Use of Sorghum Germplasm and its Impact on Crop Improvement in India

R.V. Vidyabhushanam, B.S. Rana, and Belum V.S. Reddy

Director, NRCS, Rajendranagar; Project Coordinator, AICSIP, Rajendranagar, Hyderabad; and Plant Breeder, ICR1SAT, Patancheru, Andhra Pradesh

The traditional sorghum cultivars and landraces grown in India over centuries have been selected primarily for their ability to survive under stress conditions rather than for high productivity. They are characterized by tall stature, late maturity, localized adaptation, and low harvest index.

Grain Yield and Agronomic Desirability

In order to achieve a breakthrough in productivity and enhance sorghum production in the country, the Indian Council of Agricultural Research (ICAR) in collaboration with the Rockefeller Foundation initiated the hybrid sorghum development program in the early 1960s. To meet the program's requirements temperate sorghum material from the USA, and tropical germplasm from India and Africa were assembled.

Since the establishment of the All India Coordinated Sorghum Improvement Project (AICSIP) in 1969, nearly 500 hybrids and 1000 varieties from various breeding programs were tested and 45 cultivars were released in India. The first sorghum hybrid released in the country in 1964, CSH 1, has clearly demonstrated the possibility of realizing average grain yields of the order of 2.5-3.0 t ha^{-1} even under rainfed conditions. More important, it introduced the concept of genotypic alteration to match the environment. Systematic breeding with selected temperate and tropical germplasm has provided material of the appropriate height and maturity for the development of hybrids and high-yielding varieties.

Since its establishment in 1972, ICRISAT has made efforts to (I) diversify the germplasm base to enhance yield levels, and (2) to identify resistance sources and use them to develop varieties and seed parents. This contributed to the release of 2 cultivars in Burma, 2 in Burkina Faso, 1 in Ethiopia, 3 in India, 12 in Latin American countries, 1 in the Sudan, 1 in Yemen, 1 in Zambia, and 2 in Zimbabwe.

The major germplasm sources utilized so far in varietal improvement include temperate lines from USA, Zerazera lines from Ethiopia and Sudan, and some lines of Indian origin. The male-sterile gene sources used were mainly CK 60, 172,2219,3675, 3667, and 2947. These were further diversified by using parents such as CS 3541, BT x 623, population derivatives (Bulk-Y, Indian Synthetic, FLR, Rs/B, US/B, Serere,

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), 1989. Collaboration on Genetic Resources: summary proceedings of a Joint ICRISAT/NBPGR(ICAR) Workshop on Germplasm Exploration and Evaluation in India, 14-15 Nov 1988, ICRISAT Center, India. Patancheru, A.P. 502 324, India: ICRISAT.

Diallel, and WAE), IS 6248, IS 2225, IS 3443, IS 12611, IS 10927, IS 12645, IS 517, IS 1037, IS 19614, E 12-5, ET 2039, E 35-1, Lulu 5, M 35-1, and Safra. In the development of restorer parents and varieties, the basic germplasm sources used were IS 84, IS 3691, IS 3687, IS 3922, IS 3924, IS 3541, IS 6928, ET 2039, Safra, E 12-5, E 35-1, E 36-1, and IS 1054, IS 1055, IS 1122, IS 1082, IS 517, IS 19652, Karper 1593, IS 10927, IS 12645, IS 12622, IS 19652, IS 18961, GPR 168, and IS 1151.

Although germplasm material from different regions of the world was used to develop improved cultivars, the number of lines involved was rather small. This has led to a plateauing of yields in the rainy-season genotypes and only marginal increases in the postrainy-season genotypes. To break the plateau, efforts are being made to involve recently collected accessions from Ethiopia, Yemen (AR), Cameroon, and Nigeria.

Resistance to Biotic and Abiotic Stresses

The main strategy' adopted for the control of insect pests and pathogens including *Striga* has been incorporation of resistance. In pursuit of this objective, systematic studies were initiated in 1964 to screen the germplasm material for sources of resistance against key pests and diseases. This area of study was intensified during the past decade in collaboration with ICRISAT. So far, the bulk of the germplasm and breeding material has been screened for most of the important pests and diseases. This has facilitated the identification of several sources of resistance to various pests and diseases.

Among the insect pests, the most exhaustive screening was carried out for shoot fly and stem borer. Many of the resistant sources were found to exhibit low infestation under high pest pressure. The resistant sources identified are predominantly of Indian origin, while a few are from Ethiopia, Nigeria, the Sudan, and USA. The stable resistant sources for shoot fly and stem borer are IS 1082, IS 2205, IS 5604, IS 5470, IS 5480 (India), IS 18577, IS 18554 (Nigeria), IS 2312 (the Sudan), IS 18551 (Ethiopia), IS 2122, IS 2134, and IS 2146 (USA). Some of these have been used both in the Indian and ICRISAT programs. Besides, other Indian germplasm lines like M 35-1 (IS 1054), BP 53 (IS 18432), Karad Local (IS 18417), Aispuri (IS 18425), etc. were used to impart resistances.

Extensive screening of the germplasm was also carried out for midge, and many resistant sources identified. Notable among these are DJ 6514 (IS 18700), IS 18961, S-GIRL-MR 1 (IS 18699), TAM 2566 (IS 18697), IS 3443, IS 12573C, and AF 28 (IS 18698). The lines DJ 6514 and IS 3443 were used at ICRISAT to develop an improved midge-resistant variety, ICSV 197 (SPV 694).

Spectacular success was achieved in the identification and utilization of disease-resistant sources. Highly stable resistant sources were identified for all foliar diseases. The tan-pigmented plant type was found to be associated with foliage diseases. Grain-mold resistance was found to be moderate in the white-grain background. For charcoal rot, E 36-1, QL 101, QL 102, and QL 104 have been identified as the most stable resistant types.

A notable feature of disease resistance has been the availability of multiple resistance in some lines. Based on multilocation evaluation over the years, the following lines were found to have multiple disease resistance: ICSV 1, ICSV 120, ICSV 138, IS 2058, IS 18758, and SPV 387 (anthracnose and rust); IS 3547 (grain molds, downy mildew, anthracnose and rust); IS 14332 (grain molds, downy mildew, and rust); IS 17141 (grain molds and anthracnose); IS 2333 and IS 14387 (grain molds and downy mildew); and IS 3413, IS 14390, and IS 21454 (grain molds and rust). These lines are currently being used in the breeding programs.

Resistance to *Striga* has been reported in several indigenous sources. Based on extensive laboratory and field screening, ICRISAT identified many *Striga*-resistant lines from the germplasm. However, many of these sources could not be used in the breeding programs due to their undesirable agronomic base. Some germplasm lines used in *Striga* resistance breeding are IS 18331 (N 13), IS 87441 (Framida), IS 2221, IS 4202, IS 5106, IS 7471, IS 9830, and IS 9951. Some of the breeding lines like 555, 168, SPV 221, SPV 103, etc. proved to be useful resistant sources. The *Striga*-resistant variety SAR 1 developed at ICRISAT from the cross 555 x 168 was released for cultivation in *Striga-endemic* areas. Several other promising selections derived from the mentioned resistant sources, both from ICRISAT and Indian programs, have been identified.

Nearly 1300 germplasm lines and 332 breeding lines were screened for early- and mid-season drought stresses. The most promising for various droughts are:

- Early-season and terminal drought: E 36-1, DJ 1195, DKV 17, DKV 3, DKV 4 IS 12611, IS 6928, and DKV 18.
- Mid-season stress: DKV 1, DKV 3, DKV 7, DJ 1195, ICSV 378, ICSV 572, ICSV 272, ICSV 273, and ICSV 8295.

Conversion

Tall, late and photoperiod-sensitive landraces are converted into dwarf and early types for use in breeding programs. The landraces involved are Zerazera (8 lines), Guinnense (3), Kaura (5), and Durra/Caudatum (5).

Populations for Multiple Resistances

Three populations are under development at ICRISAT. These are ICSP 1BR/MFR (resistance to grain mold, stem borer/shoot fly, and midge), ICSP 2BR/MFR (resistance to grain mold and *Striga,* and improved stand establishment) both with rainy-season adaptation, and ICSP 3BR/MFR (resistance to stem borer/ shoot fly and rust, and improved grain quality) with postrainy-season adaptation. Several resistance

sources from the germplasm are transferred to these populations. Their distributions, by region and trait are as follows:

ICSP 1BR/MFR and ICSP 2BR/MFR (rainy season) populations:

- From India (8 lines), Ethiopia (3), Sudan (2), Nigeria (1), Zimbabwe (2), Egypt (1), USA (9), and Australia (2).
- Resistant to shoot fly (3), stem borer (6), midge (5), grain mold (1), leaf diseases (3), and *Striga* (1); good grain (3), stand establishment (3), and early and dwarf (13).

ICSP 3BR/MFR (postrainy season) populations:

- From India (13), Ethiopia (27), Nigeria (12), Sudan (8), Botswana (8), Cameroon (8), Yemen (12), Malawi (1), South Africa (1), Egypt (1), USA (6), Mexico (I), and Australia (3).
- Bold grain (20); with postrainy-season adaptation and resistance to terminal drought (29); photoperiod-sensitive (2), temperature-insensitive (28); resistant to shoot fly/ stem borer (4) and downy mildew (1); stay-green (6); stand establishment (3), and early and dwarf (3).

High-Lysine Sorghums

The high-lysine sorghum lines, IS 11167 and IS 11758 from Ethiopia were used in the breeding program for transferring the gene to a desirable agronomic background. Some promising high-lysine derivatives with shrivelled and plump grain have been obtained.

Sweet Sorghums

Based on evaluation of the germplasm, several sweet-stalked sorghum lines were selected. Notable among these are: IS 20963, IS 15428, IS 3572, IS 2266, IS 9890, IS 9639, IS 14790, IS 21100, IS 8157, and IS 15448. These materials, which were further screened at some of the centers of the Sorghum Project, were found to be very promising.

Forage Sorghum Improvement

The forage sorghum germplasm was systematically evaluated over several years at Hisar Center for various yield and quality traits, for which a wide range of variability has been noted. The lines identified with desirable forage attributes were IS 1044, IS 12308, IS 13200, IS 18577, IS 18578, and IS 18580. In respect of quality parameters IS 1059, IS 2944, IS 3247, IS 4776 and IS 6090 were selected for low HCN, and IS 3247 and PJ 7R for low tannin content.

The need for further critical evaluation of germplasm materials and their utilization in forage sorghum improvement is keenly felt. This work is being strengthened in the Sorghum Project and the National Centre has initiated a program on forage sorghum improvement.