2004

Evaluation of the USDA Shafter cotton (Gossypium spp.) collection for agronomic and fiber traits

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EVALUATION OF THE USDA SHAFTER COTTON (*GOSSYPIUM* SPP.) COLLECTION FOR AGRONOMIC AND FIBER TRAITS

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agriculture and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Science

in

The Department of Agronomy

by
Jimmy Xavier Zumba
B.S., Escuela Agrícola Panamericana “Zamorano University”, Honduras, 1999
December 2004

ACKNOWLEDGMENTS

To God, Mary (mother of Jesus) and Jesus (my shepherd) for giving me the strength, happiness, blessing, courage, and show me the way to get where I am now and where I want to and will be.

To my beloved mother Laura for being the example to follow, and my inspiration; also to my daughter Nayiba for being the reason of my life. To my sister Magaly, brothers Geovanny and Pedro for their tireless support and understanding, and to my niece Lucita and my nephew Ian.

To Jose M. Miselem at Zamorano for introducing me to Dr. Carl Motsenbocker. To Dr. Motsenbocker for allowing me to come into the U.S. and giving me the chance to work for him initially at Louisiana State University, Ag Center, Department of Horticulture.

I would like also to thanks to Dr. Gerald O. Myers for giving me the chance to not only work for him as a Research Associate at the LSU Ag Center Department of Agronomy where I was entrusted with all his cotton research projects, but also for this friendship and to do this project under his guidance.

To Dr. Myers, Dr. Collins Kimbeng as well as to Dr. Charles Overstreet for being my committee members, and also for their patience, individual time and talents for helping me organize my ideas and be able to put together this good piece of work.

To the USDA-ARS at College Station especially to Dr. Ed Percival for providing the cotton seeds for this study. To Dr. Jack E. Jones for his advices about cotton breeding.

To Ivan Dickson for introducing me to Dr. Myers and helping me to get my current job, as well as to Mrs. Gladys Carmona. You both have a very special place in my heart for all the invaluable advice that I received from them.

My appreciation is extended to all the faculty members in the Department of Agronomy especially to Dr. Freddie Martin for giving me the chance to work in this prestigious and respected department. I would also like to extend sincere appreciation to everyone in the main office (Mrs. Bobbie, Mrs. Becky, Mrs. Connie, Mrs. Jere, and Mrs. Jodie) for being helpful, nice, and supportive, as well as to my co-workers, and student workers. To the LSU AgCenter for paying part of my tuition and the time off that they have granted me for my classes.

To my little and missed city, Pasaje, and to my beautiful beloved country, Ecuador.

To my friends and everybody, who have been my support and have helped me in any way and in some point in my life, my respects and wishes of success.

A todos con amor, respeto y admiración. Agradecidamente Jimmy.

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ABSTRACT

Many recent additions to the US Cotton Germplasm collection are uncharacterized for common germplasm descriptors.

Our objective was to evaluate a subset of this germplasm for their potential to contribute to future plant improvement efforts. One hundred fifty four cotton germplasm lines from the former USDA cotton breeding program at Shafter, California were evaluated in the field (LSU AgCenter Northeast Research Station, Saint Joseph, LA) in 2003 along with three modern commercial varieties (Delta and Pine Land 'Deltapearl', 'Fibermax 958', and 'Phytogen 355'). Due to limited seed availability, an unreplicated modified augmented statistical design-2 was used, with single row plots 6.14 m long sown at a rate of 7-10 plants m^{-1}. The following descriptors were considered: leaf and calyx pubescence; flower maturity; leaf, pollen and petal color; petal spot; glanding; presence of extra floral nectarines; bract shape. High volume instrumentation (HVI) fiber properties: length, strength, micronaire uniformity, and elongation; and cotton fiber yield. Eleven germplasm lines had yields within 10% the check average, with the top three highest yielding germplasm lines being SA 1961, 1962 and 1960 yielding 1635, 1477, and 1439 lbs $acre^{-1}$, respectively. SA 2085 could be used to reduce insect damage since it was nectariless. There were 26 germplasm lines graded as having smooth leaves which could be used to reduce the ovipositing of bollworm eggs and get cleaner lint at harvest. In this germplasm, 66 % evaluated had long fiber and the top three were SA 2093, 1983, and 2091, with fiber lengths of 1.27, 1.26, and 1.25 inches, respectively. Much of this germplasm evaluated (82%) had very strong fiber and the top three were SA 2036, 2085, and 2044, with 40.5, 40.0, and 39.7 G/tex, respectively. Six germplasm lines had very high elongation and the top three were SA 2092, 1968, and 2069, with 8.4, 8.1, and 8.1 %, respectively. Over half of the

germplasm evaluated (55%) had fine micronaire of between 3.8 and 4.6. In summary, these recent additions to the US Cotton Germplasm Collection present a valuable resource for improving cotton varieties with resistance to insects, yield and fiber quality.

INTRODUCTION

Cotton (*Gossypium* spp.), is the most important textile fiber crop in the United States and in the world as well as the second most important oilseed crop in the world after soybeans (Khan, M. A., et al., 2002). Cotton as with any other crop has a center of diversity. There are four domesticated species of cotton. *Gossypium arboreum* L. and *Gossypium herbaceum* L., both diploids, are native to the Old World. *G. arboreum* remains an important crop in India, whereas *G. herbaceum*, important in earlier times, is today grown mostly for local use in the drier areas of Africa and Asia. *Gossypium barbadense* L. and *Gossypium hirsitum* L., both allotetraploids, are native to the New World. The center of morphological diversity for *G. barbadense* is South America, with range extension into Mesoamerica and the Caribbean. *G. hirsitum* is indigenous to Mesoamerica, but its current range includes the Caribbean, northern South America, and some Pacific Islands. Much of the cultivated cotton hectarage throughout the world is in the temperate zone, although cotton is native to tropical and semitropical areas (Smith and Cothren, 1999). *G. barbadense*, commonly known as extra-long-staple, Egyptian, or Pima cotton, supplies about 8% of the current world production of fiber; the fabric is mostly used for the production of luxury fabrics and sewing thread. *G. hirsitum*, known most widely as Upland cotton, contributes about 90% of the current world production; upland cotton fibers are used in manufacture of a variety of textile products, cordage, and other non-woven products.

Currently, cotton is produced in 17 states across the southern United States; with 5 states producing over one million bale each, during 2002. Texas devotes more area for cotton production and produces more cotton than any other state, producing 5,037,000 bales (bale = 480 lbs) in 2002. Texas annually accounts for 25-30% of U.S. cotton production. Other states producing over one million bales in 2002 were Arkansas, California, Georgia, and Mississippi.

These 5 states produced 71 % of the Upland cotton in the United States in 2002 (Louisiana Farm Reporter, 2002). Cotton is one of the most important crops in the southern United States, and it is one of the most important agricultural commodities for many states.

Germplasm is the genetic source material used by plant breeders to develop new cultivars, and one of the consequences of successful plant breeding can be an increased erosion or reduction in genetic variability for the crop undergoing selection. There is also a danger that valuable genetic resources may be lost to future breeding programs as the areas of genetic diversity are developed and as agriculture becomes more intensified (Stoskopf, et al., 1993).

As a result, breeders need to effectively manage their breeding populations to preserve adequate genetic variation so that future improvements through selection can occur. Proper management of germplasm resources by the breeder includes introducing new germplasm resources on a regular basis to develop new recombinants and hence increase genetic variability. The breeder must carefully evaluate breeding materials being discarded during selection because the breeder tends to keep only those plants with superior performance. The breeder has tremendous responsibility to insure that adequate genetic variability remains available in the crop for use by future generations, and proper management of plant germplasm resources is necessary to insure that future improved cultivars can withstand stresses such as caused by insect and disease pests, and climate extremes (Poehlman and Sleper, 1995).

The principal objectives in breeding cotton are high production of lint fiber, improvement in fiber and seed quality, early maturity, adaptation to mechanical harvesting, resistance to stress environments, and for host-plant resistance/tolerance to disease and insect injury. Other considerations are important according to the location of the cotton breeding program.

The American Cotton Producers formed a Blue Ribbon Yield Committee in 1999, to identify the cause of the severe economic stresses that they were experiencing (American Cotton Producers, 1999). Producer leadership had become increasingly concerned about recent trends in Upland cotton yields in the U.S. Average yields across the Cotton Belt reached a high of 702 pounds per acre in 1987; but since then have leveled off, indicating that the crop may have reached yield stagnation. Improvement through breeding in any crop species requires genetic diversity, yet diversity in cotton has narrowed in recent years because many successful varieties share common parents and grandparents ('DES 56' and 'Deltapine 90'), confirming the narrow gene base for most of the current varieties either in release or development. The introduction of transgenic technology to cotton breeding has provided significant benefits to the industry; the first transgenic traits developed and commercialized in cotton are input traits, designed to confer insect and herbicide resistance to existing varieties. The impact of transgenic cotton varieties on yield trends is unclear.

According to the Blue Ribbon Yield Committee, either through conventional or genetically enhanced technologies, current varieties must be changed or new varieties developed that have the ability to better adapt to environmental stress and have the genetic potential through improved yield factors, to take varieties to new levels of sustainable, more stable yield improvement.

One relevant way to have cotton germplasm information available for breeding purposes is through the thorough evaluation of the existent, yet uncharacterized material. The main objective of this study was to evaluate to cotton germplasm from the discontinued USDA breeding program in Shafter, California for both agronomic and fiber characteristics.

The USDA was heavily involved in the development of improved *G. hirsutum*, mostly Acala type cottons in California through the support of a variety and germplasm development program located in Shafter. In the early 1990's, however, a program decision was made by the USDA to discontinue variety development and this led to the subsequent closure of its cotton improvement program at Shafter. In an effort to preserve the valuable germplasm developed there, advanced breeding lines were donated to the U.S. cotton collection. Data on the merits of this material was not, however, transferred. Our objective was to determine the value of a subset of this material for use in contemporary cotton improvement programs. Data will be collected on common GRIN descriptors and for HVI fiber properties. This complements efforts underway at Mississippi State University (by Dr. Ted Wallace) to evaluate an additional subset of this material.

REVIEW OF LITERATURE

Crop plants have been domesticated for a very long period of time, but the germplasm resources accumulated in the process are being eroded very rapidly. Wild plant populations that did not acquire broad genetic diversity during this evolutionary period eventually succumbed to the ravages of disease, drought, cold, competition with weeds, or other unfavorable environmental stresses. Some of these wild populations were selected to become landraces, farmer-selected cultivated lines originally evolved from wild plant populations, that survived to become modern crop cultivars in the countries of origin and progenitors of modern cultivars in other countries. Unfortunately, progress in breeding, often by selection and purification of these heterogeneous landraces, inevitably led to more uniformity and less genetic variability within the improved cultivars than was present in the original landraces. In addition to the immense genetic diversity in the landraces that emerged as the cultivated cultivars of the last century and the early part of this century, there is tremendous genetic variability in the related wild species for almost all plant characteristics. Not all of the plant genotypes found in nature can be conserved in germplasm collections, but those species that may be useful to plant breeders need to be sampled and stored before the natural habitat in which they are now found are destroyed (Poehlman and Sleper, 1995).

Germplasm is useful to extent that that is available for future cotton improvement in fiber quality, yield or pest resistant improvements. The first, and most essential, step in making germplasm available is its acquisition. Generally, this means seed from the primary and secondary centers of diversity (Smith and Cothren, 1999), or from countries where cotton has been cultivated for years and these germplasm have developed some specific characteristics under different climatic conditions.

The importance of conserving and introducing new plant germplasm was officially recognized early in the United States. In 1819, United States foreign officers were instructed to collect seeds and plants potentially useful for cultivation in the United States and to provide information on the climate and soil conditions to which they were adapted. In 1898, an Office of Foreign Seed and Plant Introduction, later to become the Office of Foreign Plant Introduction, was established in the United States Department of Agriculture. The United States program for germplasm conservation evolved into a National Plant Germplasm System (NPGS), now the model system for the United States Department of Agriculture's National Genetic Resources Program. While collection and maintenance of germplasm still plays a major role, more attention is now being given to the evaluation of the germplasm resources and dissemination of this information on the accessions to plant breeders. If a germplasm collection is to be utilized fully, information on the accessions must be documented so that plant breeders can identify potentially useful strains. This is aided by a computerized information retrieval system. In the United States, the computerized Germplasm Resources Information Network (GRIN) is maintained at the United States Department of Agriculture. Without this information a breeder may need to screen thousands of strains to find those with the desired genes (Poehlman and Sleper, 1995). The GRIN is part of a large Data Base Management System (DBMS), maintained by the Plant Genetics and Germplasm Institute, Beltsville, Maryland (Percival, 1987).

The National Collection of *Gossypium* germplasm is maintained by the USDA-ARS at College Station, TX. The number of accessions is over 10,000. While these numbers are small compared to those of other major crop collections, the presence of about 40 exotic species adds great variability to the collection. Over a period of many years, a U.S. *Gossypium* germplasm collection has been built up that represents a significant accumulation of scientific capital. This material was obtained, and continues to be accumulated, from planned explorations to various parts of the world, by donations of individual collectors, and by exchanges with other similar international collections. These activities continue to make available and preserve the broadest possible genetic base for cotton. The collection provides source material for basic studies in genetics, cytogenetics, taxonomy, and other disciplines, as well as for applied studies in screening for resistance to pests and diseases, environmental stress, and in plant productivity, and seeds from the collections continue to be made available to cooperators and researchers from around the world.

As mentioned previously, cotton is natively a crop adapted to tropical and subtropical climates. A shift in the climatic adaptation of the plant has been necessary to enable its successful cultivation in more temperate environments. Germplasm screening for useful characteristics is important for making information available of yet uncharacterized material. The screening includes observing plants for growth habit; measuring productivity, boll size, or fiber strength; evaluation for resistance to various pests and diseases; or screening for any character deemed to be useful or potentially useful. Screening programs typically are open ended examinations of all available material to determine the range of variability for the type of resistance or other character in question and to identify those particular accessions with extremes of expression (e.g. resistance to a disease) (Kohel and Lewis, 1984).

To make sure germplasm is accessible and useful, satisfactory records must be taken. In addition to an identification number, it is desirable to keep records on the amount of seed in storage and its age, to use as a guide for seed rejuvenation or replenishment. Monitoring the amount of seed in storage involves keeping data on the amounts of seed (a) put into storage at initial collection or in subsequent cycles of seed increase and (b) withdrawn from storage for germination tests or for distribution to users. Additional data of value in germplasm records are the so-called "descriptors," data on the botanical and agronomic characteristics of the items in the collection. These descriptors may concern such traits as plant stature, flower color, fruit size, geographic provenance, resistance to diseases or pests, fiber properties, phytochemical characters, etc. It is important to include data from as many descriptors as possible so that users can select material from the germplasm collection that is most likely to serve their particular needs (Kohel and Lewis, 1984).

When desirable germplasm has been located, the cotton breeder then wishes to transfer the desirable traits from the germplasm source to otherwise adapted agricultural cultivars. The ease of doing so depends, in part, on the mode of inheritance of the trait that is to be transferred and, in part, on the closeness of the relationship between the donor and recipient. A trait that is simply inherited (one or a few genes) can often be transferred effectively even when the two lines are not closely related (Kohel and Lewis, 1984).

High yield and high-quality lint fiber are the ultimate objectives in the breeding of cotton. The yield of cotton plant is determined by (1) number of bolls, (2) size of the bolls, and (3) percent of lint. The characteristic contributing most to yield is number of bolls. For plants to be high-yielding, they must be prolific and set a large number of bolls. Cotton cultivars differ in size of boll. Boll size is expressed as the weight in grams of seedcotton (lint + seeds) per boll. Normally, cultivars that set a high percentage of five-lock bolls are superior in yielding ability to cultivars with four-lock bolls. Lint production is affected by seed-set because lint is produced on the surface of the seed and by the density of the lint on the seed (Poehlman and Sleper, 1995).

The rapid advances in spinning technology in recent decades resulted in increasingly new demands concerning fiber properties. The adoption of new spinning methods, the advances in the traditional spinning process and the higher consumer demands call for extensive research and improvement of the raw material to keep pace with the current quality requirements of the spinning industry. The major quality parameters for the traditional ring system, the open end, rotor spinning, and the recent innovation such as the friction (DREF) and the air-jet spinning, are given in Table 1 in descending order of importance. In Table 2 are given the acceptable limits for the same parameters in ring and rotor spinning (Kechagia and Harig, 1998).

Table 1. Important cotton fiber properties for different spinning systems*

Ring**	Rotor**	Friction**	Air jet**
Length	Strength	Strength	Fineness
Uniformity	Fineness	Fineness	Length
Strength	Length	Length	Uniformity
Fineness	Uniformity	Uniformity	Strength
Elongation	Cleanliness***	Fiber friction***	Cleanliness***

* Taken from Kechagia, U. E., and Harig, H., 1998
** Descending order of importance
*** Not taken in this study

Table 2. Acceptable limits for efficient spinning of cotton fiber into yarn*

Fiber Properties	Ring spinning	Rotor or open end spinning
Length	min 1-1 1/8 inch	min 7/8 inch
Uniformity	min 45%	min 45%
Micronaire	3.5-5.0	max 4
Maturity**	min 80%	min 70%
Strength	min 25 g/tex	min 26 g/tex
Foreign matter**	max 2%	max 1.5%

* Taken from Kechagia, U. E., and Harig, H., 1998
**Not taken in this study

Earliness in cotton is influenced by (1) how early the cotton plant begins to set squares and then flowers, (2) how rapidly the new flowers develop, and (3) the length of time required for the bolls to mature. Rapid fruiting and early maturity reduce losses to disease and insects, facilitates harvesting with a mechanical picker, and increases production efficiency by reducing inputs of fertilizer, protective chemicals, or irrigation water. Small compact plants with small bolls and seeds are generally associated with earliness in a cotton cultivar (Poehlman and Sleper, 1995).

A compact, rapid-fruiting plant that does not lodge on fertile soils, with bolls spaced along the main stems and set high enough off the ground is desired. A natural tendency to shed leaves upon maturation of the bolls, or ease of defoliation; small or deciduous bracts; and smooth leaves free of hairs will reduce the amount of leaves and trash in the seed cotton (Poehlman and Sleper, 1995).

Water is often a limiting resource for cotton production in dry areas of the world. Limited sources of irrigation water and higher fuel costs for pumping is causing breeders to look for cotton strains with more efficient water use under drought conditions. Genetic variability for root growth and dry matter accumulation has been demonstrated among exotic strains and selections from breeding populations growing in drought environment. Recurrent selection to improve drought tolerance would involve crossing among drought-tolerant strains to form a source population from which selections could be made under drought stress conditions. Selection of *G. barbadense* strains in periods of high temperature at low elevations resulted in development of Pima strains with greater heat tolerance (Poehlman and Sleper, 1995).

Many disease problems are associated with cotton production. Breeding for host-plant resistance has been an effective method of control of the major disease pathogens. Development of multidisease resistance has received much attention in the breeding of resistant cultivars (Poehlman and Sleper, 1995). The most active areas currently attempting to exploit the germplasm collection are several programs seeking to find host plant resistance to various insects. Researchers are exploring insect response to morphological changes in the plant (nectariless types, modified bract form), chemical changes in the plant (high gossypol, high tannin), and different types of pubescence to affect feeding or egg laying of the insect (Kohel and Lewis, 1984).

California provides a good example of the successful introduction, adaptation and development of cotton germplasm. According to Hyer and Bassett (1985), cotton was first grown in California in small plots on Spanish mission lands; later cotton culture was tried, generally unsuccessfully, in the central valleys by immigrants who had turned to farming after failures at gold prospecting. After abandoning cotton culture in the central valleys in the 1880's cotton returned with the development of irrigation in the Imperial Valley in the early 1900's and cotton culture became commercially successful in California in the San Joaquin Valley in 1909. Although *Gossypium hirsutum* Upland varieties were tried, most of the interest was in *G. barbadense* American-Egyptian varieties. This interest was particularly intensive during World War I due to the increased demand for these high strength varieties. After the war, demand for American-Egyptian cotton dropped and growers' attention turned to the higher yielding Upland varieties. It was at this time that Acala cotton came on the scene in California. Acala cotton was first planted in the United States in Texas in 1907. After several years of growth and selection some material was sent to Oklahoma in 1914 where further selections were made. There, a row 8 was selected and seed was sent back to Texas where it was mixed with Texas Acala stocks. This mixed cotton was labeled Acala 8 and sent to California where it was grown at Arvin in 1919 and in Arvin and Indio in 1920. It was seed from these plantings that served as a nucleus for all commercial planting of Acala cotton in California for the next decade. Acala was found to be well adapted to San Joaquin Valley conditions and became well accepted by the growers. From 1932-39 varietal releases came from the P12 stocks at Shafter; these P12 stocks came to Shafter from Indio where some different Acala stocks were being maintained.

In 1939 a new Acala variety, 'P18C', was released to the growers. This was also derived from the P12 stocks and was grown until 1948. Acala cotton found its way into New Mexico and from a Texas stock called 'Young's Improved Acala', breeders selected a strain designated as 1064. From this was derived Acala 1517 which was found to possess superior fiber length and strength and *Verticillium* wilt tolerance to that found in other Acala types. Acala 1517 was brought to California and at Shafter 'Acala 4-42' was selected out of it. The Acala 4-42 plant type is distinctly different from that of 1517 so outcrossing may have taken place during the development of Acala 4-42. Acala 4-42 was released to the growers in 1949 and continued in production until 1966. Twelve distinct sibs, or families, making up the original Acala 4-42 release have been identified. During the time when Acala 4-42 was grown, further selection pressure within the families and elimination of some of the families making up the composite resulted in further increases in yield, fiber strength and wilt tolerance. These fiber improvements established an excellent reputation for California Acala in the cotton mills of the world that still exists today. Because of these excellent qualities California Acala demands a premium in most years (Hyer and Bassett, 1985).

In 1967, 'Acala 4-42' was replaced by 'Acala SJ-1'. With the advent of Acala SJ-1 and subsequent Acala varieties, the germplam base was greatly broadened by the introduction of non-Acala germplasm into the Acala stocks. Acala SJ-1 was derived from a cross of a Shafter line AXTE 1 and New Mexico Acala 1517D. AXTE 1 had in its background Triple Hybrid material; triple hybrid came from crosses of *G. arboreum*, an Asiatic diploid cotton, *G. thurberi*, a wild Arizona diploid cotton, and *G. hirsutum*. New Mexico breeders have hypothesized that Acala 1517D carries Pima genes made available through outcrossing. In 1974, 'Acala SJ-2' replaced Acala SJ-1. This variety was a selection out of the same breeding material from which 'Acala SJ-

1' was derived. From the mid 1960's special effort was made by breeders to incorporate higher levels of wilt resistance into Acala varieties. This resulted in the release of 'Acala SJ-3', 'Acala SJ-4' and 'Acala SJ-5' in 1975, 1976 and 1979, respectively. Acala SJ-4 and Acala SJ-5 were major breakthroughs in wilt resistance, carrying some of the highest levels of any known Upland variety. Acala SJ-4 and Acala SJ-5 were derived from a cross of the Shafter breeding line C6TE and New Mexico Acala B3080. C6TE has Triple Hybrid in its background (Hyer and Bassett, 1985).

There are many successful examples of the use of germplasm resources screening in cotton improvement; selected examples of which have been reviewed by Kohel and Lewis (1984). A disease of localized occurrence is cotton rust, caused by *Puccinia cacabata*. It is of importance in the southwestern U.S. and northwestern Mexico, where its incidence is variable but its economic impact can be significant. Fungicidal control of the disease is costly and not wholly satisfactory. *G. anomalum* and a few cultivars of *G. arboreum* were rust resistant, although all the other species were susceptible. Through interspecific hybrids and artificial polyploids plus a backcrossing scheme accompanied by continued screening for resistance, success was achieved in transferring this resistance into agronomically acceptable germplasm of *G. hirsutum*. Now rust resistant cultivars are available for planting in those areas where rust is a significant problem, and the costs of disease control and disease loss are thereby avoided. Another disease problem resolved by recourse to germplasm resources is bacterial blight disease caused by *Xanthomonas malvacearum*. Since the disease organism exists in a variety of strains at differing levels of virulence, plant breeders have generally combined two or more genes for resistance and, through selection, raised the effectiveness of the polygenic background in developing new blight resistance genotypes. Satisfactory blight resistance cultivars of both *G. hirsutum* and *G. barbadense* have been available for many years.

Selected examples of germplasm screening for cotton improvement have also been reviewed by Meredith (1991). Improving fiber quality has been an objective from the beginning of cotton breeding history. Modern textile mills which spin yarns at much faster speeds require greater fiber strength and fineness and less short fiber, neps and trash. The original association of yields and strength from interspecific crosses were strongly negative and even prompted some breeders to forecast that high yields and high strength were not possible. The cause of this negative association was either linkage or pleiotrophy. If linkage was the cause of the negative association, then conventional pure line breeding had little chance of success. Four alternatives were available to breeders. These were random intercrossing within segregating populations, frequent crossing among distantly related cultivars or strains, mutation breeding, and the backcross breeding method. All four methods were tried successfully in cotton, increasing both yield and fiber strength in the last 60 years.

Recent examples in cotton of the value of germplasm evaluation for the improvement of the crop are available. Green (2002) cited that Delta and Pine Land Company has developed a new program to facilitate germplasm exchange from three different breeding programs located in Brazil, Australia, and Greece, and a standardized database which includes information on yield, fiber quality, and disease reaction. West *et al* (2004) screened 24 cultivars for *Rhizoctonia solani* at Texas A&M. He founded that three varieties were resistant (‘Stoneville 506’, ‘Lankart 57’, and ‘LoneStart’), and all share a common lineage. Fish and Earl (2003) reported that 22 commercial cultivars were screened for water use efficiency and epidermal conductance. Young *et al* (2004) reported the use of germplasm from the Texas race stocks for resistance to the reniform nematode, and selected 53 out of 117 lines evaluated for further assessment and possible advancement. Mekala *et al* (2004) screened upland cotton for resistance to cotton fleahopper and found that 3 pilose varieties (‘Lankart 142’, ‘Suregrow 747’, and ‘Stoneville 474’) were the most resistant out of seventeen.

Many cotton scientists and cotton producers have become increasingly concerned about a leveling off of Upland cotton yields in the U.S., indicating that the crop may have reached yield stagnation. There is a greater awareness of the importance of germplasm evaluation and characterization and the critical role new germplasm variability will play in the development of cotton varieties with improved yield, fiber quality, and disease resistance. To this end, Louisiana State University and Mississippi State University are collectively evaluating different accessions from the National Collection of *Gossypium* germplasm, as well as private companies and others public institutions for useful characteristics to incorporate into the cotton breeding program. We report here on the evaluation of 154 accessions acquire from the former USDA breeding program in Shafter, CA for their potential to contribute to the agronomic and fiber quality improvement of cotton.

MATERIALS AND METHODS

The USDA-ARS, SPA, National Collection of *Gossypium* germplasm, at College Station, Texas has a high percentage of uncharacterized germplasm, and one of their objectives is to get standardized information from these germplasm lines to assess their potential to contribute to future variety development. The one hundred fifty four cotton germplasm lines evaluated herein was a random subset from the National Collection of *Gossypium* germplasm. The materials plus systematic and random checks were planted on May 14, 2003 in Saint Joseph, LA at the LSU AgCenter Northeast Research Station. Field plots were maintained by Station personnel as recommended by LA Cooperative Extension Service guidelines.

The field dimensions were 36 rows wide and 6 tiers deep, each tier (row) being 6.14 meters long, with rows being spaced 1 meter apart, and an intrarow seed density of 7-10 plants per meter. Due to limited seed availability, the trial was laid out as a modified augmented design (MAD) type-2 design using Agrobase Generation II (Agronomix, 2004). This design provides row and column error controls using both systematic (control plot) and random (control subplots) placement of repeating checks. It is specifically designed for the unreplicated testing of a large number of treatments. The design is laid out as a split plot with whole plots arranged in rows and columns as a Latin Square. In this specific case, each whole plot being the control plot. The control plot was planted to 'Phytogen PSC 355'. To estimate error, a random number of whole plots are selected and checks (Delta and Pine Land 'Deltapearl' or 'Fibermax 958') are assigned to control subplots.

Data collected from a MAD type-2 design is subject to three types of data analysis. The first analysis consists of the unadjusted data values. The second analysis looks for row and column variability by evaluating the control plots. If significant row and/or column variation is found through an analysis of variance, row and column control plot mean deviations from the overall control plot mean are calculated. These deviations are used to adjust treatment values. The third analysis involves the regression of control subplot values upon control plot values.

This allows for the identification of field variability that does not conform to that which may exist within a column and row arrangement. If a significant regression is found, this is used to calculate an additional adjusted treatment value. A regression based adjusted treatment value cannot also be adjusted row and/or column deviations and vice-versa.

Field evaluation was divided into three parts: the first data collection was taken on inflorescences; the second data collection was taken prior to harvest; the third data collection was taken at harvest. Descriptor data was recorded as per GRIN guidelines augmented with some additional phenotypic measurement.

The first data collection that was taken at flowering, approximately two and half months after planting, included the follow traits: photoperiodicity, calyx hair, leaf color, leaf hair, petal color, petal spot, pollen color, and stem pubescence. All these descriptors are standards for cotton and are detailed in the computerized Germplasm Resources Information Network (GRIN). The second data was taken just prior to harvest and indicated the relative maturity of the accessions when the commercial check, Phytogen PSC 355, had 50 % of its bolls opened. The third data collection was taken at harvest and consists of the measurement of plant height and single row plot seedcotton weight, after rows were harvested with a one-row spinable cotton picker. In addition, 25 open cotton bolls of each germplasm were collected right before to harvest. The 25 bolls were picked at random from any plant and any portion of the plant in each germplasm row.

The 25 cotton bolls were ginned at the LSU Cotton Breeding Lab using a 7 saw laboratory gin (Parter-Morrison, Dennis Manufacturing Inc.). Lint and cottonseed weights were recorded, and the cottonseed was then delinted (using 95 % sulfuric acid) and the seeds counted.

Plots weights were converted into seedcotton yields (lbs acre^{-1}). Lint yields were calculated by multiplying seedcotton yield by lint percentage (lint wt/seedcotton wt) as determined from the boll samples. Lint yields were analyzed using Agrobase Generation II according to the trial design and are reported as unadjusted and adjusted lint yields in lbs acre^{-1}.

Lint collected from the ginning process was analyzed using the High Volume Instrumentation (HVI 900™ Zellweger Uster), at the LSU Cotton Fiber Lab. The characteristics evaluated on the fiber were: fiber length (inches), fiber uniformity (%), fiber strength (g/tex), fiber elongation (%), and fiber fineness (micronaire).

RESULTS AND DISCUSSION

Botanic and Agronomic Traits

The frequency and the descriptor values of the one hundred fifty four cotton germplasms are summarized in Tables 3, 4, 5, and 6. No plant among the germplasm lines evaluated showed a deviant characteristic from the mentioned descriptors in Tables 5 and 6. The commercial check and control plot, PSC 355, was the main check indicator for percent open bolls at maturity. Only two germplasm lines (SA 1993 and SA 1995) opened 50 % of their bolls a week earlier than PSC 355; nineteen germplasm lines opened their bolls at the same time as PSC 355; twenty germplasm lines were a week later than PSC 355; most of the germplasm lines evaluated, ninety six, were between one and half or two weeks later than PSC 355; seventeen germplasm lines were two or more weeks later than PSC 355. The commercial checks and control subplots, FM 958 and Delta Pearl, were just a few days (less than a week) later than PSC 355. Depending on the cotton breeders' objectives and their locations, maturity preferences may range from full season to early maturity cotton. Anecdotally, full season cotton varieties tend to yield a bit more cotton with better fiber quality than early season cotton varieties but have a greater exposure risk to insect problems because of their earliness (Gerald Myers, personal communication). All the germplasm lines and the commercial checks were in bloom at the same time, indicating that there was not a photoperiodic germplasm line.

With regards to their stems, the commercial checks, Delta Pearl and PSC 355, were graded as hairy plants and one commercial check, FM 958, was graded as a variety with few hairs. There were five germplasm lines with no hairs (glabrous). Of the remainder of the germplasm lines, one hundred thirty six had few hairs on the plants, there were twelve hairy germplasm lines, and just one germplasm (SA 1986) was rated as very hairy.

Table 3. Frequency of the botanic traits at flowering for 154 germplasm lines of the USDA Shafter Cotton Collection (Part A)

	Open bolls (Maturity)	Blooming (Maturity)	Pubescence (Plant Hairiness)	Bract Shape	Glanding (Gossypol)	Nectaries
	-2= 1Week early	0= no flower				
	-1= 3~4 days early	1= 8 wks late				
	0= same	2= 6 wks late	1= no hairs			
	+1= 1week late	3= 4 wks late	2= few hairs	1= normal	1= glanded	1= nectaried
	+2= 1.5~2 wks late	4= 2 wks late	3= hairy*	2= frego	2= glandless	2= nectariless
Score	+3= +2 wks	5= normal	4= very hairy	3= segregated	3= segregated	3= segregated
-2	2					
0	19					
1	20		5	153	146	152
2	96		136	1	5	1
3	17		12		3	1
4			1			
5		154				
Delta Pearl	0.778	5	2.94	1	1	1
FM 958	0.278	5	2	1	1	1
PSC 355	0.042	5	3	1	1	1

*Common cotton characteristic

Table 4. Frequency of the botanic traits at flowering for 154 germplasm lines of the USDA Shafter Cotton Collection (Part B)

	Calyx Hair	Leaf Hair	Leaf Color	Petal Color	Petal Spot	Pollen Color
		1= no		1= yellow		
		2= few	0= dark green	2= cream*		
	1= absent*	3= moderate*	1= green	3= cream/red	0= none	1= yellow
	2= few	4= hairy*	2= red	4= segregated*	1= light	2= cream
	3= present	5= very hairy	3= dark red	5= dark yellow	2= medium	3= segregated
	4= hairy	6= pilose	5= segregated	6= light yellow	3= heavy	4= dark yellow
Score				7= red		
0					154	
1	27	26	154			7
2	118	116		154		146
3	9	12				1
4						
5						
Delta	1.9	1.94	1	2	0	2
FM 958	1.9	1.94	1	2	0	2
PSC 355	2.0	3	1	2	0	2

*Common cotton characteristic

Table 5. Descriptors of the botanic traits at flowering for 154 germplasm lines of the USDA Shafter Cotton Collection (Part A)

	Open bolls (Maturity)	Blooming (Maturity)	Pubescence (Plant Hairiness)	Bract Shape	Glanding (Gossypol)	Nectaries
	-2= 1Week early	0= no flower				
	-1= 3~4 days early	1= 8 wks late				
	0= same	2= 6 wks late	1= no hairs			
	+1= 1week late	3= 4 wks late	2= few hairs	1= normal	1= glanded	1= nectaried
	+2= 1.5~2 wks late	4= 2 wks late	3= hairy*	2= frego	2= glandless	2= nectariless
SA_No	+3= +2 wks	5= normal	4= very hairy	3= segregated	3= segregated	3= segregated
1956	2	5	2	1	1	1
1957	2	5	2	1	1	1
1958	2	5	2	1	1	1
1959	0	5	2	1	1	1
1960	2	5	2	1	1	1
1961	2	5	2	1	1	1
1962	2	5	2	1	1	1
1963	2	5	2	1	1	1
1964	2	5	2	1	1	1
1965	2	5	1	1	1	1
1966	2	5	2	1	1	1
1967	0	5	2	1	1	1
1968	2	5	2	1	1	1
1969	2	5	2	1	1	1
1970	2	5	2	1	1	1
1971	2	5	2	1	1	1
1973	2	5	2	1	1	1
1974	2	5	2	1	1	1
1975	0	5	1	1	1	1
1976	2	5	3	1	1	1
1977	1	5	2	1	1	1
1978	2	5	1	1	1	1
1979	1	5	3	1	1	1
1980	2	5	2	1	1	1
1981	2	5	2	1	1	1
1982	2	5	2	1	1	1
1983	2	5	2	1	1	1
1984	2	5	2	1	1	1
1985	2	5	2	1	1	1
1986	2	5	4	1	1	1
1987	2	5	2	1	1	1
1988	2	5	2	1	1	1
1989	2	5	2	1	1	1
1990	2	5	2	1	1	1

*Common cotton characteristic

Table 5. (continued)

SA_No	Open bolls (Maturity)	Flowers (Maturity)	Pubescence (Plant Hairiness)	Bract Shape	Glanding (Gossypol)	Nectaries
1991	2	5	2	1	1	1
1992	2	5	2	1	1	1
1993	-2	5	2	1	1	1
1994	2	5	2	1	1	1
1995	-2	5	2	1	1	1
1996	2	5	2	1	1	1
1997	2	5	2	1	1	1
1998	2	5	3	1	1	1
1999	2	5	2	1	1	1
2000	0	5	2	1	1	1
2001	0	5	2	1	1	1
2002	2	5	2	1	1	1
2003	2	5	2	1	1	1
2004	3	5	2	1	1	1
2005	2	5	2	1	1	1
2006	3	5	2	1	1	1
2007	1	5	2	1	1	1
2008	3	5	2	1	1	1
2009	3	5	2	1	1	1
2010	1	5	2	1	1	1
2011	0	5	2	1	1	1
2012	2	5	2	1	2	1
2013	3	5	2	1	2	1
2014	3	5	3	1	1	1
2015	2	5	3	1	1	1
2016	3	5	2	1	1	1
2017	0	5	3	1	1	1
2018	2	5	2	1	1	1
2019	3	5	2	1	1	1
2020	3	5	2	1	1	1
2021	3	5	2	1	1	1
2022	0	5	2	1	1	1
2023	2	5	2	1	1	1
2024	2	5	2	1	1	1
2025	2	5	2	1	1	1
2026	2	5	2	1	1	1
2027	2	5	2	1	1	1
2028	3	5	2	1	1	1
2029	2	5	2	1	1	1
2030	2	5	2	1	1	1

Table 5. (continued)

SA_No	Open bolls (Maturity)	Flowers (Maturity)	Pubescence (Plant Hairiness)	Bract Shape	Glanding (Gossypol)	Nectaries
2031	2	5	2	1	1	1
2032	2	5	2	1	1	1
2033	2	5	2	1	1	1
2034	2	5	2	1	1	1
2035	1	5	2	1	1	1
2036	2	5	2	1	1	1
2037	2	5	2	1	2	1
2038	2	5	2	1	1	1
2039	2	5	2	1	1	1
2040	2	5	2	1	1	1
2041	2	5	2	1	1	1
2042	2	5	2	1	1	1
2043	2	5	2	1	1	1
2044	2	5	2	1	1	1
2045	2	5	2	1	1	1
2046	3	5	2	1	1	1
2047	3	5	3	1	1	1
2048	3	5	2	1	1	1
2049	1	5	3	1	1	1
2050	2	5	2	1	1	1
2051	2	5	2	1	1	1
2053	0	5	2	1	1	1
2054	1	5	2	1	1	1
2055	1	5	2	1	1	1
2056	0	5	2	1	1	1
2057	2	5	1	1	1	1
2058	1	5	2	1	1	1
2059	2	5	2	1	1	1
2060	1	5	2	1	1	1
2061	1	5	2	1	1	1
2062	1	5	2	1	1	1
2063	1	5	2	1	1	1
2064	0	5	2	1	1	1
2065	0	5	2	1	1	1
2066	0	5	3	1	3	1
2067	2	5	2	1	1	1
2068	2	5	2	1	1	1
2069	2	5	2	1	1	1
2070	2	5	2	1	1	1
2071	1	5	2	1	1	1

Table 5. (continued)

SA_No	Open bolls (Maturity)	Flowers (Maturity)	Pubescence (Plant Hairiness)	Bract Shape	Glanding (Gossypol)	Nectaries
2072	0	5	3	1	1	1
2073	1	5	2	1	1	1
2074	2	5	2	1	2	1
2075	3	5	2	1	1	1
2078	2	5	2	1	3	1
2079	0	5	2	1	1	1
2080	2	5	2	1	3	1
2081	0	5	2	1	1	1
2082	2	5	2	1	1	1
2083	2	5	2	1	1	1
2084	0	5	2	1	1	1
2085	2	5	2	1	1	2
2086	1	5	2	1	1	1
2087	0	5	2	2	1	1
2088	3	5	1	1	1	1
2089	2	5	2	1	1	3
2090	2	5	2	1	1	1
2091	2	5	2	1	1	1
2092	2	5	2	1	1	1
2093	2	5	2	1	1	1
2094	2	5	2	1	1	1
2095	2	5	3	1	1	1
2096	2	5	2	1	1	1
2097	1	5	2	1	1	1
2098	2	5	2	1	1	1
2099	2	5	2	1	1	1
2100	2	5	2	1	1	1
2101	2	5	2	1	1	1
2102	2	5	2	1	1	1
2103	1	5	2	1	1	1
2104	2	5	2	1	1	1
2105	2	5	2	1	1	1
2106	2	5	2	1	1	1
2107	2	5	2	1	1	1
2108	2	5	2	1	1	1
2109	3	5	2	1	1	1
2110	2	5	2	1	2	1
2111	1	5	3	1	1	1
2112	1	5	2	1	1	1

Table 5. (continued)

SA_No	Open bolls (Maturity)	Flowers (Maturity)	Pubescence (Plant Hairiness)	Bract Shape	Glanding (Gossypol)	Nectaries
2113	0	5	2	1	1	1
D.PEARL	0.778	5	2.94	1	1	1
FM 958	0.278	5	2	1	1	1
PSC 355	0.042	5	3	1	1	1

A hairy stemmed plant is a common cotton characteristic, and most cotton breeders would rather have smooth plants in their program. Wilson and Shepherd, (1987) found no significant differences on yield between hirsute cotton (hairy) and glabrous cotton (smooth) and Jones et al (1971) found a slight but not statistically significant difference in yield between both, with the average lint percentages for smooth and hairy being 37.7% and 38%, respectively. Since smooth cottons are known to produce less gin trash than normal hirsute cottons, it is quite possible that the lint of hairy cotton contained more trash than the lint of smooth cottons and therefore had an inflated lint percentage (lint + leaves debris / bolls wt). Lege et al (1992) reported that glabrousness reduces egg laying by as much as 50% by making the plant unattractive as an oviposition site for the bollworm [*Helicoverpa zea* (Boddie)].

Only one germplasm (SA 2087) had frego bract shape, and all the others including the commercial checks had a normal bract shape. Jones and Andries (1969) reported that frego bract biotypes average up to 69% less loss from boll rot than their near-isogenic normal bract strains; Jones et al (1978) reported also that frego bract is susceptible to tarnished plant bugs, and it is sufficient to cause excessive delays in maturity and severe reductions in lint yields in some years.

Table 6. Descriptors of the botanic traits at flowering for 154 germplasm lines of the USDA Shafter Cotton Collection (Part B)

	Leaf Hair	Leaf Color	Calyx Hair	Petal Color	Petal Spot	Pollen Color
				1= yellow		
	1= no			2= cream*		
	2= few	0= dark green		3= cream/red		
	3= modify*	1= green	1= absent*	4= segregated*	0= none	1= yellow
	4= hairy*	2= red	2= few	5= dark yellow	1= light	2= cream
	5= very hairy	3= dark red	3= present	6= light yellow	2= medium	3= segregated
SA_No	6= pilose	5= segregated	4= hairy	7= red	3= heavy	4= dark yellow
1956	3	1	1	2	0	2
1957	2	1	1	2	0	2
1958	2	1	1	2	0	2
1959	2	1	1	2	0	2
1960	2	1	1	2	0	2
1961	1	1	1	2	0	2
1962	1	1	1	2	0	2
1963	1	1	1	2	0	2
1964	1	1	1	2	0	2
1965	1	1	1	2	0	2
1966	1	1	2	2	0	2
1967	1	1	2	2	0	2
1968	1	1	1	2	0	2
1969	1	1	1	2	0	2
1970	1	1	1	2	0	2
1971	1	1	3	2	0	2
1973	1	1	1	2	0	2
1974	2	1	2	2	0	2
1975	1	1	1	2	0	2
1976	3	1	2	2	0	2
1977	2	1	2	2	0	2
1978	2	1	1	2	0	2
1979	3	1	3	2	0	1
1980	2	1	1	2	0	2
1981	2	1	1	2	0	2
1982	2	1	2	2	0	2
1983	2	1	2	2	0	2
1984	2	1	1	2	0	2
1985	2	1	2	2	0	2
1986	3	1	3	2	0	2
1987	2	1	2	2	0	2
1988	2	1	1	2	0	2
1989	1	1	1	2	0	2

*Common cotton characteristic

Table 6. (continued)

SA_No	Leaf Hair	Leaf Color	Calyx Hair	Petal Color	Petal Spot	Pollen Color
1990	2	1	2	2	0	2
1991	2	1	2	2	0	2
1992	2	1	2	2	0	2
1993	2	1	2	2	0	2
1994	2	1	1	2	0	2
1995	2	1	2	2	0	2
1996	1	1	2	2	0	2
1997	1	1	1	2	0	2
1998	3	1	2	2	0	2
1999	1	1	1	2	0	2
2000	2	1	2	2	0	2
2001	2	1	2	2	0	2
2002	2	1	1	2	0	2
2003	2	1	2	2	0	2
2004	2	1	2	2	0	2
2005	2	1	2	2	0	2
2006	2	1	2	2	0	2
2007	2	1	2	2	0	2
2008	2	1	2	2	0	2
2009	1	1	2	2	0	2
2010	2	1	2	2	0	2
2011	3	1	2	2	0	2
2012	1	1	2	2	0	2
2013	2	1	2	2	0	2
2014	2	1	2	2	0	2
2015	2	1	3	2	0	2
2016	2	1	2	2	0	2
2017	3	1	2	2	0	1
2018	2	1	2	2	0	2
2019	2	1	2	2	0	2
2020	2	1	2	2	0	2
2021	2	1	2	2	0	2
2022	2	1	2	2	0	2
2023	2	1	2	2	0	2
2024	1	1	1	2	0	2
2025	2	1	2	2	0	2
2026	2	1	2	2	0	2
2027	2	1	2	2	0	1
2028	2	1	2	2	0	2
2029	2	1	3	2	0	2
2030	2	1	2	2	0	2

Table 6. (continued)

SA_No	Leaf Hair	Leaf Color	Calyx Hair	Petal Color	Petal Spot	Pollen Color
2031	2	1	2	2	0	2
2032	2	1	2	2	0	2
2033	2	1	2	2	0	2
2034	2	1	2	2	0	2
2035	2	1	2	2	0	2
2036	2	1	2	2	0	2
2037	2	1	2	2	0	2
2038	2	1	2	2	0	2
2039	2	1	2	2	0	2
2040	2	1	2	2	0	2
2041	2	1	2	2	0	1
2042	2	1	2	2	0	2
2043	2	1	2	2	0	2
2044	2	1	2	2	0	2
2045	2	1	2	2	0	2
2046	2	1	2	2	0	2
2047	3	1	3	2	0	2
2048	1	1	2	2	0	2
2049	3	1	2	2	0	2
2050	2	1	2	2	0	2
2051	2	1	2	2	0	2
2053	2	1	2	2	0	2
2054	2	1	2	2	0	2
2055	2	1	2	2	0	2
2056	2	1	2	2	0	2
2057	2	1	2	2	0	2
2058	2	1	2	2	0	2
2059	2	1	2	2	0	2
2060	2	1	2	2	0	2
2061	2	1	2	2	0	2
2062	2	1	3	2	0	2
2063	2	1	2	2	0	2
2064	2	1	2	2	0	2
2065	2	1	2	2	0	1
2066	3	1	2	2	0	2
2067	2	1	2	2	0	2
2068	2	1	2	2	0	2
2069	1	1	2	2	0	2
2070	2	1	2	2	0	2
2071	2	1	2	2	0	3

Table 6. (continued)

SA_No	Leaf Hair	Leaf Color	Calyx Hair	Petal Color	Petal Spot	Pollen Color
2072	3	1	3	2	0	2
2073	2	1	2	2	0	2
2074	2	1	2	2	0	2
2075	1	1	2	2	0	2
2078	2	1	2	2	0	2
2079	2	1	2	2	0	2
2080	1	1	1	2	0	2
2081	2	1	2	2	0	2
2082	2	1	2	2	0	2
2083	2	1	2	2	0	2
2084	2	1	2	2	0	2
2085	2	1	2	2	0	2
2086	2	1	2	2	0	2
2087	2	1	2	2	0	2
2088	1	1	2	2	0	1
2089	2	1	2	2	0	2
2090	2	1	2	2	0	2
2091	2	1	2	2	0	2
2092	2	1	2	2	0	2
2093	2	1	2	2	0	2
2094	2	1	2	2	0	2
2095	3	1	3	2	0	2
2096	2	1	2	2	0	2
2097	2	1	2	2	0	2
2098	2	1	2	2	0	2
2099	2	1	2	2	0	2
2100	2	1	2	2	0	2
2101	2	1	2	2	0	2
2102	2	1	2	2	0	2
2103	2	1	2	2	0	2
2104	2	1	2	2	0	2
2105	2	1	2	2	0	1
2106	2	1	2	2	0	2
2107	2	1	2	2	0	2
2108	2	1	2	2	0	2
2109	1	1	2	2	0	2
2110	2	1	2	2	0	2
2111	2	1	2	2	0	2
2112	2	1	2	2	0	2

Table 6. (continued)

SA_No	Leaf Hair	Leaf Color	Calyx Hair	Petal Color	Petal Spot	Pollen Color
2113	2	1	2	2	0	2
D.PEARL	1.94	1	1.9	2	0	2
FM 958	1.94	1	1.9	2	0	2
PSC 355	3	1	2.0	2	0	2

Most of the germplasm lines evaluated, one hundred forty six, and all the commercial checks were glanded; five germplasm lines were glandless, and three germplasm lines were segregating (SA 2066, SA 2078, and SA 2080) for the glanded trait. Bottger et al (1964) reported that glanded cottons have 3 and 4 ½ times more gossypol in the seedling and leaves, respectively, than in comparable samples of glandless cottons, and he also reported that gossypol has a toxic effect on *Spodoptera exigua* (Hubner) (armyworms), *Helicoverpa zea* (Bobbie) (Bollworms), *Spanogonicus albofasciatus* (Reuter) (black fleahopper), and *Maecolaspis flavida* (Say) (grape colaspis), or at least inhibits their growth. According to Calhoun (1997) some breeding programs aimed at insect resistance have begun to select for the presence of glands on the sepal margin, because of the high correlation between high gossypol content and frequency of glands on the upper edge of the sepals of Upland cottons.

All the commercial checks and one hundred fifty two germplasm lines were nectaried; one germplasm was nectarless (SA 2085), and also one germplasm was segregating (SA 2089) from nectarless. McCarty et al (1983) noted that over a three years period, nectarless cottons averaged 5.7% higher total yields than nectaried cottons, when grown without early season insect control. However, no differences in total yield were detected between the nectaried/nectarless cottons when grown with early season insect control. Nectarless cottons tend to be earlier maturing than their nectaried counterparts and result in reduced *Heliothis* spp. oviposition, reduced pink bollworm damage, and reduced numbers of tarnished plant bugs, *Lygus lineolaris*.

Hairs on the leaves and modified leaves (from few hairs to hairy) are common cotton characteristics. The commercial checks, Delta Pearl and FM 958, were graded as having few hairs and the commercial check PSC 355 was considered intermediate with few hairs to hairy. Twenty six germplasm lines had smooth leaves; most of the germplasm lines evaluated, one hundred sixteen, had few to intermediate hairs in their leaves.

All the commercial checks and one hundred eighteen of the germplasm lines evaluated had few hairs on their calyx; twenty seven germplasm lines did not have hairs in their calyx, and nine germplasm lines had a bit more hair present than the commercial checks. The absence of hair on the calyx is a common cotton characteristic. A hairy calyx would help to protect the flower from piercing and chewing insects that feed on young flowers.

All the one hundred fifty four germplasm lines and all the commercial checks evaluated had a pretty much uniform green leave color. The cream flower color is a common flower characteristic of Upland cotton, and all the germplasm lines evaluated including the commercial checks had a cream petal color. Petal spot is a distinguishing characteristic of Acala and Pima cottons, and all the germplasm lines evaluated including the commercial checks did not have petal spot, so this subset of germplasm lines did not have an Acala type line. All the commercial checks and most of the germplasm evaluated, a total of one hundred forty six, had cream pollen color; seven germplasm lines had yellow pollen color, and one germplasm was segregating (SA 2071) for pollen color.

The height of plants in this study varied widely from between 26.3 to 94.7 inches. Most of the germplasm lines had heights in the range of 35 and 55 inches (Table 7 and 8). The commercial checks had heights for Delta Pearl, FM 958, and PSC 355 of 48, 40.9, and 48.3 inches, respectively (Table 8). Most cotton breeding programs would prefer to have plant heights anywhere between 36 inches and 54 inches, to make them adaptable to stripper or picker harvesting.

Table 7. Plant height frequencies for 154 germplasm lines of the USDA Shafter Cotton Collection

Height (inches)	Frequency
<29.9	2
30-34.9	3
35-39.9	22
40-44.9	23
45-49.9	32
50-54.9	45
55-59.9	19
60-64.9	4
>65	7

Table 8. Plant heights for 154 germplasm lines of the USDA Shafter Cotton Collection

SA_No	Inches	SA_No	Inches	SA_No	Inches	SA_No	Inches	SA_No	Inches	SA_No	Inches
1956	38.7	1984	40.3	2011	45.0	2038	56.7	2066	45.0	2095	51.3
1957	54.3	1985	52.0	2012	50.0	2039	53.7	2067	51.3	2096	57.7
1958	39.7	1986	53.0	2013	53.0	2040	56.0	2068	44.3	2097	53.7
1959	41.3	1987	57.0	2014	46.0	2041	50.3	2069	48.7	2098	58.3
1960	53.7	1988	56.7	2015	60.0	2042	53.3	2070	40.0	2099	67.3
1961	52.0	1989	69.0	2016	52.0	2043	45.0	2071	34.0	2100	39.0
1962	51.7	1990	53.3	2017	39.7	2044	49.3	2072	39.0	2101	53.0
1963	44.7	1991	50.3	2018	55.3	2045	46.3	2073	29.3	2102	53.3
1964	59.0	1992	55.7	2019	50.7	2046	40.7	2074	94.7	2103	57.0
1965	46.0	1993	35.7	2020	49.3	2047	43.7	2075	34.0	2104	38.0
1966	51.3	1994	43.7	2021	50.0	2048	55.0	2078	47.7	2105	49.7
1967	46.3	1995	34.7	2022	45.7	2049	52.3	2079	38.3	2106	50.7
1968	49.0	1996	49.3	2023	52.3	2050	49.3	2080	39.3	2107	43.0
1969	50.7	1997	44.7	2024	47.7	2051	37.0	2081	37.3	2108	53.0
1970	39.7	1998	54.0	2025	51.7	2053	44.0	2082	52.3	2109	56.7
1971	45.7	1999	60.3	2026	53.7	2054	42.7	2083	45.7	2110	51.3
1973	50.7	2000	48.0	2027	50.7	2055	46.7	2084	45.3	2111	53.0
1974	48.0	2001	44.3	2028	73.0	2056	45.0	2085	50.0	2112	41.7
1975	42.0	2002	51.3	2029	65.3	2057	48.7	2086	38.0	2113	44.3
1976	58.7	2003	50.0	2030	56.7	2058	38.0	2087	44.3	D.Pearl	48.0
1977	48.7	2004	48.0	2031	69.3	2059	50.0	2088	51.0	FM 958	40.9
1978	35.0	2005	54.3	2032	64.7	2060	36.3	2089	53.0	PSC 355	48.3
1979	37.0	2006	35.7	2033	55.3	2061	43.3	2090	41.7		
1980	45.3	2007	39.7	2034	55.3	2062	44.7	2091	55.7		
1981	52.0	2008	45.7	2035	58.0	2063	41.7	2092	43.7		
1982	69.7	2009	46.0	2036	67.0	2064	26.3	2093	37.7		
1983	52.3	2010	35.7	2037	59.7	2065	36.0	2094	51.3		

Cotton Fiber Quality Traits

The variability of the fiber properties in cotton is an unfavorable element in a market that pits this natural fiber against artificial, more uniform products represented by synthetic fibers. Fiber properties vary as a function of the cultivar but also as a function of the environment and production practices (Clouvel, P. *et al*. 1998).

The descriptors and their frequency counts for several cotton fiber quality traits are summarized in Tables 9 and 10. The ratings for fiber property standards were taken from the Cotton Incorporated, U. S. Cotton Fiber Chart for 2001. Cotton fiber quality descriptors measured were: length (inches), uniformity (%), strength (g/tex), elongation (%), and fineness (micronaire).

Table 9. Fiber quality descriptors frequencies for 154 Germplasm lines of the USDA Shafter Cotton Collection

UHM = Fiber Length (in)	frequency
Extra long (>1.26)	1
Long (1.11-1.26)	100
Medium (0.99 - 1.10)	52
Short (<0.99)	1
UI = Length Uniformity	frequency
Very high (above 85)	71
High (83-85)	74
Average (80-82)	9
Low (77-79)	0
Very Low (below 77)	0
GTEX = Strength (g/tex)	frequency
Very strong (>32)	127
Strong (30-32)	18
Base (26-29)	9
Weak (21-25)	0
Very weak (<20)	0
El = Elongation (%)	frequency
Very high (above 7.6)	6
High (6.8-7.6)	49
Average (5.9-6.7)	76
Low (5.0-5.8)	21
Very low (below 5)	2
MIC = fineness (mic)	frequency
high (>4.6)	68
ideal (3.8-4.6)	84
low (<3.8)	2

Table 10. Fiber quality descriptors for 154 germplasm lines of the USDA Shafter Cotton Collection

SA_NO	Length	Uniformity	Strength	Elongation	Micronaire
1956	1.01	83.3	33.6	7.5	4.3
1957	1.11	85.1	32.7	6.4	4.4
1958	1.08	84.2	32.5	7.2	4.4
1959	1.13	84.0	30.1	7.5	4.1
1960	1.11	85.7	37.2	6.5	4.6
1961	1.07	84.6	34.3	6.5	4.6
1962	1.09	85.2	36.9	6.7	4.7
1963	1.17	84.4	37.5	5.9	4.3
1964	1.16	85.3	33.9	5.8	4.4
1965	1.15	85.4	35.4	6.1	4.4
1966	1.12	86.0	35.6	5.4	4.9
1967	1.11	84.5	35.5	5.3	4.6
1968	1.20	84.4	31.1	8.1	3.8
1969	1.10	83.6	33.7	5.7	4.8
1970	1.17	85.8	35.5	5.7	4.6
1971	1.12	84.5	36.1	6.3	4.6
1973	1.12	84.2	33.1	6.9	4.3
1974	1.19	83.3	30.7	6.9	4.1
1975	1.04	83.1	33.8	6.1	4.9
1976	1.13	84.3	36.6	5.0	4.8
1977	1.15	84.4	32.7	7.1	4.1
1978	1.14	83.0	36.8	6.3	4.5
1979	1.16	85.7	37.1	6.1	4.5
1980	1.13	83.7	29.0	6.4	4.4
1981	1.18	84.1	33.8	7.3	4.4
1982	1.12	83.7	37.7	5.1	4.6
1983	1.26	86.7	34.7	7.2	4.0
1984	1.17	82.6	34.2	6.4	3.5
1985	1.08	84.2	30.4	7.2	4.3
1986	1.17	85.1	36.2	6.2	4.4
1987	1.10	85.4	33.9	7.0	4.8
1988	1.11	85.1	35.8	6.4	4.7
1989	1.17	84.6	38.6	7.7	4.0
1990	1.13	84.6	36.9	5.6	5.1
1991	1.16	84.0	33.4	6.1	4.5
1992	1.07	81.3	34.2	5.9	4.8
1993	1.18	82.6	31.4	7.3	4.0
1994	1.23	84.9	33.5	6.5	4.0
1995	1.10	83.3	28.5	6.7	4.5
1996	1.15	84.5	32.0	6.5	4.5
1997	1.07	84.6	36.1	6.4	5.0
1998	1.15	85.4	37.6	7.1	4.3
1999	1.12	86.4	35.6	6.8	5.0
2000	1.15	84.6	34.4	6.3	4.6
2001	1.12	85.6	29.9	5.5	4.6

Table 10. (continued)

SA_NO	Length	Uniformity	Strength	Elongation	Micronaire
2002	1.16	86.0	36.0	6.0	4.8
2003	1.02	84.3	31.0	5.7	4.8
2004	1.21	83.8	34.0	5.5	4.4
2005	1.16	85.0	34.2	6.4	4.4
2006	1.12	83.8	37.6	7.6	4.1
2007	1.09	85.1	37.0	6.7	4.2
2008	1.11	85.7	33.3	6.8	4.3
2009	1.16	85.2	37.5	5.7	4.9
2010	1.14	85.0	31.6	6.2	4.6
2011	1.10	83.9	29.8	5.7	4.5
2012	1.12	85.7	33.7	6.1	4.8
2013	1.14	85.3	37.5	6.6	4.8
2014	1.14	84.9	34.5	6.7	4.8
2015	1.12	85.1	37.8	6.3	4.6
2016	1.08	84.5	33.7	6.4	4.5
2017	1.03	83.5	29.9	7.3	4.8
2018	1.15	85.6	38.1	6.2	5.1
2019	1.14	85.3	38.0	6.4	4.6
2020	1.19	86.4	37.7	6.6	4.6
2021	1.18	85.8	36.1	7.5	4.7
2022	1.09	85.6	35.1	6.7	4.9
2023	1.12	84.3	35.1	6.6	4.6
2024	1.09	84.8	36.7	6.7	4.9
2025	1.16	85.7	35.9	7.0	4.7
2026	1.13	84.1	37.1	6.3	4.7
2027	1.05	82.6	31.7	7.2	4.8
2028	1.15	86.7	34.0	6.4	4.1
2029	1.11	84.2	32.7	7.5	4.8
2030	1.12	85.1	35.8	7.2	4.4
2031	1.07	85.5	36.2	6.9	4.2
2032	1.08	85.2	36.0	7.7	4.4
2033	1.09	85.2	36.9	6.7	4.7
2034	1.08	85.4	37.9	6.3	5.0
2035	1.07	85.2	38.4	5.9	4.9
2036	1.15	86.8	40.5	6.5	4.5
2037	1.12	84.3	34.4	7.3	4.9
2038	1.08	84.1	39.1	6.9	4.8
2039	1.15	85.2	38.7	6.3	4.6
2040	1.15	85.1	33.3	5.4	4.8
2041	1.11	81.5	35.1	5.8	4.3
2042	1.11	83.7	36.1	5.9	4.9
2043	1.10	85.3	35.4	6.6	4.7
2044	1.08	85.2	39.7	5.7	5.3
2045	1.14	87.3	38.6	6.2	4.5
2046	1.17	85.6	38.2	6.5	4.3

Table 10. (continued)

SA_NO	Length	Uniformity	Strength	Elongation	Micronaire
2047	1.07	85.1	38.2	5.8	5.1
2048	1.07	84.1	30.9	8.0	4.4
2049	1.19	85.1	38.5	5.4	4.5
2050	1.17	85.3	36.5	7.3	4.6
2051	1.12	83.2	31.2	7.1	4.3
2053	1.11	83.1	29.2	6.8	4.4
2054	1.10	84.2	30.9	7.2	4.3
2055	1.05	83.7	33.0	5.9	4.7
2056	1.13	83.5	32.3	6.4	4.4
2057	1.10	83.5	32.8	7.5	4.4
2058	1.14	85.7	29.8	6.3	4.3
2059	1.08	85.9	36.6	6.4	4.7
2060	1.13	84.0	34.8	7.1	4.8
2061	1.22	85.0	33.2	7.0	3.8
2062	1.08	83.7	34.3	7.2	3.8
2063	0.99	81.5	31.0	6.4	4.9
2064	1.13	83.5	29.9	7.3	3.5
2065	1.13	84.5	31.4	6.5	4.4
2066	1.13	84.4	33.7	6.1	4.4
2067	1.04	83.5	35.1	5.9	4.6
2068	1.13	85.4	34.0	7.5	4.1
2069	1.10	84.9	31.4	8.1	4.9
2070	1.13	83.5	33.5	7.3	4.6
2071	1.19	85.4	33.8	6.2	4.3
2072	1.12	83.8	34.8	7.2	4.6
2073	1.14	86.3	34.0	6.6	4.4
2074	1.10	85.0	34.4	7.0	4.7
2075	1.08	83.2	34.7	6.6	5.4
2078	1.08	85.0	37.3	6.3	5.1
2079	1.10	84.4	29.2	7.5	4.3
2080	1.12	82.9	30.8	6.7	4.3
2081	1.07	83.5	30.3	6.4	4.7
2082	1.10	85.6	34.3	5.7	5.4
2083	1.12	84.0	33.2	7.1	4.4
2084	1.04	83.0	30.9	6.7	4.5
2085	1.12	86.3	40.0	5.8	4.8
2086	1.16	84.1	32.6	6.6	4.7
2087	1.10	84.8	33.0	6.9	4.8
2088	1.10	84.0	32.8	7.2	3.8
2089	1.13	86.2	36.2	6.1	4.5
2090	1.14	85.4	36.8	6.1	4.8
2091	1.25	86.3	37.9	5.7	4.9
2092	1.17	84.4	35.3	8.4	5.6
2093	1.27	85.1	34.0	6.2	4.2
2094	1.09	84.5	37.6	7.2	4.9

Table 10. (continued)

SA_NO	Length	Uniformity	Strength	Elongation	Micronaire
2095	1.08	83.8	36.1	6.9	4.8
2096	1.07	85.8	37.3	7.2	5.4
2097	1.15	85.1	34.5	6.3	4.7
2098	1.14	86.5	35.9	6.7	4.7
2099	1.11	84.3	34.0	6.9	5.1
2100	1.16	86.5	36.1	6.5	4.8
2101	1.07	84.3	36.3	7.0	4.9
2102	1.04	84.5	38.1	6.2	5.5
2103	1.11	85.0	37.1	6.1	4.9
2104	1.12	85.4	34.3	7.1	4.8
2105	1.05	82.5	33.3	6.8	5.3
2106	1.14	83.1	35.9	5.8	5.0
2107	1.14	86.1	33.9	6.6	4.6
2108	1.18	85.3	38.0	4.9	5.1
2109	1.06	83.9	35.4	7.1	4.8
2110	1.13	85.2	36.6	6.7	4.6
2111	1.18	85.6	35.2	6.5	4.6
2112	1.18	82.4	33.6	6.0	4.3
2113	1.13	84.0	35.0	6.5	4.9
FM 958	1.16	84.89	33.32	5.32	4.93
Delta Pearl	1.19	84.21	31.68	5.69	4.99
PSC 355	1.11	84.76	33.28	8.23	5.23

Most of the germplasm lines evaluated, one hundred lines, were considered as having long fiber with an upper high mean (UHM) length between 1.11-1.26 inches including all the commercial checks. One germplasm line (SA 2093) had extra long fiber with UHM length of 1.27 inches. One germplasm line (SA 2063) had a short fiber length with an UHM of 0.99 inch.

Nearly all the germplasm lines evaluated, one hundred forty five, had high or very high fiber length uniformity (above 83%), including all the commercial checks. The remaining nine had an average fiber length uniformity of 80-82%. None of the germplasm lines had low fiber length uniformity. According to Kechagia and Harig (1998) length uniformity is more influenced by ginning rather than by variety or environment.

One hundred forty five germplasm lines had strong or very strong fiber, with their strength above 30 g/tex. Nine germplasm lines had a base strength of 26-29 g/tex. The commercial check, Delta Pearl, had strong fiber (31.68 g/tex) and the fiber of the other two commercial checks, FM 958 and PSC 355, were considered very strong with values of 33.32 and 33.28 g/tex, respectively. High fiber strength lines are desirable as Artzt (1998) and Suh *et al*. (1998) found that there is a direct correlation between fiber strength and yarn tenacity or yarn strength.

Fifty five germplasm lines had high or very high (above 6.8 %) fiber elongation, seventy six germplasm lines had an average fiber elongation between 5.9-6.7%, and twenty three had low or very low fiber elongation. The commercial checks, FM 958 and Delta Pearl, had low elongation values of 5.32 and 5.69 % respectively, and PSC 355 had a very high elongation value of 8.23 %. Kechagia and Harig, (1998) reported that fiber elongation is correlated with both micronaire and strength.

Eighty four germplasm lines had an ideal fineness of between 3.8-4.6 micronaire; sixty eight were high (above 4.6). None of the commercial checks had an ideal fineness, all were above the ideal range with values of 4.93, 4.99, and 5.23 mic for FM 958, Delta Pearl, and PSC 355, respectively. Allen (1998) reported that cotton with a micronaire value of 4.5 or greater is more desirable for use in nonwoven roll goods manufacturing since high micronaire cotton contains fewer neps or small bundles of entrangled fibers which result in unsightly appearing fabric; it is well documented that finer fibers (lower micronaire) are more prone to nep formation. The acceptable limits for parameters in ring and rotor spinning are given in Table 2.

Yield Parameters

Right before harvest 25 cotton bolls were collected by hand from each germplasm row, and the bolls were ginned and the seeds delinted. Yield parameters from these 25 boll samples are listed at Table 11, and those include: Boll weight (g/boll), lint percent, fuzzy seed weight (g), lint index (g), and clean seed or cottonseed wt (g).

Most of the germplasm lines bolls were heavier than those of the commercial checks, with the heaviest boll weight among the germplasm lines belonging to SA 2045 (Table 12) which weighed 8.1 grams per boll. Among the commercial checks, FM 958 had the heaviest bolls at 5.7 g.

The fraction (by weight) of the lint separated from a seedcotton sample by ginning is called lint percent, and it is a very important yield determining parameter. As can be seen in Table 13, the three commercial checks had the highest lint percent with values of 42.7%, 42.2%, and 42.1 % for Delta Pearl, PSC 355, and FM 958, respectively. SA 2063 and SA 2024 had the highest lint percent among the germplasm lines evaluated with values of 40.2%, and 40.1% respectively. These lint percent were obtained from ginning the cotton bolls with a 10 saw laboratory gin instead a commercial gin; lint percent from a commercial gin could drop few percentage points in relation to a lab lint percent, but any field lint % above 38-39 would be considered very good (Dr. Jack E. Jones, personal communication). The reason why the lint percent from cotton bolls harvested by hand and ginned with a laboratory gin lab are higher than the cotton harvested by machine and ginned in a commercial gin is because the cotton bolls harvested by hand are cleaner and do not undergo an additional stage of cleaning by passage through a lint cleaner. A heavy boll with bigger seeds does not necessarily produce a high lint percent, but generally a lighter boll with smaller seeds produces a higher lint percent. Most

Table 11. Cotton yield parameters at laboratory for 154 germplasm lines of the USDA Shafter Cotton Collection

SA_NO	Boll weight (g/boll)	Lint %	100 Seeds (g)		
			Fuzzy seed wt.	Lint index	Seed Wt.
1956	6.1	34.6	10.9	1.9	9.0
1957	6.5	36.9	12.4	2.1	10.3
1958	7.1	36.7	12.5	2.2	10.4
1959	5.6	32.5	12.2	1.6	10.6
1960	7.9	36.0	13.0	2.0	10.9
1961	7.6	37.0	12.2	2.2	9.9
1962	6.3	36.5	12.4	1.8	10.7
1963	6.3	31.9	14.2	1.1	13.2
1964	6.4	33.2	13.1	1.9	11.3
1965	7.7	34.2	14.7	1.9	12.9
1966	7.1	36.1	13.2	2.1	11.1
1967	6.6	37.7	13.4	1.5	11.9
1968	6.2	34.4	13.0	1.9	11.1
1969	5.4	34.5	12.3	1.7	10.6
1970	6.6	35.9	13.0	2.5	10.6
1971	6.7	34.1	13.2	2.3	10.9
1973	7.2	37.5	13.6	2.0	11.6
1974	5.9	33.2	12.3	1.8	10.5
1975	6.0	31.8	13.1	1.8	11.4
1976	6.6	36.6	14.0	2.5	11.6
1977	7.4	32.6	14.0	2.4	11.7
1978	4.9	34.2	12.1	1.7	10.5
1979	6.3	34.7	12.7	2.0	10.7
1980	7.0	36.7	13.8	2.1	11.7
1981	6.2	35.5	12.2	1.6	10.6
1982	5.5	34.4	11.5	1.5	9.9
1983	6.1	31.7	14.5	2.1	12.4
1984	5.6	29.3	12.2	1.5	10.8
1985	4.9	33.6	12.1	2.3	9.8
1986	5.7	35.7	13.9	2.3	11.6
1987	7.8	36.1	14.5	2.6	12.0
1988	6.9	35.4	15.5	2.6	12.9
1989	3.8	28.6	12.7	2.3	10.3
1990	6.6	36.8	13.3	2.2	11.2
1991	6.6	34.1	13.7	2.2	11.4
1992	6.5	37.2	13.6	1.8	11.8
1993	4.7	31.7	11.0	1.5	9.5
1994	5.7	32.0	13.3	1.4	11.9
1995	5.6	31.2	11.9	1.5	10.3
1996	6.7	36.1	13.6	1.5	12.1
1997	7.3	37.0	13.3	2.1	11.3
1998	6.5	38.9	12.7	2.0	10.7
1999	7.2	35.6	13.6	2.3	11.3
2000	6.4	35.8	11.8	1.7	10.1

Table 11. (continued)

SA_NO	Boll weight (g/boll)	Lint %	100 Seeds (g)		
			Fuzzy seed wt.	Lint index	Seed Wt.
2001	6.1	36.8	11.7	1.7	10.0
2002	6.1	36.3	12.4	2.2	10.2
2003	5.8	32.9	12.5	1.2	11.2
2004	6.7	31.3	13.7	2.2	11.4
2005	6.3	34.7	13.1	1.7	11.4
2006	6.3	35.6	12.3	2.0	10.3
2007	6.7	37.6	12.0	2.0	10.0
2008	6.9	37.2	12.6	1.9	10.7
2009	6.2	34.8	12.3	1.8	10.5
2010	5.7	35.7	12.1	1.5	10.5
2011	5.3	38.1	10.2	1.2	9.0
2012	6.9	36.2	13.7	2.3	11.4
2013	6.6	38.0	12.8	1.4	11.0
2014	6.3	36.5	13.7	1.9	11.8
2015	8.0	32.5	15.5	2.2	13.3
2016	6.7	33.0	13.2	1.9	11.3
2017	5.6	33.7	12.0	1.4	10.5
2018	6.5	35.0	14.3	2.2	12.0
2019	6.8	34.8	13.6	2.5	11.1
2020	7.4	34.6	13.4	2.2	11.1
2021	7.0	36.8	14.0	2.0	12.0
2022	6.4	38.1	12.4	1.4	11.0
2023	6.7	39.3	11.8	1.3	10.5
2024	7.0	40.1	12.6	1.7	11.0
2025	6.1	37.8	11.9	1.4	10.5
2026	6.0	36.2	12.4	1.7	10.8
2027	5.0	34.6	11.6	1.4	10.2
2028	6.6	32.8	13.6	1.8	11.7
2029	6.0	37.2	12.1	1.6	10.5
2030	7.3	36.9	13.3	2.3	11.0
2031	8.0	38.1	13.0	2.0	11.0
2032	7.1	35.8	14.2	2.9	11.3
2033	6.6	38.6	12.5	1.9	10.6
2034	6.6	38.6	13.0	1.8	11.2
2035	6.1	37.3	12.6	1.9	10.7
2036	6.3	36.5	11.5	1.5	10.1
2037	6.4	38.9	12.2	1.8	10.4
2038	6.3	36.2	11.9	1.5	10.4
2039	6.2	38.0	11.8	1.5	10.4
2040	5.9	35.8	12.1	1.7	10.5
2041	5.2	32.1	12.7	2.2	10.5
2042	6.7	37.2	13.1	2.1	11.1
2043	7.0	36.9	12.6	1.9	10.7
2044	6.6	35.6	14.0	1.7	12.3
2045	8.1	33.9	13.7	2.2	11.5

Table 11. (continued)

SA_NO	Boll weight (g/boll)	Lint %	100 Seeds (g)		
			Fuzzy seed wt.	Lint index	Seed Wt.
2046	6.8	34.1	14.2	2.5	11.7
2047	5.7	35.8	13.1	1.6	11.5
2048	7.0	37.8	12.3	1.7	10.6
2049	4.9	37.1	12.1	1.4	10.7
2050	6.6	35.2	11.6	1.6	10.0
2051	6.5	38.8	12.4	2.0	10.5
2053	5.3	35.6	11.4	1.3	10.1
2054	5.6	34.8	11.6	1.1	10.4
2055	5.9	36.6	12.5	1.9	10.6
2056	5.9	35.9	11.4	1.3	10.1
2057	6.0	35.8	12.6	1.5	11.1
2058	5.5	35.2	11.9	1.7	10.1
2059	6.4	34.7	12.7	1.8	10.8
2060	6.0	36.7	12.2	1.4	10.8
2061	6.3	36.8	11.3	1.5	9.7
2062	6.0	34.9	11.5	1.8	9.7
2063	4.7	40.2	9.0	1.3	7.7
2064	5.4	35.6	11.4	1.7	9.8
2065	5.8	34.2	11.7	1.8	10.0
2066	5.4	33.6	12.4	2.3	10.2
2067	6.4	35.7	12.8	1.9	10.8
2068	6.0	32.8	12.3	1.7	10.6
2069	5.8	35.7	12.5	2.2	10.4
2070	5.9	36.5	12.7	1.9	10.8
2071	5.8	33.4	12.2	1.6	10.7
2072	5.7	36.5	11.7	1.5	10.2
2073	5.5	35.1	11.6	1.6	9.9
2074	4.9	36.8	11.6	1.8	9.8
2075	4.1	23.9	11.4	0.9	10.5
2078	6.3	35.8	12.9	1.6	11.3
2079	4.7	31.1	9.9	1.3	8.6
2080	5.7	35.0	12.2	1.5	10.6
2081	4.5	38.8	10.0	1.4	8.6
2082	6.2	34.0	14.3	2.4	11.9
2083	5.8	32.2	11.8	1.9	9.9
2084	6.0	34.5	11.6	1.7	9.8
2085	6.2	37.1	13.3	2.1	11.2
2086	4.6	39.2	9.6	1.9	7.7
2087	5.2	36.2	10.6	2.0	8.6
2088	4.0	25.6	10.1	1.1	9.0
2089	5.5	35.3	11.7	1.7	10.0
2090	5.1	36.4	12.2	1.3	10.8
2091	5.7	37.6	11.9	1.5	10.4
2092	5.9	33.3	10.8	1.4	9.4

Table 11. (continued)

SA_NO	Boll weight (g/boll)	Lint %	100 Seeds (g)		
			Fuzzy seed wt.	Lint index	Seed Wt.
2093	7.5	37.5	13.7	2.1	11.6
2094	6.6	38.6	12.6	1.9	10.8
2095	6.7	36.6	13.3	2.4	10.9
2096	5.9	37.2	12.5	2.0	10.5
2097	6.9	36.0	13.5	2.3	11.2
2098	6.1	38.2	13.2	1.7	11.5
2099	6.2	37.1	13.2	2.2	11.0
2100	6.5	37.6	12.8	2.1	10.8
2101	6.1	35.1	12.6	1.4	11.2
2102	6.3	35.4	12.4	1.5	10.8
2103	6.5	35.7	13.2	2.1	11.2
2104	7.1	38.2	12.5	1.6	10.9
2105	5.7	34.6	12.8	1.8	11.0
2106	6.3	35.6	13.7	2.1	11.6
2107	5.9	35.7	12.5	1.5	11.0
2108	6.5	33.4	13.9	2.2	11.7
2109	7.2	38.6	13.2	2.0	11.2
2110	6.6	38.1	12.7	2.4	10.3
2111	5.7	34.8	12.3	1.9	10.4
2112	5.2	33.6	11.1	1.6	9.5
2113	6.9	35.8	12.7	2.1	10.6
FM 958	5.7	42.1	11.3	1.4	9.9
D.PEARL	4.9	42.7	9.2	1.3	7.9
PSC 355	4.8	42.2	10.1	1.3	8.8

cotton breeding programs want to have plants that bear heavy bolls with high lint percent, which could translate into higher lint yields.

After ginning the cotton bolls in the lab, a total of 100 seeds of each germplasm were weighed before and after delinting. Before delinting weight measurements allow the calculation of fuzzy seed weight, and there were many germplasms lines with heavier fuzzy seed weights (Table 14) than the commercial checks. The difference in weight between fuzzy seed (seedcotton) and clean seed (cottonseed) is called lint index, which is the weight of the lint that is still attached to the seed after ginning and before it is fire or acid delinted. The lint index for the commercial checks (Table 15) was low with 1.4, 1.3, and 1.3 g for FM 958, PSC 355, and Delta Pearl, respectively. Most of the germplasm lines evaluated had a relatively high lint index and the germplasm line, SA 2032, had a lint index of 2.9 gr. There were many germplasm lines with a lower lint index than the commercial checks and the germplasm, SA 2075, had the lowest lint index (0.9 gr.), but this germplasm line has naked seed, which means that the seed cannot keep the lint attached to it. There has not been a clear use so far for the lint attached to the seed or lint index; therefore, it is better to have a lower lint index, because this leads to an increase in the lint percent of the cotton harvested; increasing in this way the lint production.

Table 12. Top 10 heaviest boll weights for 154 germplasm lines of the USDA Shafter Cotton Collection

SA_NO	**Boll weight (g/boll)**	**Lint %**
2045	**8.1**	33.9
2015	**8.0**	32.5
2031	**8.0**	38.1
1960	**7.9**	36.0
1987	**7.8**	36.1
1965	**7.7**	34.2
1961	**7.6**	37.0
2093	**7.5**	37.5
1977	**7.4**	32.6
2020	**7.4**	34.6
FM 958	**5.7**	42.1
D.PEARL	**4.9**	42.7
PSC 355	**4.8**	42.2

Table 13. Top 10 lint percent for 154 germplasm lines of the USDA Shafter Cotton Collection

SA_NO	Lint %	Boll weight (g/boll)
D.PEARL	**42.7**	4.9
PSC 355	**42.2**	4.8
FM 958	**42.1**	5.7
2063	**40.2**	4.7
2024	**40.1**	7.0
2023	**39.3**	6.7
2086	**39.2**	4.6
1998	**38.9**	6.5
2037	**38.9**	6.4
2051	**38.8**	6.5
2081	**38.8**	4.5
2094	**38.6**	6.6
2033	**38.6**	6.6

Table 14. Top 10 fuzzy seed (g/100seeds) for 154 germplasm lines of the USDA Shafter Cotton Collection

SA_NO	Fuzzy seed wt.	Lint index	Cottonseed wt.
2015	**15.5**	2.2	13.3
1988	**15.5**	2.6	12.9
1965	**14.7**	1.9	12.9
1987	**14.5**	2.6	12.0
1983	**14.5**	2.1	12.4
2082	**14.3**	2.4	11.9
2018	**14.3**	2.2	12.0
1963	**14.2**	1.1	13.2
2032	**14.2**	2.9	11.3
2046	**14.2**	2.5	11.7
FM 958	**11.3**	1.4	9.9
PSC 355	**10.1**	1.3	8.8
D.PEARL	**9.2**	1.3	7.9

Table 15. Bottom 10 lint index (g/100 seeds) for 154 germplasm lines of the USDA Shafter Cotton Collection

SA_NO	Lint index	Fuzzy seed wt.	Cottonseed wt.
2075	**0.9**	11.4	10.5
2088	**1.1**	10.1	9.0
2054	**1.1**	11.6	10.5
1963	**1.1**	14.2	13.1
2011	**1.2**	10.2	9.0
2003	**1.2**	12.5	11.3
2063	**1.3**	9.0	7.7
D.PEARL	**1.3**	9.2	7.9
PSC 355	**1.3**	10.1	8.8
2053	**1.3**	11.4	10.1
2056	**1.3**	11.4	10.1
2023	**1.3**	11.8	10.5
FM 958	**1.4**	11.3	9.9

There were many germplasm lines with heavier clean seeds (Table 16) than the commercial checks. It is preferred for a cotton breeder to have a germplasm with heavy bolls, high lint percent, light or small cottonseeds and low lint index, which could translate into higher lint yields.

Yield was analyzed according to the modified augmented design-2 subroutine of Agrobase Generation II. Adjusted mean lint yield for the control plot entry, PSC 355, was 1480 pounds per acre (Table 17). Significant main plot effects were found but subplots effects were not significant (Table 18). Control subplots adjusted means were 1554 and 1181 lbs acre^{-1} for Delta Pearl and FM 958, respectively. Eleven germplasms had adjusted mean yields that were within 10% of the control plot or subplot entry mean yields, above 1264 lbs acre^{-1} (Table 19).

There were two germplasm lines, SA 2046 and SA 2051, which had an adjusted negative yield; this is because their single rows did not produce above the adjustment mean of their subplot.

Table 16. Top 10 cottonseed wt (g/100 seeds) for 154 germplasm lines of the USDA Shafter Cotton Collection

SA_NO	**Cottonseed wt.**	**Fuzzy seed wt.**	**Lint index**
2015	**13.3**	15.5	2.2
1963	**13.2**	14.2	1.1
1988	**12.9**	15.5	2.6
1965	**12.9**	14.7	1.9
1983	**12.4**	14.5	2.1
2044	**12.3**	14.0	1.7
1996	**12.1**	13.6	1.5
2018	**12.0**	14.3	2.2
2021	**12.0**	14.0	2.0
1987	**12.0**	14.5	2.6
FM 958	**9.9**	11.3	1.4
PSC 355	**8.8**	10.1	1.3
D.PEARL	**7.9**	9.2	1.3

Table 17. Cotton yields (lbs $acre^{-1}$) for 154 germplasm lines of the USDA Shafter Cotton Collection

SA_NO	Adjusted	Unadjusted
1956	523	156
1957	1203	836
1958	794	427
1959	892	525
1960	1439	1072
1961	1635	1269
1962	1477	1085
1963	887	496
1964	1337	945
1965	1342	951
1966	1256	864
1967	1317	926
1968	732	467
1969	1024	759
1970	985	720
1971	1080	816
1973	1113	849
1974	651	387
1975	928	638
1976	859	569
1977	1260	971
1978	511	221
1979	940	650
1980	1026	737
1981	629	689
1982	807	867
1983	330	390
1984	548	607
1985	484	544
1986	495	555
1987	568	653
1988	853	938
1989	303	388
1990	843	928
1991	664	749
1992	541	626
1993	678	636
1994	415	373
1995	485	443
1996	1022	980
1997	1310	1268
1998	823	781
1999	963	921
2000	1061	1019
2001	1089	1072

Table 17. (continued)

SA_NO	Adjusted	Unadjusted
2002	1401	1384
2003	806	789
2004	705	688
2005	399	381
2006	408	391
2007	662	729
2008	511	578
2009	564	631
2010	718	785
2011	1019	1086
2012	801	867
2013	647	689
2014	501	543
2015	736	778
2016	684	726
2017	655	697
2018	705	748
2019	665	834
2020	569	738
2021	403	572
2022	571	740
2023	975	1144
2024	869	1038
2025	859	1028
2026	627	796
2027	728	872
2028	534	678
2029	1011	1155
2030	668	812
2031	743	887
2032	458	602
2033	303	799
2034	203	699
2035	372	868
2036	661	1157
2037	939	1435
2038	464	960
2039	94	590
2040	429	925
2041	60	582
2042	732	1253
2043	243	764
2044	286	807
2045	116	637
2046	-58	463

Table 17. (continued)

SA_NO	Adjusted	Unadjusted
2047	46	440
2048	46	440
2049	782	1176
2050	746	1140
2051	-93	301
2053	366	760
2054	395	789
2055	8	403
2056	278	697
2057	300	719
2058	105	524
2059	412	831
2060	151	570
2061	390	809
2062	1096	768
2063	1083	755
2064	697	368
2065	1213	885
2066	1024	695
2067	1045	716
2068	947	594
2069	1162	809
2070	897	543
2071	1046	693
2072	1037	684
2073	966	612
2074	608	381
2075	489	262
2078	737	510
2079	750	523
2080	950	724
2081	1280	1053
2082	1086	859
2083	810	583
2084	855	604
2085	804	552
2086	962	710
2087	1353	1101
2088	682	430
2089	1119	867
2090	417	165
2091	909	657
2092	230	302
2093	388	461
2094	877	949

Table 17. (continued)

SA_NO	Adjusted	Unadjusted
2095	781	853
2096	602	674
2097	1161	1233
2098	471	569
2099	1342	1439
2100	706	803
2101	743	840
2102	1231	1328
2103	710	808
2104	648	618
2105	1081	1052
2106	1021	991
2107	469	439
2108	1109	1080
2109	803	773
2110	1064	1060
2111	904	900
2112	505	500
2113	930	925
FM 958	1181	
Delta Pearl	1554	
PSC 355	1480	

Table 18. Anova for the yield for 154 germplasm lines of the USDA Shafter Cotton Collection

Sources	df	SS	MS	F-Value	Pr>F
Total	23	2947189.36			
Rows	5	1656014.891	331202.978	4.05	0.0158
Columns	3	65896.528	21965.509	0.27	0.8468
Residual	15	1225277.941	81685.196		

Grand Mean = 1693.259
R-squared = 0.9723
C.V. = 16.88%

Table 19. Germplasm lines with yield within 10% of the check average

SA_No	Lbs acre^{-1}
1961	1635
1962	1477
1960	1439
2002	1401
2087	1353
1965	1342
2099	1342
1964	1337
1967	1317
1997	1310
2081	1280
D.PEARL	1554
PSC355	1480
FM958	1181

SUMMARY AND CONCLUSIONS

Constant evaluation and characterization of the existent, yet uncharacterized germplasm is useful, and it is many times the cornerstone for the development of new and better varieties. Evaluating the cotton germplasm lines from the discontinued USDA breeding program in Shafter, California, found that many of these germplasm lines have desirable agronomic and fiber characteristics traits that could be used to introduce variability in the development of new breeding populations.

A majority of the lines were similar to the commercial checks for all the agronomic descriptors, but there were a few germplasm lines that could help any cotton breeding program aimed at pest resistance to develop new cotton varieties resistant or tolerant to piercing and sucking insects. There were five germplasm line evaluated (SA 2012, 2013, 2037, 2074, and 2110) that graded as glandless, which could be used in animal feeding because they might have a low gossypol concentration in their seeds. SA 2085 could be used to reduce insect damage since it was nectariless. There were 26 germplasm lines graded as having smooth leaves which could be used to reduce the attack of bollworms and give cleaner lint at harvest (Table 6). Eleven germplasm lines had yields within 10 % of the commercial checks average, with the top three highest yielding germplasm lines being SA 1961, 1962 and 1960, yielding 1635, 1477, and 1439 lbs acre^{-1}, respectively.

There was not an Acala type germplasm among this subset evaluated; nevertheless, this material as a whole had superior fiber quality characteristics compared to the commercial checks and with regards to USDA classing grades. A total of 66 % of the Shafter Collection cotton evaluated had long fiber and the top three were SA 2093, 1983, and 2091, with 1.27, 1.26, and 1.25 UHM (inches), respectively. A majority (82%) of the Shafter Collection had very strong fiber and the top three were SA 2036, 2085, and 2044, with 40.5, 40.0, and 39.7 G/tex, respectively. Six germplasm lines had very high elongation and they were SA 2092, 1968, 2069, 2048, 1989, and 2032 with 8.4, 8.1, 8.1, 8.0, 7.7, and 7.7 % respectively. Over a half of the Shafter Collection cotton evaluated (55 %) had fine micronaire of between 3.8 and 4.6 mic.

In summary, these recent additions to the US Cotton Germplasm Collection present a valuable resource for improving cotton varieties with resistance to insects, better yield and fiber quality.

REFERENCES

1. Agrobase Generation II, 2004. Agronomix Software, Inc. Winnipeg, Canada.

2. Allan, H. C., 1998. Preparing Cotton, Web Forming and Bonding Methods for Cotton nonwovens. *In* P. Dugger and D. Richter (ed) Proc. Beltwide Cotton Production Research Conference, San Diego, CA. 5-9 Jan. National Cotton Council of America, Memphis, TN.

3. American Cotton Producers. 1999. Report of the American Cotton Producers Blue Ribbon Yield Committee. 7pp.

4. Artzt, P., 1998. Quickspin-Method-A praxis-Proved Method for Qualification of Raw Material. *In* P. Dugger and D. Richter (ed) Proc. Beltwide Cotton Production Research Conference, San Diego, CA. 5-9 Jan. National Cotton Council of America, Memphis, TN.

5. Bottger, G. T., Sheehan, E. T., and Lukefahr, M. J., 1964. Relation of Gossypol Content of Cotton Plants to Insect Resistance. Volume 57, No. 2, p 283-285. Journal of Economic Entomology.

6. Calhoun, D. S., 1997. Inheritance of High Glanding, an Insect Resistance Trait in Cotton. Volume 37, No. 4, p 1181-1186. Crop Science.

7. Clouvel, P., Goze, E., Sequeira, R., Dusserre, J., and Cretener, M., 1998. Variability of Cotton Fiber Quality. Proc World Cotton Research Conference 2, "New Frontiers in Cotton Research" 6-12 Sept. Athens, Greece.

8. Fish, D. A., Earl, H. J., 2003. Screening Cotton Germplasm for Variation in Water use Efficiency and Epidermal Conductance. *In* Proc. Beltwide Cotton Production Research Conference, Nashville, TN. 6-10 Jan. National Cotton Council of America, Memphis, TN.

9. Green, C. C. 2002. D&PL Global Advanced Testing Program Genetic Diversity, Efficiency. *In* Proc. Beltwide Cotton Production Research Conference, Atlanta, GA. 8-12 Jan. National Cotton Council of America, Memphis, TN.

10. Hyer, A. H., and Bassett, D. M., 1985. Acala cotton in California: a historical perpective. p. 74-75. *In* J.M. Brown (ed) Proc. Beltwide Cotton Production Research Conference, New Orleans, LA. 6-11 Jan. National Cotton Council of America, Memphis, TN.

11. Jones, J. E., Sloane, L.W., and Major, A. J., 1971. Isogenic Studies of D_2 Smoothness in Upland Cotton. Proc Beltwide Cotton Production Research Conference.

12. Jones, J. E., and Andries, J. A., 1969. Effect of Frego Bract on the Incidence of Cotton Boll Rot. Volume 9, No 4, p 426 - 428. Crop Science.

13. Jones, J. E., Williams, J. W., Brand, J. W., Clower, D. F., and Bowman, D. T., 1978. Interaction Effects of the Okra Leaf, Frego Bract and Glabrous Traits on Pest Resistance and Agronomic Characters. Proc Beltwide Cotton Production Research Conference.

14. Kechagia, U. E., and Harig, H. 1998. New Perspectives in Improving Cotton Fiber Quality and Precessing Efficiency. Proc World Cotton Research Conference 2, "New Frontiers in Cotton Research" 6-12 Sept. Athens, Greece.

15. Khan, M. A., Myers, G. O., and Stewart, J. McD. 2002. Molecular Markers, Genomics, and Cotton Improvement, p. 253-284. In M. S. Kang, CROP IMPROVEMENT, Challenges in the Twenty-First Century.

16. Kohel, R. J., and Lewis, C. F., 1984. COTTON. Agronomy No 24. American Society of Agronomy, Inc., Crop Science Society of America, Inc., Soil Science Society of America, Inc. Madison, Wisconsin.

17. Ledge, K. E., Smith C. W., and Cothren, J. T., 1992. Genotypic and Cultural Effects on Condensed Tannin Concentration of Cotton Leaves. Volume 32, No. 4, p. 1024 – 1028. Crop Science.

18. Louisiana Farm Reporter. 2002. Vol 2:24. Dec. 17, 2002. Louisiana Agriculture Statistics Service, Baton Rouge, LA.

19. McCarty, J. C., Meredith, W. R., Jenkins, J. N., Parrot, W. L., Bailey, J. C., 1983. Genotype X Environmental Interaction of Cottons Varying in Insect Resistance. Volume 23, No. 5, p. 970-973. Crop Science.

20. Meredith, W. R., 1991. Contributions of Introductions to Cotton Improvement, p. 127 - 146. *In* H. L. Shands and L. E. Wiesner (ed) Proc. Use of Plant Introductions in Cultivar Development Part I. Las Vegas, Nevada, 1989. Crop Science Society of America, Inc. Madison, Wisconsin.

21. Percival, A. E., 1987. The National Collection of *Gossypium* Germplasm. Southern Cooperative Series Bulletin No. 321. College Station, Texas.

22. Poehlman, J. M. and Sleper, D. A. 1995. Breeding Field Crops. Iowa State University Press. Ames, Iowa.

23. Smith C. W. and Cothren J. T. 1999. Cotton: Origin, History, Technology and Production. John Wiley & Son, Inc. New York.

24. Stoskopf, N. C., Tomes, D. T., and Christie, B. R., 1993. Plant Breeding, Theory and Practice. Westview Press, Inc. Colorado.

25. Suh, M. W., Koo, H. J., and Cui, X., 1998. Prediction of Yarn Tensile Properties Based on HVI Testing of 36 U.S. Upland Cottons. *In* P. Dugger and D. Richter (ed) Proc. Beltwide Cotton Production Research Conference, San Diego, CA. 5-9 Jan. National Cotton Council of America, Memphis, TN.

26. West, J., Smith, C. W., and Thaxton, P. 2004. Screening Upland Cotton for Resistance to *Rhizoctonia solani*: Methodology and Results. *In* Proc. Beltwide Cotton Production Research Conference, San Antonio, TX. 5-9 Jan. National Cotton Council of America, Memphis, TN.

27. Wilson, F. D., and Shepherd, R. L. 1987. Plant Pubescence, Genetic Background, and Seasonal Effects on Agronomic and Fiber Properties of Upland Cotton. Volume 27 No. 5 p. 865 – 868. Crop Science.

28. Young, L., D., Stetina S., R., and Meredith, W., R. 2004. Development of Cotton Germplasm with Resistance to Reniform Nematode. *In* Proc. Beltwide Cotton Production Research Conference, San Antonio, TX. 5-9 Jan. National Cotton Council of America, Memphis, TN.

VITA

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