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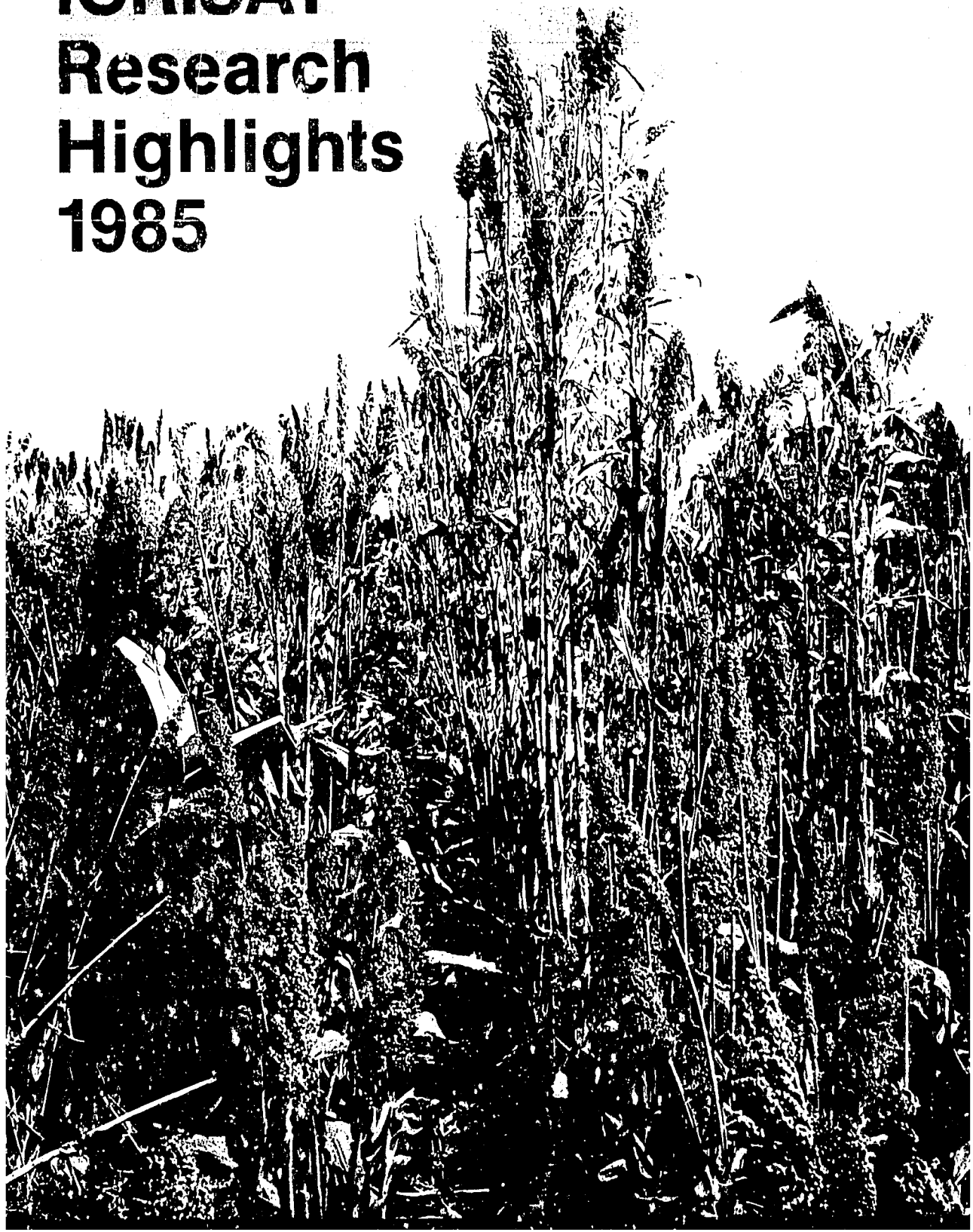
# ICRISAT Research Highlights 1985



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*Cover: ICRISAT scientist explores genetic diversity of sorghum in Zimbabwe.*

# Contents


3 *About ICRISAT*

4 *Introduction*

6 *Augmenting Genetic Resources*

9 *Developing Disease Resistance*

13 *Controlling Insects*

16 *Using Bacteria and Fungi*

17 *Enduring Physical Stresses*

19 *The Making of Hybrids*

22 *Breeding Improved Crop Lines*

28 *Improving Management of Resources*

31 *Studying Farmers' Options*

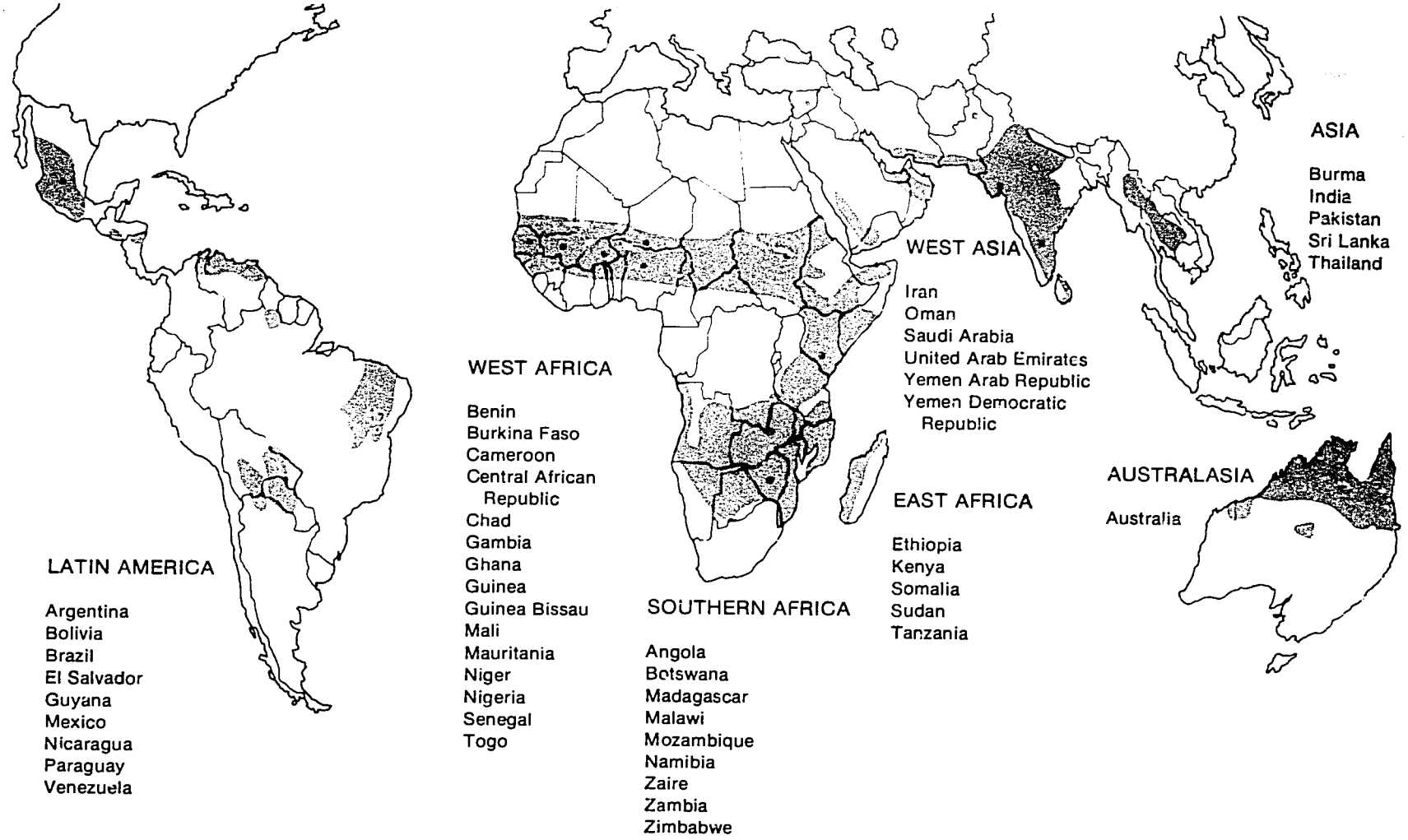
35 *Training Activities*

39 *Strengthening the Research Base in Africa*

43 *In Other Research*

44 *Senior Staff*

*Governing Board*




*Semi-arid areas (in yellow) covered by ICRISAT's mandate. Green squares indicate location of ICRISAT Center in India and Sahelian Center in Niger; red dots indicate collaborative research stations where ICRISAT scientists have been posted.*

# About ICRISAT

ICRISAT is one of 13 international centers in a worldwide research network devoted to improving food production in less developed countries. ICRISAT's mandate is to improve the yield, stability, and food quality of five crops basic to life in the semi-arid tropics (SAT) and to develop farming systems that will make maximum use of the human and animal resources and the limited rainfall of the region.

The seasonally dry semi-arid tropics are spread over nearly 20 million square kilometers and cover all or parts of 50 nations on five continents. They include much of South Asia, parts of Southeast Asia, West Asia, and Australia, two wide belts of Africa, areas of South America and Central America, and much of Mexico.

The SAT is a harsh region of limited, erratic rainfall and nutrient-poor soils. It is populated by more than 700 million people, most of whom live at subsistence levels and depend for their food on the limited production of small farms.

The crops researched by ICRISAT are sorghum and pearl millet—two of the major cereals in the SAT—and chickpea, pigeonpea, and groundnut, the most important food legumes of the region. Groundnut, rich in oil, is also an important cash crop for the SAT farmer. The four others are all primarily subsistence food crops; over half the total production of each—in some places nearly all of it—is consumed on the farms where it is grown.

ICRISAT's headquarters are at Patancheru, India, 26 km northwest of Hyderabad, but it also has scientific staff posted in seven countries of Africa, in Mexico, Pakistan, and Syria, and at five cooperative research stations of agricultural universities in India. Principal operations in Africa are in Burkina Faso, Kenya, Malawi, Mali, Niger, Sudan, and Zimbabwe. Scientists were previously posted also in Nigeria and Senegal, but funding for these positions has ceased. The search is on for a suitable site to locate a West Africa regional program for sorghum.

The two main bases for ICRISAT's future work in Africa, as currently envisaged, will be at the new Sahelian Center near Niamey, Niger, and the SADCC/ICRISAT sorghum and millets improvement program at Matapos, near Bulawayo, Zimbabwe, set up in response to an invitation from the nine-nation Southern African Development Coordination Conference (SADCC).

# Introduction

For ICRISAT, 1985 has been a year of consolidation and further progress. We put into effect several suggestions emerging from the two external reviews in 1984—on ICRISAT's research and training activities and on its management.

There was a gradual move toward more strategic and sharply focused research in all five ICRISAT crops. More efforts were made to help strengthen national programs, training activities were enlarged, and long-term research and management plans were developed, both at ICRISAT Center and for our multilocational work in Africa.

New and important sources of variability were added to our genetic resources accessions, widening the base that crop improvement scientists can exploit.

Progress was made in efforts to combat major yield reducers of all ICRISAT crops—drought and physical stresses, diseases, and insect pests. Techniques developed for screening resistant materials were confirmed as efficient, new resistant materials identified, and mechanisms of genetic transfer better understood. Bacteria and fungi that can benefit crop growth were studied, and methods to exploit them were successfully demonstrated.

Two pearl millet hybrids, developed from ICRISAT material, have performed exceptionally well in Indian multilocational trials. These are likely to be released in India in 1986. Work continued in sorghum, millet, and pigeonpea on the basic and complex research that precedes the production of hybrid seeds.

Several crop lines developed or improved by ICRISAT scientists were released or recommended for release to farmers in many parts of the semi-arid tropics. Among them was ICGS 11 in India, the first groundnut from ICRISAT to be recommended for release. Other lines reached advanced stages of prerelease testing, and improved breeding materials continued to be provided to scientists in national programs. Taken together, they can add substantially to crop production in the semi-arid tropics.

Research continued on ways to improve management of available resources. Some practices were evolved that can be quickly transferred, and other findings gave useful insights for long-term planning. Analysis of data from socioeconomic studies, in India and in countries of Africa, yielded valuable inferences. Work on farming systems and socioeconomics was merged during the year into a single program on Resource Management, to give these related areas of research a better perspective.

*Trainees at ICRISAT Center studying diseased plants with a groundnut pathologist (left). ICRISAT received more trainees in 1985 than in any previous year.*

ICRISAT's training activities expanded this year to take in more than 200 participants, with a corresponding expansion in regional training efforts.

Important progress on these and other aspects is outlined on the following pages, and is described in fuller detail in the 1985 Annual Report.

ICRISAT has also strengthened its research base in Africa through a network of cooperation with national, regional, and international institutions that have common interests. Further progress was made with establishing the ICRISAT Sahelian Center in Niger and the regional cereals improvement project in Zimbabwe. These will serve as the focal points of research in West Africa and southern Africa, two major regions within the semi-arid tropics.

We can thus look to the future with hope, confident that our work to date and the experience gained will help us better address the problems of crop production in the semi-arid tropics.

**L.D. Swindale**
Director General

# Augmenting Genetic Resources

Unimproved crop lines traditionally grown by farmers, known as landraces, and their wild relatives growing in the natural habitat are an invaluable heritage of mankind. They need to be preserved, studied, and used judiciously to help crop production. With increasing urbanization and dependence on large-scale agricultural projects, many such plant types are becoming extinct. Arresting and reversing this trend is an urgent ecological need.

ICRISAT has been given the mandate for holding the genetic resources of all its crops. It added to its gene bank this year 3 505 new accessions of its five crops and 105 of minor millets. And a total of 54 434 seed packets were distributed—30 380 to ICRISAT scientists, 8 044 to breeders in India, and 16 010 to those in 61 other countries. Anyone who has a genuine need of seed samples is sent some on request.

But ICRISAT's work extends beyond holding and distributing such seeds. Collecting expeditions, in close cooperation with national programs, are undertaken in areas of promise or from where material is now lacking. Collected seeds are preserved so their viability is intact. They are then screened and evaluated, and data are maintained on their origin and traits. This aids

*Children in Swaziland display primitive sorghum landraces. ICRISAT aims to use its collections for crop improvement work that can lead to better future harvests.*

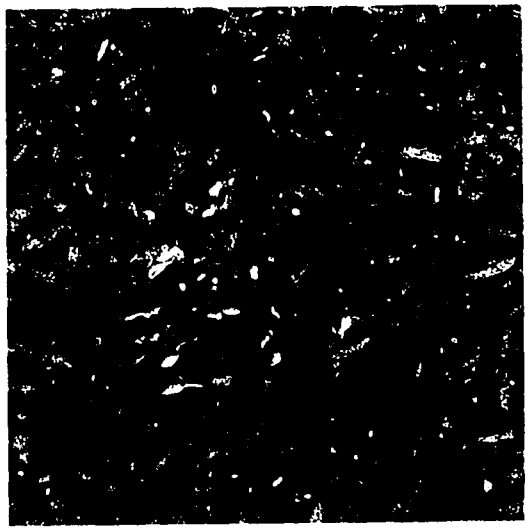
*Children in Malawi shell vegetable pigeonpea. ICRISAT added to its resources this year important sources for developing improved vegetable-type pigeonpeas*

ready retrieval of lines to meet requests and match desired traits, so that the accessions can be effectively used in crop improvement.

Collecting missions in 1985 yielded 226 new sorghum accessions in Lesotho and Swaziland, 271 pigeonpea landraces in the Caribbean, 206 chickpea accessions in Bangladesh and in Tamil Nadu, India, and 95 groundnut landraces in Tanzania. National and regional programs cooperate with ICRISAT scientists and take active part in the collecting expeditions. The samples collected are also retained by the national program.

The new sorghum accessions, belonging mainly to the races kafir and Durra kafir, include some with genes for cold tolerance and some primitive landraces from Swazi-

*New groundnut accessions from Tanzania offer diversity in pods and seeds.*



land on the verge of extinction. They thus add to the diversity of ICRISAT's total collection, as do the new accessions in the other three crops.

The pigeonpeas have a range of desirable agronomic traits, including a rich source for improving long-duration, vegetable-type pigeonpea. The chickpeas include some desi samples with extra-large seeds.

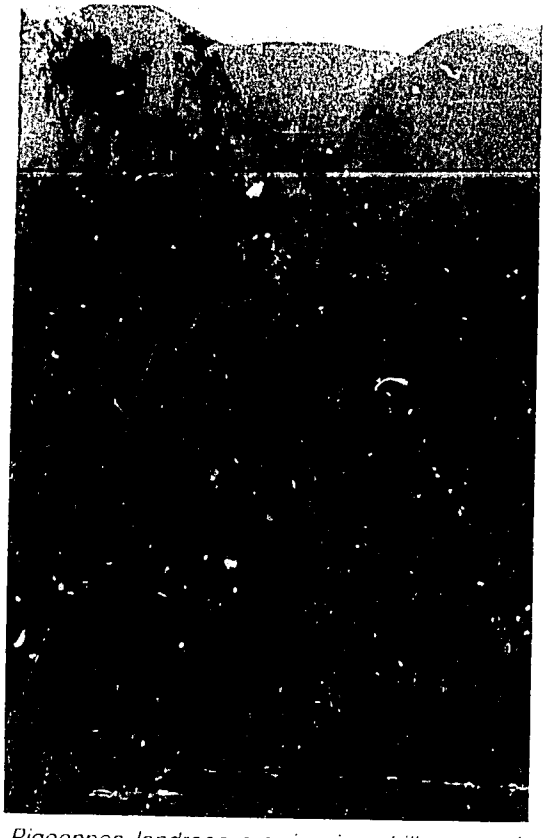
Among the landraces already held and distributed from ICRISAT's gene bank, two kafir sorghum landraces from South Africa, IS 9302 and IS 9323, have been approved for release in Ethiopia under different names.

New sources of male sterility were identified in pearl millet, and the African germplasm lines so identified are now being used in breeding programs.

A total of 400 pigeonpea accessions were screened for insensitivity to photoperiod (length of daylight) and 20 were found to be moderately insensitive. These may be useful in breeding more widely adapted lines.

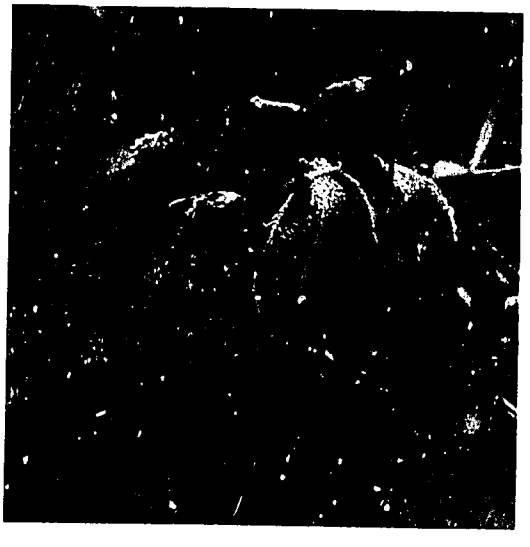
Work in 1985 also included classifying into landrace groups of a number of pearl millet accessions from Burkina Faso, Cameroon, Ghana, India, Malawi, Niger, Nigeria, South Africa, Sudan, Zambia, and Zimbabwe. Germplasm databases for chickpea and pigeonpea, already compiled, were revised and edited. They are ready for publication in catalog form. This should help enhance use of accessions in crop improvement work.

ICRISAT's genetic resources work thus provides a solid base from which multidisciplinary teams of scientists, at ICRISAT and elsewhere, can draw both information and materials for their crop improvement efforts. How that base is utilized by ICRISAT scientists is described on some of the following pages.



*Pigeonpea landrace growing in a hilly area of Malawi. ICRISAT scientists have collected samples from here as well.*

*Chickpea with multiple pods obtained by induced mutation in ICRISAT's genetic resources unit. Further experiments are in progress.*



# Developing Disease Resistance

Diseases are a major problem affecting crop yields. The typical farmer in the semi-arid tropics has very limited means to counter them. And several national programs are not in a position to undertake the kind of multidisciplinary research that is required to identify and combat diseases, and thus to effectively counter the losses they cause.

ICRISAT's work on developing crops with resistance to diseases, therefore, has many facets:

- studies on occurrence of diseases;
- identifying pathogens or disease-causing organisms;
- studies on survival and spread of pathogens under various conditions;
- developing techniques for screening genotypes, both in the laboratory and in the field under induced disease pressures, for levels of resistance;
- identifying sources of resistance to one or more diseases;
- testing stability of resistance over a range of locations;
- understanding genetics of resistance;
- incorporating resistance into well-adapted lines; and
- testing advanced breeding lines for adaptation and yield levels.

As reported over the last 3 years, ICRISAT now has lines with multiple resistances in all of its crops. Important further progress was made in 1985 on most of the facets listed above. There was evidence that ICRISAT materials were doing well in multilocational tests for disease resistance conducted by national programs, ICRISAT scientists identified new sources of resistance or confirmed resistances in breeding lines, and the mechanisms of disease resistance and their transfer were better understood in some instances.

Two pearl millet varieties with high levels of resistance to smut and downy mildew, ICMV 82132 and ICMV 8283, were entered

*The common wilt in sorghum: ICRISAT scientists studied the disease and gathered information of use in controlling it.*

*Pearl millet lines susceptible (foreground) and resistant (background) to ergot disease. Several promising lines have been identified and a new resistant composite formed.*

in yield trials of the Indian national program, following their good performance the previous year in an international adaptation trial. These are the first ICRISAT varieties with smut resistance to advance this far in testing.

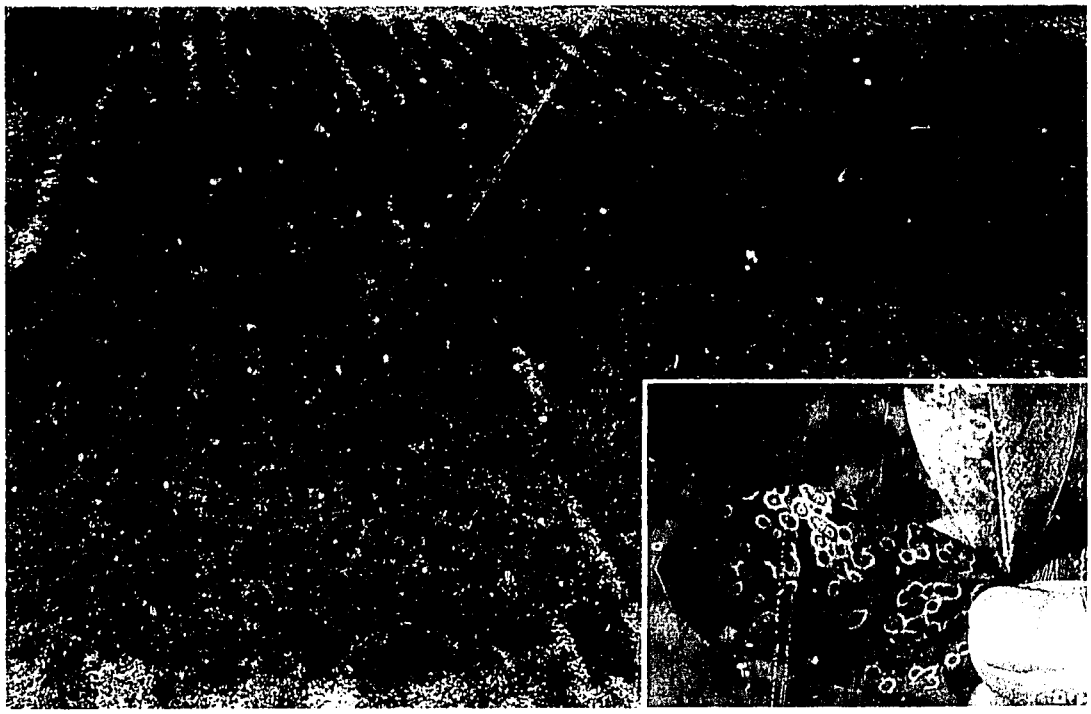
Also reaching advanced stages of testing in Burma were some wilt-resistant chickpea genotypes from ICRISAT, having performed well there.

Two pigeonpea genotypes from ICRISAT were found resistant to sterility mosaic disease at 10 locations in India. One of these, ICP 7867, was also resistant to fusarium wilt, thus combining resistance to the two most damaging pigeonpea diseases. Similarly, two of ICRISAT's chickpea lines showed resistance to fusarium wilt at 13 of 20 test locations across the semi-arid tropics.

In groundnuts, new lines obtained by incorporating genes from wild species that confer resistance against late leaf spot and rust were evaluated and found successful at ICRISAT Center and at Bhavanisagar in southern India. They have now been entered in disease resistance trials of the Indian national program.

Collaborative research carried out at the USDA Plant Disease Containment Laboratory in Maryland, USA, has identified 10 ICRISAT sorghum lines that can be a valuable source of downy mildew resistance for

*Grain-mold resistance found in colored-grain sorghums has been transferred to a white-grained type (inset). Farmers prefer the white grains for consumer acceptance.*



*Studying bud necrosis disease on groundnuts at ICRISAT Center: inset shows close-up of a symptom.*

breeders worldwide. In tests at that laboratory, 75 sorghum lines previously identified as resistant to downy mildew were exposed to 16 isolates of the pathogen from Argentina, Brazil, Ethiopia, Honduras, India, Nigeria, and USA. Reactions differed, but the 10 lines now identified—all from ICRISAT's international nursery for this disease—were resistant to all isolates of the pathogen.

At ICRISAT Center, several ergot-resistant pearl millet lines were identified as being resistant also to smut and downy mildew; in addition they have a good yield potential. Based on these lines, a new composite has been constituted to breed improved ergot-resistant varieties.

Screening germplasm accessions at ICRISAT Center, 70 more chickpea genotypes were identified as being resistant to wilt and root rot. In sorghums, six agronomically elite lines were identified as highly resistant to downy mildew in ICRISAT's advanced screening nursery at Dharwad in southern India.

Screening groundnuts for resistance to bud necrosis disease, ICRISAT scientists identified many lines with a low incidence of the disease. They are confident that this is mainly because the lines are resistant to thrips, the insect that spreads bud necrosis by acting as a carrier of its causal agent, the tomato spotted wilt virus. Such virus-vector relationships, and their impact on crop lines, are a separate subject of study in themselves, calling for interdisciplinary work.

The common wilt in sorghum has been a relatively unknown disease in northern India. ICRISAT scientists this year found evidence of its incidence, identified the cause as a specific fungus, and showed that it is transmitted through the seed. Similarly, the fungus causing fusarium wilt in pigeonpea was shown to be internally seedborne; genotypic differences in seed infection were also noted.

*Promising pigeonpea line (center) resists wilt and blight diseases, while that at right is wiped out.*

Preliminary results from tests at ICRISAT Center indicate that grain-mold resistance identified in colored-grain sorghums can be transferred to white-grained types. Successful transfer of mold resistance has been achieved from three colored-grain sorghums into white-grained lines.

Scientists at ICRISAT Center used several species of a particular taxonomic section of wild relatives of groundnut to incorporate desirable genes into improved lines. The traits those genes bestow include resistance to rust, late leaf spot, and bud necrosis diseases. This is the first such use of those species.

A modified enzyme-linked technique was developed and used successfully by ICRISAT groundnut scientists, in collaboration with the Peanut Collaborative Research Support Program (Peanut CRSP, USA), to identify peanut stripe virus in southeast Asia. The method can be used even in countries where specialist plant virology laboratories are not available.

That technique was also used to test seed of 745 groundnut accessions originating from southeast Asian countries, now with ICRISAT's genetic resources unit, for the possible presence of peanut stripe virus. All the tests were negative, confirming that this material can now be safely supplied to users around the world.

ICRISAT's work in disease resistance thus goes beyond the mere identification or supply of improved lines. The numerous activities described here provide an effective research base from which scientists—at ICRISAT and elsewhere—can evolve resistant crop lines for the benefit of farmers worldwide.

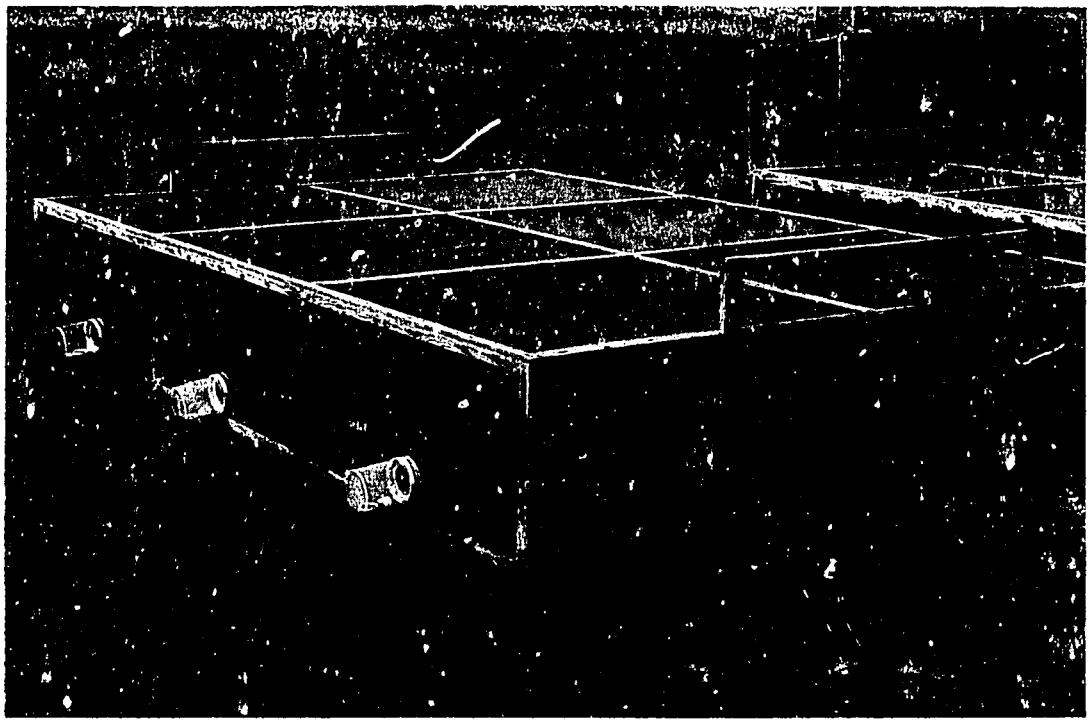
# Controlling Insects

Insects are another major cause of reduced yields in food crops. ICRISAT's work in this area is also multipronged. In addition to studying resistance mechanisms and identifying sources of natural resistance, ICRISAT scientists work on pest surveys, monitoring insect populations, biological control through parasites and predators, and improved agronomic practices, including safer and more efficient methods of applying pesticides. The overall aim is to arrive at integrated pest management strategies that can help farmers get better yields in their fields.

Important progress was made in 1985 in several of these areas. A major destroyer of both chickpeas and pigeonpeas is the *Heliothis* pod borer. Several chickpea genotypes selected by ICRISAT for resistance to that pest performed well in India's national trials. One of them has been outstanding in 3 years of testing and is now included in the national crossing program. Making similar advances is an ICRISAT pigeonpea, ICPL 332, the first *Heliothis*-resistant line to be entered in India's multilocational trials, which has been retained for further tests.

A midge-resistant sorghum variety identified by ICRISAT, ICSV 197, is now being used as an improved breeding source by national programs in Argentina and El Salva-

*Sorghum plants are screened in cages under induced insect pressure to identify shoot fly resistance.*



*ICRISAT scientist proudly displays pigeonpea line that is resistant to the* Heliothis *pod borer*

dor and by ICRISAT regional program scientists in Mali and Mexico. It is also being extensively tested by the Indian national program, and by the University of Agricultural Sciences, Dharwad, Karnataka, in midge-endemic areas of that Indian state.

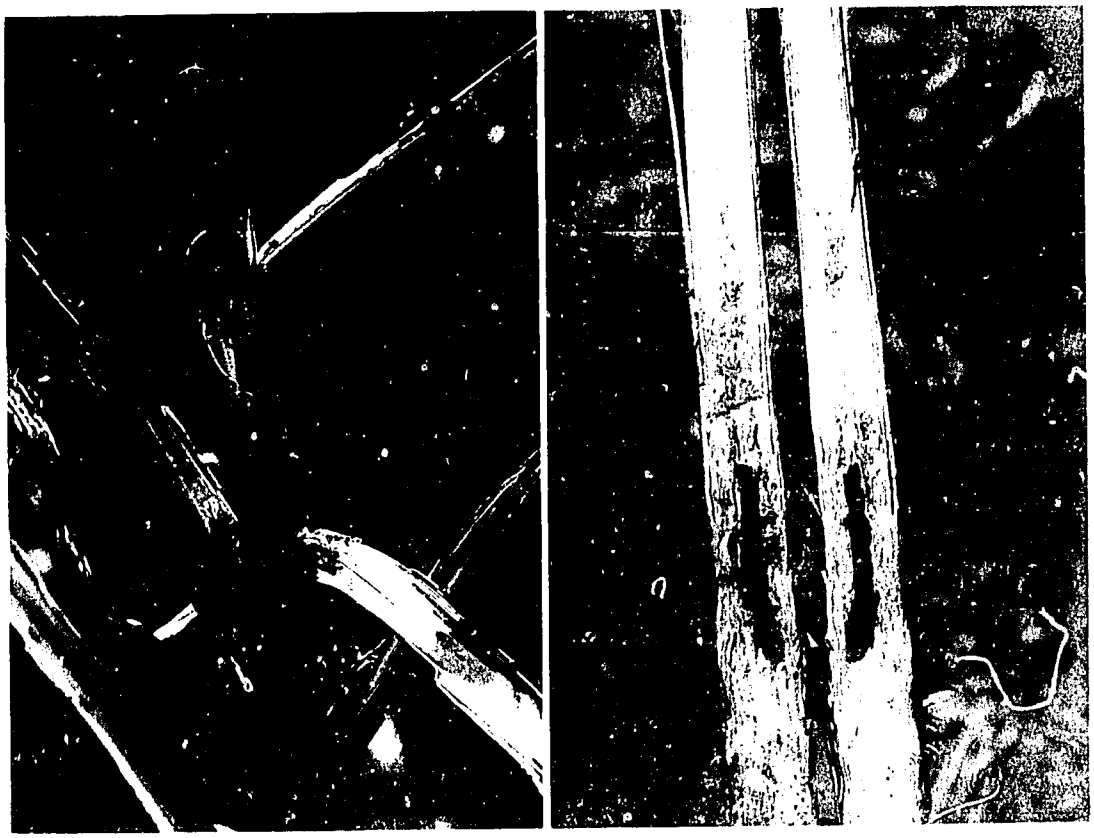
Groundnut lines previously identified for resistance to thrips and leafhoppers were tested during the rainy season at ICRISAT Center under natural pest infestations in a high-input environment, using optimum levels of fertilizer and supplemental irrigation. Several of them outyielded the two high-yielding, but susceptible, controls by more than 30%.

Based on a large-scale field trial at ICRISAT Center, valuable information has been gathered on the economic significance and control of the groundnut leaf miner, a major problem in India and Southeast Asia. The data are now being incorporated into a computer model to find out, among other things, the degree of host-plant resistance required to avoid use of insecticides without reducing farmers' incomes. Several lines showing a high degree of resistance to this pest have been identified.

A total of 345 wild sorghums from the genetic resources accessions were screened for resistance to shoot fly, and 13 were identified as having high levels of resistance. Their genes can now be incorporated into otherwise well-adapted sorghums.

In Mali, resistance to head bugs was identified in 3 of 11 sorghum cultivars tested. In

*Head bugs and ergot disease take their combined toll of this pearl millet head at Samaru, Nigeria.*



*Two views of stem borer damage in sorghum. Valuable data has been gathered to help develop control measures.*

another experiment there, head bug infestation was induced at different stages of sorghum growth; later infestations did the least damage.

Scientists at the ICRISAT Sahelian Center in Niger monitored populations of two major insect pests on pearl millet, stem borer and earhead caterpillar, and gathered information of value in designing control measures. In cooperation with the Commonwealth Institute for Biological Control, a study was initiated on natural enemies of both pests.

Studying agronomic control measures for the earhead caterpillar in Niger, three tillage treatments—two of them common farming practice in the Sahel—were tried on plots with high infestations the previous year. One of them—deep plowing—reduced insect incidence considerably. In a varietal trial for resistance to the caterpillar, carried out with scientists of the Niger national program and the Institut du Sahel, 6 of 14 entries showed negligible infestation.

In more basic research at ICRISAT Center, a specific nuclear virus was shown to reduce the *Heliothis* pod borer on pigeonpea during a field trial.

Analyzing results from stem borer yield-loss trials in sorghum, ICRISAT scientists have concluded that early infestation by the pest (15-20 days after emergence) caused yield losses, but later infestations did not. This finding can be valuable in economizing on efforts to control stem borers.

# Using Bacteria and Fungi

Among the microorganisms abounding in nature, some specific strains of bacteria or fungi can be used to help crop production. Such strains help plants absorb nutrients from the air and soil, grow better, and yield more grain. ICRISAT scientists work on identifying these and on finding ways to use them profitably.

Over the past 3 years, three strains of rhizobial bacteria identified as beneficial by ICRISAT—IC 76, IHP 195, and NC 92—have been recommended to inoculant manufacturers in India. The production of chickpea, pigeonpea, and groundnut can be boosted, each by the use of one of the identified strains.

This year, a system was developed for producing and packaging rhizobial inoculants, using low-cost, locally available materials. Its operation was successfully demonstrated to inoculant manufacturers.

Work initiated in earlier years continued also on beneficial fungal strains associated with the root zone of plants, known as mycorrhiza. Inoculation with such strains has been found to help both pearl millet and pigeonpea.

The fungus aids uptake of phosphorus from the soil, thus enhancing plant growth. At the ICRISAT Sahelian Center in Niger, inoculation of a local landrace of pearl millet with the fungus increased the plant's uptake of phosphorus by several times. As phosphorus is the most wanting element in soils on which pearl millet is grown in West Africa, the potential of that finding is encouraging.

In similar tests with pigeonpea at ICRISAT Center, growth responses to inoculation with mycorrhiza were clearly shown, with the response being greater in sterilized than in unsterilized soil.

The studies will continue.

*Studying soil and crop responses to mycorrhizal inoculation at ICRISAT Sahelian Center. The fungus has been found to aid crop growth in pearl millet through improved phosphorus uptake.*

# Enduring Physical Stresses

High soil and air temperatures, drought, poor soils, sandstorms, and highly variable rainfall are individually and collectively the bane of the farmer in the semi-arid tropics.

ICRISAT scientists study the interaction among those factors and crop growth, and strive to identify lines that can endure those stresses and produce a harvest. They also evolve farming systems and improved practices that can help the farmers face the harsh environment with greater confidence.

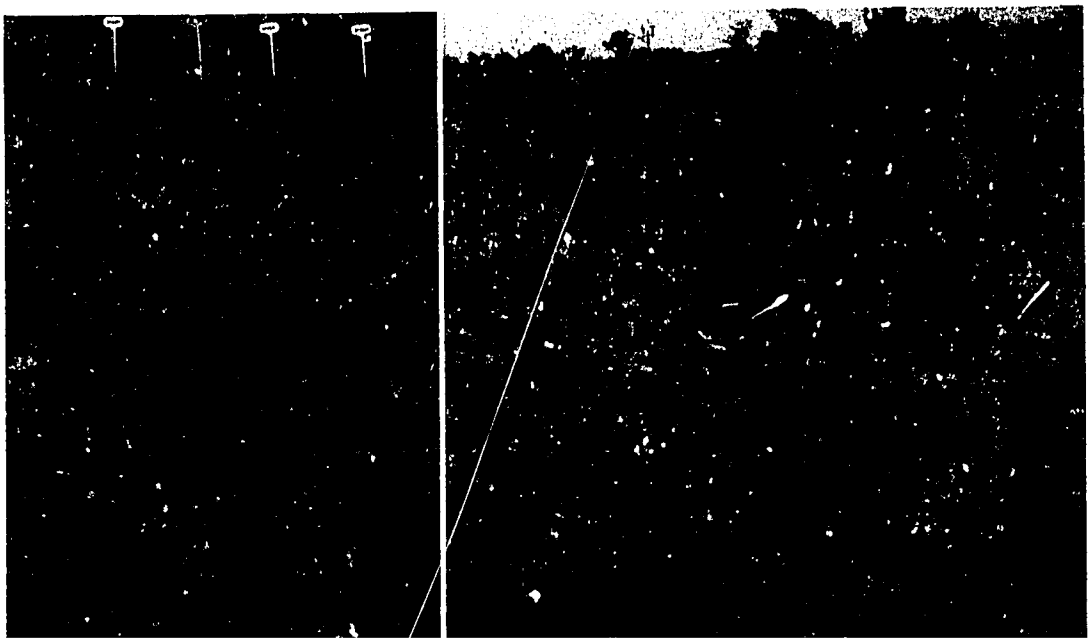
While evolving improved crop lines is important, just as important is developing techniques to routinely screen them against adverse physical conditions. The techniques often involve simulating conditions to match nature's extremes. ICRISAT scientists made important progress this year with work on such techniques initiated in earlier years.

Laboratory and field techniques developed at ICRISAT Center were successfully used by scientists in Mali and Niger to study how seedlings emerge under high soil temperatures. The ability of sorghum and millet seedlings to emerge is a crucial factor that can help the plant survive the heat in the Sahel, where soil temperatures can reach 55° C.

Seedling vigor to break through soil crusts is also valuable in droughty environments. Using previously developed field techniques, some 150 sorghum lines were screened at ICRISAT Center for their ability to emerge through soil crusts and 22 of them were identified as measuring up to expectations.

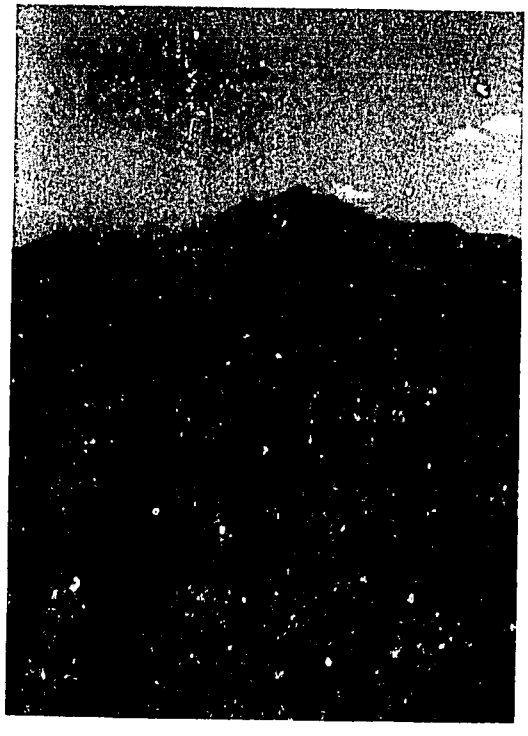
The timing of drought within the crop's life cycle, as well as its intensity, are both important in understanding how drought affects a

*Screening for emergence through soil crusts (left) at ICRISAT Center. At right, trainee at ICRISAT Sahelian Center, Niger, learns a technique to study plant establishment.*



*Screening of chickpeas for drought tolerance at ICRISAT Center. Previously identified genotypic differences were confirmed this year.*

*Groundnut lines being tested for drought tolerance at Anantapur in southern India.*



crop. Studying both timing and intensity of drought during grain filling in pearl millet, ICRISAT scientists quantified data over 2 years and gathered information of value in selecting cultivars of proper growth duration for areas prone to drought at different stages of crop growth.

An international groundnut trial of early-maturing cultivars was organized in 1985 and distributed to 48 locations worldwide. In Botswana, where rainfall during the crop season was only 205 mm, several entries in the trial outyielded the local cultivar by nearly 50% in preliminary screening. They matured in 119-126 days, as against 142 days for the local. Trials at ICRISAT Center confirmed the drought tolerance of several progenies of NC Ac 17090, a parent line identified earlier as resistant to rust and late leaf spot diseases.

ICRISAT scientists also tested 42 groundnut genotypes at Anantapur, a droughty site in southern India marked by low and erratic rainfall. Two sowing dates were observed to

study drought effects at different growth stages of the plants; the first sowing received 315 mm of rain, the second 200 mm. In both trials, several entries outyielded the local cultivar, TMV 2; these lines had earlier been identified in trials at ICRISAT Center as resistant to foliar diseases and tolerant of drought.

This is reassuring, not merely because of the genotypes identified as tolerant, but also because the validity of our method of screening is thus confirmed. In similar trials with chickpeas at ICRISAT Center, scientists found that previously identified genotypic differences were consistent. Lines that were relatively drought tolerant on a red soil also performed best on those black soils where water-holding capacity was low.

# The Making of Hybrids

For commercial farmers and government agencies looking for quick results, hybrids are a relatively easy means of boosting yields. But they require careful basic research and an efficient seed industry that is rigorous in quality control.

Because subsistence farmers in many countries of the semi-arid tropics do not have access to such seeds, ICRISAT's initial work focused on varieties. Farmers traditionally prefer to grow local varieties, as they can then use their crop as the source of seed for

*This pearl millet hybrid, based on an ICRISAT-developed parent line, has done exceptionally well in Indian multilocational trials. It is expected to be released soon to farmers in India.*

the next planting.

But ICRISAT's mandate is worldwide and there are several countries in the semi-arid tropics with well-developed seed producing agencies. Recognizing this, the Institute has also paid attention to hybrids, and its efforts have begun to show results on a larger scale.

One illustration of that success is the excellent performance the past 2 years—in tests of the Indian national program—of two pearl millet hybrids, ICMH 451 and ICMH 501, based on ICRISAT-bred parent lines. Yet others are the success of sorghum hybrids Hageen Durra 1 in Sudan and SPH 221 in India. Officially released to Sudanese farmers in 1982, Hageen Durra 1 continued to do well even during a general drought and its seed is being multiplied for planting on a much wider area. Authorities in India recommended for release this year ICRISAT sorghum hybrid SPH 221.

A fairly complex process precedes these results. Experiments involving numerous lines are laid out, where the male parents in certain lines of bisexual plants—such as sorghum and pearl millet—are sterilized by genetic intervention. The resultant female lines are then fertilized by pollen from other lines, carried by wind. Not all lines so crossed result in hybrids capable of producing sufficient seed. Those that do are then tested for yield—the main criterion for setting the process in motion—first at research stations, then in multilocational trials by national programs, which include farmers' fields. And only those that result in significant yield gains on-farm and produce grains of acceptable quality are released to farmers.

To aid effectively in that process of selection, scientists need to make detailed observations. Male and female parents identified for crossing have to flower at the same time and they have also to be resistant to major diseases. The genetic purity of the male and female parents has to be constantly ensured. And the process of rendering some selected lines male sterile is in itself quite delicate, requiring technical finesse.

*Pigeonpea breeder studies male-sterile line, to which bees will carry pollen (inset), fertilizing it and producing hybrid seed.*

Not all national programs have the infrastructure to support this process, even if they have a seed industry that can exploit its results. This is where ICRISAT steps in, providing basic and strategic research support to national programs that can be productive in their own situations.

In sorghums, for example, ICRISAT scientists this year planted a detailed observation nursery in Burkina Faso, studied 45

recently developed female parents, and identified 15 for further testing, adaptation, and potential use in making hybrids. As some of these show a high resistance to foliar diseases, they can be of considerable value to the national program.

At ICRISAT Center, similarly, sorghum scientists evaluated more than 300 female parents for their potential as hybrids. Two male-sterile lines resistant to shoot fly are now ready for hybrid production, and two other lines resistant to midge were identified for conversion into male-sterile lines. A total of 34 cooperators (6 in India, 28 elsewhere in the world) were supplied with 45 male-sterile lines selected for superior agronomic traits, so that their stability and yield can be tested further.

With pigeonpeas, the process of producing hybrids has been developed only recently, and its potential has not been exploited commercially. Because pigeonpea is a predominantly self-pollinated crop, lines that are genetically male-sterile need to be identified, and their potential for use in making hybrids explored. ICRISAT has pioneered work in this area and shown that hybrid seed production is economically viable in pigeonpea.

Crossing blocks are grown where natural insect populations carry pollen from the male parent row to several rows of the male-sterile line, from which fertile plants have been removed. This work has already attracted the attention of two private seed companies in India.

Hybrids evolved by this process are being tested in India. ICRISAT pigeonpea hybrid ICPH 8 has done exceedingly well at Hisar, Haryana, during 3 of the last 4 years. But when it was tested across 22 locations in India, yields ranged widely. Since it ranked first or second among six entries in 11 of 15 trials in India in 1984, it will be tested further.

To stabilize the future performance of pigeonpea hybrids across environments and

*Sorghum nursery grown in Burkina Faso to help identify suitable female parents for making hybrids.*

cropping systems, male-sterile lines are now being developed with high combining ability, diverse genetic backgrounds, and varying growth periods. To aid this process, ICRISAT scientists have already identified male-sterile pigeonpea lines with sufficiently large seeds, which are also resistant to two major diseases, wilt and sterility mosaic.

But evidence of the best use by a national program of ICRISAT's strategic research comes from the development of pearl millet hybrids in India. Seed of two hybrids, ICMH 451 and ICMH 501, produced from two male-sterile lines developed by ICRISAT, is already being multiplied in anticipation of their likely release in 1986. One of those male-sterile lines, 81A, is increasingly being used in Indian hybrid programs. In 1985, 10 hybrids of the 39 under initial tests in India were made using 81A. And ICRISAT has contributed 8 of the 21 male-sterile lines in the Indian national program's seed parent nursery, indicating that further advances can be expected from this work.

These are some ways in which ICRISAT scientists strive to strengthen the research efforts of national programs, with higher and stabler crop yields as the common goal.

# Breeding Improved Crop Lines

Improving crop lines is always a complex and time-consuming process. It is especially so within ICRISAT's mandate, given the gravity and range of problems in the semi-arid tropics. It involves identifying problems in specific environments, studying the genetics of specific crop lines, and developing improved varieties or hybrids that can resist the major yield reducers and stabilize or boost yields in one or more of the given regions. Such improved lines then need to be tested extensively before release to farmers.

Earlier pages in this publication described ICRISAT's multidisciplinary work on drought, diseases, and insect pests. Here the focus is on some end results.

Through cooperative endeavors with national agricultural programs, ICRISAT has attempted over the years to shorten the time lag involved in exchange of detailed crop information and crop materials. More importantly, the involvement of national programs in collaborative testing at various stages has speeded up the release of crop lines to farmers, a decision that remains the prerogative of the concerned national program.

During 1985, several crop lines developed or improved by ICRISAT scientists reached farmers in different parts of the world. Among the lines so released or recommended for release were seven sorghums, four pearl millets, three pigeonpeas, two chickpeas, and a groundnut. Many others reached advanced stages of testing, moving a step nearer release to farmers.

Among sorghums, ICRISAT hybrid SPH 221 was recommended for release to farmers in India for rainy-season cultivation. It has been renamed CSH 11 by the Indian program. In Zimbabwe, two ICRISAT sorghum varieties were released under the names of SV 1 and SV 2. So were four others

SPN-221

in Latin America: SPV 387 under the name of Surano in Honduras; a white variety called Blanco 86 in Mexico; a variety called ICTA-Mitlan-85 in Guatemala; and another called ISIAP Dorado in Venezuela. The last named variety has already been released in El Salvador and Mexico.

Two other ICRISAT sorghums were selected during 1985 for minikit (prerelease) trials on farmers' fields in India, and two were promoted to the Indian program's advanced hybrid trials for rainy season 1985. Similarly, multilocational trials in Burkina Faso led to two new high-yielding selections being identified. They have good panicle and grain characteristics and will be evaluated in on-farm trials in 1986.

Among pearl millets, ICRISAT-bred varieties continued to be increasingly important in India and in countries of Africa. After 6 years of national testing, synthetic variety ICMS 7703 was released for general cultivation in India. It was found high yielding and disease resistant, and some 270 tonnes of its seed was produced by the concerned agency for distribution to farmers.

In Niger, three pearl millet varieties--ITMV 8001, ITMV 8002, and ITMV 8304, bred by ICRISAT in collaboration with the national program—were released to farmers for general cultivation.

Pearl millets now in advanced testing offer even greater promise. ICRISAT's synthetic variety ICMS 7704, tested in Indian multilocational trials over the last 5 years, equals the grain yield of the already-released ICMS 7703 and gives 14% more fodder. It also gives 35% more fodder than the widely used commercial hybrid BJ 104, and has a high level of downy mildew resistance, making it the best dual-purpose variety identified so far in the Indian trials. Two other varieties were chosen for large-scale multiplication and testing on farmers' fields in Mali, as was yet another in Cameroon. Four new varieties from ICRISAT's cooperative program in Senegal, and two from the cooperative program in Niger, are now in the second series

*ICRISAT's pearl millet synthetic ICMS 7703 has been released for general cultivation in India.*

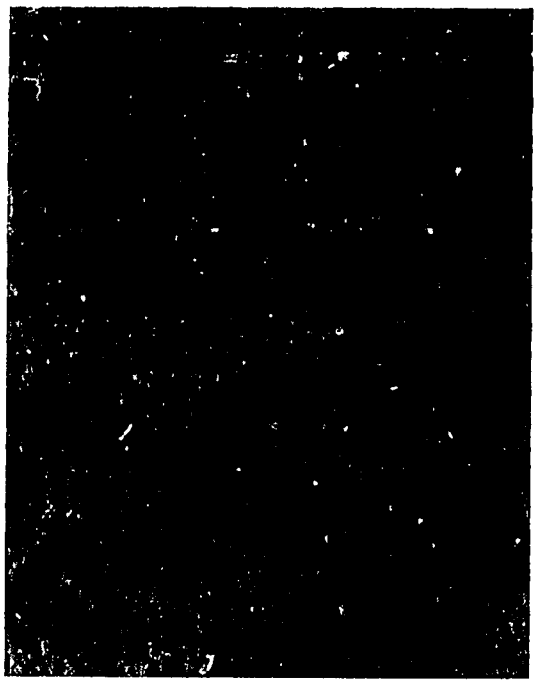
of regional tests conducted by the Institut du Sahel. Five varieties bred by the cooperative program in Burkina Faso have been proposed for prerelease trials.

An ICRISAT pearl millet released earlier, WC-C75 (now identified as ICMV 1), continued to be cultivated in India on a large scale, and results from trials in Zambia indicate that the variety may soon be released there. Two varieties released in Senegal in 1984 now occupy more than 15% of the millet area in their northern zone. These varieties are also now under extensive testing in Mali.

ICRISAT's first groundnut selection to reach farmers will be ICGS 11. It was recommended by the Indian national program for release in the central and peninsular zones of India. Suitable for irrigated cropping in the postrainy season, ICGS 11 outyielded the local controls by an average of 25 and 40% in adaptive trials in the two regions.

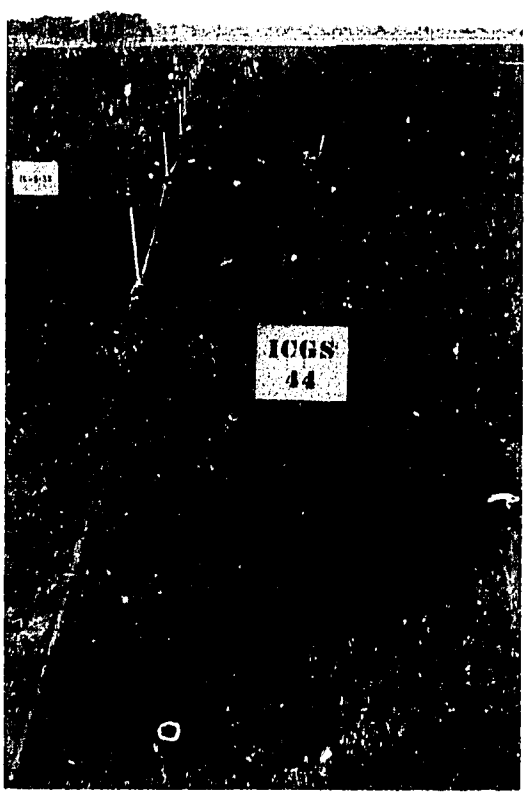
Three other groundnut selections from ICRISAT have reached the stage of adaptive trials in India. ICGS 44 was recommended for postrainy, irrigated cropping in India's western zone, which includes Gujarat, India's main groundnut-producing state. It outyielded the four local cultivars against which it was tested by 16 to 39%. Similarly, ICGS 1 and 5 are being evaluated for rainy-season cropping in the states of Rajasthan, Punjab, Haryana, Uttar Pradesh, and Bihar.

As irrigated groundnut cultivation has expanded greatly in central and southern India in recent years, the development of high-yielding, adapted cultivars—such as ICGS 11 and 44—is expected to have a significant impact on production.



*This bold-seeded groundnut has been identified as suitable for the confectionary trade.*

*This ICRISAT groundnut selection, ICGS 44, is in prerelease adaptive trials in India for postrainy, irrigated cropping. Another ICRISAT selection, ICGS 11, has already been recommended for release.*




The confectionary trade is among the largest users of groundnut. ICRISAT scientists contributed 13 selections with larger seeds, improved for the confectionary trade, for wider testing in India in the 1985 rainy season. They also set up an international trial for this purpose and sent 24 lines to researchers in 15 countries.

Among pigeonpeas, ICRISAT's short-duration genotype ICPL 87 was released this year to farmers in India. Its yields exceeded 5 tonnes per hectare in a multiharvest system developed at ICRISAT. Although most pigeonpeas grown in the world are long-duration, tall types, usually intercropped with a cereal, ICRISAT scientists are confident that short-duration genotypes, like ICPL 87, have a great potential, even as a monocrop.

But work continues simultaneously on improving the traditional longer-duration

*ICRISAT pigeonpea ICPL 87 has been released to farmers in India*

pigeonpeas, with emphasis on breeding for resistance to diseases, insects, and other stresses. Two such new lines were released this year: ICP 8863, renamed Maruti, in Karnataka, India, and ICP 7035 in Fiji, renamed Kamica (which means sweet; its seeds are large and sweet when eaten green). Maruti is resistant to fusarium wilt disease and will be of value to many farmers who have suffered serious losses from the disease. Kamica is resistant to two diseases, fusarium wilt and sterility mosaic, and tolerant of another, phytophthora blight.

Two other ICRISAT pigeonpeas did exceptionally well in Indian tests, and one of them has been identified for release in northwestern India. The variety so identified is ICPL 151, an early maturing indeterminate genotype, which has large cream colored seeds, is high yielding, and has tolerance to sterility mosaic. It can be used as a rotation crop with wheat. ICRISAT's early-maturing hybrid ICPH 8 gave an average yield of 2250 kg/ha in 16 tests across India, 26% more than the best control cultivar of the same growth duration.

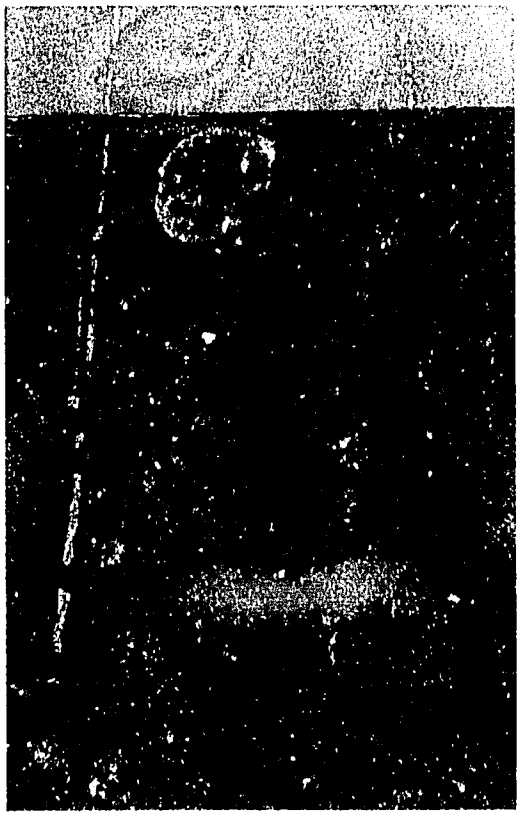
Very high yields were reported from trials in several countries of pigeonpeas supplied by ICRISAT: more than 5 t/ha in Argentina and Thailand, and more than 3 t/ha in the Philippines.

In chickpeas, ICRISAT's kabuli-type ICCC 32, with resistance to wilt and root rots and some tolerance of *Heliothis* pod borer and soil salinity, has been identified for release in India's northwest plains. It has also been tested in prerelease trials in central India, where it outyielded the control by 30%. Another kabuli genotype, GNG 149, selected from ICRISAT material by breeders at the Sriganganagar Agricultural Research Station in Rajasthan, India, has been identified

for release in India's northwest plains.

Numerous other chickpea lines from ICRISAT performed well in demonstration or adaptive trials in India. Two early-maturing, wilt-resistant kabuli lines and one desi chickpea were distributed for demonstrations in peninsular India. Similarly, seed of ICCC 37, a high-yielding desi chickpea, was supplied on request to the Government of Andhra Pradesh in India for large-scale multiplication and prerelease trials. There were 12 ICRISAT chickpea selections in advanced yield trials in Tamil Nadu, and 3 in Gujarat. In addition, 12 other lines, selected from ICRISAT material by breeders in Indian research stations and contributed by them to the national trials, also performed well.

*This ICRISAT chickpea has been identified for release in the northwest plains of India.*



*Scientists discuss ICRISAT's early-maturing pigeonpea hybrid ICPH 8, which gave good yields across 16 test locations in India.*

In Nepal, two ICRISAT chickpeas, ICCC 4 and ICCC 13, continued to yield well, while ICRISAT's ICCL 82148 gave excellent results in Bangladesh.

ICRISAT's contribution to improvement in all of its crops is thus multifaceted. While the lines, varieties, and hybrids released this year—added to those released in earlier years—will make a significant impact on production wherever these crops are grown, ICRISAT continues to provide national programs with selected breeding material that can be used in their own crop improvement efforts.

Thus, ICRISAT's strategic research on genetic improvement of varieties and hybrids is expected to have an even greater impact in future years.

# Improving Management of Resources

Learning how to manage the available resources of climate and environment—soils, rainfall, sunshine—for better crop production is yet another facet of ICRISAT's research. ICRISAT scientists study many factors to assess the cropping patterns or farming systems most appropriate for given regions, and then identify those that make maximum use of the available natural, human, and animal resources. Their findings can be of use to crop planners within nations and regions, as well as to farmers.

Long-term weather patterns are studied in relation to crop production, so that crops can be planned for specific weather trends. Agronomic studies identify the crops, varieties, crop combinations, and cultural practices most suitable for a range of farm situations. Ways to conserve and better utilize soil and water resources are explored, as are availability of fertilizer, crop responses to fertilizer, and tillage methods. Simple, modified equipments that can help the farmer obtain better results are also studied.

As with crop improvement, ICRISAT conducts its research on managing resources in cooperation with national agencies and other specialized research institutions. It

*Millet plot at left was fertilized with locally produced rock phosphate, showing dramatic gains over the control plot (right). This work was carried out at the ICRISAT Sahelian Center, in collaboration with the International Fertilizer Development Center*

recognizes that even within the semi-arid tropics, each region is diverse, and that research must pool all available knowledge if suggested improvements are to be effective.

A collaborative study in Niger, with the International Fertilizer Development Center, confirmed that a form of rock phosphate, processed from locally available material, is as good as water soluble phosphate. It is also less expensive than imported phosphatic fertilizers. Yields at least doubled with 24 kg of phosphorus applied per hectare, both on the research station and in on-farm trials.

Among the inputs suggested to farmers in ICRISAT's village studies in Niger, use of phosphorus is being adopted by farmers and a general increase in use (up to 60 kg/ha) has been noted. An improved low-cost production package was tested on a pilot scale in farmer-managed and researcher-managed tests in four villages in Burkina Faso. The package includes runoff-reducing bunds made from field rocks, mechanically built tied ridges, a low dose of chemical fertilizer, and the improved ICRISAT white-sorghum variety ICSV 1002. Yield increases exceeding 175% were obtained under complete farmer management.

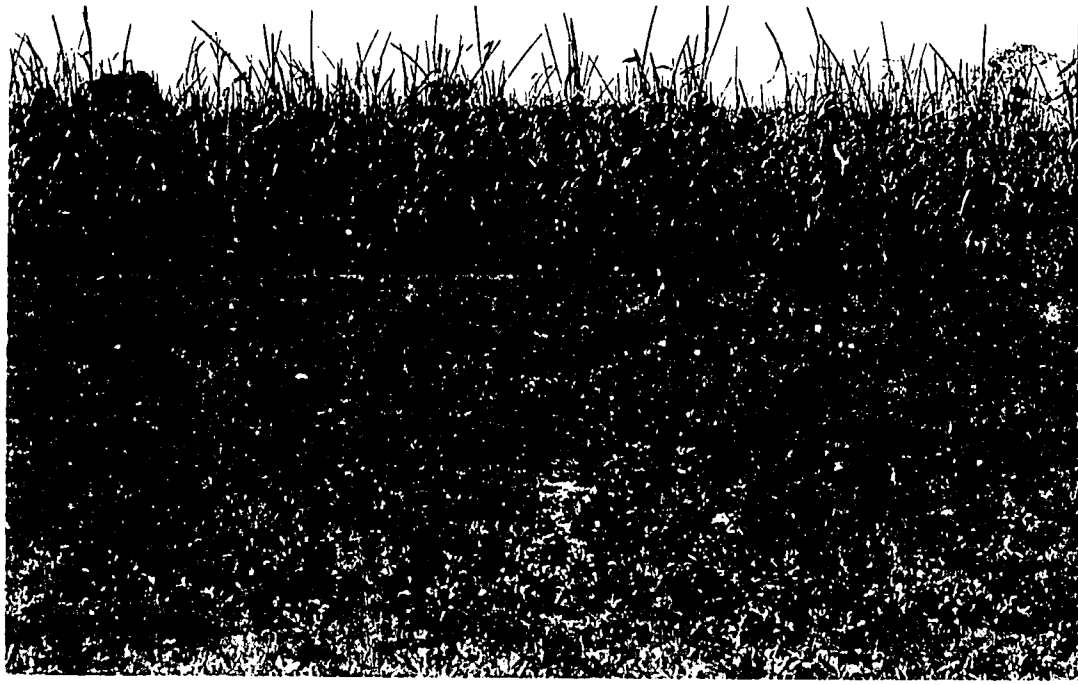
In collaborative work in Niger with scientists of the International Institute of Tropical Agriculture, impressive cowpea yields were noted. The growing period of some new early-maturing cowpeas was found to range between 55 and 70 days after sowing. The highest grain yield obtained in a sole crop was 1760 kg/ha, with minimal insecticide protection. Since cowpea hay is used for forage, dual-purpose cultivars were also identified. The best such line gave 1600 kg of grain and 2070 kg of hay per hectare in less than 70 days, while the traditional cultivar gave no grain and 3530 kg of hay. Cowpeas are also used widely in the Sahel as an intercrop with millet.

Tillage studies over 2 years in sandy soils in West Africa showed that ridging has many advantages. It loosens soil bulk density and improves plant establishment; provides a weed-free seedbed that is clean for a considerable period of time, thus saving time and labor; provides more uniform stands than traditional planting; and reduces wind erosion up to 50%.

*Workshop participants view agroforestry experiments at ICRISAT Center.*

At the ICRISAT Sahelian Center in Niger, combining crop residues (pearl millet straw) with fertilizers has given a 10-fold increase in yield. Tillage experiments on red soils at ICRISAT Center gave several valuable insights:

- off-season tillage enhanced water infiltration and enabled earlier sowing;
- tillage without soil inversion reduced crusting and sealing because it left sandy soil on the surface;



*Early-maturing groundnuts (foreground) being studied at the ICRISAT Sahelian Center, where collaborative experiments with the International Institute of Tropical Agriculture confirmed the benefits of intercropping cowpea and millet (background).*

- deep tillage (to 20-25 cm) reduced runoff and soil loss for 2-5 years; and
- subsoiling of deeper red soils increased infiltration, root proliferation, and maize dry-matter production.

Collaborative experiments with India's Central Research Institute for Dryland Agriculture, conducted in farmers' fields in the droughty 1985 rainy season, showed that simple hand-metering equipment covered as much area in the same time and gave as good sorghum yields as mechanical seed-and-fertilizer drills. But the latter saved labor by 50% and gave 12% more pigeonpea yields.

Data from long-term crop-rotation experiments on black soils at ICRISAT Center were analyzed. Initial results confirm the good residual effects of grain legumes, which fix nitrogen biologically. Grain yields of rainy-season sorghum with no added fertilizer increased from 1400 to 3400 kg/ha where an intercrop of pigeonpea and cowpea was grown the previous year.

Experiments over 3 years on black soils in India showed that germination and emergence of cereal crops were not adversely affected by placing fertilizer with the seed.

Testing continued in several Indian states of ICRISAT's watershed-based technology for double cropping deep black soils. That technology was adopted and modified successfully on a wide scale by Karnataka's Department of Agriculture in 1984.

Recognition of that success has come in an indirect way. The Government of India, aware of the need for greater attention to dryland agriculture, has created a national watershed development program for rainfed agriculture and appointed the previous Director of Agriculture in Karnataka as the Agriculture Production Commissioner in New Delhi.

In a workshop held at ICRISAT on training needs for dryland agriculture, with particular reference to ICRISAT's technology for deep black soils, specific training needs were identified. Meeting those needs will require strong collaborative efforts involving India's

national institutions, agricultural universities, and ICRISAT.

Analyzing weather and production trends over the past two decades in Sahelian West Africa, ICRISAT scientists found the downward trend in groundnut yields related to a decline in rainfall that had resulted in a shorter growing season. That finding addresses a specific problem in some African countries, once exporters of groundnut: how to stabilize and restore yields. The answer: earlier-maturing and drought-resistant groundnuts, some of which have already been identified through ICRISAT's research.

Work also began at ICRISAT Center on agroforestry research. A working group meeting was held to review ongoing research, explore collaborative linkages, and identify ways in which trees and food crops can be profitably grown together on farmers' fields. A representative of the International Council for Research in Agroforestry attended; the Indian national program, which already has research in progress on several facets of agroforestry, was well-represented.

Results from ICRISAT's work in 1985 thus offered encouragement in many respects. Some specific practices were evolved that can be transferred fairly quickly. Other findings indicated the potential of continued research, and yet others gave useful insights for long-term planning.

# Studying Farmers' Options

ICRISAT conducts socioeconomic studies, in addition to its bioscientific research. Such studies aim both to identify constraints that affect agricultural development and to assess technological options in farmers' situations. The effort is to account for the human and institutional factors in agricultural development, sometimes neglected areas of research.

Studies continued in 1985 on, among others: income levels of farm households, with reference to stability measures such as crop insurance; factors affecting availability of labor; common property resources; prospective benefits from intercropping; effects of rock bunds and earthen contour bunds; and preferred qualities of marketed groundnut.

ICRISAT economists analyzed income levels over 9 years of 104 rural households in three Indian villages and found income levels low and their variability high. Average annual per capita incomes were less than US$ 100 (1977 prices), with a mean CV of 35%—data that confirm the uncertainty of agricultural production in India's semi-arid tropics.

Based on simulated models, crop insurance was found to have a negligible impact (about 1% of mean household income) on smoothing fluctuations in incomes of farm households in India. As the farmers derive their income from several sources, stabilizing the yields of any one crop would not appreciably help reduce fluctuations in their incomes. Flexible public works programs, such as the Maharashtra Employment Guarantee Scheme, have proved effective in protecting poor rural households from sharp fluctuations in income and consumption.

The economists found in another study, though, that improved crop lines can yield sufficient benefits at the national level to offset any regional or sectoral variations they may accentuate. Thus, research on varieties and hybrids that can stabilize yields, by retaining and enhancing resistance to yield-reducing factors, is not to be ignored.

Labor is an important constituent of agriculture. Concern has often been expressed that the new technologies introduced may take away employment and reinforce inequities. ICRISAT's study of factors affecting labor supply in rural India suggests that nutritional status, health, wealth, skill, and caste all play a part, for both men and women. But both nutritional status and caste figure more prominently for women than for men. Whether the woman comes from a nuclear or an extended family does not seem to affect her decision to work in this context, a finding at variance from the situation in developed countries. Women also seem to willingly work longer hours than men, carrying their young children along to the place of work.

Labor-intensive technologies, designed for the deep black soils of the Indian semi-arid tropics, can increase wages by 67% for men and 48% for women, tripling the income from labor for the average household. Even if income from other sources does not change, total annual household income could increase by 79%. This confirms that employment-generating technology would especially benefit low-income households, who depend on wages from the labor market.

Continued studies on common property resources, such as village pastures, wastelands, and ponds, to which villagers have open access, suggest that such resources help reduce the income inequalities among rural households. The poorest households rely the most on common property resources, making gainful use of them whenever the demand for labor shrinks.

*ICRISAT economist discusses rock-bund experiment with farmers in Koho village, Burkina Faso.*

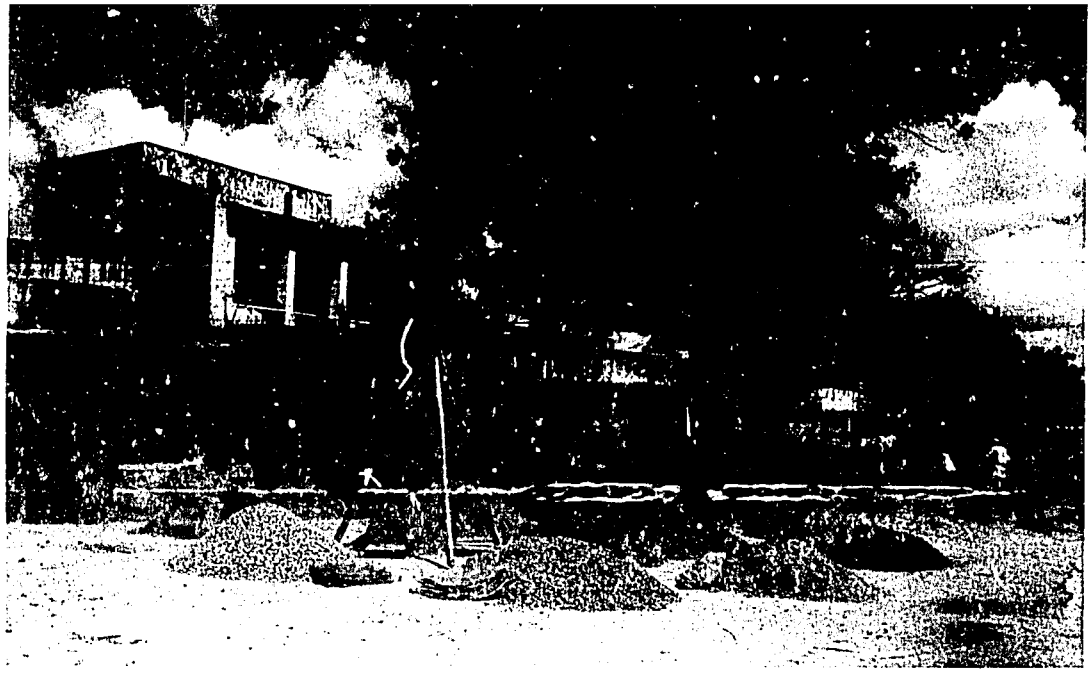
*Intercropping holds the most promise for those dryland regions where rainy season cropping is widely practiced, ICRISAT economists found. Controlled experiments would be needed to quantify that trend on farmers' fields*

ICRISAT economists also found that small-farm households and landless labor get more than 70% of their fuel needs from common property resources. This suggests that making crop byproducts, such as harvested dry stalks, or quick-growing trees available could result in less dung being used for fuel, making it available for use as crop manure.

ICRISAT economists found in the Indian villages they studied that intercropping holds the most promise for those dryland regions where rainy season cropping is extensively practiced. The traditional belief that growing two crops simultaneously on the same plot, instead of one, will reduce the farmers' risks seems to be valid, but controlled agronomic experiments would be needed to rigorously quantify that trend.

ICRISAT scientists have been studying the effects of earthen bunds in villages in Burkina Faso over the last 3 years, in collaboration with the national agency responsible there for a contour-bunding program. The earthen bunds increased mean yields of millet by 43%, and of sorghum by 30%. As the bunds are essentially a soil and water conservation measure, those short-term benefits can be further increased with more judicious selection of sites, indicated by continued research, adequate maintenance, and complementary use of fertilizer.

Testing began this year in Burkina Faso of a water harvesting system using rock bunds, introduced by the Oxford Famine Relief Agency. Immediate yield benefits, measured against investment costs, varied considerably for farmers across rainfall zones, with



*Groundnut samples at an Indian market. Some 370 samples were studied to obtain data on trader perceptions of groundnut quality in relation to market prices. The data can later be used by breeders in crop improvement work.*

the best results obtained where runoff tends to be high and where the bunds allowed less water to seep through.

While further research would be needed to pinpoint areas where the rock-bund system can work well, preliminary interviews indicate that farmers' advice may be very useful in identifying suitable land configurations for this technology. Nearly all farmers reported that considerable soil and organic matter accumulated at the bunds, suggesting that long-term benefits may exceed the short-term results. Learning from their perceptions, the tests will be modified, keeping in view the resources available within the villages.

Market studies for food grains, especially in relation to quality preferences, are another generally neglected area of research in the semi-arid tropics, though such research has picked up over the last decade or so. ICRISAT economists undertook this year an analysis of some 370 groundnut samples from five grain markets in Andhra Pradesh and Gujarat, India.

They recorded the market prices and measured seven traits of the groundnut samples that both traders and groundnut breeders considered important. A mathematical model was then designed to relate the prices to those quality characteristics. The analysis indicated that shelling percentage, oil content, and 100-seed weight were important, but damaged or infested seeds had a lesser role in depressing prices than was generally believed.

A further task now will be to collect a new set of samples, predict their prices based on the above analysis, and then compare them with prevailing market prices. If the estimates closely match prevailing prices, the model can be used to screen groundnut lines for consumer preferences and provide breeders with information that can aid their crop improvement efforts.

ICRISAT's socioeconomic studies thus play an important role in finding ways to speed up transfer of new technologies, whether they relate to improved varieties or better ways to manage available resources.

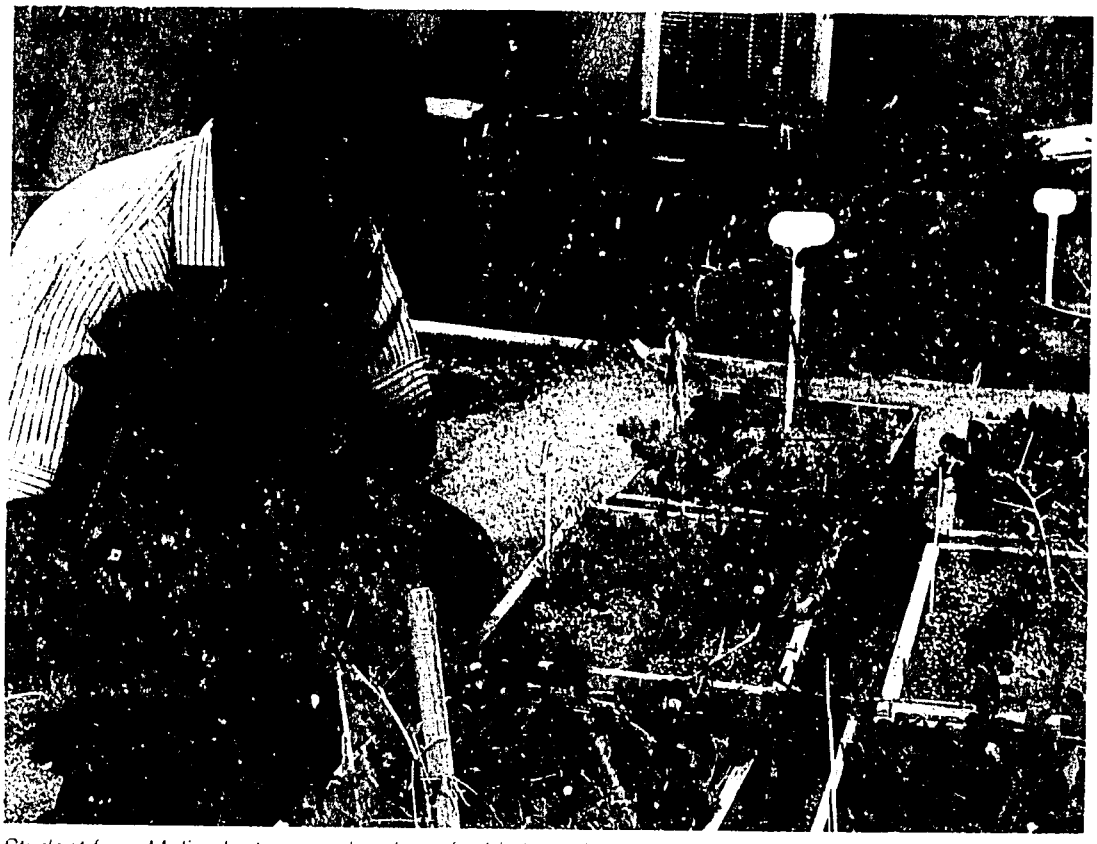
# Training Activities

Recognizing that training plays a crucial role in agricultural development and transfer of technology, ICRISAT enlarged its training efforts this year. More than 1100 people from 72 countries have completed training at ICRISAT Center since the program's inception in 1974. Regional training efforts have expanded in recent years, with ICRISAT scientists posted in African and Latin American countries offering research advice and guidance to students and technicians.

During 1985, there were 195 participants from 49 countries in training programs at ICRISAT Center, with the content of training varied to match individual needs within the Institute's mandate. In addition, more than 12 students from 4 countries worked with ICRISAT scientists in Burkina Faso, Mali, and Niger.

Thirty-two in-service fellows—holding midlevel scientific positions in the national research programs of 21 countries—took

*Research scholar conducts physiological experiments with groundnuts.*



*Student from Mali selects groundnut lines for his breeding experiment.*

part in intensive skill-development programs in plant pathology, entomology, agroclimatology, crop improvement, microbiology, or farm development.

A total of 109 in-service trainees from 38 countries completed training programs for 6 months in various aspects of crop improvement, crop production, or resource management, with a large group of 81 in the long-term, rainy-season program.

Eighteen postdoctoral fellows from four countries were at ICRISAT Center during the year. Seven of them completed research on optimizing use of light and water, insect populations and migration patterns, on-farm research, effects of land fragmentation, genetics of disease resistance, or nematology.

Theses research on a wide range of topics was conducted by 30 students from 13 universities and 11 countries. The 10 who completed studies worked on effects of drought stress on seed development, growth responses and heritability estimates in groundnuts, input markets, economics of water management, sorghum dehulling devices, genotypic interactions in intercropping systems on shallow black soils, chemical control measures, and resistance to insect pests in pulses.

The apprentice program, which provides work-study experience, was utilized by five participants from four countries.

A number of short-term courses were also conducted.

A second 6-week in-service training pro-

gram for economists working in national agricultural research programs was held at ICRISAT Center during 1985. Six African countries—Burkina Faso, Ethiopia, Kenya, Malawi, Nigeria, and Sudan—were represented among the 11 participants. The program aimed at strengthening the ability of participants to carry out socioeconomic research that can aid agricultural development. Special emphasis was placed on the use of microcomputers, particularly in budgeting analysis, on whole-farm modeling, and on survey research methods.

The sixth international training course in pigeonpea and chickpea pathology was conducted, with 16 participants from 9 countries—Bangladesh, Chile, Ethiopia,

*Research fellow studying head bugs on sorghum.*

*In-service trainee from the Philippines examines short-duration pigeonpea.*

*Ethiopian research scholar studies chickpea yields*

India, Mexico, Nepal, Pakistan, Syria, and Thailand.

Six scientists from four Central American countries—Costa Rica, El Salvador, Guatemala, and Mexico—received in-service training for 5 months with ICRISAT scientists based in Mexico. Sorghum breeding and agronomy were the focus of this training.

The ICRISAT Sahelian Center trained six students from Niger during 1985. In addition, students from the Agricultural Technical School in Niger attended a 1-week course at the Sahelian Center to gain practical experience with animal traction, rainfall simulation, farm equipment, and agricultural surveying.

In Burkina Faso, two students worked on their thesis research with ICRISAT scientists on *Striga*, a weed that affects sorghum and millet, and a third on a sorghum physiology problem. A postgraduate student from France participated in *Striga* research for his degree.

ICRISAT thus offered substantial training support during 1985 to scientists and national programs worldwide.

# Strengthening the Research Base in Africa

Africa contains a major part of the world's semi-arid tropics. And considering the gravity of the continent's food production problems, it is likely to be an area of growing world attention. ICRISAT's research amply recognizes this. While important research is conducted in India, Latin America and several other parts of the semi-arid tropics, Africa always remains an important focus.

Many scientists are posted at African locations, and testing and collaborative research is undertaken in many African countries. Results from such research are reported under appropriate headings in this booklet. ICRISAT also offers considerable research support to national programs in eastern, southern, and West Africa, working with other developmental agencies to create a network of cooperative action and research.

Such support takes many forms: research teams based in the region; regional workshops; facilitating exchange of scientists; training; short-term consultancy; and the setting up of special projects, often through cosponsorship. ICRISAT has set up the ICRISAT Sahelian Center at Sadoré, near Niamey,

*ICRISAT training officer explains phosphorus deficiency symptoms in sorghum to local researcher in Zimbabwe.*

Niger, to focus on West Africa; two regional programs in southern Africa, for cereals at Bulawayo, Zimbabwe, and for groundnuts at Chitedze, near Lilongwe, Malawi; and an eastern African coordinator's office in Nairobi, Kenya. ICRISAT scientists work also from Burkina Faso, Mali, and Sudan.

Although active research has been in progress at the ICRISAT Sahelian Center only since 1981, work there already points to possible new technologies for the Sahelian zone, as already reported. A donor's meeting was held there in 1985, to review ongoing work and make plans. Progress has been made with contracts for construction of the main campus buildings, which are now expected to be completed late in 1987. The Sahelian Center will then become a full-fledged research facility focusing its work on the problems of the Sahel.

Considerable progress was also made in constructing laboratories, a training center, and houses for local staff in the regional sorghum and millet program based at Bulawayo, Zimbabwe. Through consultations in the region, research needs and priorities have been determined and a sound technical program established. Set up in response to a call from the Southern African Development Coordination Conference (SADCC), the regional program has been reviewed favorably by its major initial donor, the U.S. Agency for International Development. Other donors have now come forward to support the venture.

An international symposium on agrometeorology of groundnut was held at the Sahelian Center, cosponsored by WMO, FAO, the U.S. Peanut CRSP, and ICRISAT, in cooperation with the Niger national program. The symposium was preceded by a week-long training course for 12 agrometeorologists from 10 African countries.

Regional workshops were also held on groundnut, sorghum, and pearl millet in eastern, southern, and West Africa. Research, adaptation, and strengthening of cooperative networks were the focus of attention in all five workshops.

Exchange of scientific visits during the year helped lend greater focus to ICRISAT's efforts. Scientists and technical staff from ICRISAT spent from several weeks to several months at one or more African locations.

*Construction makes headway at ICRISAT's southern African regional cereals improvement project, based at Matopos, near Bulawayo, Zimbabwe.*

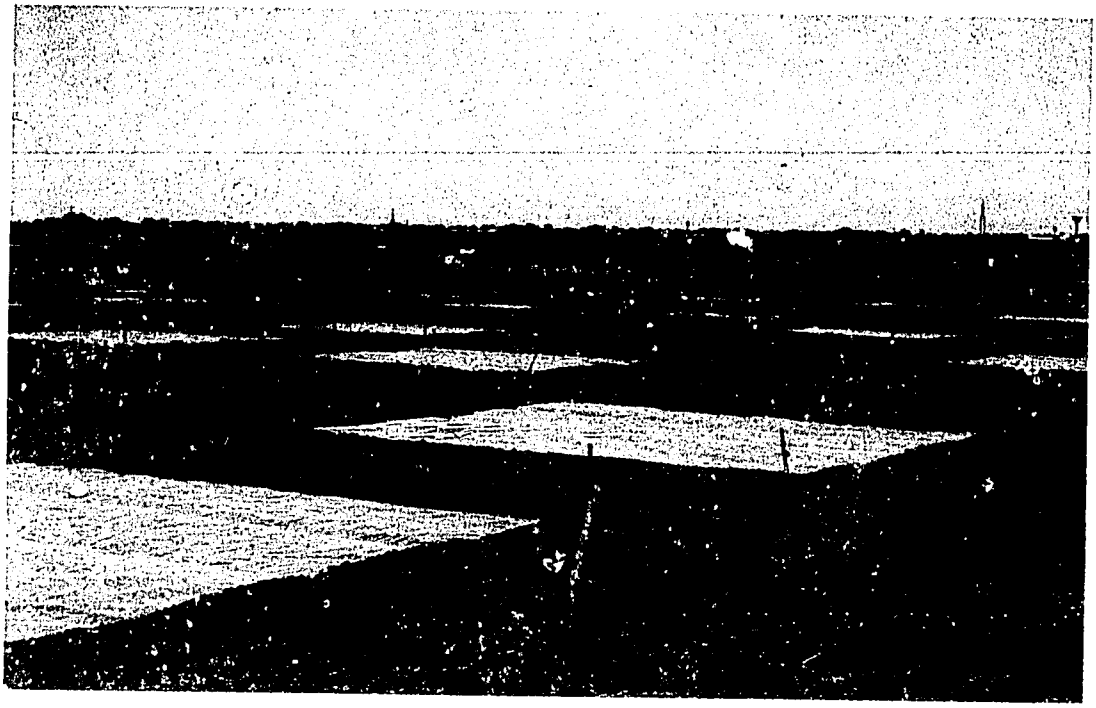
*A promising sorghum nursery grown in Zimbabwe. A sound technical program for cereals has been established in that country, in consultation with scientists in the region.*

Three of them researched problems of pearl millet: one established a downy mildew nursery at Mali; another showed through field studies in Niger the importance of a particular strain of mycorrhiza in phosphorus uptake; and a third gathered data of value in improving stand establishment. Others helped scientists in different parts of Africa with their work on germplasm evaluation, sorghum breeding, and insect screening in groundnuts. Yet others set up computer programs to analyze socioeconomic data, discussed experimental designs and methods for statistical analyses, and helped develop training programs in the region.

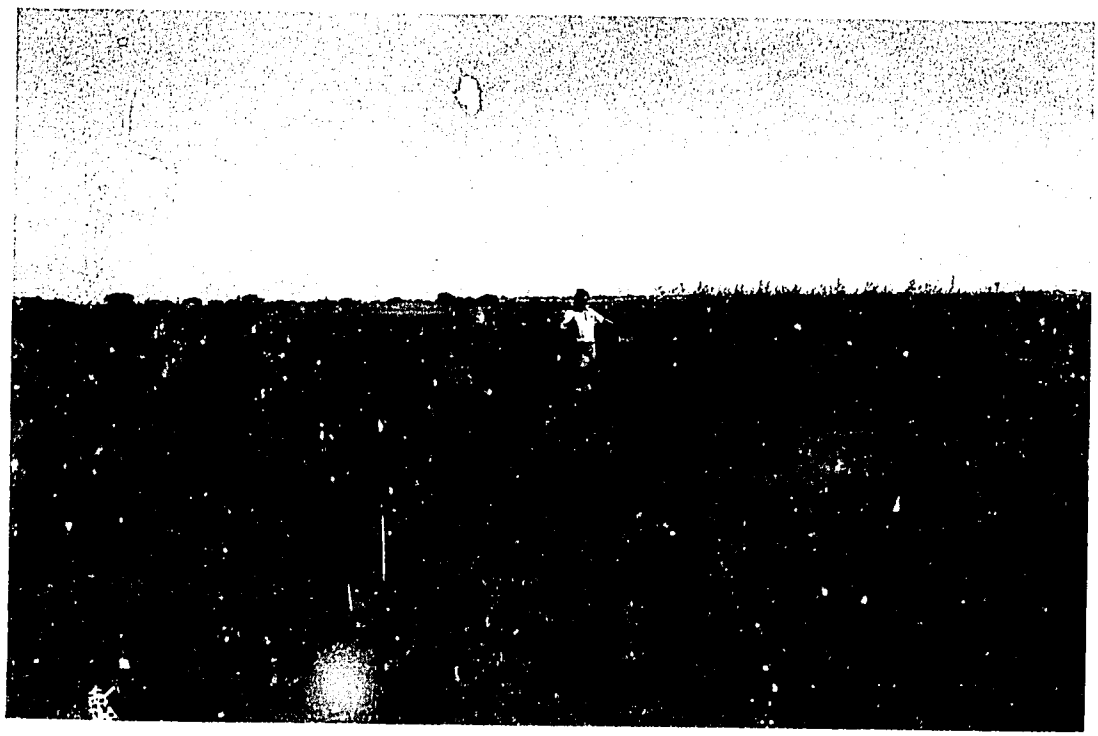
Seven senior agricultural scientists from eastern and southern Africa, representing Ethiopia, Lesotho, Malawi, Sudan, Tanzania, and Zambia, came to ICRISAT Center as part of a study tour of India. Priority areas for research were identified during discussions with the visitors. These include finger millet; resistance in sorghum to birds and to the weed, *Striga*; grain storage technology; grain quality and color preferences; and soil studies.

Ready availability of research information is another priority need in many parts of the semi-arid tropics. A Sorghum and Millet Information Center (SMIC) has functioned at ICRISAT Center since 1976, under financial support from Canada's International Development Research Centre. During 1985, seven workshops were held in four African countries in an effort to widen the scope and utilization of this service. About 120 participants from 14 countries attended these workshops.

In addition to its research and training, ICRISAT thus makes a special effort to address the problems of crop production in Africa, facilitating the setting up of institutional networks that can speed up the search for answers to those problems.



*Soil solarization experiment, begun at ICRISAT Center (above), has shown positive effects on pigeonpea growth. Those effects are visible below: in front is the crop grown on nonsolarized soil, at back the one benefitting from residual effects of solarization.*



# In Other Research

- Work continued on developing five broad-based sorghum populations, incorporating multifactor resistances. Each of those populations is intended to have resistances to a set of diseases and insect pests identified as priority needs in geographical regions within the semi-arid tropics. Hundreds of sorghum lines have been studied for resistances, variability in performance, and transfer of genes. The inferences drawn are being used in further crossing.

- In research on pigeonpeas, solarization was found to have marked stimulatory effects on growth and yield. Soil solarization is a technique of heating the soil by covering it with transparent polythene sheets during the summer. The technique has so far been used primarily to control soilborne pathogens and was used by ICRISAT scientists to study control of wilt disease. They discovered in the process that the technique did more than just inhibit the disease. It suppressed weed growth and nematode populations, and enhanced soil nitrate levels. Residual effects were also observed in the season following the treatment. Further studies are in progress to confirm, explain, and explore these effects.

- A package of agronomic practices was developed to adapt early-maturing pigeonpeas for monocropping in peninsular India. This information has been documented for dissemination and use.

- ICRISAT launched its Asian Grain Legumes Program by appointing a Coordinator, following a review and planning meeting held at ICRISAT Center. The program aims to improve the availability in Asian countries of ICRISAT expertise and plant material, by linking together in a network the activities of national, regional, and international research organizations.

# ICRISAT Senior Staff—as of December 1985

## Administration

L.D. Swindale, Director General
J.S. Kanwar, Director of Research
C.R. Jackson, Director of International Cooperation (until October)
M.G. Wedeman, Assistant to Director General
S.P. Ambrose, Principal Government Liaison Officer and Principal Administrator
B.C.G. Gunasekera, Principal Soil and Water Scientist (International Cooperation)
S.J. Phillips, Special Assistant to Director General for Educational Affairs
V. Balasubramanian, Senior Executive Officer (Director General's Office)
Joyce Gay, Senior Administrative Secretary to Director General
M.S.S. Reddy, Scientist (from May, on contract)
Sunetra Sagar, Senior Administrative Secretary to Director of Research
S. Krishnan, Senior Administrative Officer (International Cooperation)
S. Ramachandran, Administrative Officer (International Cooperation)
D. Mitra, Fiscal Manager
A. Banerji, Assistant Manager (Fiscal)
V.S. Swaminathan, Senior Accounts Officer
A.N. Venkataswamy, Accounts Officer
C.P. Rajagopalan, Accounts Officer
P.A.V.N. Kumud Nath, Accounts Officer (from March)
B.K. Johri, Personnel Manager
Y. Bharadwaja, Assistant Personnel Manager (until July)
N.S.L. Kumar, Senior Personnel Officer
P. Suryanarayana, Senior Personnel Officer
R. Vaidyanathan, Purchase and Stores Manager (on sabbatic leave from October)
C.R. Krishnan, Assistant Manager (from June)
K.P. Nair, Senior Purchase Officer
D.K. Mehta, Senior Stores Officer
D.V. Rama Raju, Senior Purchase Officer
K.C. Saxena, Stores Officer
K.R. Natarajan, Shipping and Purchase Officer
S.K. Dasgupta, Senior Scientific Liaison Officer (Visitors' Services, until February)
A. Lakshminarayana, Scientific Liaison Officer (Visitors' Services)
Harish Sethi, Scientific Liaison Officer (from May)
K.K. Sood, Senior Security Officer
A. Ekbote, Security Officer
K.K. Vij, Senior Administrative Officer (Delhi Office)
V. Lakshmanan, Assistant Manager (Administration)
N. Surya Prakash Rao, Resident Medical Officer
R. Narsing Reddy, Transport Officer (on study leave)
G. Vijayakumar, Transport Officer
K. Jagannadham, Administrative Officer (Transport)
A. Rama Murthy, Travel Officer (from March)

## International Cooperation

### ICRISAT Sahelian Center, Niger

C.R. Jackson, Director, ISC and West African Programs (from November)
K.F. Nwanze, Principal Millet Entomologist and Acting Director (until November)
K. Anand Kumar, Principal Millet Breeder and Team Leader, Millet Improvement Program
B.B. Singh, Principal Millet Breeder, (Maradi)
M.V.K. Sivakumar, Principal Agroclimatologist
D.S.C. Spencer, Principal Economist
M.C. Klaij, Principal Soil and Water Management Scientist
C.A. Giroux, French Writer/Editor
B.D. Marvaldi, Project Development Officer
P.G. Serafini, Research Farm Manager
D.C. Goodman Jr., Regional Administrative Officer
L.K. Fussell, Principal Millet Agronomist
C. Renard, Principal Agronomist and Team Leader, Resource Management Program (from April)
J. Werder, Principal Millet Pathologist (from February)
A. Batiano, Principal Soil Chemist (ICRISAT/IFDC)
Maimouna S. Dicko, Principal Animal Nutritionist (ICRISAT/ILCA)
B.R. Ntare, Principal Cowpea Breeder/Agronomist (ICRISAT/IITA)
R.C. Chase, Principal Soil Scientist (Texas A&M University)
L. Marchais, Principal Geneticist (ORSTOM)
S. Tostain, Principal Geneticist (ORSTOM)
A. Tekete, Principal Agronomist (University of Hohenheim, from April)
T.J. Stomph, Research Assistant
P. Ouedraogo, Research Assistant (from February)
Solange D. Gabriel, Executive Assistant, Liaison

### Burkina Faso

C.M. Pattanayak, Principal Sorghum Breeder and Team Leader
K.V. Ramaiah, Principal Cereal Breeder—*Striga* (on sabbatic leave from December)
S.N. Lohani, Principal Millet Breeder
P.J. Matlon, Principal Production Economist
Helga Vierich, Principal Social Anthropologist (until August)

M.D. Thomas, Principal Sorghum Pathologist
D.S. Murty, Principal Sorghum Breeder (from June)
S. Lingani, Administrative Assistant, Accounts
B. Ouedraogo, Administrative Assistant, General Services

### Mali

J.F. Scheuring, Principal Cereals Breeder and Team Leader
S.V.R. Shetty, Principal Agronomist
S. Toure, Administrative Officer
I. Kassambara, Computer Analyst (from April)

### Nigeria

S.O. Okiror, Principal Millet Breeder

### Senegal

S.C. Gupta, Principal Millet Breeder (until October, on sabbatic leave, April-August)

### Kenya

Brhane Gebrekidan, SAFGRAD/ICRISAT Coordinator for Sorghum and Millet, Eastern and Southern Africa

### Sudan

R.P. Jain, Principal Millet Breeder

### Malawi
### Regional Groundnut Improvement Program for Southern Africa

K.R. Bock, Principal Groundnut Pathologist and Team Leader
S.N. Nigam, Principal Groundnut Breeder

### Zimbabwe
### SADCC Regional Sorghum and Millet Improvement Project

L.R. House, Project Manager
W. Williams, Administrative Officer
A.B. Obilana, Principal Sorghum Breeder (from July)
S.C. Gupta, Principal Millet Breeder (from October)
E.W. Nunn, Farm Development Specialist (until May)
D.S. Bisht, Farm Development Specialist (from June)
W.A.J. de Milliano, Principal Cereals Pathologist (from December)

### Syria

K.B. Singh, Principal Chickpea Breeder
M.V. Reddy, Principal Chickpea Pathologist (until February)

### Pakistan

M.S. Rahman, Principal Chickpea Breeder/Plant Pathologist

### Mexico

V.Y. Guiragossian, Principal Sorghum Breeder
C.L. Paul, Principal Sorghum Agronomist

## Research Programs

### Sorghum

S.Z. Mukuru, Principal Plant Breeder and Program Leader
L.K. Mughogho, Principal Plant Pathologist
J.M. Peacock, Principal Plant Physiologist
K. Leuschner, Principal Cereals Entomologist
D.S. Murty, Plant Breeder (on sabbatic leave from June)
Belum V.S. Reddy, Plant Breeder (on sabbatic leave until April)
B.L. Agrawal, Plant Breeder
P.K. Vaidya, Plant Breeder (from April)
N. Seetharama, Plant Physiologist (on sabbatic leave until August)
R.K. Maiti, Plant Physiologist (until January)
P. Soman, Plant Physiologist
Suresh Pande, Plant Pathologist
R. Bandyopadhyay, Plant Pathologist
S.L. Taneja, Entomologist
H.C. Sharma, Entomologist
H.D. Patil, Senior Research Associate
S.P. Jaya Kumar, Administrative Officer
P. Ramesh, Research Fellow
N.F. Beninati, International Intern (from October)

### Pearl Millet

S.B. King, Principal Plant Pathologist and Program Leader
F.R. Bidinger, Principal Plant Physiologist
J.R. Witcombe, Principal Plant Breeder
K.K. Lee, Principal Cereals Microbiologist
K.N. Rai, Plant Breeder
B.S. Talukdar, Plant Breeder
Pheru Singh, Plant Breeder
S.B. Chavan, Plant Breeder
G. Alagarswamy, Plant Physiologist (on sabbatic leave until October and on secondment from November)
V. Mahalakshmi, Plant Physiologist
S.D. Singh, Plant Pathologist
R.P. Thakur, Plant Pathologist

S.P. Wani, Microbiologist
K.R. Krishna, Microbiologist
Nirmala Kumar, Administrative Officer
P.Q. Craufurd, International Intern
(from February)

## Pulses

Y.L. Nene, Principal Plant Pathologist
and Program Leader
D.G. Faris, Principal Plant Breeder, Pigeonpea
W. Reed, Principal Entomologist
(on sabbatic leave until April)
C. Johansen, Principal Agronomist
H.A. van Rheenen, Principal Plant Breeder, Chickpea
J. Arihara, Associate Physiologist (from May)
N. Ae, Associate Microbiologist (from May)
K. Okada, Assistant Microbiologist
(from December)
K.C. Jain, Plant Breeder, Pigeonpea
K.B. Saxena, Plant Breeder, Pigeonpea
S.C. Gupta, Plant Breeder, Pigeonpea
Harjit Singh, Plant Breeder, Pigeonpea
(until October)
D.M. Pawar, Senior Agricultural Officer
(Cooperative Trials)
M.D. Gupta, Senior Research Associate
(on study leave)
Onkar Singh, Plant Breeder, Chickpea
C.L.L. Gowda, Plant Breeder, Chickpea
S.C. Sethi, Plant Breeder, Chickpea
Jagdish Kumar, Plant Breeder, Chickpea
(on sabbatic leave until July)
J.H. Miranda, Senior Research Associate, Chickpea
O.P. Rupela, Agronomist (Microbiology)
J.V.D.K. Kumar Rao, Agronomist (Microbiology)
N.P. Saxena, Agronomist (Physiology)
Y.S. Chauhan, Agronomist (Physiology)
N.V. Ratnam, Senior Research Associate
S.S. Lateef, Entomologist
S. Sithanantham, Entomologist
M.P. Haware, Plant Pathologist
M.V. Reddy, Plant Pathologist (from March)
A.M. Ghanekar, Plant Pathologist
V.S. Bisht, Research Fellow (until September)
D.R. Dent, International Intern (until December)
I.S. Dundas, International Intern
S. Dwivedi, Research Fellow (until October
S.B. Sharma, Research Fellow (until November)
P.K. Anand Rao, Research Fellow

## Groundnut

R.W. Gibbons, Principal Plant Breeder
and Program Leader
D. McDonald, Principal Plant Pathologist
D.V.R. Reddy, Principal Plant Virologist
J.H. Williams, Principal Plant Physiologist
J.P. Moss, Principal Cytogeneticist
(on sabbatic leave until October)
J.A. Wightman, Principal Entomologist
L.J. Reddy, Plant Breeder (on sabbatic
leave from July)
P. Subrahmanyam, Plant Pathologist
(on sabbatic leave until April)
M.J. Vasudeva Rao, Plant Breeder
V.M. Ramraj, Plant Physiologist
V.K. Mehan, Plant Pathologist
P.T.C. Nambiar, Microbiologist
P.W. Amin, Entomologist
A.K. Singh, Cytogeneticist
D.C. Sastri, Cytogeneticist
S.L. Dwivedi, Plant Breeder
R.C. Nageswara Rao, Plant Physiologist
G.V. Ranga Rao, Entomologist (from July)
P. Subrahmanyam, Administrative Officer
S.N. Azam Ali, International Intern (until October)
K.M. Dick, International Intern
M. Dutta, Research Fellow (until December)
H.A. Hobbs, International Intern
S. Nahdi, Research Fellow

## Resource Management

M. von Oppen, Program Leader
(from October) and Program Leader,
Economics (until September)
R.P. Singh, Program Leader, Farming Systems
(February-October)
S.M. Virmani, Principal Agroclimatologist
(on sabbatic leave until August)
J.R. Burford, Principal Soil Chemist
C.W. Hong, Principal Soil Scientist
(ICRISAT/IFDC)
C.K. Ong, Principal Agronomist,
Cropping Systems
A.B.S. King, Cropping Systems Entomologist
(ICRISAT/TDRI)
R.J. Van Den Beldt, Principal Agronomist,
Agroforestry (from March)
A. Schutt, Assistant Engineer,
Soil Fertility Unit, (ICRISAT/University
of Hamburg, from December)
K.B. Laryea, Principal Soil Physicist
(from November)
T. Takenaga, Principal Agricultural Engineer
T.S. Walker, Principal Economist (from June)
R.A.E. Mueller, Principal Economist
D. Sharma, Coordinator, On-farm Research
Piara Singh, Soil Scientist
A.K.S. Huda, Agroclimatologist
K.L. Sahrawat, Soil Chemist
T.J. Rego, Soil Scientist (on sabbatic leave
until October)

K.P.R. Vittal, Soil Scientist (until June)
M.R. Rao, Agronomist
M.S. Reddy, Agronomist (on leave from November)
M. Natarajan, Agronomist
C.S. Pawar, Entomologist
A.A.H. Khan, Engineer
Sardar Singh, Soil Scientist
K.L. Srivastava, Agricultural Engineer
R.K. Bansal, Agricultural Engineer
R.C. Sachan, Agricultural Engineer
Prabhakar Pathak, Agricultural Engineer
N.K. Awadhwal, Agricultural Engineer/Soil Physicist
S.K. Sharma, Senior Research Associate
V.M. Mayande, Engineer
N.S. Jodha, Senior Economist
R.N. Athavale, Senior Hydrologist (from June, on contract)
R.D. Ghodake, Economist (on leave from September)
R.P. Singh, Economist
K.G. Kshirsagar, Senior Research Associate
K.V. Subba Rao, Senior Research Associate
M.J. Bhende, Senior Research Associate
R.S. Aiyer, Senior Administrative Officer
Surendra Mohan, Senior Administrative Officer
R.T. Hardinan, International Intern (until May)
K.A. Dvorak, International Intern (from January)
N.V. Narasimhan, Research Fellow
V. Ballabh, Research Fellow

## Support Programs

### Biochemistry

R. Jambunathan, Principal Biochemist
Umaid Singh, Biochemist (on sabbatic leave until September)
V. Subramanian, Biochemist
S. Sivaramakrishnan, Plant Biochemist/Physiologist (from June)
T.A. Krishnamurthi, Senior Administrative Officer (from August)
Santosh Gurtu, Senior Research Associate
M.S. Kherdekar, Senior Research Associate

### Electron Microscopy

A.K. Murthy, Engineer

### Genetic Resources

M.H. Mengesha, Principal Germplasm Botanist and Program Leader (on sabbatic leave)
W.H. Skrdla, Germplasm Botanist and Acting Program Leader
K.E. Prasada Rao, Senior Botanist
R.P.S. Pundir, Botanist
V. Ramanatha Rao, Botanist
S. Appa Rao, Botanist (on sabbatic leave)
P. Remanandan, Botanist

### Plant Quarantine

B.K. Varma, Chief Plant Quarantine Officer
Upendra Ravi, Senior Research Associate
N. Rajamani, Senior Administrative Officer

### Fellowships and Training

D.L. Oswalt, Principal Training Officer
A.S. Murthy, Senior Training Officer
B. Diwakar, Senior Training Officer
T. Nagur, Senior Training Officer (on sabbatic leave from November)
S.K. Dasgupta, Senior Training Officer (from February)
Faujdar Singh, Training Officer (from March)
T.A. Krishnamurthi, Senior Administrative Officer (until July)
V.S. Raju, Senior Secretary (from August)

### Information Services

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J.B. Wills, Research Editor
Susan D. Feakin, Research Editor
S.R. Beckerman, Visiting Research Editor (until August)
S.M. Sinha, Assistant Manager, Art and Production
D.R. Mohan Raj, Editor
Madhu Reddy, Editor
J.J. Abraham, Editor (from August)
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G.K. Guglani, Senior Art Visualizer
T.R. Kapoor, Senior Composing Supervisor
A. Antonisamy, Printshop Supervisor
N.V.N. Chari, Administrative Officer

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Murari Singh, Statistician

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S.M. Luthra, Assistant Manager (Computer Services)
J. Sai Prasad, Assistant Manager (Computer Services)
T.B.R.N. Gupta, Senior Computer Programmer/Analyst
C. Kameswara Rao, Computer Programmer/Analyst
J. Gnanasekharan, Computer Programmer/Analyst (from October)
S.V. Nanda Kishore, Computer Programmer/Analyst (from December)

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P.K. Sinha, Senior Documentation Officer
P.S. Jadhav, Library Officer
S. Prasannalakshmi, Library Officer

## Housing and Food Services

G.W. Conover, Manager
S. Mazumdar, Assistant Manager (Food Services)
B.R. Revathi Rao, Assistant Manager (Housing)
D.V. Subba Rao, Assistant Manager (Warehouse)

## Physical Plant Services

V.P. McGough, Manager (from May)
P.M. Menon, Assistant Manager (Administration)
Sudhir Rakhra, Chief Engineer (Civil)
D. Subramaniam, Chief Engineer (Electrical)
C.K. Belliappa, Assistant Manager (Workshop, from May)
S.K.V.K. Chari, Senior Engineer (Electronics and Instrumentation, on study leave)
N.S.S. Prasad, Senior Engineer (Electronics and Instrumentation)
A.R. Das Gupta, Senior Engineer (Communication)
D.C. Raizada, Senior Engineer (Airconditioning)
N.V. Subba Reddy, Horticulture Officer (until August)
D.V.S. Verma, Engineer (Machineshop)
R. Thiyagarajan, Engineer (Automobiles)
A.N. Singh, Engineer (Heavy Equipment and Tractors)
S.W. Quadar, Engineer (Office Equipment)
K.R.C. Bose, Engineer (Civil)
V.S. Raju, Senior Secretary (until July)

## Farm Development and Operations

D.S. Bisht, Manager (until May)
S.N. Kapoor, Manager (Farm Operations)
S.K. Pal, Senior Plant Protection Officer
K. Ravindranath, Senior Engineer (Farm Machinery)
M. Prabhakar Reddy, Senior Agricultural Officer
M.C. Ranganatha Rao, Senior Engineer
S. Abid Ali Khan, Agricultural Officer
N.V. Subba Reddy, Horticulture Officer (from August)
K. Santhanam, Senior Administrative Officer

# ICRISAT
# Governing Board—1985


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