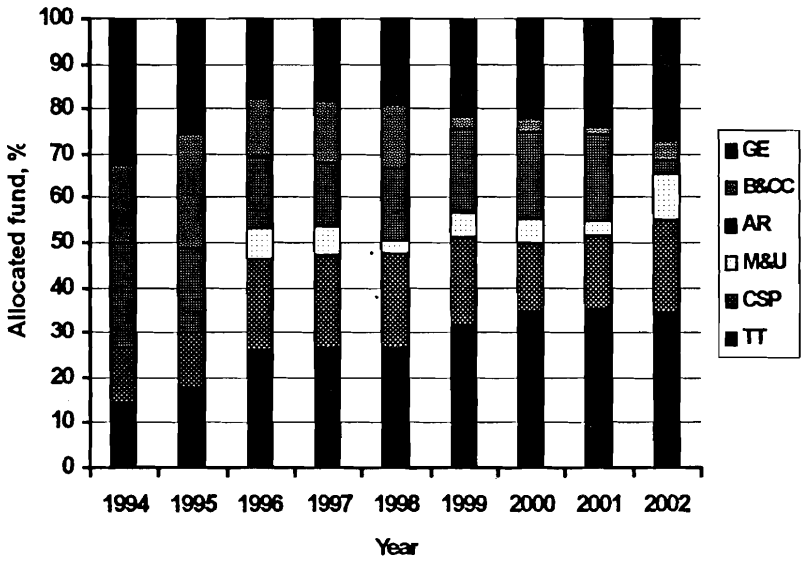

Fig. 1. Proportion of funds allocated to the different projects of WECAMAN, 1994-2002. (GE=Genetic Enhancement, B&CC=Biological & Cultural Control, AR=Agronomic Research, M&U=Marketing & Utilization, CSP=Community Seed Production, TT=Technology Transfer).

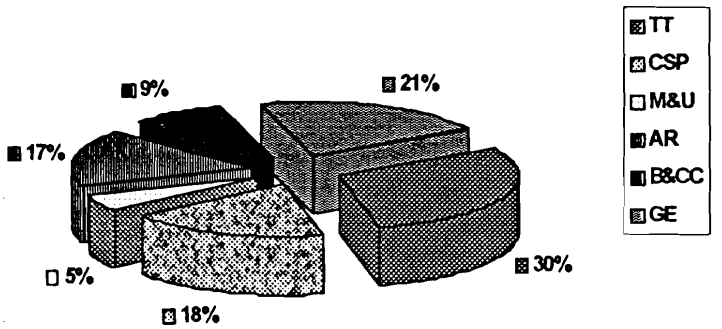

Fig. 2: Total funds allocated to the different WECAMAN projects 1994-2002

Second, whereas most of the other projects were awarded on competitive basis, TT projects were assigned under certain guidelines in such a way that all member countries participated.

The strategies of WECAMAN to promote the adoption of available maize technologies in member countries include:

i. National maize workshops and Annual Planning Sessions;
ii. Regional Uniform Variety Trials;
iii. On-Farm Tests and Demonstrations;
iv. Training courses and workshops;
v. Enhancement of exchange of ideas and technical experience among NARS scientists;
vi. Promotion of community level seed production.

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i) National maize workshops and Annual Planning Sessions

The success of any agricultural research enterprise depends on effective linkages with agricultural extension and development institutions as well as with national and international agricultural research institutions. Some of the individual research institutions in WCA are well linked with others in the country as well as with international research systems. Moreover, the institutions enjoy good relationships with national extension agencies, NGOs and relevant development agencies. National research institutions of others countries appear not so well linked. Since 1994, WECAMAN has been encouraging and assisting member countries to organize National Maize Workshops and Annual Planning Sessions facilitated by WECAMAN in member countries is an effort to foster linkages between researchers, extensionists and farmers in countries where such were not in existence. The objective is to encourage researchers, extensionists and farmers to collectively review and discuss research findings, grower recommendations and agricultural policies. Member countries that had not been organizing maize workshops and annual planning sessions have been provided financial support to initiate these activities. For example with the financial support of WECAMAN, maize workshops and annual planning sessions have been initiated and firmly established in Benin and Togo.

Often technologies fail in the transfer phase due to late involvement of the extensionist. Bringing in the extensionists very early in the technology development phase allows active participation of the extensionsists in the design, implementation and evaluation of the technologies in WECAMAN member countries. Such an approach builds confidence in all stakeholders thus improving the efficiency of individual roles in the planning and execution of technology development and dissemination. Through the maize workshops and annual planning sessions, it has been possible to bring in the extensionists very early in the technology development phase, not just at the technology transfer phase.

ii) Regional Uniform Variety Trials

An important vehicle for the direct exchange and evaluation of elite germplasm and other technologies has been the Regional Uniform Variety Trials (RUVT) conducted by all member countries of WECAMAN. The importance attached to regional testing of improved technologies is twofold: to accelerate the process of verification and validation of the performance of technologies under different environmental and socio-economic conditions and to publicize germplasm and related technologies available in the NARS and IARCs. The ultimate goal of the regional trials is the identification, on-farm testing and eventual release of the varieties evaluated in the trials by the NARS.

Submission of the entries for the trials is open to all Network member countries, particularly but not limited to lead NARS; that is, countries specifically assigned breeding projects. Through the RUVT, less endowed countries with respect to technology development have identified varieties suitable for target ecologies in their countries. WECAMAN also collaborates with the IITA Maize Program to distribute to member countries, trials for the intermediate and late maturing maize varieties.

A total of 436 sets of RUVT (comprising 224 sets of RUVT-Early and 212 sets of RUVT Extra-early) were evaluated at various locations in Network member countries between 1993 and 2000 (Fig. 3).

In addition to the RUVT, two Regional *Striga* Variety Trials (RSVT) were offered to the NARS collaborators for the first time in 2001. These were the Regional Early *Striga* Trial (90-95 days to maturity) and the Regional Extra-early *Striga* Trial (80-85 days to maturity) which comprised *Striga* resistant/tolerant cultivars. The sets of the RUVT and RSVT dispatched to the NARS collaborators on request in 2001 and the recovery rates are shown in Table 2. Based on the results of the regional testing program of 2001, the following *Striga* resistant early varieties have been identified as promising for further evaluation on-farm and promotion for adoption:

- EV DT 97 STR C1
- AC 94 TZE Comp 5-Y
- TZE_W Pop x 1368 STR C1
- AC 94 TZE Comp 5-W

Normally, the NARS follow up the RUVT with requests for seed of varieties found promising in their respective countries for further evaluation in national adaptive trials and demonstrations. In Table 3 is presented the quantities of seed dispatched by WECAMAN Coordinator to WECAMAN partners on request from 1998 to 2001.

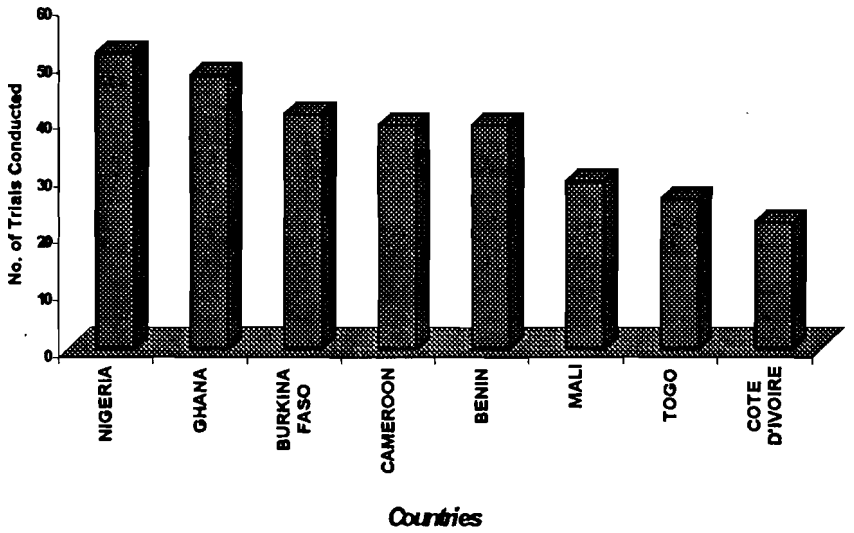

Fig. 3: Number of Regional Uniform Variety Trials conducted by WECAMAN member countries, 1994-2000

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Table 2. Number of sets of Regional Striga Trials dispatched to WECAMAN partners in 2001 and the data recovery rates

Countries/Organizations	Regional *Striga* Trial - Early	Regional *Striga* Trials - Extra-early
Cameroon	1	1
Tchad	2	2
Burkina Faso	1	1
Benin	2	2
IITA-Nigeria	2	2
Mali	1	1
IAR-Nigeria	2	2
Chana	1	1
CNRA-Côte d'Ivoire	1	1
IITA-Côte d'Ivoire	2	2
Total dispatched	**15**	**15**
Total Returned	**11**	**12**
Recovery rate (%)	**73**	**80**

Table 3. Amount of seed dispatched to the NARS partners and other collaborators on request from 1998 - 2001

Country	Amount of seed (kg)			
	1998	1999	2000	2001
Ghana				15
Senegal	15			
Guinea	45			
Tchad	16	5.5		35
Sierra Leone				6
Côte d'Ivoire	184.5	75.5	822	93
Ethiopia	10			
Togo	25	25		4
Benin	35	37	100	60
Kenya	6.5		4	4
Nigeria	32	17	67.5	10
Aventis Crop Science, Champaign, USA				4
D.R. Congo				2
Mali	127.5	37.5	10	
Niger	20	20		
Mauritania	20	20		
CIMMYT-Kenya	6.5	6.5		
Total	**543**	**251**	**263.5**	**233**

iii) On-Farm Trials and Demonstrations

On-farm trials and demonstrations are important avenues to show the effectiveness of new technologies to farmers. Therefore, WECAMAN provides funds to all its member countries for the conduct of on-farm trials and demonstrations, including farmer participatory methods of testing varieties and agronomic practices.

Most of the WECAMAN member countries are faced with the problem of low extension: farmer ratio. Therefore member countries are encouraged to work with farmer groups (instead of individual farmers) who, in turn, would then be encouraged to demonstrate their work to colleagues through formal visits and field days. Also, WECAMAN encourages closer collaboration with non-traditional agents such as NGOs for the diffusion of technologies to farmers.

WECAMAN encourages NARS scientists to organize field days each season to re-emphasize the technical aspects of the technologies being promoted. The field days offer the opportunity for the farmers, extensionists and the WECAMAN scientists to discuss current production problems and proffer solutions or explore ways of avoiding such problems in the future. Farmers from the vicinity are invited to attend the field days. By so doing the field days serve to help the spread of knowledge of the new technologies being promoted. WECAMAN insists that on-farm research activities should include agronomists and economists. Also, farmer participatory methods of on-farm testing of varieties and crop management practices have been exposed to WECAMAN member countries and are being emphasized in order to improve the adoption of available technologies.

All on-farm trials funded by the Network include farmers' field days at different stages of crop growth. This approach enables the researchers and extension workers to visit farmers' fields, so that the farmers can conduct the scientists through their fields. The visit to the farmers' fields enables scientists to obtain a feedback on the performance of new technologies evaluated by the farmers. Farmers not involved in the evaluation of a particular technology have the opportunity to see the performance of the technology on the field of their participating colleagues.

A total of 2595 on-farm trials were funded by the Network from 1995 to 2000, ranging from 78 to 768 for individual member countries (Fig.4), and an average of about 371 per year for the whole sub-region. As shown in Figure 5, there have been dramatic increases in the number of on-farm trials in the last few years.

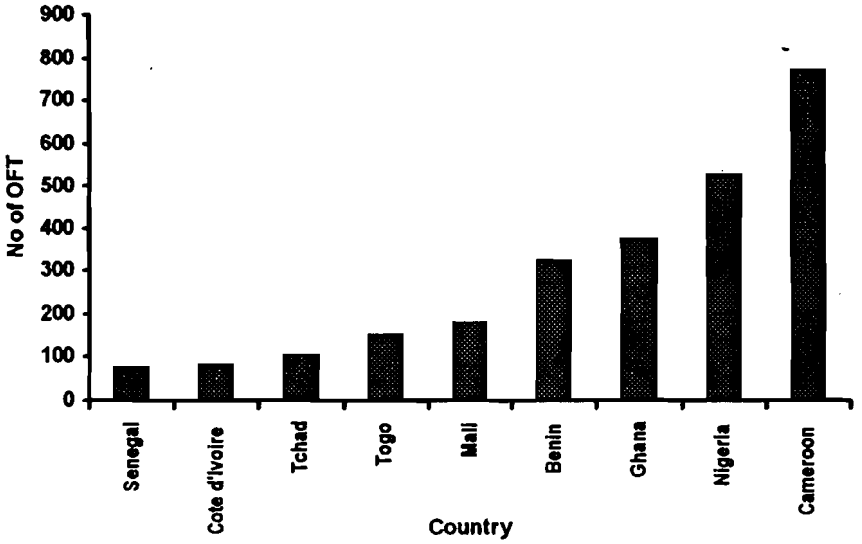

Fig. 4: Total number of on-farm trials (OFT) funded by WECAMAN in member countries, 1996-2001

One of the NGOs that has been much involved in the transfer of maize technology in collaboration with WECAMAN is the Sasakawa Global 2000 (SG 2000). This group has successfully employed the Production Test Plot (PTP) program as an effective tool to demonstrate new technologies and to convince farmers to adopt them. The PTP embodies the "learning and doing" principle and allows the farmer to weigh under his own circumstances the risks, costs and benefits of the new technology. The PTP is about 0.5 ha (1 acre) in size and it is usually adjacent to the farmer's fields for comparison purposes. Under the PTP program, researchers, extensionists and SG 2000 staff hold several planning sessions at central locations and at regional level to plan the PTP program

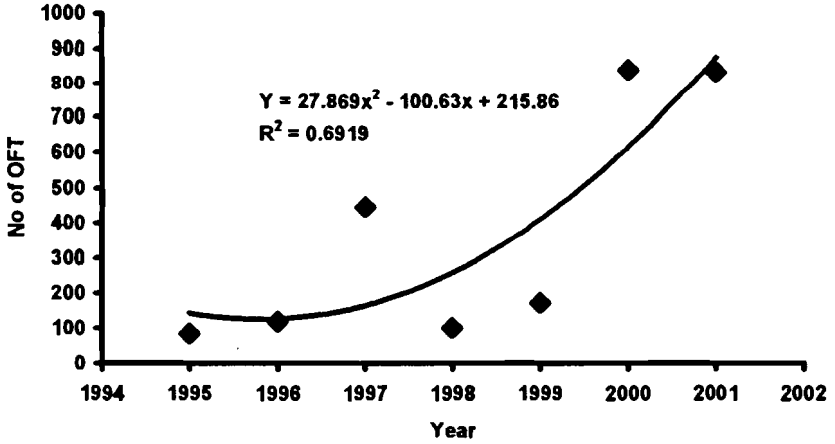

Fig. 5: Total number of on-farm trials in WECAMAN member countries, 1995-2001

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for the year. The PTP planning sessions have also helped to strengthen the research-extension linkage by providing a forum that facilitates contributions from technical staff coming from the various participating organizations. During the planning process, "technology gaps" are identified and the researchers are encouraged to focus their efforts on filling these.

Extension staff carefully selects the PTP farmers and a contract is signed between the extension services and SG 2000. The contract specifies the inputs received from the program, the value as well as the repayment schedule.

SG 2000 is presently promoting the adoption of technologies in Ghana, Benin, Mali, Guinea, Nigeria and Togo using the PTP program. The Network is encouraging the adoption of the PTP approach for promotion of new technologies in the other WECAMAN member countries.

WECAMAN provides research grants through the competitive grant scheme to conduct and identify appropriate complementary crop management options to maximize yield of the identified varieties on-farm.

Highlights of the results of on-farm trials and demonstrations carried out since 1997 are as follows:

Nigeria

Based on the data on the performance of the extra-early varieties on station, in multi-location tests and on-farm, the varieties ACR 97 TZL Comp1-W, 95 TZEE-W_1 and 95 TZEE-Y_1 have been registered and released to Nigerian farmers. The National Committee on Registration and Release of new crop varieties and Livestock breeds approved the recommendations for registration and release of the varieties by IAR Samaru. The new varieties have been designated as SAMMAZ 11, SAMMAZ 12 and SAMMAZ 13 for the ACR 97 TZL Comp1-W, 95 TZEE-W1 and 95 TZEE-Y_1 respectively. The new varieties would likely be sold to farmers by the Nigerian seed companies beginning from 2002 season. At least, twenty kilograms of breeder seed of each of the released varieties will be delivered to the National Center for Genetic Resources and Biotechnology (NACGRAB), Ibadan, for long term storage in the gene bank.

- Thirty copies of the Maize Production Bulletin were produced under the project for some Government officials of Nigeria desirous of starting large scale maize production in Zamfara and Katsina States. In addition, the Hausa version of the TV program on extra-early maize and seed production was revised and aired at the Katsina State Broadcasting Service.

- Results of on-farm trials in Nigeria showed that intercropping an extra-early maize with four legumes, *Controsema pascuorom, labab pompeureus*, soybean variety, TGX 1448 and cowpea variety IT 94 K - 4403 significantly increased grain yield of maize.

- The results of 14 demonstrations established on farmers' fields at the EPHTA benchmark site, Layin-Taki/Kaya in Northern Nigeria showed that the intercrop of the legume trap crops soybean (Samsoy 2), groundnut (RMP 91) with the improved *Striga* tolerant open-pollinated maize variety, ACR 97 TZL Comp1-W resulted in significantly higher stand count and crop vigor score compared with the farmers practice. *Striga* infestation and incidence were

significantly lower on the plots planted with the improved maize hybrid, Oba Super I and Acr 97 TZL Comp1-W compared with the farmers' variety. Higher maize yields were generally obtained with groundnut intercrop compared with the soybean, probably due to the competition of the latter with maize. The maize grain yield when Oba Super 1 and Acr 97 TZL Comp1-W were intercropped with Samsoy 2 and RMP 91 were 19%, 22%, 19% and 43% respectively higher than the farmers' practice. Results of interviews with farmers indicated that the improved *Striga* control technologies were the "best bet" *Striga* control options and thus were preferred to the farmers' practice. About 150 kg of breeder seed and 1100 kg of foundation seed of the *Striga* resistant varieties Acr 97 TZL Comp1-W and Acr 94 TZE Comp5-W were produced in support of the promotional campaign.

- The project on the promotion of the adoption of maize varieties was expanded from 2 communities to cover 4 communities in Zamfara state and from 6 to 8 communities in Katsina State in 2001. A total of 340 kg of seed was given to 96 farmers. 13,685 kg of seed of 95 TZEE-Y_1 and TZEE-W_1 was produced through the farmer groups.
- One demonstration plot of 0.5 ha each was established in Katsina and Zamfara States in the year through community participation.

- 318 farmers participated in field days in 2001 while 3 farmer groups were linked with input distribution agencies.

- 16 farmers participated in the Large Irrigation Project during the 2000/2001 dry season using two varieties, ACR 90 Pool 16 DT and 95 TZEE-W1. The mean grain yield of ACR Pool 16 DT was 2.9 t ha^{-1} with the yield ranging from 2.0 to 4.4 t ha^{-1}. Average Gross Margin from green maize sale was ₦40000 ha^{-1} for ACR 90 Pool 16 DT and ₦27000 for 95 TZEE-W_1. The average gross margin for the grain sale was ₦34000 for ACR 90 Pool 16 DT and ₦1600 for 95 TZEE-W_1.

Togo

- The improved early maize varieties, DMR ESR-W, TZE Comp4 C_2 and TZE Comp3 C_2 and the extra-early varieties 95 TZEE-W_1 and 95 TZEE-Y_1 were introduced through on-farm trials to the districts of Tone and Tandjoare of the Kara Region of Togo in 1999. The improved varieties were compared with the early local check AB11 and the extra-early check TZE SR-W x Gua 314. The improved varieties have confirmed their high performance in on-farm trials over a period of 3 years and are earmarked for official release in Togo.

- Results of three year study to determine the most economic population density for the production of early and extra-early varieties in the Kara and Savanna Region of Togo have shown that 0.65 m x 0.40 m, with two plants/hill giving a population density of 76923 plants/ha is the most economic. The study has also resulted in the modification of the fertilizer recommendation through the use of mucuna in the rotation system. The recommended fertilizer dose could be reduced by 33 to 50% without a reduction in grain yield through rotation of maize with mucuna.

- The results of a study conducted from 1999 to 2001 in the savanna Region of Togo has confirmed the effectiveness of maize-legume rotation for the control of *Striga hermonthica* and improvement of soil fertility. The highest grain yield was obtained in Djambengou zone following a two year rotation of the early maize variety, 92 TZE Comp 4 with the sole crop of the cowpea variety, TVX 1850 OI F and the soybean variety, Jupiter. Similar results were observed for the maize varieties, TZLW Comp1 C4 and AB 11 at Lokpanou, Tami and Naki East. The results also showed that maize grain yield was higher when it was rotated with soybean or cowpea than when it was intercropped with the cowpea or soybean.

- The improved early maize varieties, DMR ESR-W, TZE Comp4 C_2 and TZE Comp3 C_2 and the extra-early varieties 95 TZEE-W_1 and 95 TZEE-Y_1 were introduced through on-farm trials to the districts of Tone and Tandjoare of the Kara Region in 1999. The improved varieties were compared with the early local check AB11 and the extra-early check TZE SR-W x Gua 314. The improved varieties have confirmed their high performance in on-farm trials over a period of 3 years and are earmarked for release in 2002.

Benin

- On-farm trials were conducted in the Sudan savanna zone (Angaredebou) and at Guene and Birni-Lafia in the Sudano Sahel zone of Benin in 1999 and 2000 to determine the best spacing to maximize grain yield of extra-early maize. The results of the studies showed that Guene and Birni-Lafia, a spacing of 0.75 x 0.40 gave the highest grain yield and was preferred by the famers while in Angaredebou the farmers opted for 0.80 x 0.30 m because this gave a higher number of ears.

- Eighteen on-farm trials were established in 2000 and 2001 in *Striga* infested fields in Zakpota in the coastal savanna zones of Benin to compare the *Striga* tolerant early (EV DT 97 STR C_1) and extra-early (TZEE-W Pop STR) varieties and the *Striga* susceptible local variety, Jame de Za. Results have shown that EV DT 97 STR C_1 supported the lowest number of *Striga* plants followed by TZEE-W Pop STR with the local variety supporting the highest number of *Striga* plants. The *Striga* tolerant varieties also were superior to the local variety in terms of grain yield with EV DT 97 STR C_1 producing the highest grain yield.

- On-farm trials were established in the Sudan Savanna zone (Bensékou and Angaredebou) and the northern Guinea savanna zone (Sokka) in 1997 and 1998 to determine the best spatial arrangement to maximize grain yield and the net benefits in a maize-groundnut association. The results of the study showed that in both the northern Guinea and the Sudan savanna zones, the maize-groundnut intercrop involving the normal maize population (two rows of maize and two rows of groundnuts) and 2/3 of the normal maize population (two rows of maize and three rows of groundnuts) produced higher grain yield compared to the pure maize and groundnut (Tables 2 and 3). However, the economic analyses in 1998 revealed that in the Sudan savanna zone, the farmer had a net benefit of 93410 FCFA and 124620 FCFA for the normal population density and 2/3 of the normal density, respectively, compared to 104883 FCFA for the pure maize and 32734 FCFA for the pure groundnut. In the northern Guinea savanna zone, the net benefit for the pure maize was higher than those of the normal population density and the 2/3 of the normal population density. The economic analysis of 1997 showed a net benefit of 67% and 2.38% for the adoption of the maize-groundnut

association using the normal population density and 2/3 of the normal density, respectively, compared to the pure maize and groundnut. Most farmers interviewed indicated preference for the two spatial arrangements compared with the pure culture of maize and groundnut because of the contribution to food security and improvement in soil fertility

Tchad

- Results of on-farm trials conducted in 8 villages in Tchad from 1999-2001 have revealed the varieties, TZE Comp 3 C_2, DMR-ESR-Y, AC 90 Pool 16 DT and 95 TZEE-Y_1 as outstanding. Based on the results, seed of the four varieties are being produced through the WECAMAN community seed production scheme to promote the new varieties.

- Four improved maize varieties, TZE Comp 3 C_2, DMR ESR-Y, ACR 90 Pool 16 DT and 95 TZEE-Y_1 were compared with the local variety CMS 8602 in on-farm trials in 8 villages in Tchad. Sixty farmers were involved in the trials. Results showed TZE Comp3 C_2 as the most promising entry with a grain yield of 3991 kg/ha. This was followed by 95 TZEE-Y_1 (2840 kg/ha) and ACR 90 Pool 16 DT (2175 kg/ha) in that order. One hundred and twenty seven farmers attended the field day organized to promote the new varieties during the growing season.

Mali

- On-farm trials involving two QPM varieties, Mamaba, Dembagnyuman (Obatanpa) and the local normal endosperm variety, Sotubaka were conducted from 1999-2001 in the CMDT and OHVN zones in Mali. Results showed that Sotubaka is the most stable variety in terms of grain yield especially in the humid zones. However, the QPM varieties, Mamaba and Debagnyuma produced satisfactory grain yield in less favorable environments. It should be noted that Mamaba was highly appreciated by farmers for the taste and grain filling. In addition, it was less prone to bird attack. Based on the results, Debagnyuma and Obatanpa are being vigorously promoted for adoption in Mali.

Cote d'Ivoire

- Through the collaboration of the Ivorian national maize program with WECAMAN, the two early maize varieties, DMR-ESR-Y, TZE Comp 4 and the extra-early varieties, CSP- SR BC_5 and TZESR-W x Gua 314 identified in on-station trials in Côte d'Ivoire after several years of multi-location tests were evaluated on-farm in 1996 and 1997 and showed superior performance. In 1998, the four varieties were used in demonstrations involving ten farmers. Large plots (2500 m^2 per variety) were used. The objectives were to verify the performance of the varieties on-farm and to expose the varieties to as many farmers and extension agents as possible. The results have confirmed that the early and extra-early varieties have superior yield and are stable in most of the farmers' fields. As a result, large quantities of seed of the varieties have been produced through the community seed production project and are already available to farmers in several communities.

Ghana

- The on-farm evaluation of cropping systems in Ghana was initiated in 1999 to compare groundnut-maize rotation with farmers practice of maize-maize production. Results of on-farm trials in 2001, showed that maize following groundnut gave significantly higher ($P<0.05$) maize grain yield than maize following maize in 4 communities (Chinchang,Silbelle, Piisi and Nakong) in the Upper West Region of Ghana. The analysis of the data for 2000 and 2001 for Chinchang and Silbelle showed that grain yield of maize in 2001 was significantly greater than that of 2000.

Cameroon

- Twenty farmer-managed on-farm trials were established during the 2001 second cropping season in Cameroon to evaluate the economic profitability of maize-cowpea intercropping as a stem borer control method at the farmers' level and to promote the adoption of the available new, high yielding maize varieties. The technologies demonstrated were:improved maize variety, fertilizer application, planting methods (row planting, plant density), plant arrangement (maize-cowpea intercropping) and time of weeding. Results revealed no significant differences among the maize-cowpea intercropping, the protected maize and the control treatments. Cowpea yield of the intercrop was very low probably due to poor photosynthetic activity leading to high biomass production with no seeding.

- A total of 18 on-farm trials were established on farmers' fields in the forest zone of Cameroon to compare improved and local varieties under farmers' conditions and to demonstrate the superiority of the improved varieties in controlling stem borer attack. One hundred and eighty-six participants attended the farmers' field day organized on 21 December, 2001 at Mbangassina. Of the three varieties evaluated on-farm (CMS 8704, AK 9522 and Local), AK 9522 was selected by the people in the study area as the most preferred for local dishes based on the color and taste.

- On-farm trials involving the improved maize varieties, CMS 8704, CMS 8501, AK 9552 DMR and AK 9528 DMR were conducted in the forest zone of Cameroon in 2000 and 2001 using participatory varietal evaluation approach. The results have led to the identification of CMS 8704 as the most stemborer tolerant and high yielding variety fallowed by AK 9522 DMR. CMS 8722 were preferred when the maize was consumed as dry grain.

Senegal

.Results of on-farm trials conducted in seven villages in Senegal from 1999-2001 revealed that the varieties DMR-ESR-W, Syn 9243, 95 TZEE-W1, TZEE-W SR BC_5 and across Pool 16 DT as the most promising white endosperm varieties. In the yellow endosperm group, Early Thai and KD 22 were identified as the most promising for promotion for adoption. The four varieties, Syn 9243, AC 90 Pool 16 DT, 95 TZEE-W, and DMR-ESR-W are earmarked for official release in 2002. To this end, the necessary protocols for the release of the varieties are being prepared in consultation with the Ministry of Agriculture

- Results of on-farm trials conducted in seven villages in Senegal showed 95 TZEE-W_1 and Syn 9243 as the most promising in the Kour Serigne Thioye and Kour Mamou Ndary zones, respectively.

Through the on-farm trials funded by WECAMAN in member countries several varieties and agronomic practices have been exchanged among WECAMAN member countries and some of these have been released to farmers (Table 4). For example, the extra-early variety TZEE-W SR has been released in seven countries, namely, Benin, Ghana, Cameroon, Burkina Faso, Côte d'Ivoire, Senegal and Tchad. Similarly, Pool 16 DT has been released in seven countries. A total of 16 extra-early and 24 early varieties have been made available in WCA and more are being worked on. Also, there has been a spillover of some cultural practices. The early and extra-early varieties as well as the improved agronomic practices promoted by WECAMAN have contributed significantly to increased maize production and productivity (Table 5) through movement of maize into new frontiers.

Several improved technologies are in the pipeline at the Network (Table 6) and the NARS (Table 7) levels for release and promotion by Network member countries through funding support from WECMAN. In the extra-early maturity group, there are nine *Striga* resistant varieties available at the Network level for testing through the RUVT. In the early maturity group, there are ten *Striga* resistant varieties and six new non-*Striga* resistant varieties still undergoing on-farm testing in WECAMAN member countries. In addition, three cultural practices are being tested on-farm by NARS. A major emphasis of WECAMAN at present is to promote the adoption of the available *Striga* resistant varieties and other control methods such as maize-legume rotation or mixtures to ensure sustained, high maize production in the long-term.

Table 4. Maize technologies transferred across countries among researchers or research systems through WECAMAN, 1994-2001

	Type and name of technology	Countries adopting technology	Source of technology
A.	**Improved varieties**		
1)	DMR-ESR-Y	Cameroon, Mali, Tchad, Guinea	IITA
2)	Ikenne 8149 SR	Togo	Togo/IITA
3)	AB11	Togo, Nigeria	Togo
4)	DMR-ESR-W	Benin, Côte d'Ivoire, Cameroon	IITA
5)	Pool 16 DT	Cameroon, Benin, Togo Ghana, Côte d'Ivoire Burkina Faso, Senegal	WECAMAN
6)	TZEE-W SR BC_5	Benin, Côte d'Ivoire Ghana, Cameroon Senegal, Tchad	WECAMAN WECAMAN
7)	Maka SR	Burkina Faso	WECAMAN/ Mauritania
8)	TZESR-W X Gua 314	Togo, Côte d'Ivoire, Nigeria	WECAMAN
9)	CSP SR BC_5	Côte d'Ivoire	WECAMAN
10)	TZEF-Y SR	Nigeria, Mali	WECAMAN
11)	TZE Comp 4	Guinea, Tchad, Côte d'Ivoire Senegal	IITA
12)	Obatanpa	Mali, Benin, Ghana Burkina Faso, Togo, Cameroon, Senegal, Tchad	Ghana
13)	95 TZEE-Y_1	Nigeria, Senegal, Tchad	WECAMAN
14)	95 TZEE-W_1	Nigeria	WECAMAN
B.	**Improved cultural practices**		
	1. Increased plant population for higher grain yield of early and extra-early varieties	Ghana, Benin Togo, Cameroon, Burkina Faso , Nigeria, Senegal	Cameroon Nigeria Benin
	2. Earlier date of fertilizer application (top dressing) for increased yield of early and extra-early varieties	Benin, Togo, Burkina Faso, Ghana, Cameroon, Senegal	Cameroon Benin
	3. Use of maize - legume rotation to improve soil fertility and maize grain yield	Benin, Ghana, Nigeria Cameroon, Togo, Cote d'Ivoire	Benin, Ghana Cameroon

Table 5. Maize production trends* and the adoption of improved technologies in some selected countries in West and Central Africa

	Average area harvested		Average production		Average yield		Technologies adopted by NARS through WECAMAN
	90-92	97-99	90-92	97-99	90-92	97-99	
	('000 ha)		('000 t)		(t/ha)		
West/Central Africa							
Benin	413	607	413	738	1	1.2	Kamb 88 Pool 16 DT, DMR ESR-W, Obatanpa, EV DT 97 STR C1, TZEE-W SR
Burkina Faso	201	261	302	362	1.5	1.4	SR 22, KPB, KPJ, KEB, KEJ, TZEEW SR 97, Obatanpa, 90 Pool 16 DT, DMR-ESR-W
Cameroon	220	392	396	583	1.8	1.5	CMS 8501, CMS 8704, CMS 9015, CMS 8606, TZEE-W SR, CSP x TZEE-Y
Chad	270	122	243	148	0.9	1.2	TZEE-W SR BC_5, Across 90 Pool 16 DT, Obatanpa, TZE Comp3 C_2, TZE Comp4 C_2, 95 TZEE Y, DMR-ESR Y
Côte d'Ivoire	675	700	540	573	0.8	0.8	TZESR-W x Gua 314, DMR-ESR-Y, TZE Comp4, CSP SR BC5
Ghana	525	683	683	1,015	1.3	1.5	Dorke SR, TZEE-W SR BC_3, Obatanpa, maize virus screening techniques
Guinea	90	85	81	88	0.9	1.0	Obatanpa, TZEW Comp4, DMR-ESR-Y, AK 9331 SR
Mali	172	195	224	324	1.3	1.7	Nielene, Appolo, DMR ESR-Y, Tiamante, Tuxpeno-1, TZEF-Y SR BC_3, SR 22
Nigeria	1517	4,111	1,820	5,419	1.2	1.3	95 TZEE-W_1, 95 TZEE-Y_1, Obatanpa, DMR-ESR-W, DMR-ESR-Y, TZE Comp4, TZE Comp3, TZEE-Y SR BC5, TZEF-Y SR, TZE-SR-W x Gua 314
Senegal	104	61	114	57	1.1	0.9	Pool 16 DT, 95 TZEE-Y, TZE Comp4, Obatanpa, TZEEW SR, DMR-ESR-Y
Togo	270	377	243	384	0.9	1.0	TZESR-W x Gua 314, Obatanpa, 95 TZEE-Y, 95 TZEE-W_1, TZE Comp4, AB11 Maize virus screening techniques
Across countries	4457	7594	5059	9691	1.15	1.23	

a) Optimal plant population for higher grain yield of early and extra-early varieties.
b) Optimal time of fertilizer application (top dressing) for increased yield of early and extra-early varieties.
c) Use of local sources of fertilizer and organic matter for soil improvement.
d) Use of a row of maize to two rows of groundnut in maize groundnut association to maximize grain yields.
e) Use of appropriate dates of planting in maize-legume intercrop to maximize grain yields.
f) Use of maize-legume rotation to control *Striga*, improve soil fertility and maize grain yield

Table 6: Promising technologies in the pipeline at the Network level in 2001

Attributes	Name of technology
1. Extra-early varieties	99 TZEF-Y STR, Sine TZEE-W STR, Ferke TZEE-W STR, 98 TZEE-W STR, 99 TZEE-Y STR, 2000 Syn EE-W, 99 Syn EE-W.
2. Early varieties	98 Syn WEC, EV DT-W 97 STR C_1, 99 Syn WEC, EV DT-W 2000 STR, EV DT-Y 2000 STR, 2000 Syn WEC, EV DT-W 99 STR, TZEW-Pop x 1368 STR, Acr 94 Pool 16 DT STR, Acr 94 TZE Comp 5-W, Acr 94 TZE Comp 5-Y, TZE Comp 5 C_0, TZE Comp 3 C_2, EV DT-W 98 C_1, AK 9331 DMR SR, EV DT-Y 98 C_1, AC 92 TZE Comp5-W.
3. Cultural practices	i) The use of maize-legume rotations for *Striga* control, improved soil fertility and increased grain yield. ii) Maize-pigeon pea association for the improvement of soil fertility

2.4. Training courses, workshops, and exchange visits.

The Network has used training courses and workshops as an avenue to upgrade the skills of NARS scientists especially in relatively new methodologies. One such area is farmer participatory methods of on-farm testing and variety evaluation. The Network organized a workshop on this theme in 1998. Eleven NARS scientists were trained in the use of selected participatory rapid approval (PRA) methods to communicate with farmers and to identify their constraints and opportunities, identify and prioritize research and extension themes and the use of PRA tools to analyze problems at different stages of research process. Following the course, Ghana, Nigeria,

Cameroon and Benin have adopted the farmer participatory methods of on-farm testing and varietal evaluation.

Similarly in 1995, a workshop was held on *Striga* control and technology transfer with 8 NARS scientists participating. The scientists were provided practical experience in the analysis of *Striga* problems, research on control techniques, and the dissemination of information and transfer of available technologies using the accelerated participatory research method

Table 7. Promising maize technologies in the pipeline for release/promotion by Network member countries in 2001

Countries	Technologies
Benin	TZE-W Pop C_0, EV DT 97 STR C_1, TZE-Y Pop C_0, IWD STR, 95 TZEE-Y, DMR-ESR-Y, IWF STR
Côte d'Ivoire	Acr 94 TZE Comp5-W, Acr 94 TZE Comp5-Y, EV DT 97 STR C_1, IWD STR C_0,
Mali	Obatanpa (QPM), 99 TZEF-Y STR, TZEF-Y STR
Nigeria	95 TZEE-Y_1, 95 TZEE-W1, TZEF-Y SR, TZE-SR-W x Gua 314, TZE Comp4, TZE Comp5-W-SR
Togo	95 TZEE-Y_1, 95 TZEE-W_1, TZE SR-W x Gua 314, TZE Comp4, DMR-ESR-W
Cameroon	CMS 9015, CMS 8806, CMS 8501, CMS 8704, Syn E_1, TZEE-W SR, CSP x TZEE, CMS 9213 x Exp_1 42
Ghana	Dadaba, Mamaba, Cidaba, Dodzi
Tchad	TZEE-W SR BC5, Across 90 Pool 16 DT, TZE Comp3 C_2, TZE Comp4 C_2, 95 TZEE-Y_1, Obatanpa, DMR-ESR-Y
Senegal	Across 90 Pool 16 DT, TZE Comp3 C_2, TZE Comp4 C_2, Obatanpa, DMR-ESR-W_1, TZEE-W SR BC_5, Syn 9243
Guinea	K 9303, DMR-ESR-Y, TZE Comp4, AK 9331 SR
All countries	a) Optimal plant population for higher grain yield of early and extra-early varieties. b) Optimal time of fertilizer application (top dressing) for increased yield of early and extra-early varieties. c) Use of local sources of fertilizer and organic matter for soil improvement. d) Use of a row of maize to two rows of groundnut in maize-groundnut association to maximize grain yields. e) Use of appropriate dates of planting in maize-legume intercrop to maximize grain yields. f) Use of maize-legume rotation to control *Striga*, improve soil fertility and maize grain yield.

Another workshop was held in 1995 on the preparation of extension materials in which 15 researchers and communication specialists from WECAMAN member countries were trained in the development of appropriate extension materials to promote the transfer of maize technologies in their countries. Following the workshop, WECAMAN provided financial support to Benin, Togo, Cameroon and Burkina Faso for the production of extension bulletins. Extension bulletins that characterize released maize varieties in Benin, Togo, Cameroon, Burkina Faso, Mali, Nigeria and Ghana are in use by both farmers and extensionists of the respective countries.

A brief summary of the training courses and workshops is presented in Table 8. Generally, the training courses and workshops organised by WECAMAN have improved the capacity of the NARS to effectively transfer new technologies to farmers in the sub-region.

2.5. Enhancement of exchange of ideas and technical experience among national program scientists and development agencies

Monitoring tours involving scientists from WECAMAN member countries are organized biennially to visit maize-related research and development activities of two selected countries at time. The monitoring tours have provided unique opportunities to appraise *in situ* the feasibility and potentials of the Network output in member countries. Participants of the tours usually return to their respective countries to adapt successful technologies and development strategies.

The Coordinator and selected members of the Steering Committee (Table 9) have been used as consultants to visit other national maize programs to assess the progress being made in the implementation of the approved work plan and to exchange expertise. This has contributed to the development of national experts with broader horizon and depth. This has also improved the capability of national scientists to generate and transfer technology. Other mechanisms to ensure the exchange of scientific information, technologies and promote technology transfer include publication and distribution of Network Steering Committee reports, Network annual technical reports and proceedings of the Regional Maize Workshop for West and Central Africa published by WECAMAN.

Table 8. Workshop, training courses and scientific monitoring tours organized by WECAMAN to promote technology transfer, 1988-2000

Type of workshop	Output	Potential impact on technology transfer
Striga control and technology transfer (1995)	8 NARS scientists were provided practical experience in the analysis of *Striga* problems, research on control techniques, and the dissemination of information and transfer of available technologies using the accelerated participatory research method.	
Farmer participatory methods of on-farm testing and variety evaluation (1998)	11 NARS scientists were trained in the use of selected participatory rapid approval (PRA) methods to communicate with farmers and to identify their constraints and opportunities, identify and prioritize research and extension themes and the use of PRA tools to analyze problems at different stages of research process.	Following the course, Ghana, Nigeria, Cameroon and Benin have adopted the farmer participatory methods of on-farm testing and varietal evaluation
Maize Quality, processing and utilization (1998)	A forum was provided to 13 utilization experts from WECAMAN member countries for the exchange of information on the available improved methods of processing and utilization of maize and to establish functional linkages between WECAMAN and post-harvest technologists of WECAMAN member countries in order to promote the expansion of demand for maize processing and utilization.	The workshop has facilitated the exchange of information on the available improved post-harvest technologies and provided an opportunity for WECAMAN to link up with the maize transformation initiatives in member countries and to explore ways of improving maize storage in order to stimulate the dissemination of appropriate post-harvest technologies.
Preparation of extension materials (1996)	15 researchers and communication specialists from WECAMAN member countries were trained in the development of appropriate extension materials to promote the transfer of maize technologies in WECAMAN member countries	Following the workshop, WECAMAN provided financial support to Benin, Togo, Cameroon and Burkina Faso for the production of extension materials. At present, extension bulletins that characterize released maize varieties in Benin, Togo, Cameroon, Burkina Faso, Mali, Nigeria and Ghana are in use by both farmers and extensionists of the respective countries.
Scientific monitoring tours (1989, 1991, 1994, 1996, 1998 and 2000)	62 NARS scientists with IITA researchers have visited NARS of Ghana, Burkina Faso, Nigeria, Cameroon, Cote d'Ivoire, Benin, Togo and Mali. During the tours the scientists evaluated the entries of the regional trials and monitored the progress of the collaborative research projects. The tours gave the participants the opportunity to know each other's programs.	Facilitated the exchange of technologies, improved research collaboration and understanding of problems common to agricultural production.
Biennial regional maize workshops (1987, 1989, 1991, 1995, 1997, 1999 and 2000)	366 NARS scientists have attended the Biennial West and Central Africa Regional Maize Workshop from 1987 to 2001. The workshops provided the forum for national scientists to acquire skills for communicating research findings.	Motivated scientists towards professionalism and fulfillment as well as promotion of exchange of information, techniques and technologies.

Table 9. Consultation visits to national maize programs by the Network Coordinator, IITA scientists and selected members of the Steering Committee, 1994-1999

Year	Country Visited	Visitor
1994	Togo	Network Coordinator
	Benin	Network Coordinator
	Cameroon	Network Coordinator
1995	Burkina Faso	Network Coordinator
	Ghana	Network Coordinator
	Benin	Network Coordinator
	Togo	Network Coordinator
	Cote d'Ivoire	Network Coordinator
	Burkina Faso	Network Coordinator
	Cameroon	P.Y.K. Sallah
1996	Togo	Jean Monhouanou
	Benin	N'Tji Coulibaly
	Nigeria	Titus Ngoumou Nga
	Cote d'Ivoire	Alona Biliwa
	Mali	Network Coordinator
1997	Togo	Network Coordinator, and O.A. Ogungbile
	Benin	Network Coordinator and Anguete Kouame
	Burkina Faso	Network Coodinator
	Cameroon	Network Coordinator

2.6. Promotion of Community Seed Production in WECAMAN member countries

Several maize varieties have been released in the individual Network member countries through the Network's efforts. However, the adoption of the improved varieties is not as high as desirable partly due to lack of well-organized seed industry in some member countries. The problem of lack of seed availability is most serious with the extra-early and early maturing varieties. Because of the lower grain yield potential of early and extra-early varieties, seed production in these maize types is not as profitable as in the intermediate and late varieties. Therefore making available to farmers seed of the improved early and extra-early varieties, is one of the potential means of ensuring high adoption of the released maize varieties and thereby reducing some of the constraints of maize production in certain parts of the sub-regions.

Towards this end, WECAMAN has been funding community seed production projects in member countries since 1993. The objectives are to:

- Train farmers in the techniques of maize seed production;

- Strengthen the capacity of seed producers to produce good quality seed;
- Encourage NARS scientists to work with selected farmers and non-governmental organizations in the development of on-farm community level seed production schemes.

Many farmers have been trained in the techniques of seed production (Fig. 6). The strategy of Network members involved in the community level seed production scheme has been to provide technical advice, seed and other inputs to the collaborating farmers. At harvest, the farmers are required to pay back either with seed or money from their seed sales. The member countries have established revolving funds to ensure the sustainability of the project and also to reach more farmers each year. Several seed production models have been adopted in WECAMAN member countries for the community seed production scheme. Using these models, large quantities of seed of the released maize varieties are produced annually in Cameroon, Togo, Benin, Burkina Faso, Mali and Ghana.

The community seed production project has made significant positive impact on the availability of good quality breeder, foundation and commercial seed of early and extra-early varieties in the member countries (Fig. 7-9). Also, the availability of good quality seed has promoted rapid diffusion and adoption of the extra-early and early varieties (Elemo, 1999; Asumadu and Ampong, 2001; Onyibe *et al.*, 2001).

It is interesting to note that in Cameroon, the seed production unit of IRAD has assisted the government to promulgate a seed legislation and to establish a varietal release committee. Also, the Upper East Region of Ghana is gradually becoming an important maize producing region as a result of the availability of seed of early and intermediate varieties through the WECAMAN community seed production scheme. Farmers can now obtain their maize seeds at the district capitals of the region without travelling several kilometres to the Regional capital or to Southern Ghana (Kanton, 1999).

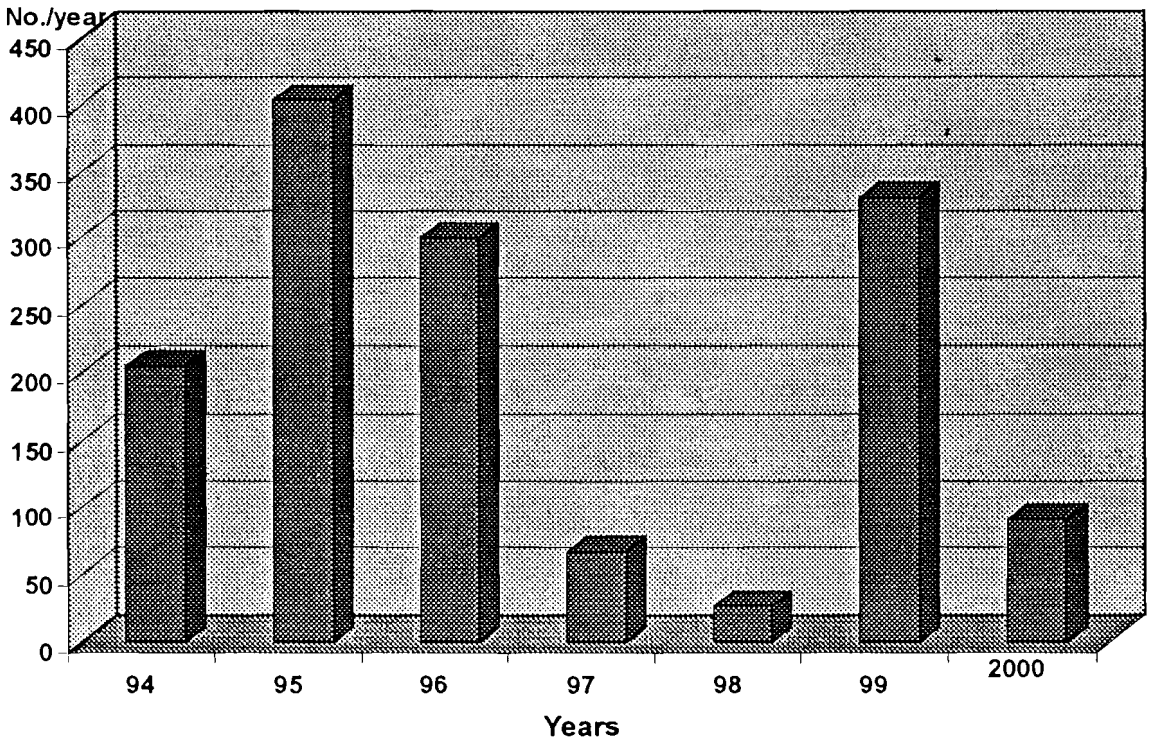

Fig. 6: Number of farmers trained in seed production in WECAMAN member countries under the community seed production scheme, 1994-2000

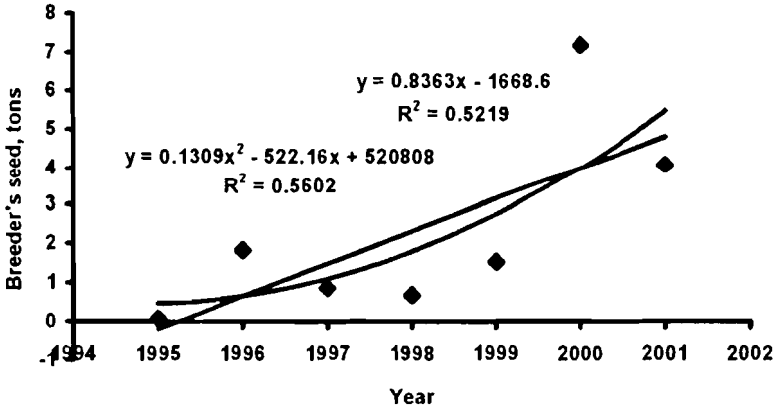

Fig 7. Breeder's seed produced in the community seed production project of WECAMAN

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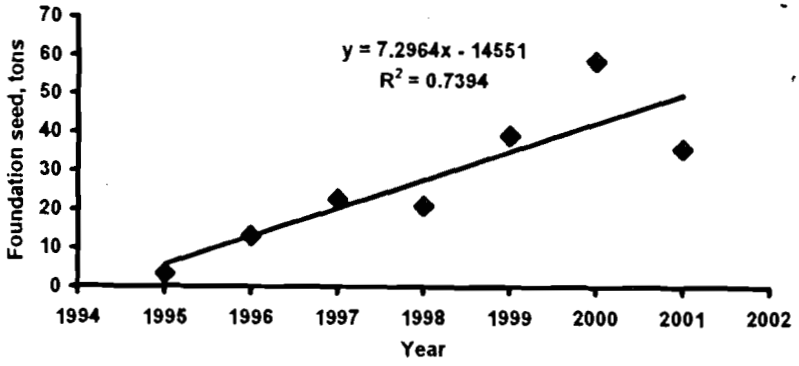

Fig. 8: Foundation seed produced in the community seed production project of WECAMAN, 1995-2001.

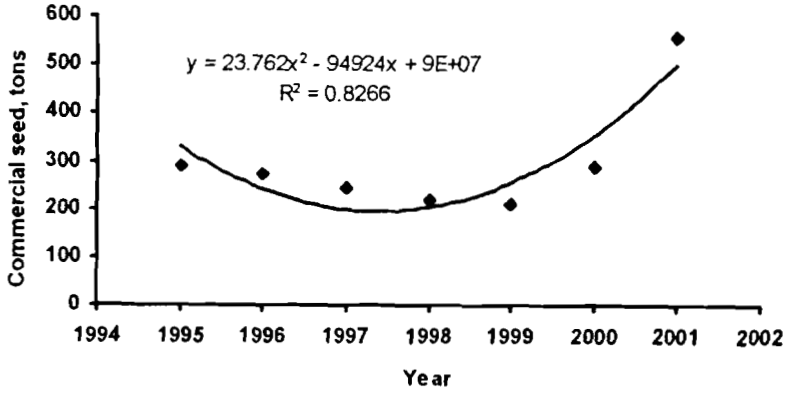

Fig. 9: Commercial seed produced in the community seed production project of WECAMAN, 1995-2001.

2.7. Studies of marketing systems to document the evolution of domestic maize production and how it can be used to influence policy in WECAMAN member countries

There has been concern in certain circles that a sudden increase in maize production in WCA could lead to a glut in the marketing system that, in turn, would lead to lower prices thereby making maize production less profitable and unattractive to farmers. If this occurs, it would lead to disastrous consequences on the adoption of improved maize technologies in the sub-region.

To facilitate the effectiveness of adoption, the Network endeavors to develop appropriate linkages of NARS with producers, extension services, NGOs, processors and markets for agricultural produce thereby facilitating rapid adoption of improved technologies. Furthermore, the Network must try to improve the research capacity of National Agricultural Research and Extension Systems (NARES) for policy analysis. The NARES should be equipped to use such analysis to influence policies that will strengthen the linkages between maize production and marketing and obtain the support of various stakeholders for maize research.

As a first step towards the realization of this goal, the Network has provided financial support for several studies on maize marketing systems and utilization. For this subject also, the results of the studies have been published in earlier proceedings of the Network (Langyintuo, 1999; Ahmed, 2001; Gyasi, 2001) and only the highlights will be summarized here.

The results of a study on the marketing system in Ghana indicated that the existing marketing system allows the maize farmers to make profit. However, a comparison between the current prices with the standard of living shows that maize farmers are worse off today than they were 19 years ago. The long marketing chain that maize passes through from producers to consumers raises the marketing margin to about 76% of the farm gate price. Over 60% of the marketing margin goes into marketing costs such as storage and transportation. The very high transport cost may be attributed to the poor road Networks and other logistics. Although farmers are aware of prices being low for maize soon after harvest, those in the Northern and Upper West Regions of Ghana still sell up to 75-80% of their production within the first three months after harvest to meet their cash needs.

Another study of the market system in Ghana revealed that maize trade is mainly in the hands of the private sector. Involvement of government, parastatal or non-governmental organizations (NGOs) is limited to emergency evacuation only. Among the private traders, women dominate the maize trade in northern Ghana. Aged between 30 and 50 years, females constitute 70% of all maize sellers. Due partly to the lack of adequate capital, 80% of the females are retailers. In contrast, all the 36% male traders interviewed in 1997 were wholesalers who were able to mobilize enough working capital and storage facilities. Consequently, male traders handle about 60% of maize marketed in the area. Price offered at home is usually 5% lower than that in the market. However, farmers receive an effective price of about 17% lower because the strategy employed in measuring the grain, irrespective of location, adds 12% more grain than required. Generally, three systems of financing takes place: a trader finances the production of maize and therefore buys the

produce; or the trader obtains money from a money lender, purchases the grain and sells it; or the trader finances all of his/her purchases, and thus bears all the risks.

The results of maize marketing and utilization studies conducted in Togo in 1999 and 2000 showed that 11.7% of the maize traders are males, while 88.3% are females. The price of a 100kg bag of maize varies from 8000FCFA at harvest to 20,000FCFA during the lean period. The major marketing problems facing the traders include lack of storage facilities, poor state of the roads and cheating by the transport owners. Maize consumption has increased from 5% of the population in 1989 to 10% of the population in 2000.

Maize marketing in northern Nigeria is very important in terms of the structure and volume of flow. The marketing system is efficient and traders use several trade and financing strategies to remain competitive in the market. However, the marketing system is faced with problems of sourcing adequate capital to finance the trade as well as lack of transportation facilities to move the grain from rural areas to markets and urban areas. In spite of these constraints, tremendous potential exists for market expansion at the domestic and subregional levels.

Research into various ways of maize utilization is another way to pre-empt a possible glut in the maize marketing system. In 1998, a Workshop was organized on Maize Quality, Processing and Utilization. This workshop provided a forum for 13 utilization experts from WECAMAN member countries to exchange and discuss information on the available improved methods of processing and utilization of maize in WCA. This also afforded the opportunity to establish functional linkages between WECAMAN and post-harvest technologists of WECAMAN member countries in order to promote the expansion of demand for maize processing and utilization.

The workshop also facilitated the exchange of information on the available improved post-harvest technologies and provided an opportunity for WECAMAN to link up with the maize transformation initiatives in member countries. Ways of improving maize storage in order to stimulate the dissemination of appropriate post-harvest technologies were also discussed at the workshop.

Apart from the workshop, studies on post-harvest handling and utilization of maize in the region have been conducted. In Mali, comparison of the normal endosperm maize, Sotubaka, and the QPM variety, Obatanpa, showed that the two varieties gave the same quality of biscuits but that the biscuits prepared from Obatanpa were superior in terms of quality proteins. However, Obatanpa was much better appreciated for the preparation of "to" and couscous in terms of the color, aroma and texture. The two varieties were comparable in terms of taste.

The possibility of using wheat flour substituted with 15%, 30%, and 50% maize flour compared with 100% wheat flour in making bread (moka) was also investigated in Mali. The results revealed that moka prepared from 50% maize mixed with wheat flour was preferred to moka prepared from 100% wheat flour. In terms of storage, no significant differences were observed between moka prepared with wheat flour substituted with 15%, 30% and 50% maize flour and that prepared with 100% wheat flour.

Also in Mali, studies have shown that the QPM variety, Dembanyuman, could be used to prepare consumer acceptable porridge for children just like the normal maize (Sotubaka), sorghum, and

millet. Also, consumer acceptable biscuits could be prepared from 50% Dembanyuman and 50% wheat composite flour. The technology is being demonstrated to consumers to promote adoption.

The results of maize utilization studies in Tchad showed that wheat flour could be composited with 30% maize flour for the preparation of consumer acceptable biscuits. Also, an infant food has been prepared from 60% fermented maize flour, 20% soybean, 8% dehulled maize flour and 12% sugar. In addition, consumer acceptable "beignet" has been prepared from a composite flour of 50% maize and 50% wheat. The studies conducted in Tchad further showed that spaghetti (douede), cake (soumbis), pancake, beignet, biscuits and couscous normally prepared from wheat and other cereals could also be prepared from maize flour without any problem.

2.8 Human Resources Development

In an effort to improve the research capacity and capability of NARS scientists and to promote technology exchange and transfer in member countries, WECAMAN has organized several workshops, training courses and scientific monitoring tours. Among the courses and workshops were the technician training courses, production of training and extension materials, *Striga* control and technology transfer, maize utilisation, computer course and participatory on-farm testing and varietal selection.

2.8.1. Technician Training Course

The Technician Training Course was initiated in 1988 at Ouagadougou, Burkina Faso to "mitigate the problem of lack of skilled research support personnel in the sub-region". The course was designed to upgrade the skills of national maize program technicians in the management of field experiments. It covers a 5-month period, usually from July to November, that corresponds to the cropping season thus making it possible to expose the participants to the latest developments in maize production research throughout a full planting season.

The course is practical-oriented but it is backed up with theory to improve the trainees' understanding of maize breeding and production strategies and techniques. The broad topics covered in the course include identification, layout and implementation of the various experimental designs, data collection and analysis, seed production and report writing. Apart from the lectures and practical classes, each trainee is assigned a project to manage from planting to harvesting. The trainee collects and analyses the data, summarizes results, writes a project report and submits bound copies of the report to the Network Coordinator, who is the Principal Resource Person.

To date, 52 technicians have participated in the course (Table 10).

Some obvious immediate impacts of the Technician Training Course are the improved quality of data from the Regional Uniform Variety Trials (RUVTs) and the capacity of technicians to maintain research activities effectively with little supervision from the scientist.

Table 10. Participants of WECAMAN training courses, 1991-2000

Course title	Year	Duration	No of Participants
Seminar for research agronomists	1991	2 weeks	11
Seed Production	1995	2 weeks	27
Striga control and technology transfer	1995	2 weeks	8
Preparation of extension materials	1996	1 week	15
Advanced statistical computing	1996	2 weeks	17
Farmer participatory methods of on-farm testing and variety evaluation	1998	2 weeks	11
Workshop on maize quality, processing and utilization	1998	2 weeks	13
Breeding for stress tolerance in maize	1999	1 week	13
Workshop on breeding *Striga* resistance in cereals and seminar on marker assisted breeding	1999	1 week	10
Advanced statistical computing course for breeders and agronomists	2000	2 weeks	14
Impact assessment of maize stress management technologies	2000	2 weeks	9
Biotechnology workshop in maize	2002	1 week	11
Travel workshop	2001	1 week	15
Technician training course	1988-2001	5 months	52
Total			**226**

2.8.2. Scientists' Training Courses and Workshops

A total of 174 national scientists and extensionists have participated in the training courses and workshops conducted for the NARS scientists in WCA (Table10). The participants were from WCA although participants from east Africa, specifically Kenya and Uganda, attended the seed production course. One of the objectives of WECAMAN's training courses was to upgrade the skills of scientists in maize production strategies. The training courses have been organized to address specific skills that would lead to increased maize production. A few examples will suffice:

i. One major constraint to the adoption of improved maize technologies in the sub-region is lack of effective, efficient and well-organized seed production, certification and distribution system. Apart from Nigeria and, to a much limited extent, Ghana, none of the countries in the region had organized seed industries of any kind.

ii. User-friendly information for the promotion of improved technologies was not readily available to extensionists in WCA.

iii. Abiotic and biotic stresses, including *inter alia* moisture and low N, streak virus disease and *Striga*, were cross cutting to all countries in the sub-region.

iv. Presentations at the First Biennial Regional Maize Workshop organized by the Network in 1995 clearly revealed the necessity to update the knowledge of NARS scientists in the design, analysis, interpretation and communication of research.

Individual NARS, particularly the strong ones, and especially the international agricultural research centers (IARCs) in the sub-region; that is, IITA and CIMMYT had conducted research and put infrastructures in place to address these issues. Since the issues were cross cutting, we expected that it would be cost effective to provide training to NARS scientists through the Network. Thus, for the last decade of the twentieth Century, as much as funds permitted, the Network gradually tackled the production constraints through improved skill acquisition by the scientists.

2.8.3. Visiting scientists' scheme of the AMS Project

One of the problems of researchers in WCA, especially of the relatively small NARS, is that the scientists are relatively few and therefore work in isolation. To alleviate this problem to some extent, the African Maize Stress (AMS) Project of WECAMAN has instituted a visiting scientist scheme for national scientists of member countries since 1998. Through the scheme, four maize breeders and one entomologist have been sponsored by the project for six months attachment to the AMS Project at IITA. The visiting scientist scheme has provided an opportunity for the scientists to upgrade their skills and to identify at first hand technologies and genetic materials from IITA that have potential for high grain yield and adaptation to their respective countries.

2.8.4. Biennial Regional Maize Workshops

Biennial Regional Maize Workshops, held since 1987 (Table 11), provide a forum for scientists to acquire skills for communicating research findings to their peers. The workshops are an invaluable means of motivating scientists towards professionalism as well as for promoting exchange of information, techniques and technologies. Intending participants at the Workshop first submit abstracts of their papers. The abstracts are reviewed and screened by a panel of three scientists and participants whose abstracts are selected are invited to submit the full papers later at the Workshop. The Network usually sponsors individuals whose papers are accepted to the Workshop. After the Workshop, the papers are peer-reviewed and published as the proceedings of the Workshops.

Table 11. Information on WECAMAN regional biennial workshops, 1987-99.

	1987	1989	1991	1995	1997	1999
No. of Participants	**35**	**41**	**77**	**94**	**59**	**60**
No. of Countries	15	15	17	17	12	12
No. of Scientific papers	-	20	20	41	51	40
No. of General papers	10	10	13	10	12	6
Total No. of papers	**10**	**30**	**33**	**51**	**67**	**46**

2.8.5. Scientific Monitoring Tours

Monitoring tours have been organized biennially to see maize-related research and development activities of two selected countries at a time. The monitoring tours have provided a unique opportunity to appraise *in situ* feasibility and potentials of the Network output in member countries. The monitoring tours serve as a forum for interaction among the participating national scientists with respect to maize research, extension and production. During the tours, the scientists learn at first hand how research, extension and production of maize are organized in a country and the research-extension linkages put in place to promote technology transfer. The participants of the monitoring tour usually return to their respective countries, taking along with them successful technologies and development strategies for adoption. About 62 scientists have participated in the monitoring tours since 1988.

With the limited funds available to the Network, 174 scientists; that is, nearly 16 scientists per member country have been trained. If facilities were available for the trained scientists to apply the skills they have acquired and/or train others, the research and extension capabilities of the national programs would be strengthened within a few years.

Only a preliminary analysis and evaluation is presented here and the findings presented show that a full impact assessment of WECAMAN training courses is justified. However, observations such as good presentations of scientific papers at conferences, well written research proposals, properly conducted research projects, and well written progress reports, clearly indicate that WCA scientists have benefited from the training courses organized by the Network.

Some of the courses also have impacted some maize production practices in the sub-region. Following the seed production course, the participants have played leading roles in the establishment of community seed production schemes in the respective WECAMAN member countries. Participants have trained over 1,500 farmers in the techniques of seed production and maintenance of large quantities of breeder, foundation and commercial seed of released varieties and promoted the diffusion and utilization of improved maize varieties (Badu-Apraku *et al.*, 1999b). Although the problem of seed availability for planting may not have been totally solved, the community-based seed production scheme of WECAMAN has alleviated the problem to a large extent.

Similarly by the end of the Workshop on Production of Extension Materials, the participants were tasked to adapt the extension materials produced during the Workshop to their own environments and submit them to the Coordinator for editing and publication. Extension bulletins that characterize the available maize varieties in Benin, Togo, Cameroon, Burkina Faso, Mali and Ghana have been published with financial support of WECAMAN and are in use by farmers and extensionists in these countries.

The training provided through the courses and workshops have made a valuable contribution towards improved technical capacity of national scientists and technicians. The number of

scientists actively participating in the Network has gradually increased from 35 during the 1987-93 era, to 75 in the 1994-97 and 105 in the 1998-2000 eras (Fig. 10). Thus the networking approach has made an impact by putting in place a team of well-trained researchers.

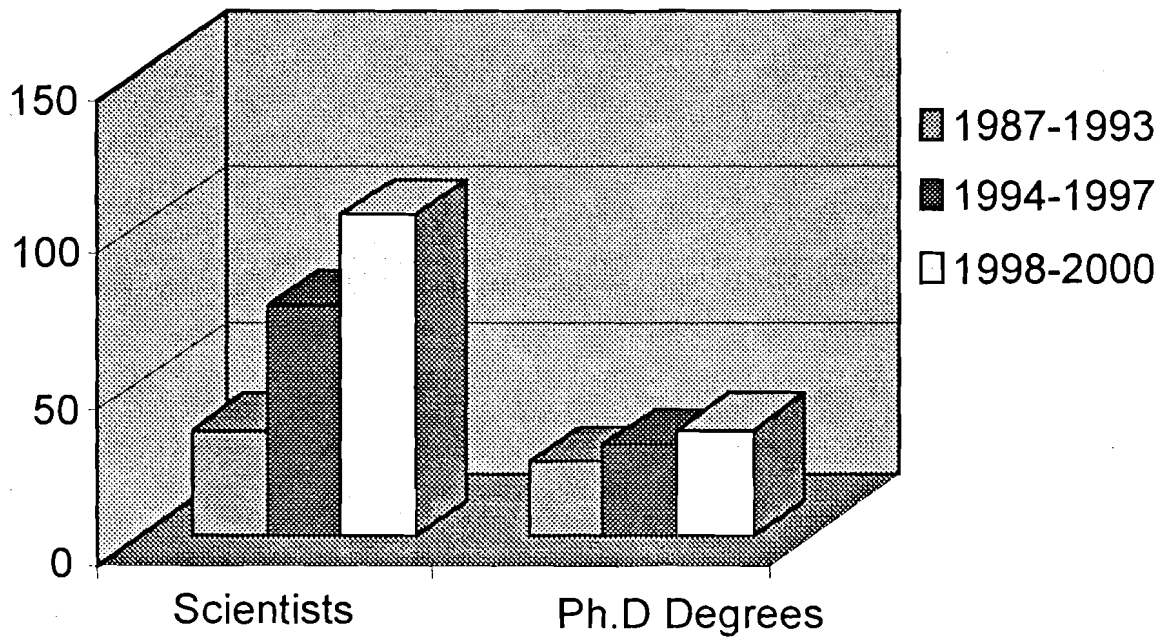

Fig.10 Number of scientists involved in the collaborative research projects of WECAMAN in the 1987-1993, 1994-1997 and the 1998-2000 eras.

The impact of the training courses and workshops on the research capability and capacity of NARS include:

(i) Increased research output as evident from the number of collaborative research projects executed at the national level,

(ii) Improvement of capabilities in data analysis as shown by the quality and number of technical reports and papers presented during the Regional Maize Workshops,

(iii) Good presentations of scientific papers at conferences,

(iv) Preparation of well structured, focused and convincing research proposals,

(v) Improvement of data recovery from collaborating NARS,

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(vi) Release of improved varieties and agronomic practices,

(vii) Improved understanding of cropping systems and the need for adopting soil/water conservation,

(viii) Increased maize output in the sub-region.

(ix) Improved understanding of cropping systems and the need for adopting soil/water conservation,

(x) Increased maize output in the sub-region.

(xi) Group training has helped to build interpersonal relationships and enhanced trust and confidence in exchange of information and maize germ plasm among scientists in the sub-region.

(xii) Group training has helped to build interpersonal relationships and enhanced trust and confidence in exchange of information and maize germ plasm among scientists in the sub-region

2.9. Impact assessment

With the increasing scarcity of funds, it has become imperative to justify further investments in maize research in the sub-region. In order to mobilize resources for technology generation and transfer, and to improve the efficiency of technology transfer activities in member countries, WECAMAN has sponsored NARS scientists from Burkina Faso, Togo, Benin, Ghana, Nigeria, Cameroon, Cote d'Ivoire, and Mali to impact assessment workshops organized by the Purdue University and INSAH. Following the workshops the Network provided financial support for impact studies in the respective countries. Highlights of some of the studies were as follows:

In Burkina-Faso, an economic model was used to determine the impact of maize research and extension in improving social welfare (Laraba, 2001). The results showed an internal rate of return (IRR) of 35.3% during the period from 1982 to 1998. These results revealed high adoption of the released improved maize varieties to satisfy the needs of farmers.

Using a combination of cross-sectional and time series data, economic surplus methods were employed to estimate varietal adoption rates, social rates of return and net social gains from maize research and extension during the 1986-97 period in Nigeria (Phillip, 2001). Analysis of the basic data indicated varietal adoption rates of 7.8%, 49.6% and 42.6% per annum for local, improved OP and hybrid varieties, respectively. The IRR was 23% and the net present value (NPV) was about $330,000 during the 1986-97 period. Although the model was unable to support increasingly high adoption rate of hybrid maize under the observed on-farm and macro-economic conditions, incremental yield gains by both open pollinated and hybrid varieties improved both the IRR and NPV.

In Mali, the adoption rate of the improved varieties during the period 1991 to 1996 was 74%. Improved maize varieties such as Tiamante was adopted by more than 50% of the producers, Tuxpeno by 38%, TZE-SR-W by 22%, EV8422-SR by 15% and Sotubaka, by 10%. The reasons mentioned by the farmers for the adoption of the improved varieties are: high grain yield, early maturity, desirable taste, ease of processing and storage, good flour yield and increased income. The net income of the maize producers was about $200/ha for improved varieties compared to about $95/ha for local varieties, an increase of about 110% for the improved varieties. The constraints to a wider adoption of the improved varieties included ignorance of farmers of the importance of seed of improved varieties and lack of information on the improved varieties (Sanogo *et al.*, 2001).

Enyong *et al.* (1999) conducted a detailed farm level survey of 345 farm households in 16 villages in the North Province of Cameroon, using structured questionnaire and focus group interview. The results showed that maize was quickly replacing sorghum in the diet and cropping systems of the rural dwellers. The rapid displacement of sorghum, the traditional staple food crop in this Province, by maize was found to be linked to several factors, including mainly early maturity, high yield, better taste, high market prices, availability during hunger period and color.

In Ghana,

These results and others not presented herein show that generally in the sub-region, maize technology adoption rate, social rate of return, and the social gains from maize research and extension have been positive. We conclude that investment in maize research and technology transfer during this period was well justified.

3.0. IMPACT OF WECAMAN

The goal of WECAMAN is to strengthen the capacity and capability of NARS of the member countries to:

- conduct high quality research;
- generate and transfer appropriate technologies for use by farmers.

The objectives of the collaborative research projects conducted by WECAMAN were to:

- optimize the strength and comparative advantage of strong NARS to solve specific production problems;
- motivate NARS scientists to increase research output and be creative;
- enhance the capacity of the scientists to generate and transfer technology;
- improve the research management capability of NARS scientists.

Data and the different types of analyses presented here show convincingly that the Network has gone far in achieving the objectives. Some of the crosscutting constraints tackled by the Network were too formidable for any individual NARS to handle single-handedly. It was also quite convenient for the member countries to have access to expertise, services, commodities and

supplies from international agricultural research centers (IARCs). Research facilities at IITA, for example, and the germplasm from IITA and CIMMYT were made readily available to Network members through the coordinating office. The Network approach therefore is a cost-effective means of solving maize production constraints on a regional or sub-regional basis.

The collaborative research and regional trials coordinated by WECAMAN have resulted in the development of a large number of improved maize varieties and related technologies which have been exchanged within the Network. The availability of early and extra-early varieties has created niches for maize production, consumption, and improved food security in WCA. The extra-early varieties are ready for harvest as green maize (eaten boiled or roasted) in about 60 days, or as dry grains in 75-80 days. The extra-early varieties can therefore be harvested at a time when the previous harvests are depleted and when all other staples are not ready and as a result, they are useful for filling the hunger gap in July. Early and extra-early varieties promoted by WECAMAN have contributed to increased maize production and productivity through movement of maize into new frontiers.

Furthermore, the promotion and high adoption of intermediate maturing varieties for high yield in the northern fringes of the moist savanna has resulted in phenomenal increase in maize production in WCA for the past ten years with an average annual growth rate of 4.1%. High annual growth rates have been recorded in Burkina Faso (17.1%), Ghana (8.3%) and Mali (7.5%). WECAMAN has clearly stimulated national scientists to solve maize production problems with significant returns to investment in the maize programs estimated to be 74% in Ghana, 78% in Burkina Faso and over 100% in Mali during the past decade (Oehmke, 1997)

One secret of the resounding success of WECAMAN is its management structure. The Network is managed by a democratically elected Steering Committee (SC). Eight national scientists are elected on the SC. An Ad-hoc Research Committee (ARC) screens all research proposals and recommends those to be funded to the SC. The ARC also evaluates the reports of the funded research projects and recommends to SC projects the Network should terminate or continue funding. Members of the ARC are experienced scientists from non-WECAMAN member countries.

It is evident that the ARC has been an important player in WECAMAN activities. The idea of SC as the decision-making entity had been in operation in earlier regional projects such as SAFGRAD, but the WECAMAN Steering Committee introduced the research committee system.

4.0. FUTURE CHALLENGES OF WECAMAN

Despite the success in improved maize production so far recorded in the sub-region, the Network is still faced with the challenges of pushing up the maize yield curve of WCA in the new millennium. Although total maize production has increased in the sub-region, the increase has resulted from extensive rather than intensive cultivation Fakorede *et al.*, 2001). FAO statistics showed that average maize yield in the sub-region has increased from the long-standing 1.0 t/ha to about 1.4 t/ha during the 1983-92 decade. Average yield in researcher-managed on-station and on-farm research is about 6 t/ha. Therefore, one of the present challenges for researchers is to reduce the yield gap between research and production.

The use of competitive grant scheme by WECAMAN has significantly aided the identification of appropriate technologies including stress tolerant varieties and complementary crop management options. Some of the identified technologies are in the pipeline at the Network and the NARS levels for release and promotion by Network member countries through funding support from WECAMAN. These include the use of *Striga* resistant varieties for sustainable *Striga* control. In the extra-early maturity group, there are nine *Striga* resistant varieties available at the Network level for testing through the RUVT. In the early maturity group, there are ten *Striga* resistant varieties and six new non-*Striga* resistant varieties still undergoing on-farm testing in WECAMAN member countries. In addition, six crop and soil management practices are being tested on-farm by NARS. Future emphasis of WECAMAN would be to promote the adoption of the available *Striga* resistant varieties; soil and crop management practices to ensure sustained high maize production in the long term.

Given the current moderate level of *Striga* resistance of the available maize varieties and the inherently low fertility status of the soils of the savannas of WCA, there is a need to combine host plant resistance with other control methods such as maize-legume rotation to improve soil fertility and ensure progressive reduction of the *Striga* seed bank to an acceptable level. Through studies funded by WECAMAN in Nigeria, Benin, and Togo, soybean (Samsoy), cowpea (TVX 1850-OIF) and groundnut (RMP 91) varieties have been identified as possessing high germination stimulant activity. These legumes when used in rotation with *Striga* tolerant maize varieties cause suicidal germination of *Striga* seed, reduce the damage caused by S. *hermonthica* and result in increased maize yield (WECAMAN 2000). These legumes need to be extensively evaluated on-farm in rotation with the *Striga* tolerant maize varieties.

A myriad of problems faces the Seed industry in WCA. A strategy of WECAMAN to ensure high adoption of released maize varieties, is to promote seed production of improved maize varieties. The community seed production schemes need to be supported and expended to promote the production and distribution of not only stress tolerant varieties but also the QPM and other varieties in an effort to increase maize production and productivity in the sub-region. An area of immediate concern is the transformation of successful community based seed production schemes of WECAMAN into micro-enterprises with participating farmers as shareholders for sustainability.

The moderate level of resistance to *Striga* identified to date and incorporated into maize in WCA by IITA and WECAMAN is quantitatively inherited and no cases of immunity have been reported (Kim, 1994, Kling et *al.* 1996). The available resistance therefore does not limit the reproduction of the parasite. IITA scientists have identified an accession of perennial teosinte (Zea diploperennis) that supports little or no emergence of *Striga hermonthica*. Also, a program initiated to identify molecular markers tightly linked to *Striga* resistance genes is almost completed. The markers would facilitate the transfer of the *Striga* resistant genes to a wide array of germplasm adapted to the major maize agro-ecologies in Africa through marker-assisted backcrossing. WECAMAN and IITA have made limited progress in developing drought tolerant germplasm for WCA even though some promising drought tolerant varieties have been released to farmers in WCA and are presently in production. Preliminary results of studies conducted in CIMMYT has shown that marker-assisted selection based on a strategy combining quantitative trait loci (QTL) identified under drought for anthesis-silking interval (ASI) and grain weight of tropical maize inbred lines, and open-pollinated populations should be a powerful tool to improve drought tolerance (Ribaut *et* al. 1996).

WECAMAN should take advantage of the new advances in biotechnology and explore the molecular approach to the problem of *Striga* and drought in order to improve breeding efficiency so that maize varieties with enhanced drought and *Striga* resistance could be developed for farmers of WCA.

Many highly productive QPM germplasm are yet to be improved for resistance to the MSV, *Striga*, drought, storage pests and stemborers. Furthermore, none of the widely adopted maize varieties in WCA apart from Obatanpa is endowed with the quality protein trait. There is therefore a need to intensify the efforts at developing and disseminating high yielding, *Striga*, streak and drought resistant extra-early, early and intermediate QPM for the production conditions of WCA.

To ensure increased and sustained maize production and productivity in WCA that will lead to increased food security, improved nutrition and incomes of the people of WCA, WECAMAN and IITA propose a new phase of the USAID project of WECAMAN. The project will build on the achievements made by the Network and bring the results to a larger proportion of the target beneficiaries for whom maize is a major staple and source of income.

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