

APPENDIX A

Research Cost Profiles

	Total commodity			Augmented total commodity			Crop improvement			Augmented crop improvement		
	Rice	Beans	Soybeans	Rice	Beans	Soybeans	Rice	Beans	Soybeans	Rice	Beans	Soybeans
Annual expenditures												
1976	2,065	2,065	4,020	2,908	2,908	5,660	629	465	577	821	655	812
1977	2,205	2,205	3,752	3,501	3,501	5,957	682	482	640	969	766	1,017
1978	2,182	2,182	5,181	3,183	3,183	7,559	789	587	821	1,062	856	1,197
1979	2,662	2,662	5,422	4,513	4,513	9,192	880	673	1,000	1,353	1,140	1,695
1980	4,650	4,650	7,462	6,213	6,213	9,970	1,081	761	1,287	1,344	1,017	1,720
1981	4,304	4,304	5,463	5,789	5,789	7,347	1,234	853	1,447	1,545	1,148	1,946
1982	4,048	4,048	5,996	5,835	5,835	8,643	1,436	981	1,550	1,884	1,414	2,234
1983	2,417	2,417	3,568	3,305	3,305	4,878	986	683	1,005	1,246	934	1,374
1984	2,292	2,292	2,846	3,031	3,031	3,765	909	668	768	1,132	884	1,016
1985	1,935	1,935	3,543	2,850	2,850	5,217	871	593	896	1,162	873	1,320
1986	2,202	2,202	5,649	2,745	2,745	7,042	949	644	914	1,120	803	1,139
1987	3,015	3,015	4,303	3,960	3,960	5,651	1,216	792	1,080	1,487	1,040	1,419
1988	2,965	2,965	4,502	3,653	3,653	5,547	1,107	735	1,051	1,303	905	1,295
1989	3,901	3,901	6,962	4,862	4,862	8,677	1,709	1,056	1,721	2,009	1,316	2,145
1990	4,449	4,449	6,963	5,627	5,627	8,805	1,779	1,150	2,582	2,123	1,455	3,265
1991	3,585	3,585	5,878	5,086	5,086	8,340	1,444	919	2,178	1,859	1,303	3,090
1992	3,570	3,570	6,236	4,174	4,174	7,293	1,433	899	2,370	1,621	1,052	2,771

(1999 thousands U.S. dollars)

1993	4,416	4,416	7,173	5,661	5,661	9,194	1,703	1,084	2,617	2,053	1,390	3,354
1994	4,827	4,827	7,833	6,597	6,597	10,705	1,850	1,178	2,786	2,333	1,610	3,807
1995	6,034	6,034	11,317	7,886	7,886	14,791	2,268	1,478	3,524	2,789	1,932	4,606
1996	8,032	8,032	13,683	11,206	11,206	19,091	2,947	1,883	4,486	3,795	2,627	6,259
1997	5,834	5,834	11,246	8,660	8,660	16,694	2,245	1,429	3,662	3,010	2,121	5,437
1998	5,106	5,106	9,693	7,311	7,311	13,880	2,023	1,321	3,406	2,647	1,892	4,878
Sum	86,696	86,696	148,691	118,556	118,556	203,898	32,170	21,314	42,368	40,667	29,133	57,796
Present value (4%)	133,470	133,470	228,074	183,554	183,554	314,738	48,521	32,536	61,040	61,623	44,727	83,572
Present value (6%)	168,902	168,902	288,474	233,147	233,147	399,729	60,705	40,964	74,675	77,337	56,530	102,541
Annual growth rates						(percentages)						
1976-1979	7.80	7.80	12.98	13.02	13.02	18.45	12.24	13.92	20.92	17.25	19.43	26.77
1980-1989	-3.64	-3.64	-1.23	-4.73	-4.73	-2.34	1.45	0.32	-0.94	0.58	-0.81	-2.06
1990-1998	6.80	6.80	9.23	8.60	8.60	11.08	6.12	6.30	7.33	7.50	8.10	9.14
1976-1998	4.34	4.34	4.37	3.88	3.88	3.91	5.58	4.78	8.40	5.17	4.32	7.92

Source: Authors' calculations.

Note: Growth rates are compound annual growth rates. Commodity costs refer to total research cost for each commodity for Embrapa; crop improvement costs include all costs related to crop improvement research activities. Augmented costs include a prorated share of Sede and CENARGEN costs.

APPENDIX B

Sources of Commercially Significant Upland Rice Germplasm

Institution of release	Agency type	Pedigree source				Total
		Cultivar	Father	Mother	Grandparents	
Brazil						
CNPAF	Embrapa	23			2	25
IAC	Public	5	8	16	30	59
IAPAR	Public	2				2
IPEAS	Public	1				1
Traditional	Other	3		5		8
National Rice Research Project, RS Brazil	Other				1	1
<i>Brazil total</i>		<i>34</i>	<i>8</i>	<i>21</i>	<i>33</i>	<i>96</i>
International						
CIAT	International			1	3	4
IITA	International		2		3	5
IRAT	International				5	5
IRRI	International		1		2	3
<i>International total</i>		<i>0</i>	<i>3</i>	<i>1</i>	<i>13</i>	<i>17</i>
France						
CIRAD	Public	1				1
IRAT	Public		10	5		15
<i>France total</i>		<i>1</i>	<i>10</i>	<i>5</i>	<i>0</i>	<i>16</i>
Traditional or local varieties						
Traditional	Other		2	4	44	26
<i>Total traditional or local varieties</i>		<i>0</i>	<i>2</i>	<i>4</i>	<i>44</i>	<i>26</i>
Other						
Cameroon	Other				1	1
China	Other				1	1
Colombia	Other				1	1
China	Other				1	1
Philippines	Other				1	1
Côte d'Ivoire	Other				11	11
Mexico	Other		1			1
Taiwan	Other				1	1
West Africa	Other		4		5	9
Zaire	Other				10	10
Unknown cross	Other		3	4	2	9
Unknown	Other		4		16	20
<i>Total other</i>		<i>0</i>	<i>12</i>	<i>4</i>	<i>50</i>	<i>66</i>
Total		35	35	35	140	245

Source: Authors' calculations.

Note: Unknown cross means that one of the nodes in the pedigree was a cross for which it was not possible to identify the institution that did the cross.

APPENDIX C

Sources of Commercially Significant Edible Beans Germplasm

Institution of release	Type	Pedigree source				Total
		Cultivar	Father	Mother	Grandparents	
Brazil						
Embrapa	Embrapa	9	2	2	2	15
FT	Private	4	1	4	2	11
CEFET-PR	Public	1	1			
EEP	Public	1	1	2		
EPABA	Public	1	1			
IAC	Public	8	7	8	10	33
IAPAR	Public	4	1	2	4	11
IPA	Public	2	2	4		
IPEACO/EEP/MG	Public	1	1			
PESAGRO	Public	1	1			
ESAL	University	3	3			
UFV	University	1	1			
<i>Brazil total</i>		<i>31</i>	<i>13</i>	<i>18</i>	<i>22</i>	<i>84</i>
Traditional						
Traditional variety		3	6	6	36	51
<i>Traditional total</i>		<i>3</i>	<i>6</i>	<i>6</i>	<i>36</i>	<i>51</i>
International						
CIAT	International	5	13	7	30	55
<i>International total</i>		<i>5</i>	<i>13</i>	<i>7</i>	<i>30</i>	<i>55</i>
Other countries						
INIA (Uruguay)	Public	1	1			
ICA (Colombia)	Public	1	1	5	7	
CATIE (Costa Rica)	University	1	1			
Other (Costa Rica)		2	11	13		
EAP (Honduras)	University	2	2			
Cornell University (U.S.)	University	1	1			
Un. of Nebraska (U.S.)	University	1	1			
Other (Venezuela)		2	2			
CIA (Venezuela)	Public	1	1	2		
<i>Other countries total</i>		<i>1</i>	<i>3</i>	<i>2</i>	<i>24</i>	<i>30</i>
Unknown or unspecified		0	5	7	48	60
Total		40	40	40	160	280

Source: Authors' calculations.

APPENDIX D

Sources of Commercially Significant Soybean Germplasm

Institution of release	Type	Pedigree source				Total
		Cultivar	Father	Mother	Grandparents	
Brazil						
CNPSo	Embrapa	36	8	12	7	63
CPAC	Embrapa	1	2		2	5
CAC	Private	1				1
CEP/FECOTRIGO	Private		2	5	7	14
CEP/FEPAGRO	Private	1				1
COODETEC	Private	15	2	2		19
FECOTRIGO	Private	1	3			4
FEPAGRO	Private	3	1		1	5
FT	Private	21	16	10	24	71
INDUSEM	Private			2		2
OCEPAR	Private		2	1	4	7
EMGOPA	Public	10	3	3	1	17
EPAMIG	Public			1		1
Ex-DNPEA/IPEAME	Public	1		1		2
Ex-IPEAME	Public	2	11	10	23	46
Ex-IPEAS	Public	2	3	1	7	13
IAC	Public	8	5	6	14	33
UFV	University	1	2	1	9	13
UREMG/ESA	University		1	1	6	8
<i>Total Brazil</i>		<i>103</i>	<i>61</i>	<i>56</i>	<i>105</i>	<i>325</i>
United States						
Arkansas, Hale Seeds Farms	Private				1	1
Coker Pedigree Seed Co., South Carolina	Private		7	2	8	17
Nickerson American Plant Breeders/Northrup King	Private	1	2		2	5
USDA	Public	1	1	1	4	7
USDA Arlington Farm	Public			1	6	7
USDA Florida	Public	2	4	2	9	17
USDA Mississippi	Public		13	12	104	129
USDA North Carolina	Public		1	2	19	22
Arkansas AES	University	1	5	4	10	20
Florida AES	University	1				1
Louisiana AES	University	1	1	1	5	8
North Carolina AES	University				12	12
North Carolina AES/Tennessee AES	University				3	3
Tennessee AES	University			1	7	8
University of Tennessee	University			1	3	4
Missouri AES	University				3	3
Illinois AES and USDA	University/Public			1		1

Institution of release	Type	Pedigree source				Total
		Cultivar	Father	Mother	Grandparents	
Hawaii AES/USDA Arkansas	University/Public		1		3	4
Louisiana AES and USDA	University/Public	1	2			3
University of Tennessee/USDA Arlington Farm	University/Public				1	1
Clemson AES and USDA	University/Public				4	4
Illinois AES and USDA	University/Public			1	1	2
Virginia AES and USDA	University/Public				2	2
From U.S. Germplasm Bank				1		1
<i>Total United States</i>		8	37	30	207	282
Other countries						
Jilin, China					2	2
South Africa or Zimbabwe					1	1
Philippines					2	2
<i>Total other countries</i>		0	0	0	5	5
Unknown		1	14	26	131	172
Total		112	112	112	448	784

Source: Authors' calculations.

APPENDIX E

Present Value of Research Benefits with a 10 Percent Discount Rate and a Stream of Benefits Ending in 2003

	Total benefits from varietal change	All credit to last cross		Geometric rule	
		Not partitioned	Partitioned	Not partitioned	Partitioned
(thousands 1999 U.S. dollars)					
Upland rice					
Enhanced yields	2,354,440	1,578,900	840,157	802,031	426,195
Improved grain quality	238,251				
Edible beans	818,914	376,631	244,431	251,527	164,205
Soybeans	17,399,184	6,361,626	5,770,837	3,630,603	3,335,390
All three crops	20,572,538	8,317,157	6,855,426	4,684,161	3,925,790

Source: Authors' calculations.

Note: "Not Partitioned" indicates that full credit was given to Embrapa for varieties it developed alone or jointly with others. "Partitioned" indicates that Embrapa was given partial credit for varieties developed jointly with others. The present value of benefits from varietal change includes a stream of benefits from 1984 to 2003 for upland rice; 1985–2003 for edible beans; and 1981–2003 for soybeans.

APPENDIX F

Present Value of Research Benefits with a 4 Percent Discount Rate and a Stream of Benefits Ending in 1998

	Total benefits from varietal change	All credit to last cross		Geometric rule	
		Not partitioned	Partitioned	Not partitioned	Partitioned
(thousands 1999 U.S. dollars)					
Upland rice					
Enhanced yields	1,390,400	936,925	497,858	474,909	252,093
Improved grain quality	55,482				
Edible beans	431,666	177,763	116,812	122,760	8,971
Soybeans	8,423,551	2,945,227	2,777,079	1,652,994	1,569,043
All three crops	10,245,617	4,059,915	3,391,749	2,250,663	1,902,107

Source: Authors' calculations.

Note: "Not Partitioned" indicates that full credit was given to Embrapa for varieties it developed alone or jointly with others. "Partitioned" indicates that Embrapa was given partial credit for varieties developed jointly with others. The present value of benefits from varietal change includes a stream of benefits from 1984 to 1998 for upland rice; 1985–98 for edible beans; and 1981–98 for soybeans.

APPENDIX G

Present Value of Research Benefits with a 10 Percent Discount Rate and a Stream of Benefits Ending in 1998

	Total benefits from varietal change	All credit to last cross		Geometric rule	
		Not partitioned	Partitioned	Not partitioned	Partitioned
(thousands 1999 U.S. dollars)					
Upland rice					
Enhanced yields	2,060,980	1,314,733	695,995	665,553	352,023
Improved grain quality	60,855				
Edible beans	558,857	217,258	143,081	139,407	92,055
Soybeans	13,115,240	4,164,992	3,977,740	2,310,552	2,217,108
All three crops	15,735,077	5,696,983	4,816,816	3,115,512	2,661,186

Source: Authors' calculations.

Note: "Not Partitioned" indicates that full credit was given to Embrapa for varieties it developed alone or jointly with others. "Partitioned" indicates that Embrapa was given partial credit for varieties developed jointly with others. The present value of benefits from varietal change includes a stream of benefits from 1984 to 1998 for upland rice; 1985–98 for edible beans; and 1981–98 for soybeans.

APPENDIX H

Normalized Research Benefits with a 10 Percent Discount Rate and a Stream of Benefits Ending in 2003

Indicators	Total benefits from varietal change	All credit to last cross		Geometric rule	
		Not partitioned	Partitioned	Not partitioned	Partitioned
(benefit per unit cost)					
Benefits/crop improvement cost					
Upland rice					
Enhanced yield					
Baseline	24.0	16.1	8.6	8.2	4.3
Augmented	18.7	12.5	6.7	6.4	3.4
Improved grain quality					
Baseline	2.4				
Augmented	1.9				
Edible beans					
Baseline	12.2	5.6	3.6	3.7	2.4
Augmented	8.8	4.0	2.6	2.7	1.8
Soybeans					
Baseline	150.0	54.9	49.8	31.3	28.8
Augmented	108.4	39.6	36.0	22.6	20.8
<i>All three crops</i>					
Baseline	73.1	29.6	24.4	16.6	14.0
Augmented	54.1	21.9	18.0	12.3	0.3
Benefits/total crop research costs					
Upland rice					
Enhanced yield					
Baseline	8.4	5.6	3.0	2.9	1.5
Augmented	6.0	4.1	2.2	2.1	1.1
Improved grain quality					
Baseline	0.9				
Augmented	0.6				
Edible beans					
Baseline	2.9	1.3	0.9	0.9	0.6
Augmented	2.1	1.0	0.6	0.6	0.4
Soybeans					
Baseline	36.3	13.3	12.1	7.6	7.0
Augmented	26.0	9.5	8.6	5.4	5.0

(continued)

Indicators	Total benefits to varietal change	All credit to last cross		Geometric rule	
		Not partitioned	Partitioned	Not partitioned	Partitioned
(benefit per unit cost)					
All three crops					
Baseline	19.8	8.0	6.6	4.5	3.8
Augmented	14.2	5.7	4.7	3.2	2.7
(thousands 1999 U.S. dollars)					
Benefits/FTE					
Upland rice					
Enhanced yield	15,703	10,530	5,603	5,349	2,842
Improved grain quality	1,589				
Edible beans	5,386	2,477	1,607	1,654	1,080
Soybeans	59,425	21,727	19,709	12,400	11,392
All three crops	34,588	13,983	11,526	7,875	6,600

Source: Authors' calculations.

Note: FTE refers to the average annual full-time equivalent of researchers between 1976 and 1998. "Not Partitioned" indicates that full credit was given to Embrapa for varieties it developed alone or jointly with others. "Partitioned" indicates that Embrapa was given partial credit for varieties developed jointly with others. The present value of benefits from varietal change includes a stream of benefits from 1984 to 2003 for upland rice; 1985–2003 for edible beans; and 1981–2003 for soybeans.

APPENDIX I

Normalized Research Benefits with a 4 Percent Discount Rate and a Stream of Benefits Ending in 1998

Indicators	Total benefits from varietal change	All credit to last cross		Geometric rule	
		Not partitioned	Partitioned	Not partitioned	Partitioned
(benefit per unit cost)					
Benefits/crop improvement cost					
Upland rice					
Enhanced yield					
Baseline	28.7	19.3	10.3	9.8	5.2
Augmented	22.6	15.2	8.1	7.7	4.1
Improved grain quality					
Baseline	1.1				
Augmented	0.9				
Edible beans					
Baseline	13.3	5.5	3.6	3.8	2.5
Augmented	9.7	4.0	2.6	2.7	1.8
Soybeans					
Baseline	138.0	48.3	45.5	27.1	25.7
Augmented	100.8	35.2	33.2	19.8	18.8
All three crops					
Baseline	72.1	28.6	23.9	15.8	13.4
Augmented	53.9	21.4	17.9	11.9	10.0
Benefits/total crop research costs					
Upland rice					
Enhanced yield					
Baseline	10.4	7.0	3.7	3.6	1.9
Augmented	7.6	5.1	2.7	2.6	1.4
Improved grain quality					
Baseline	0.4				
Augmented	0.3				
Edible beans					
Baseline	3.2	1.3	0.9	0.9	0.6
Augmented	2.4	1.0	0.6	0.7	0.4
Soybeans					
Baseline	36.9	12.9	12.2	7.2	6.9
Augmented	26.8	9.4	8.8	5.3	5.0
All three crops					
Baseline	20.7	8.2	6.9	4.5	3.8
Augmented	15.0	6.0	5.0	3.3	2.8

(continued)

Indicators	Total benefits to varietal change	All credit to last cross		Geometric rule	
		Not partitioned	Partitioned	Not partitioned	Partitioned
(thousands 1999 U.S. dollars)					
Benefits/FTE					
Upland rice					
Enhanced yield	9,273	6,249	3,320	3,167	1,681
Improved grain quality	370				
Edible beans	2,839	1,169	768	807	533
Soybeans	28,769	10,059	9,485	5,646	5,359
All three crops	17,226	6,826	5,702	3,784	3,198

Source: Authors' calculations.

Note: FTE refers to the average annual full-time equivalent of researchers between 1976 and 1998. "Not Partitioned" indicates that full credit was given to Embrapa for varieties it developed alone or jointly with others. "Partitioned" indicates that Embrapa was given partial credit for varieties developed jointly with others. The present value of benefits from varietal change includes a stream of benefits from 1984 to 1998 for Upland rice; 1985–1998 for edible beans; and 1981–1998 for soybeans.

APPENDIX J

Normalized Research Benefits with a 10 Percent Discount Rate and a Stream of Benefits Ending in 1998

Indicators	Total benefits from varietal change	All credit to last cross		Geometric rule	
		Not partitioned	Partitioned	Not partitioned	Partitioned
(benefit per unit cost)					
Benefits/crop improvement cost					
Upland rice					
Enhanced yield					
Baseline	21.0	13.4	7.1	6.8	3.6
Augmented	16.3	10.4	5.5	5.3	2.8
Improved grain quality					
Baseline	0.6	0.0	0.0	0.0	0.0
Augmented	0.5	0.0	0.0	0.0	0.0
Edible beans					
Baseline	8.3	3.2	2.1	2.1	1.4
Augmented	6.0	2.3	1.5	1.5	1.0
Soybeans					
Baseline	113.1	35.9	34.3	19.9	19.1
Augmented	81.7	26.0	24.8	14.4	13.8
All three crops					
Baseline	55.9	20.2	17.1	11.1	9.5
Augmented	41.4	15.0	12.7	8.2	7.0
Benefits/total crop research costs					
Upland rice					
Enhanced yield					
Baseline	7.4	4.7	2.5	2.4	1.3
Augmented	5.3	3.4	1.8	1.7	0.9
Improved grain quality					
Baseline	0.2				
Augmented	0.2				
Edible beans					
Baseline	2.0	0.8	0.5	0.5	0.3
Augmented	1.4	0.6	0.4	0.4	0.2
Soybeans					
Baseline	27.4	8.7	8.3	4.8	4.6
Augmented	19.6	6.2	5.9	3.5	3.3

(continued)

Indicators	Total benefits to varietal change	All credit to last cross		Geometric rule	
		Not partitioned	Partitioned	Not partitioned	Partitioned
(benefit per unit cost)					
All three crops					
Baseline	15.1	5.5	4.6	3.0	2.6
Augmented	10.9	3.9	3.3	2.2	1.8
(thousands 1999 U.S. dollars)					
Benefits/FTE					
Upland rice					
Enhanced yield	13,745	8,768	4,642	4,439	2,348
Improved grain quality	406				
Edible beans	3,675	1,429	941	917	605
Soybeans	44,793	14,225	13,585	7,891	7,572
All three crops	26,455	9,578	8,098	5,238	4,474

Source: Authors' calculations.

Note: FTE refers to the average annual full-time equivalent of researchers between 1976 and 1998. "Not Partitioned" indicates that full credit was given to Embrapa for varieties it developed alone or jointly with others. "Partitioned" indicates that Embrapa was given partial credit for varieties developed jointly with others. The present value of benefits from varietal change includes a stream of benefits from 1984 to 1998 for Upland rice; 1985–1998 for edible beans; and 1981–1998 for soybeans.