Diversity of Primitive Upland Cotton Germplasm

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ABSTRACT

Improvement of crop species requires genetic resources that may extend from primitive or exotic species to commonly grown cultivars. The introduction of desirable traits from germplasm sources to adapted cultivars is an ongoing process. The cotton, Gossypium hirsutum L., collection of primitive accessions contains a wealth of genetic variability; however, many of the accessions are photoperiodic. The photoperiod response and failure to flower and set fruit under the long-day regime of the temperate-zone growing seasons is a major hurdle in utilising most primitive cotton germplasm. A programme was initiated several years ago convert primitive accessions to day neutrality by incorporating day-neutral genes utilising a backcross breeding approach. Useful genetic variability has been measured in the day-neutral lines for resistance to Heliothis spp., Pectinophora gossypiella (Saund.), Anthonomus grandis Boheman, Meloidogyne incognita (Kofoid and White) Chitwood, and for agronomic and fiber traits. The day-neutral accessions are now available for use in breeding programs for cultivar development and to expand genetic variability.

Introduction

Cotton, *Gossypium* spp., is an important crop world-wide. Cotton lint provides a source of high quality fiber for the textile industry. Additional important products include oil, meal, seed hulls, and linters. Continued research and improvement with *Gossypium* germplasm is essential for cotton to remain a viable, competitive crop.

Plant introduction and germplasm collecting trips have been a vital part of the history of cotton improvement. The introduction of desirable traits from germplasm sources to adapted cultivars is an ongoing process in most cotton breeding programs. Useful genetic variability has been found for many traits in the collection of primitive accessions of *Gossypium hirsutum* L. The photoperiod response and failure to flower under the long-day regime of the temperate-zone growing seasons is a major hurdle to the utilization of most primitive cotton germplasm. Because of this flowering response, their genes are not readily available for incorporation in cotton-breeding programs.

Two potential ways to overcome this problem are: (1) Cross the primitive accession germplasm and adapted cultivars at a tropical garden, where both will flower simultaneously, and select in the same environment; or (2) systematically introduce genes for day-neutrality into the germplasm accessions with a backcrossing scheme and make the germplasm available for utilization in the temperate-zone area.

The purpose of this paper is to provide information on primitive accessions in the U.S. Cotton Collection, a day-neutral conversion programme, and the variability that exists among accessions and the developed day-neutral lines. It is not an exhaustive review of the variability of primitive accessions.

Primitive Cotton Accessions

Collection trips in 1946, 1947, and 1948 to the presumed centre of origin (Mexico and Central America) of Upland cotton, *G. hirsutum*, resulted in more than 600 primitive accessions being brought to the United States (Anonymous, 1974). When grown at College Station, Texas, more than half the accessions remained vegetative (Lewis and Richmond, 1957). Hutchinson (1951) grew a large number of the primitive accessions in Africa and proposed *latifolium*, *morrilli*, *palmeri*, *richmondi*, *punctatum*, *marie*-seven geographic races of *G. hirsutum*. The names are useful in discussing groups of primitives stocks, but the term "race" is not a formal taxonomic category (Fryxell, 1976).

The primitive accessions in the *Gossypium* collection currently number close to 2,500 from collection trips during the last 50 years (Percival 1987, Anonymous 1997). The primitive accessions are part of the US National Cotton Germplasm Collection that is maintained by USDA-ARS in co-operation with Texas A&M University, College Station, Texas. It is a working collection with permanent storage at the National Seed Storage Laboratory, Fort Collins,

Colorado. As accessions are added to the collection they are routinely assigned a number with a 'T' prefix, referred to as the Texas number. The 'T' accession number, or Texas number, is most frequently used by researchers to refer to the primitive cottons. A plant inventory (PI) number has been assigned to all accessions in the collection.

The utilization of the genetic variability of the primitive accession has been limited because of their photoperiod response. A public programme was initiated in the 1970's to make available a wide range of germplasm for cotton improvement by introducing day-neutral genes into primitive germplasm accessions (McCarty *et al.*, 1979).

Conversion Program

The conversion program involves crossing short-day primitive accessions with a day-neutral donor line (commercial Mississippi Delta-type cotton) at the Cotton Winter Nursery at Tecoman, Colima, Mexico. The F_1 generation is self-pollinated at the Winter Nursery and the F_2 generation is grown at Mississippi State University, Mississippi State, MS where segregation for flowering response occurs. Large populations are grown because the number of factors controlling the short-day flowering habit is not known and varies among the accessions. Equal numbers of open-pollinated bolls are harvested from each plant that sets fruit, and the seed is bulked for each population. These F_3 seeds are increased for release and for research purposes.

One plant that sets fruit at a low node and continues to fruit is selected from the F_2 population. The F_3 progeny from this plant are backcrossed to the accession at the Winter Nursery in Mexico. The BC_1F_1 generation is self-pollinated at Winter Nursery and the resulting BC_1F_2 in grown at Mississippi State University where day-neutral plants are selected.

The same procedure is followed for each subsequent backcross and is repeated for about four backcross cycles. The day-neutral donor parent is used as the female in all subsequent crosses. This permits the backcrossed material to be in an Upland cytoplasm during conversion. The only selection made is for day-neutrality after each backcross cycle.

In the ongoing conversion program, day-neutral selections have been made in more than 1,600 F2 populations. These represent more than 1,000 different primitive accessions. More than 300 of these accessions have been classified to race.

Germplasm releases of more than 500 day-neutral lines have been made from this programme. Ninety-seven of these have been backcrossed four times to the primitive accessions. Seed of day-neutral lines has been supplied to commercial breeders and public research scientists in the United State and abroad.

The converted primitive accessions are useful for the diverse germplasm they contain. Day-neutral lines can be exploited by researchers seeking new traits and to expand the genetic base of cotton.

Primitive Accession Evaluations

A large data set of collection and evaluation information on primitive accessions has been published in regional bulletins (Anonymous 1974, Percival 1987). It is available through the Germplasm Resource Information Network (GRIN) that can be accessible electronically via the Internet.

Pest resistance is relatively common in the primitive accessions with more than 200 reported to carry resistance to one or more pest (Jenkins 1986, Jenkins and Wilson 1996). Accessions were reported to carry multiple resistance to the major pest boll weevils, *Anthonomus grandis* Boheman, tobacco budworm/ bollworm, *Heliothis virescens* (F.)/*Helicoverpa zea* (Boddie), spider mites, *Tetrancychus* spp., pink bollworm, *Pectinophora gossypiella* (Saund.), plant bugs, *Lygus* spp., and to the root-knot nematode, *Meloidogyne incognita* (Kofoid and White) Chitwood. In addition several accessions were reported to have elevated levels of gossypol that confers resistance to the Heliothines.

The accessions show variability for seed-oil percentage, seed characteristics (Kohel, 1978) and reaction to diseases, *Coletotricum gossypii* and *Verticillium dahliae* (Percival, 1987). This brief discussion points out the wealth of variability that exists in the primitive cotton accessions.

Day-neutral Primitive Accessions

Two day-neutral converted primitive accessions (T-326DN and T-1180DN) were reported by McCarty *et al.*, (1987) to have significantly less boll weevil oviposition than a commercial cultivar in laboratory test. The resistance was confirmed in field test by Jones *et al.*, (1984) and Lukefahr and Vieiera (1986). These lines were registered by Crop Science Society of America (McCarty *et al.*, 1986). Six day-neutral accessions (T-109DN, T-277-2-6DN, T-330DN, T-759DN, T-763DN and T-790DN) had significantly less boll weevil oviposition and significantly fewer damaged squares than susceptible check cultivars (McCarty and Jones 1989). These primitive day-neutral-derived lines represent sources of resistance that can be used readily for germplasm enhancement.

Shepherd (1983) evaluated 471 photoperiodic primitive accessions and found 18 that were resistant to the root-knot nematode. Twelve day-neutral lines were released (Shepherd *et al.*,1988).

Useful genetic variability was measured for several agronomic and fiber traits in 79 day-neutral accessions (McCarty and Jenkins 1992). Potentially useful trait and number of day-neutral accessions were, large boll (6), large seed (6), fine fibers (1), fiber length (1), fiber elongation (1), and fiber strength (5). The Crop Science Society of America has registered 79 lines (McCarty and Jenkins, 1993).

Summary

In summary, the primitive accessions in the U.S. Cotton Collection are a valuable source of genes for pest resistance. They also contain a wealth of variability for agronomic and fiber traits. Day-neutral germplasm lines have been developed and are available for cotton improvement programs.

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