2255 Direction of Cotton Breeding in Argentina

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Direction of Cotton Breeding in Argentina

Abstract

The cotton breeding program of INTA (National Institute for Agricultural and Livestock Technology) has been ongoing for almost 50 years in Argentina. During this time, lint yields and quality were steadily improved, and genetic resistance to important diseases like bacterial blight, blue disease, and fusarium wilt was incorporated into many cultivars. Breeding is carried out utilizing the classical Pedigree method, and after initial crossings, selections, and evaluations at the Agricultural Experimental Station of Saenz Peña, trials are conducted at different localities of the cotton region in dryland and irrigated areas. Data from regional comparisons of cultivars and promising lines are presented. They include three crop seasons (2003/2004; 2004/2005 and 2005/2006) and four localities (Saenz Peña, El Colorado, Reconquista and Santiago del Estero). Trials were grown as completely randomized block design with four replications and data from cottonseed yield, gin turnout, and High Volume Instrument (HVI) fiber technological parameters, which includes fiber length, fiber length uniformity, fiber strength, elongation and micronaire index, are reported. All selected genotypes are compared to current commercial cultivars. Cultivar Guazuncho 3 INTA and line SP 33950 SN perform outstandingly in fiber length, uniformity and strength, and also show high gin turnout values and lint yields compared with other cultivars. Some cultivars were developed for specific conditions, like Oroblanco 2 INTA which is an okra-leaf type and La Banda 300 INTA for the irrigated area.

Keywords: Argentina, breeding, INTA

Introduction

A cotton breeding program began in Argentina with the foundation of the Instituto Nacional de Tecnología Agropecuaria (INTA) (National Institute of Agricultural and Livestock Technology) after 1956, when the first national cultivar called SP Toba INTA was developed from crossings of different cultivars introduced from the United States of America (Stoneville and Deltapine germplasm). Before that, early in the twentieth century, only cultivars or selections of natural crossings of many different foreign cultivars, mainly from the different cotton growing regions of the USA, were grown. Those were heterogenic populations called "tipo Chaco." After 1969 many trispecific hybrid derived lines were used in the program which were developed by the French IRCT in the Ivory Coast (Africa) and broadly called H.A.R germplasm (*Gossypium hirsutum* x *G. arboreum* x *G. raimondii*). With these new genotypes incorporated into the program of crossings and selections, increases in fiber yield but mainly in fiber quality, earliness and boll size were obtained, resulting in the cultivar Chaco 510 INTA (Poisson 2002). Great improvements in yield were reached when the high yielding cultivar Reba P 279 from Paraguay was used after 1974 in the breeding program and cultivars Guazuncho INTA, Pora INTA, and Quebracho INTA were released and grown since 1983.

Relative to the development of disease-resistant cultivars, Saenz Peña M 58 is considered the first cultivar resistant to fusarium wilt (caused by *Fusarium oxysporum* f. sp**.** *vasinfectum*) in Argentina (late 1950s), and in 1967 Guaycuru INTA followed. In 1975, Mocovi INTA was released which had resistance to fusarium wilt and bacterial blight (caused by *Xanthomonas axonopodis* pv. *malvacearum*). In 1982 Mataco INTA

replaced Mocovi INTA, which in turn was replaced by Cacique INTA in 1994 which was also resistant to blue disease. Guazuncho 2 INTA (after 1989) replaced Guazuncho INTA and had good improvements in gin turnout and yield. After 1999 the first okra-leaf cultivar of Argentina, Oroblanco INTA, was develop to reduce boll rot at the end of the cropping season (Poisson 2003). All of these cultivars were developed at the Agricultural Experiment Station (AES) at Saenz Peña.

The general objectives of the breeding program are to obtain and promote the plantation of improved cultivars in yield and fiber quality adapted to the different regions where cotton is grown in the country (nine provinces), thus aiming at improving profits for the primary production sector and trying to satisfy the requirements of the textile industry (Poisson 2006). Trial design and development of new germplasm through an annual program of crossings are carried out at the AES of Saenz Pena in the province of Chaco, where 60 % of the country's cotton hectareage is grown.

Also at this AES, the regional genebank of INTA has its cotton collection where accessions are characterized, evaluated, documented, and preserved. Here the genetic variability available and/or recently introduced is stored and available to breeders for initiating new programs. Discarded or obsolete breeding lines possessing genetic resistance to certain diseases, good fiber quality, and/or fiber yield, are preserved and available in the future when searching for a newly desired feature (Royo 2006, 2003a, 2003b).

Supporting breeding descriptors required for registration of the new breeders` lines in the national register of cultivars in the Instituto Nacional de Semillas (INASE) (National Seed Institute) are recorded routinely by AES breeders. Promising lines are tested in three crop years and data recorded include phenology (periods and rates of floral development, of boll maturation), levels of production, lint turnout, and fiber

technological properties by planting dates. The new cultivars are tested in plant density trials in the environments where they are recommended.

Specific objectives of the program are:

- improve cottonseed yield;
- increase gin turnout;
- improve the fiber profile, specifically increase fiber strength and length, and maintain micronaire in the range of 3.8 to 4.2;
- keep or even decrease crop cycle (currently 130 to 140 days in shorter cycle cultivars) without decreasing yield potential;
- disease resistance:
    - blue disease (viral),
    - bacteria blight (*Xanthomonas axonopodis* pv. *malvacearum),*
    - fusarium wilt (*Fusarium oxysporum* f. sp**.** *vasinfectum),*
    - ramulosis or witches' broom (*Colletotrichum gossypii* var. *cephalosporioides),*
    - verticillium wilt (*Verticillium dahliae);*
    - leaf spot (*Alternaria macrospora).*

From 1988 to 1995 and from 1995 to 2000 two joint ventures of INTA with private seed companies, the first including participation of the textile companies, initiated a program of genotypic evaluations at more than 30 localities. After 2000, the program has been supported by INTA and the number of localities of trials has been reduced to 15. In the 1990s a joint venture with Monsanto was initiated to incorporate the Bt and

RR transgenic traits to six INTA cultivars and the cultivar Guazuncho 2000, which is resistant to glyfosate, resulted from that effort.

Materials and Methods

The Argentine breeding program follows the classical Pedigree method as outlined in numerous publications (Allard 1960; Poisson 2005) where after an initial cross of two different genotypes, the following generations are selfed and individual plant and progeny row selections are carried out from the F2 to the F6 or F7 generations. From the F4 generation onward in our program, the seeds not selfed are collected to carry out replicated evaluation trials. In the AES Sáenz Peña the germplasm lines are evaluated until the F6 generation, with previous generations inoculated with the pathogens causing bacterial blight and infected as possible with aphids which vector is the virus causing blue disease. After the F7 generation, selected lines are evaluated at four additional localities: El Colorado, Reconquista, Colonia Benítez (dryland); and Santiago del Estero (irrigated). Current commercial cultivars are used in all trials for comparison purposes.

Data from our regional comparative cultivars and advanced lines trials of INTA are presented below from three crop years (2003/2004; 2004/2005 and 2005/2006) and four localities of the cotton growing Argentinean regions, and including 16 genotypes (six current cultivars and 10 advanced breeder´s lines) (Table 1). Trials were planted as a randomized complete block design with four replications in plots of two rows, 10 m long. Plants were separated at a distance of 10 cm in the row and at one m between rows. Bolls were hand-picked in each plot to determine yield.

In order to evaluate differences in lint yield and quality among cultivars and lines, and years and localities, and also to evaluate the interactions between treatments

and years, and between treatments and localities, and the interaction among the three variables, the following statistical model was used:

$$y_{ijk} = \mu + \alpha_i + \lambda_j + \tau_k + \alpha\tau + \lambda\tau_{ij} + \alpha\lambda\tau_{ijk} + \varepsilon_{ijk}$$

y_{ijk} is lint yield

$\mu =$ general average

$\alpha_i = locality_i$ i = 4 (Saenz Peña, El Colorado, Reconquista, Santiago del Estero)

$\lambda_j = year_j$ j = 3 (2003/2004, 2004/2005 and 2005/2006)

$\tau_k = treatment_k$ K = 16 (Table Nº 1)

In addition to lint yield data, fiber length, length uniformity, fiber strength, fiber elongation, and micronaire index are reported below. HVI data were determined from five replications of lint per row from a 25-boll sample taken from the middle of the plants in each row.

For some variables that did not show homocedasticity and normal distribution, a logarithmic conversion was utilized to normalize the data before analysis. Data were analysed using the software InfoStat 2006 developed at the Facultad de Ciencias Agropecuarias de la Universidad Nacional de Córdoba. Means were separated by Duncan Multiple Range.

Results and discussion

Table 2 shows lint yield and quality data for six current cultivars and one promising line for the last three crop seasons across four localities (one irrigated). Oroblanco 2 INTA has low lint yields compared with the other genotypes in spite of having the highest gin turnout value, but as described later in this section it was developed for specific conditions. Guazuncho 3 INTA and line SP 33950 performed outstandingly for fiber length, fiber length uniformity, and strength, and also for gin turnout and lint yield compared with the other cultivars. Chaco 530 INTA had the best fiber length but also had the lowest gin turnout value and poor yield performance, although better than Oroblanco 2 INTA.

Lint yields and quality of six current cultivars and 10 promising lines grown in 2005/06, and 2004/2005, are shown in Tables 4 and 6, respectively. Both experiments were grown in four localities with four replications each. In 2005/06 the lines SP 48114, SP 33950 SN, SP 4504 and SP 48806 outperformed the others in lint yield. For lint turnout SP 82884 SN was the best, and for both fiber length and strength, cultivars Guazuncho 3 INTA and Chaco 530 INTA, and line SP 33950 SN had the highest values. In the year 2004/2005 lines SP 82884, SP 48114, SP 49101, SP 31646 and cultivar Guazuncho 3 INTA had the highest lint yields. Cacique INTA was the best for lint turnout. For fiber length, Chaco 530 INTA, SP 49101, and SP 33950 SN had the longest fibers, while Guazuncho 3 INTA, SP 33950 SN and La Banda 300 had the strongest fiber bundle strength.

In Tables 3, 5 and 7, the effects and interactions of the variables in Tables 2, 4, and 6, respectively, are shown. For most, the effects are significant, although in Table 2 the interaction year*cultivar/line is not significant for lint yield, so cultivars and lines behaved the same independently from the year. In the year 2004/2005 for lint yield the

effects of cultivars and lines and of localities were not significant, nor were that of the interactions. In the crop season 2005/2006, at Sáenz Peña and Reconquista, there were strong droughts and very high temperatures (45-46 ºC) (Poisson 2006), probably influencing the effects and interactions of the variables studied.

Two new cultivars will be registered in the near future, SP 33950 and SP 31915 FM. The first will replace cultivar Pora INTA, with substantially improved fiber quality, in particular fiber strength, and lower micronaire index to the desired range between 3.8 and 4.2. It maintains agronomic characteristics like good boll opening, resistance to shattering, and maintaining fiber color when harvest must be delayed. Also, it is nectariless in leaves and so diminishes insect oviposition. SP 31915 FM has brown-coloured lint and although fiber length and strength are not good, this cultivar is it to be utilized by small growers of various cotton producing provinces and to be grown organically. Line SP 48114 has high resistance to fusarium and will probably replace cultivar Cacique INTA. It has improved fiber quality and yield, and maintains resistance to blue disease and bacterial blight.

Some cultivars are adapted to very specific conditions, showing interaction with the environment for some traits. Cultivar La Banda 300 was selected for the irrigated region (Santiago del Estero) where it displays high lint yield and quality. Oroblanco 2 INTA replaced cultivar Oroblanco (both okra-leaves types) improving lint yield, gin turnout, and fiber quality, specially fiber strength, combined with earliness. It is recommended in good fertile soils like deforested lands or irrigated soils with fertilization and for narrow and ultranarrow row systems. The okra leaves reduce boll rot of lower set bolls.

Conclusion

INTA has developed and maintained a cotton breeding program for the past 50 years in Argentina that has given rise to a number of popular cultivars, constantly improved lint yields and quality properties, and conferred disease resistance to most of the economically damaging diseases. From SP Toba INTA to our current cultivars, lint yields have doubled. In all these years, INTA´s cultivars were grown on a high percent of the hectares devoted to cotton (more than 70 % and sometimes reaching close to 100 %). Currently, INTA´s breeding program needs to incorporate transgenic traits providing resistance to insects and to herbicides and is in the process of negotiation with different companies and institutes. Recently, with Guazuncho 2000, where INTA only receives a low percentage of royalty, growers turned to this transgenic cultivar and the hectareage with non-transgenic cultivars has diminished considerably.

In recent years at INTA, some researchers have started looking at using molecular markers to characterize a part of the cotton collection and trying to follow the segregation of genetic resistance/susceptibility to blue disease and bacterial blight, but the program is only in its beginnings. Also, a program of induced mutation through chemical and physical means is underway searching for changes in plant architecture and resistance to certain herbicides (Jaureguialzo 2006). A program of genetic transformation may be started soon.

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Table 1: Cultivars and advanced lines genetic origin put in the regional cultivars and advanced lines comparative trials

Cultivar/advanced line	Genetic origin
Guazuncho 3 INTA	**SP 97898 SN x SP 8334-5**
La Banda 300 INTA	**SP 2473-50 x Guazuncho 2 INTA**
Oroblanco 2 INTA	**SP 8334-5 x SP 97806 HO**
Chaco 530 INTA	**SP 8334-5 x SP 8126**
Pora INTA	**Chaco 510 INTA x Reba P 279**
Cacique INTA	**Mataco INTA x Guazuncho INTA**
SP 33950 SN	**SP 97898 SN x SP 8334-5**
SP 44825 SG	**SP 01988 SG x SP 0418**
SP 21	**SP 8558 x Gringo 63**
SP 41608	**Kc 311 x SP 11181**
SP 4504	**SP 01767 x Kc 311**
SP 48114	**SP 99035 x SP 99138**
SP 49101	**SP 902 x Gringo INTA**
SP 82884 SN	**SP 2226 SN x SP 3517**
SP 48806	**SP 3 x SP 99138**
SP 31915 FM	**Unknown natural cross in SP 811-5**

Table 2: Fiber yield and quality parameters means of 6 cultivars and 1 promising line from 4 localities of Argentina and 3 crop years (2003/04;2004/05;2005/06)

Cultivar/promising line	Lint Yield ($kgha^{-1}$)	Lint turnout (%)	Length (mm)	Length Uniformity (%)	Strength (gtx^{-1})	Elongation (%)	Micronaire Index
CACIQUE INTA	959,90 b	38,93 b	28,29 a	83,99 a	29,06 b	6,68 a	4,5 bc
SP 33950 SN	942,52 b	39,68 c	29,31 c	85,18 c	32,31 f	7,03 b	4,21 a
GUAZUNCHO 3 INTA	940,75 b	39,84 c	29,27 c	85,29 c	31,98 ef	7,22 c	4,29 a
LA BANDA 300 INTA	912,94 b	37,48 a	28,66 b	84,48 b	31,51 de	7,25 c	4,46 b
PORA INTA	897,54 b	38,69 b	28,20 a	83,96 a	28,41 a	6,68 a	4,58 c
CHACO 530 INTA	880,33 b	37,45 a	29,74 d	84,59 b	31,43 d	6,58 a	4,25 a
OROBLANCO 2 INTA	767,88 a	40,37 d	27,97 a	83,91 a	30,43 c	7,03 b	4,2 a

Different letters indicate significative differences (p<=0.05)

Table 3: **Significant (X) and not significant (0) effects for the characters measured in Table 2.**

Character	Year	Locality	Cultivar/line	Year*Locality interaction	Year*Cultivar/line interaction	Locality*Cultivar/line interaction	Year*Locality *Cultivar/line interaction
Lint yield	**X**	**X**	**X**	**X**	**0**	**X**	**0**
Gin turnout	**X**	**X**	**X**	**X**	**0**	**X**	**X**
Length	**X**	**X**	**X**	**X**	**0**	**X**	**X**
Uniformity	**X**	**X**	**X**	**X**	**0**	**0**	**0**
Stregth	**X**	**X**	**X**	**X**	**X**	**X**	**0**
Elongation	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Micronaire	**X**	**X**	**X**	**X**	**0**	**0**	**0**

Table 4: Lint yield and quality means for 6 cultivars and 10 promising lines in the year 2005/06 for 4 localities

Cultivar/promising line	Lint yield ($kgha^{-1}$)	Lint turnout (%)	Length (mm.)	Strength (gtx^{-1})	Micronaire Index
SP 48114	1013,31 i	38,53 de	28,73 de	30,36 def	4,25 d
SP 33950 SN	986,94 hi	38,75 e	29,49 fg	32,33 i	4,04 bc
SP 4504	964,00 ghi	37,84 cd	28,06 bc	30,09 de	4,25 d
SP 48806	948,75 fghi	37,65 cd	28,84 de	30,82 efg	4 b
SP 21	939,44 fghi	37,73 cd	28,48 bcde	31,84 hi	4,14 bcd
SP 49101	925,06 efghi	37,74 cd	28,84 de	31,33 gh	4,13 bcd
SP 82884 SN	908,75 defgh	40,01 f	28,24 bcd	30,08 de	4,59 e
SP 41608	898,63 defgh	37,59 c	27,95 b	29,76 cd	4,21 cd
CACIQUE INTA	895,88 defgh	37,71 cd	28,25 bcd	29,23 bc	4,19 cd
GUAZUNCHO 3 INTA	868,44 cdefg	38,49 de	29,65 g	32,16 i	4,01 b
CHACO 530 INTA	852,81 cdef	36,61 b	29,95 g	31,71 hi	3,97 b
LA BANDA 300 INTA	839,13 bcde	36,48 b	28,63 cde	30,93 fg	4,23 d
SP 44825 SG	820,94 bcd	37,57 c	28,98 ef	30,76 efg	4,24 d
PORA INTA	778,69 abc	37,11 bc	28,62 cde	28,96 b	4,24 d
SP 31915 FM	748,19 ab	32,73 a	23,25 a	22,93 a	3,66 a
OROBLANCO 2 INTA	705,69 a	39,11 e	28,33 bcd	30,17 def	3,99 b

Different letters indicate significative differences (p<=0.05)

Table 5: Significant (X) and not significant (0) effects for the characters measured in Table 4.

Character	Cultivar/lines	Locality	Cultivar/lines*Locality interaction
Lint yield	X	X	X
Gin turnout	X	X	X
Length	X	X	X
Uniformity	X	X	0
Strength	X	X	X
Elongation	X	X	X
Micronaire	X	X	X

Table 6: Lint yield and quality means for 6 cultivars and 10 promising lines in the year 2004/05 for 4 localities

Cultivar/line	Lint yield ($kgha^{-1}$)	Gin turnout (%)	Length (mm)	Strength (gtx^{-1})	Micronaire Index
SP 82884	865,81 c	40,94 e	27,19 bcd	26,04 a	5,13 h
SP 48114	851,50 c	40,88 e	27,17 bcd	28,03 cde	4,91 g
SP 49101	839,56 c	40,33 de	28,19 fg	30,16 gh	4,55 bcd
GUAZUNCHO 3 INTA	835,63 c	40,28 de	27,98 ef	31,33 i	4,61 bcde
SP 31646	829,63 c	39,96 cd	27,68 def	28,98 ef	4,4 ab
CACIQUE INTA	819,06 bc	42,23 f	27,22 bcd	27,46 bc	4,88 fg
LA BANDA 300 INTA	786,81 abc	39,63 bcd	27,57 def	30,94 hi	4,78 efg
PORA INTA	779,44 abc	39,61 bcd	26,89 bc	26,8 ab	4,96 gh
CHACO 530 INTA	777,88 abc	39,49 bc	28,66 g	30,11 gh	4,65 cde
SP 21	792,19 bc	39,9 cd	27,05 bcd	30,4 ghi	4,68 cde
SP 33950 SN	768,19 abc	39,37 bc	28,13 fg	31,13 hi	4,52 bcd
SP 44825 SG	743,94 abc	39,08 b	27,88 ef	28,69 def	4,66 cde
SP 992	739,19 abc	38,95 b	27,44 cde	28,84 ef	4,55 bcd
SP 48666	729,56 abc	38,89 b	26,23 a	27,84 cd	4,71 def
SP 4194	684,56 ab	38,04 a	26,77 ab	30,27 gh	4,28 a
OROBLANCO 2 INTA	653,06 a	37,98 a	26,69 ab	29,51 fg	4,49 bc

Different letters indicate significative differences (p<= 0.05)

Table 7: Significant (X) and not significant (0) effects for the characters measured in Table 6.

Character	Cultivar/line	Locality	Cultivar/line*Locality interaction
Lint yield	**0**	**0**	**0**
Gin turnout	**X**	**X**	**X**
Fiber length	**X**	**X**	**X**
Uniformity	**0**	**0**	**0**
Fiber Strength	**X**	**X**	**0**
Elongation	**X**	**X**	**0**
Micronaire	**X**	**X**	**X**