



CULTIVAR RELEASE

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BRS 369RF and BRS 370RF: Glyphosate tolerant, high-yielding upland cotton cultivars for central Brazilian savanna

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Abstract – BRS 369RF and BRS 370RF were developed by the EMBRAPA as a part of efforts to create high-yielding germplasm with combinations of transgenic traits. BRS 369RF and BRS 370RF are midseason cultivars and have yield stability, adaptation to the central Brazilian savanna, good fiber quality and tolerance to glyphosate herbicide.

Key words: *Gossypium hirsutum*, glyphosate tolerance, second crop season, linter yield.

INTRODUCTION

Upland cotton (*Gossypium hirsutum* L. r *latifolium* Hutch) is an economically important species for fiber and seed production in Brazilian savanna. Recent efforts have been made in order to develop crop cultivars, especially to this environment (Morello et al. 2010, Amabile et al. 2013). In the last years, with the development of early maturing soybean cultivars, it became possible to grow cotton just after soybean harvest in the same crop season. In addition, sometimes producers sow cotton at row spacing of 0.45 m. For this growing system to be successful, it is necessary availability of compact genotypes, acceptance of weed and pest management technologies, including transgenics, stripper harvesting machines, and widespread application of growth regulators (Venugopalan et al. 2013). The development of early maturing, compact and herbicide tolerant genotypes suitable to a short growing season became an aim for Brazilian cotton breeders.

The cotton breeding program of the Brazilian Agricultural Research Corporation (Embrapa) in Goiás State has run in partnership with private financial support from FIALGO (Fundo de Incentivo à Cultura do Algodão) and technical

support from Goiás Foundation. In recent years, efforts have been made to develop cotton varieties with high yield and better fiber characteristics (Morello et al. 2010, Morello et al. 2012a, Morello et al. 2012b). BRS 369RF and BRS 370RF were developed by Embrapa and partners in 2014 as part of an ongoing effort to create new cotton lines and cultivars with improved yield potential, transgenic traits and which are appropriate to be grown as a second crop in central Brazilian savanna.

GENETIC ORIGIN AND DEVELOPMENT

Biotechnological tools have been applied in cultivar development, which can add to these cultivars specific characteristics that would be difficult to obtain using conventional breeding (Parentoni et al. 2013). Transgenic tolerance to herbicide glyphosate was introduced into cotton plants and transgenic cultivars have been commercially released since 1997 in USA. This herbicide inhibits the enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSP synthase) in the shikimate acid pathway of plants. As consequence, the synthesis of the aromatic amino acids phenylalanine, tyrosine, and tryptophan is inhibited, causing plant death (Pline et al. 2003). The transgenic cotton event,

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MON 88913, was generated by an Agrobacterium-mediated transformation of cotton cells, commercially known as Roundup Ready Flex® (RF).

Cultivars BRS 369RF and BRS 370RF were derived from an initial backcross breeding program to incorporate the event MON 88913 using the cultivar BRS 293 as recurrent parent, followed by the pedigree selection method. BRS 293 (Stoneville 132 x Delta Opal) has good fiber quality, high fiber yield and adaptation to central Brazilian savanna (Morello et al. 2010). The donor, Sure Grow 125RF {(DP 50 x DES 119) x DES 119} x DES 119} (Bowman et al. 2006) is a high-yielding cotton cultivar; however, it does not have good fiber quality nor is susceptible to blue disease, caused by *Cotton Leafroll Dwarf Virus*.

BRS 369RF and BRS 370RF were originated from a biparental cross follow by three backcrosses involving cotton cultivars BRS 293 and Sure Grow 125R {(BRS 293 x Sure Grow 125R) x BRS 293} x BRS 293}, carried out in 2007 and 2008. From BC₃F₂ generation, only the plants which were homozygous for the Roundup Ready Flex® gene were advanced to progeny rows.

A total of 50 progeny rows (BC₃F_{2:3}) were grown in 2009/2010 season. They were selected based on yield potential, fiber properties, disease resistance (bacterial blight and blue disease), earliness and overall plant conformation (compactness). Two lines (CNPA GO 2009 293-1 RF and CNPA GO 2009 293-15 RF) equivalent in all measurable characteristics were bulked together to produce the variety

BRS 369RF. Similarly, three lines (CNPA GO 2009 293-4 RF, CNPA GO 2009 293-28 RF and CNPA GO 2009 293-33 RF) were bulked together to produce the variety BRS 370RF. During the subsequent season, the obtained seeds were grown and again screened for the Roundup Ready Flex® gene. BRS 369RF and BRS 370RF were treated subsequently as pure lines, evaluated in four sites in the 2010/2011 season. Afterwards, eleven trials were evaluated across the states of Bahia, Goiás, Mato Grosso do Sul, and Mato Grosso, in the 2011/2012 season.

TRAITS PERFORMANCE

BRS 369RF and BRS 370RF are of midseason maturity, and are picker-type upland cotton with growth habits similar to those of BRS 293, when grown in Santa Helena de Goiás, GO (lat 17° 48' S, long 50° 35' W, alt 562m asl). Plants have trichome on leaves and on the main stem. BRS 369RF and BRS 370RF have normal-shaped leaves and bracts (7 to 12 lobes), and are glanded and nectaried. First reproductive branch is generally inserted on the fifth node, and branches have oblique angle insertion. Flowers from plants of both cultivars have cream-colored petals, anthers, and pollen. Full-size green bolls are longer than their width and are broader in the middle. Bolls have five locules; however, four locules may occasionally occur. Open bolls resist shattering, but are not storm proof, and thus are suitable for picker harvesting. Produced lint and fuzz are white in color.

Table 1. Means of total cottonseed yield (CY), lint percentage (LP), and lint yield (LY) of the cotton cultivars BRS 369RF and BRS 293 (control), in 15 field performance trials

Counties/State	Season	BRS 369RF			BRS 293 (control)			CV*
		CY (kg ha ⁻¹)	LP (%)	LY (kg ha ⁻¹)	CY (kg ha ⁻¹)	LP (%)	LY (kg ha ⁻¹)	
Luis Eduardo Magalhães/BA	2010/11	2273.0	41.3	938.7	2275.0	41.5	944.0	16.3
Santa Helena de Goiás/GO†	2010/11	4477.8	40.2	1794.1	4247.0	40.6	1820.0	10.3
Santo Antônio de Goiás/GO†	2010/11	6995.7	40.4	2822.9	5721.4	41.4	2364.1	11.0
Chapadão do Sul/MS	2010/11	2677.7	39.9	1068.6	3128.1	42.5	1329.4	13.3
São Desidério/BA	2011/12	3277.5	41.8	1361.3	2505.0	42.3	1061.3	16.7
Riachão das Neves/BA	2011/12	3318.8	43.3	1428.8	2388.8	42.8	1023.8	24.4
Correntina/BA	2011/12	3247.5	43.8	1413.8	2512.5	43.8	1095.0	17.8
Santa Helena de Goiás/GO	2011/12	2519.2	42.7	1073.9	2730.5	45.2	1240.6	12.4
Santo Antônio de Goiás/GO†	2011/12	4412.7	43.0	1895.6	3795.1	43.2	1641.2	12.6
Cristalina/GO	2011/12	4269.4	45.7	1954.0	4229.5	46.2	1953.6	14.6
Montividiu/GO	2011/12	5472.3	42.9	2342.5	5799.3	44.8	2593.3	16.0
Chapadão do Sul/MS	2011/12	1393.9	45.5	633.3	1752.3	45.4	795.1	17.1
Sinop/MT†	2011/12	2314.4	42.9	993.1	1995.9	43.5	867.2	12.7
Primavera do Leste/MT†	2011/12	5532.9	42.4	2340.0	4798.1	43.0	2063.4	15.4
Campo Verde/MT†	2011/12	5607.5	44.1	2474.0	4120.2	44.5	1836.1	23.5
Mean		3852.7	42.6	1635.6	3466.6	43.4	1508.5	

* Coefficient of variation (%) for cottonseed yield (kg ha⁻¹); † Sown in January.

Plants are of medium size, reaching 110 to 120 cm, when 35 to 50 g of the active ingredient of growth regulator (mepiquat chloride and chlormequat chloride) are applied. At an altitude of 562 meters, first flower appear at about 53 (BRS 369RF) or 55 (BRS 370RF) days after emergence (DAE), and the first boll opens at about 110 to 120 DAE. In these environmental conditions, and using harvest-aid chemicals, BRS 369RF total harvest was carried out at 165 DAE, and BRS 370RF, at 175 DAE.

BRS 369RF and BRS 370RF have moderate resistance levels to the main diseases that occur in Brazil: they are moderately resistant to bacterial blight [caused by *Xanthomonas axonopodis* pv. *malvacearum*], to cotton blue disease [caused by *Cotton leafroll dwarf virus*- CLRDV]; they are moderately susceptible to false mildew [caused by *Ramularia areola*], ramulosis [caused by *Colletotrichum gossypii* var. *cephalosporioides*] and to *Fusarium oxysporum* f. sp. *vasinfectum* - *Meloidogyne incognita* complex. Incidence of plants with cotton blue disease symptoms was recorded in two independent assays with no control of virus vector (*Aphis gossypii*). Severity of bacterial blight and false mildew were determined based on foliar lesion area grade scale varying from 1 (no symptoms) to 5 (highly susceptible) in two field assays with no fungicide application. Resistance to cotton ramulosis was assessed in two assays artificially inoculated with *Colletotrichum gossypii* var. *cephalosporioides*, using the methods proposed by Oliveira et al. (2010). Root-knot nematode galling index was measured

using the methods described by Zhang et al. (2006). Fusarium index was assessed as described by Machado et al. (2009). For nematode galling index and Fusarium index, cotton cultivar IAC 25 was used as a resistant or partial resistant control, respectively.

Averaged across the 15 field performance trials of cultivation value and use (VCU) in central and northeastern Brazil in 2010/2011 and 2011/2012, BRS 369RF and BRS 370RF presented 8.6 and 10.7% more lint yield than BRS 293, respectively. The lint percentage was slightly higher in BRS 293; however, raw cotton yield in BRS 369RF and BRS 370RF was higher than control, reflecting in higher fiber yield (Tables 1 and 2). Taking into account only the trials sown in January, BRS 369RF and BRS 370RF produced 18.9 and 16.4% more raw cotton than the control, respectively. High Volume Instrument (HVI) measurements reveal desirable physical attributes of a medium fiber length for both new cultivars: micronaire reading ranged from 4.1 to 4.9 (BRS 369RF) and from 4.2 to 4.6 (BRS 370RF); fiber length (UHML) from 29.5 to 31.4 mm (BRS 369RF), and from 27.8 to 31.3 mm (BRS 370RF); relative strength, from 28.1 to 30.8 gf.tex⁻¹ (BRS 369RF), and from 27.9 to 30.4 gf.tex⁻¹ (BRS 370RF); reflectance, from 71.0 to 80.4% (BRS 369RF), and from 69.0 to 79.7% (BRS 370RF); yellowness (+b), from 7.1 to 8.4 (BRS 369RF), and from 7.3 to 9.0 (BRS 370RF); short fiber index, from 5.0 to 7.9 (BRS 369RF), and from 5.4 to 9.0 (BRS 370RF) (Table 3).

Table 2. Means of total cottonseed yield (CY), lint percentage (LP), and lint yield (LY) of the cotton cultivars BRS 370RF and BRS 293 (control), in 15 field performance trials

Counties/State	Season	BRS 370RF			BRS 293 (control)			CV*
		CY (kg ha ⁻¹)	LP (%)	LY (kg ha ⁻¹)	CY (kg ha ⁻¹)	LP (%)	LY (kg ha ⁻¹)	
Luis Eduardo Magalhães/BA	2010/11	2389.0	41.8	998.6	2275.0	41.5	944.0	16.3
Santa Helena de Goiás/GO†	2010/11	4545.5	39.7	1769.2	4247.0	40.6	1820.0	10.3
Santo Antônio de Goiás/GO†	2010/11	5925.7	42.2	2500.4	5721.4	41.4	2364.1	11.0
Chapadão do Sul/MS	2010/11	3072.0	39.0	1200.1	3128.1	42.5	1329.4	13.3
São Desidério/BA	2011/12	3232.5	43.0	1387.5	2505.0	42.3	1061.3	16.7
Riachão das Neves/BA	2011/12	3015.0	42.8	1282.5	2388.8	42.8	1023.8	24.4
Correntina/BA	2011/12	3476.3	43.3	1503.8	2512.5	43.8	1095.0	17.8
Santa Helena de Goiás/GO	2011/12	2375.9	43.9	1043.6	2730.5	45.2	1240.6	12.4
Santo Antônio de Goiás/GO†	2011/12	5015.9	43.9	2205.4	3795.1	43.2	1641.2	12.6
Cristalina/GO	2011/12	3761.8	45.9	1721.5	4229.5	46.2	1953.6	14.6
Montividiu/GO	2011/12	5567.3	43.7	2431.5	5799.3	44.8	2593.3	16.0
Chapadão do Sul/MS	2011/12	1850.8	45.6	843.7	1752.3	45.4	795.1	17.1
Sinop/MT†	2011/12	2592.1	42.2	1095.0	1995.9	43.5	867.2	12.7
Primavera do Leste/MT†	2011/12	5554.3	43.6	2418.6	4798.1	43.0	2063.4	15.4
Campo Verde/MT†	2011/12	5097.9	42.6	2182.3	4120.2	44.5	1836.1	23.5
Mean		3831.4	42.9	1638.9	3466.6	43.4	1508.5	

* Coefficient of variation (%) for cottonseed yield (kg ha⁻¹); † Sown in January.

Table 3. Cultivar traits of BRS 269RF, BRS 270RF and BRS 293 (control)

Traits	BRS 369RF	BRS 370RF	BRS 293
First flower (DAE)*	53	55	55 – 58
First open boll (DAE)*	110-120	110 – 120	110 – 120
Boll weight (g) ^a	5.8	5.7	6.0 – 6.5
Fiber length (UHML) (mm) ^a	30.3	29.7	28.5 – 30.5
Uniformity index (ML/UHML - %) ^a	84.6	84.2	83.0 - 85.0
Strength HVI (gf.tex ⁻¹) ^a	29.4	29.0	28.3 – 32.9
Micronaire reading ^a	4.5	4.4	3.9 – 4.5
Elongation (%) ^a	8.2	7.9	8.0 – 9.5
Reflectance – Rd (%) ^a	77.5	75.9	72 – 82
Yellowness (+ b) ^a	7.8	7.9	6.5 – 10.0
Short fiber index (%) ^a	6.8	7.2	3.9 – 6.3
<i>Cotton leafroll dwarf virus</i> ^b	0.2	0.8	0.5
False mildew ^c	3.5	3.0	3.5
Bacterial blight ^c	2.0	2.0	2.5
Ramulosis ^d	48.6	54.2	33.5 ^e
Root-knot nematode ^e	2.8	3.1	1.3 ^e
Fusarium wilt ^f	21.4	16.7	9.6 ^e

* Data recorded in Santa Helena de Goiás – GO (lat 17° 48' 15" S, long 50° 35' 43" W, alt 562m asl).

^a Means from 15 field trials in 2010/2011 and 2011/2012 seasons, in several environments (States of Goiás, Bahia, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Maranhão, Piauí, and Rondônia); ^b Incidence (%) of plants with cotton blue disease symptoms - data from two assays with no control of virus vector (*Aphis gossypii*); ^c Disease severity (grades from 1 = resistant to 5 = highly susceptible) - data from two assays with no fungicide application; ^d Amaral disease index calculated (Amaral 1969) – data from two assays artificially inoculated with *Colletotrichum gossypii* var. *cephalosporioides* using methods proposed by Oliveira et al. (2010); ^e Galling index (Zhang et al. 2006); ^f Disease index (Machado et al. 2009); ^g Cotton cultivar IAC 25 was used as a resistant/partial resistant control.

SEED MAINTENANCE AND DISTRIBUTION

BRS 369 RF and BRS 370RF are catalogued in the Ministry of Agriculture, Livestock and Food Supply under the numbers 30481 and 30480, respectively. Basic seeds are produced by Embrapa Products and Markets (Embrapa SPM).

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