caribbean food crops society

19

Nineteenth Annual Meeting
August 1983
PUERTO RICO

Vol. XIX

THE SORGHUM CONVERSION PROGRAM

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SUMMARY

The Sorghum Conversion Program (SCP), a joint venture by the Texas Agricultural Experiment Station (TAES) and the Tropical Agriculture Research Station (TARS), USDA, ARS, S&E, has provided new sorghum germplasm sources from the world collection, converting tall, late, or photoperiod sensitive sorghums from the tropics into short, early, photoperiod insensitive strains. At present there are 1,319 items in the SCP of which 423 have been fully converted. The SCP provides excellent material for breeding programs to improve traits such as disease and insect resistance, drought tolerance, sterility, yield, grain quality and others. Since there still exist numerous sorghums not yet studied, it is expected that the SCP will continue to make significant world-wide contributions as new desirable genes from different sorghum sources are identified.

INTRODUCTION

Sorghum (Sorghum bicolor (L.) Moench), is the fifth most important food grain in the world exceeded in utilization for food only by wheat, maize, rice and barley.

Sorghums are often classified into grain sorghums (grown primarily as a cereal), sorgos (for forage or syrup), broomcorn (for use in brooms) and grass sorghums (for hay and pasture). Many millions of people in Africa and Asia depend on sorghums as a dietary staple; furthermore, sorghums are widely grown throughout temperate, subtropical, and tropical climates for feed and fodder. The United States produces the largest amount of sorghum accounting for

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approximately 28% of the world production. Sorghum is well adapted to cultivation under wide extremes of environmental conditions including arid, semiarid and subtropical areas of the world. It is grown from sea level to elevations in excess of 3,000 m. The species is extremely diverse consisting of over 25,000 collected cultivars which readily intercross and produce fertile offspring (Miller, 1983). According to Miller (1983), the greatest variability in both cultivated and wild sorghums exist in the northeast quadrant of Africa but all Africa is a fertile source of diversity. Introduction of sorghums apparently began in the early 1880's during the period of slave trade with Africa when grain was brought along as food. The Caribbean area was the site of introduction for several varieties. Important introductions into the United States began in the 1880's and by 1909 most of the distinct types now used for both grain and forage were collected (Rosenow, 1975).

Sorghum is sensitive to photoperiod, being classified as a short-day plant. It has a critical photoperiod of 12:00 hours and as little differences as several minutes of light affects duration of growth (Miller, et al., 1968). A high proportion of the sorghums from tropical areas of Africa and Asia are too tall for mechanical harvest and too late for temperate climates. Tropical sorghums which are not genetically converted fail to mature during the long days and short seasons of the temperate zone areas of the world.

Since the 1950's development and use of commercial sorghum hybrids has revolutionized production of grain sorghum in the United States. Systems for accelerating the utilization of tall and late tropical sorghums aid the development of sorghums for the United States and other countries. To eliminate height and maturity limitations for tropical sorghum germplasm a program of systematic backcrossing was developed (Stephens, et al., 1967). In this program sorghum lines are crossed and backcrossed under short days in Puerto Rico and short, early genotypes are selected under long days in Texas. The Sorghum Conversion Program is a joint activity between the Texas Agricultural Experiment Station (TAES) and the United States Department of Agriculture (USDA). Conversion results by incorporating up to 8 genes (4 genes controlling maturity plus 4 genes affecting height) into tall late photosensitive sorghum lines. By means of this program, tropical sorghum germplasm becomes directly usable for temperate sorghum breeding programs. Tropical germplasm is a good source and in some instances the only source of characteristics for resistance to specific diseases and insects, grain quality, and stress tolerance.

PROCEDURE

The Conversion Program was started in 1963. At present there are 1,319 items in the program, 423 which have been fully converted. Of these 183 have been released and distributed. It is anticipated that the remaining 240 items will be released within one year.

Many of the released lines represent types that have not been readily available in temperate zones, and some of them possess characteristics difficult to obtain by other means. Notable among those observed are resistance to downy mildew (Peronosclerospora sorghi), fusarium head blight (Fusarium moniliforme), anthracnose (Colletotrichum graminicola), charcoal rot (Macrophomina phaseolina), helminthosporium leaf blight (Helminthosporium turcicum), gray leaf spot (Cercospora sorghi), lodging, grain weathering, resistance to midge (Contarinia sorghicola), Banks grass mite (Oligonychus pratensis), greenbug (Schizaphis graminum) and others. Released jointly by TAES and USDA, they are available to public and private agencies.

The World Sorghum Collection contributed greatly to the availability of new germplasm. New entries are selected from the World Sorghum Collection of over 18,000 different varieties as conversion candidates for the TAES-USDA Conversion Program.

The mechanics of the Sorghum Conversion Program, exemplified as follows, have been described previously several times (Stephens et al., 1967; Rosenow, 1967; Quinby, 1968; and Johnson et al., 1971). First the exotic sorghum(s) obtained from the World Collection and/or other sources and a source of 4-dwarf photoperiod insensitive germplasm (non-recurrent parent) are planted as daylength is decreasing and approaching 12:00 hours (see Fig. 1). This initial planting is made at Mayaguez, Puerto Rico, about September 15 each year when daylength is 12 hours and 14 minutes. At flowering time the non-recurrent parent is hand-emasculated and crossed times the exotic (recurrent parent). The F_1 generation is planted at Mayaguez anytime from February 15-20 before day-lengths increase beyond the 12:00 hours.

The F_2 generation is grown in the temperate zone (or in the long-day season) and a short-statured, early plant is selected. This planting is done normally at Chillicothe, Texas, anytime from June 1-15. The plant(s) selected at Chillicothe should be 4-dwarf and photoperiod insensitive.

Seed of the selected F_2 plants are returned to the tropical location (Mayaguez, Puerto Rico) to be backcrossed to the original exotic cultivar and the process continue (Table 1).

The short, early plant selected from the first cross contain theoretically fifty per cent of both parents except for the height and maturity genes from the temperate cultivar. The plant selected from the first backcross is theoretically 1/4 temperate material and 3/4 tropical, and after 4 backcrosses the proportion is 1/32 and 31/32, respectively (Miller, 1983). At this moment the line is considered fully converted.

In addition to releasing converted lines, two other types of bulks for each exotic are released. One bulk is called a "temperate bulk". This is selected in Texas from the F_2 of the last backcross and contain an array of height and maturity genotypes not found in the short, early converted line. The other bulk called a "tropical bulk" contain an array of height and maturity genotypes selected under short-day conditions in Puerto Rico.

IMPORTANCE

The rapidly changing sorghum industry will continue to need germplasm developed by the Sorghum Conversion Program. Miller (1983) presents some of the important economic characteristics obtained from this program. These are: a) new sources of disease resistance: downy mildew, head smut, maize dwarf mosaic virus, foliar diseases, stalk rots, kernel rots, and anthracnose; b) insect resistance: sorghum midge, greenbug, corn leaf aphid, white flies, and Bank's grassmites; c) improved plant characteristics: drought, heat and salinity tolerance, stalk strength, twin-seed, easy threshing, erect leaves, lodging resistance, improved yield of grain, yield stability under diverse environments, greater root development, leaf area retention, increased grain filling rates, increased combining ability, greater osmotic adjustment capacities, and new sources of cytoplasmic genetic sterility; d) outstanding kernel characteristics: thin pericarps, weathering resistance, reduced discoloration of the endosperm, increased protein content, superior balance of amino acids, improved flavor, expanded diversity for good product development and greater digestibility; and e) reduced genetic vulnerability-expanded diversity to reduce a narrowed germplasm base.

In addition, Schertz (1975) mentions other characteristics which have an effect on vulnerability. These are: greater nuclear diversity, fertilizer-use efficiency, solar-energy-conversion efficiency, cold tolerance, night respiration rate, tolerance to herbicides and others.

The Sorghum Conversion Program has been an useful tool to improve sorghums throughout the world. It is expected that new sources of useful germplasm will be developed from the program.

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Table 1 - Numbering system used in the program to facilitate record keeping and utilization of germplasm

SC Number	Generation Designation	Genetic Generation
0001	-0	Exotic cultivar
0001	-1	F_1 between exotic and non-recurrent parent
0001	-2	F_2 seed (sent to Texas)
0001	-3	F_3 selection (returned to Puerto Rico)
0001	-4	BC_1F_1
0001	-5	BC_1F_2
0001	-6	BC_1F_3
0001	-7	BC_2F_1
0001	-8	BC_2F_2
0001	-9 1/	BC_2F_3
0001	-10	BC_3F_1
0001	-11	BC_3F_2
0001	-12	BC_3F_3
0001	-13	BC_4F_1
0001	-14	BC_4F_2
0001	-15	BC_4F_3 converted
0001	-16	BC_4F_4 released and distributed cultivar

1/ At this generation the cross is made using the tropical exotic as female to recover the exotic cytoplasm. If successful "E" is added to the generation designation, i. e. -9E.

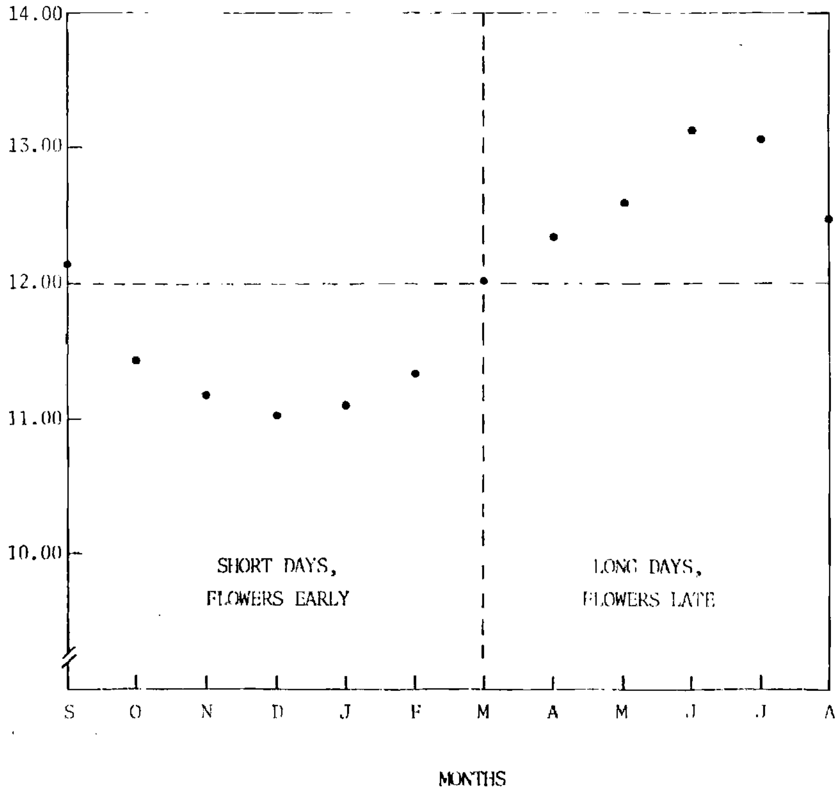

FIG. 1. RELATIONSHIP BETWEEN PLANTING DATES AND DAYLENGTH OF SORGHUM IN PUERTO RICO.