THE SORGHUM GENE GRAB

A Briefing Paper by the African Centre for Biosafety

Edward Hammond, June 2010

Contents

PO Box 29170, Melville 2109, South Africa
Tel: (011) 486 2710
Fax: 011 486 1156
www.biosafetyafrica.net

Design and layout: Adam Rumball, Sharkbuoys Designs, Johannesburg
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The African Centre for Biosafety (ACB) is a non-profit organisation, based in Johannesburg, South Africa. It provides authoritative, credible, relevant and current information, research and policy analysis on genetic engineering, biosafety, biopiracy, agrofuels and the Green Revolution push in Africa.

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Introduction

A rising tide of patent claims is privatizing key parts of the genome of sorghum, an African native and one of the world's most important food and feed crops. In parallel, the hybrid sorghum seed industry is undergoing consolidation as biotechnology companies compete to position themselves to profit from, what they believe will be, a rapidly growing sorghum seed market.

African farmers domesticated sorghum from wild grasses, and they and other farmers worldwide continue to grow the crop, and to develop and nurture its genetic diversity. But African farmers do not stand to benefit from the rush to patent sorghum genes and produce proprietary sorghum hybrids. Instead, the sorghum gene grab will benefit Northern corporations and universities, who care little about Africa's enormous contribution to the crop's genetic diversity or orienting their efforts to African needs.

Two relatively new phenomena – the expanding agrofuels industry and global warming – are propelling the wave of commercial interest. Sorghum may prove especially useful for agrofuels because of its flexibility. Sorghum varieties can produce sugars, plant matter (biomass), and grain, which can all be converted to bioethanol. And as agriculture adapts to global warming, sorghum's profile is rising because of its tolerance of drought and water scarcity (particularly in comparison to maize), conditions that are likely to become more common in the coming years.

Although important in many world regions, including Africa, India, and China, sorghum has received less attention from industrial agriculture concerns than more widely grown commodity crops such as soya and cotton. As a result, there are comparatively few patent claims over sorghum, and more small enterprises have been involved in sorghum breeding and seed production. This situation is, however, rapidly changing.

The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) is unfortunately not addressing the problem of sorghum privatization, despite the fact that some of the sorghums under patent claims are held "in trust" for the world's farmers and come from countries who are Parties to the ITPGRFA. This is so for two main reasons:

First, most of the patent claims are from the United States, which has signed but not ratified the Treaty. Second, US gene banks have copies of major parts of the sorghum collection of the International Center for International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and are not applying the treaty's provisions to use and distribution of these copies.

Sadly, the practical result of this situation is that the "in trust" status of tens of thousands of African sorghum varieties appears to be meaningless, a situation that may come as a particular shock to African countries that donated most of ICRISAT's collection. These countries may have believed that the ITPGRFA would provide for more equitable use of these varieties and a measure of protection from proprietary claims.

The Patent Applications

Sorghum patent claims have recently been lodged by US companies, Ceres and Edenspace, as well as by Texas Agricultural and Mechanical University (Texas A&M) and Rutgers University. Key traits that these and other research programs are seeking to control include sorghum flowering, plant growth (biomass), sugar content, and cold and salt tolerance. New sorghum patent claims published since late 2009 include:

Applicant[1]	Number[2]	Title	Claims
Ceres Inc. *California, US*	WO2010033564	Transgenic Plants Having Increased Biomass	20 sorghum gene sequences, and others that can be used in sorghum, for cellulosic agrofuels. US government holds an interest due to research funding.
	WO2009146015	Promoter, Promoter Control Elements, and Combinations, and Uses Thereof	18 sorghum gene sequences and transgenes using them.
	WO2009114733	Nucleotide Sequences and Corresponding Polypeptides Conferring Modulated Growth Rate and Biomass…	Dozens more sorghum gene sequences related to growth rate and plant size as well as growth under salt and other stress conditions.
	US PVP 201000045 US PVP 201000046	Sorghum varieties ES 5200 and ES 5201	Two "high biomass" sorghum varieties. Likely provided by Texas A&M.
Edenspace *Kansas, US*	WO2009149304	Plant Gene Regulatory Elements	48 sorghum gene sequences, similar genes, and their use.
Texas A&M University *Texas, US*	WO2010011935	Intergeneric Hybrid Plants Between Sorghum and Saccharum and Methods for Production Thereof	Crosses between sorghum and other species (esp. sugarcane), including those derived from sorghum line Tx3361 (see below).
	WO2010011680	Discovery and Utilization of Sorghum Genes (Ma5/Ma6)	Hybrid agrofuel sorghums that do not flower or flower late, and related genes, proteins, and gene markers.

Applicant	Number	Title	Claims
	US20100064382	Plants and Seeds of Sorghum Line Tx3361	Related to WO2010011935, this US patent application covers the Tx3361 sorghum plant, and plants produced from Tx3361, a sorghum with traits from a Chinese sorghum called Nr.481.
	US PVP 201000093	Sorghum variety R07007	A sorghum variety with unusual flowering traits. Related to patent application WO2010011680 above.
Rutgers University *New Jersey, US*	WO2010006338	Compositions and Methods for Biofuel Crops	> 100 sorghum genes differentially expressed between grain and sweet sorghum varieties, and use to manipulate sugar and cellulose content of agrofuel sorghum.
Kansas State University *Kansas, US*	US20100115663	Acetyl-CoA Carboxylase Herbicide Resistant Sorghum	Resistance to ACC-type herbicides, found in Bolivian sorghum. Licensed to DuPont.
	US20080216187	Acetolactate Synthase Herbicide Resistant Sorghum	Resistance to ALS-type herbicides. Licensed to DuPont.
Temasek Life Sciences *Singapore*	WO2010011175	Method of High Frequency Regeneration of Sorghum	Method for asexual reproduction of sorghum plants by organogenesis.
Nagarjuna Group *Hyderabad, India*	US20100058496	Transgenic Sweet Sorghum with Altered Lignin Composition…	A sorghum gene sequence and its use to create sweet sorghum plants with better processing characteristics.

Many recent patent claims, including the bulk of those lodged by Ceres, Edenspace, and Rutgers University, are broad claims designed to control sets of promoter genes and other generic genetic components of sorghum. These are not claims on a specific gene from a specific variety, such as the patent on an aluminum tolerance gene from a Tanzanian sorghum.[3] Instead, they are a grab for strategic territory on the sorghum genome, in an effort to control sequences and mechanisms that can be used in a variety of ways to create sorghum cultivars. These are the contemporary biotech equivalent of an 18th Century

European explorer planting his flag on an ill-understood foreign land and claiming it for himself or his sovereign, as if by divine right subordinating all other interests in the territory.

Patents on the sorghum genome are the contemporary biotech equivalent of an 18th Century European explorer planting his flag on an ill-understood foreign land and claiming it for himself or his sovereign, as if by divine right subordinating all other interests in the territory.

Many of these new patent claims are less the result of studying sorghum itself than leveraging advances in other areas of genomics. This is frequently a mathematical and statistical exercise. In general terms, this is how it works:

The genes of the laboratory plant *Arabidopsis thaliana* and those of rice (*Oryza sativa*) are better characterized than those of sorghum. That is, through long efforts involving many labs, scientists have pieced together a relatively good idea of what sections of genetic code serve what function in those plants (i.e. a functional genetic map).

"The" Sorghum Genome

There is no single sorghum genome any more than there is a single genome of other higher species. Different sorghum populations and individuals have varying genes. Thus, what is referred to as the sorghum genome is really the genome of a single "reference" variety of the plant.

The sorghum sequencing project was sponsored by the US government's Department of Energy, with participation from ICRISAT and five US universities: Cornell, Rutgers, Mississippi State, Georgia, and California (at Berkeley). The 697 million bases of the sorghum reference genome were published in early 2007.[4] Sorghum was selected for sequencing because of its current importance as a crop; new interest in its agrofuel potential and the desire to use sorghum as a model for understanding the genome of other grasses of tropical origin that have the same photosynthesis pathway (called "C4").[5]

The scientists chose to sequence a variety called Tx623. Often used in research, Tx623 was released by Texas A&M University in 1977. It is a cross between a so-called "kafir" sorghum and a zerazera variety.[6] The "kafir" sorghum, called Combine Kafir 60, was the US descendant of seeds introduced from South Africa in the late 1800s. The zerazera was collected by Texas A&M in Dire Dawa, Ethiopia in 1961.[7]

http://www.fsa.usda.gov/Internet/FSA_MediaGallery/sorghum2315892191.jpg

Although the sorghum genome has been sequenced, not much of it is understood. That is because knowing the order of chemical "letters" in sorghum DNA does not explain how it works. Yet by comparing sequences between sorghum and other plants (especially *Arabidopsis* and rice), and using mathematical methods to analyze similarities and differences, researchers can tentatively identify the function of gene sequences in sorghum.

In other words, if a particular gene sequence has a known function in *Arabidopsis* and that function is common to many plants, a sequence with the same function is likely to be present in sorghum. But because *Arabidopsis* and sorghum are not close relatives, the gene in sorghum (if present) is likely to have its genetic "letters" (chemical bases) rearranged. Recognizing the gene in its rearranged form can be difficult; but by using statistical comparisons, the companies believe they can pinpoint the functionally same sequence ("homolog") in sorghum. It is these homologs that the companies are often seeking to patent.

In the case of Rutgers University, a related but somewhat different approach was used. There, scientists compared genes in sweet sorghum to those in grain sorghum, using genetic tools designed for rice. They identified differences in the gene expression between grain and sweet sorghum types and are seeking to patent a number of those differences and their use in creating sorghum seeds.

In WO2010011935, Texas A&M University claims the use of a sorghum gene called "iap". The name stands for "inhibition of alien pollen" and is written in lower case because the recessive form of the gene is of most interest. ("IAP", in upper case, refers to the dominant form of the gene.) The recessive form of the gene, which Texas A&M found in Chinese sorghum seeds, permits sorghums to be pollinated by certain other species, resulting in hybrid plants that cross species and even genus lines.

The University's claims cover use of the iap gene in general, the gene in its form as found in the Chinese sorghum, when it is bred (or genetically engineered) into other sorghums and the plants that result from crosses with other species. Their claims are particularly oriented towards crosses with sugarcane for producing agrofuels but also include hybrids between sorghum and maize, millets, other grasses and other plants.

http://www.efcars.net/wp-content/uploads/2009/04/sorghum.jpg

In addition to patents, Texas A&M University and Ceres are pursing US Plant Variety Protection certificates[8] for three sorghum varieties. Two of these, the Ceres varieties ES 5200 and ES 5201 are high biomass sorghums that Ceres has already placed on the market. These varieties have most likely been provided to Ceres by Texas A&M, and documents obtained from Texas A&M suggest they may be produced from African farmers' seeds. Both Ceres and Texas A&M have actively resisted disclosing where these sorghum varieties come from. Ceres has been particularly vehement, hiring a Texas law firm to resist freedom of information requests to Texas A&M filed on behalf of the African Centre for Biosafety.[9]

The third sorghum variety, R07007, is said to be from the US state of Colorado by Texas A&M, which is seeking variety protection (and patents) for it. To date, Texas A&M has not answered requests to reveal the full origin of this germplasm.

Sorghum Industry Consolidation and Alliances

In Africa, most sorghum seed is open pollinated and is saved by farmers and replanted, or is shared between farmers or farmers' groups or farming communities. Outside of the African continent and particularly in the North sorghum seed production is more commonly an industry venture and typically, hybrid seed is purchased annually. Sharing and/or saving seed may become illegal if the variety is patented or under plant variety protection or patent claims. Seed saving is less practical because of the characteristics of hybrid seed.

As expectations for the potential future use of sorghum as an agrofuel crop surge, the sorghum seed industry (especially in the US) is in the process of feverish consolidation. Multinational companies are taking over smaller concerns and are forging alliances with universities and other diversified companies to heighten their vertical integration and create larger proprietary portfolios.

Ninety percent or more of US sorghum seed, as well as seed exported to Latin America and Asia, is produced on the high plains of the Texas "Panhandle" (the northernmost region of the state), where producing sorghum seed has become a specialty in many areas. Until recently, many Texas sorghum seed producers were relatively small private companies. Since 2008, however, a number of Texas seed growers and breeders have been acquired by larger companies. These larger companies are competing for position in a seed market where more farmers are turning to sorghum because of the demand from agrofuel refineries and the need for drought tolerant crops.

Advanta, an international seed brand now owned by the Mumbai-based conglomerate United Phosphorus, has bought Garrison & Townsend and Crosbyton Seed, both Texas companies. With these purchases, Advanta has captured nearly one-third of the US sorghum seed market (plus some exports to Latin America and Asia, where Advanta already has seed operations).[10]

In August 2009, NuFarm, an agrochemical multinational based in Victoria, Australia, bought Richardson Seeds and MMR Genetics, also both from the Panhandle.[11] NuFarm is a business partner with Monsanto and, in December 2009, the Japanese giant Sumitomo group took a 20% stake in the company, investing over Aus $600 million.[12] MMR Genetics, which is led by a former Texas A&M sorghum breeder, also has an agrofuel sorghum research and development agreement with Mendel Biotechnology of California.[13] Mendel is partially owned by Monsanto, and the two latter companies themselves have an agrofuel collaboration agreement.[14]

Company	Acquisition / Alliance
Ceres	Controls Texas A&M sorghum research program
Chromatin	Bought Sorghum Partners and Milo Genetics (Texas)
Advanta[15]	Bought Garrison & Townsend and Crosbyton (Texas)
NuFarm	Bought Richardson Seeds and MMR Genetics (Texas), Lefoy (Victoria, Australia)
Syngenta	Cross-licensing with Edenspace (Kansas).
DuPont	Herbicide resistance traits from Kansas State University[16]
Mendel Biotechnology	Research and development agreement with MMR Genetics

In April 2010, Chromatin, Inc, leaped into the sorghum seed market. A Chicago-based biotechnology company backed by venture capitalists, Chromatin, purchased both Sorghum Partners and Milo Genetics (again both Texas companies).[17] In doing so, Chromatin announced its intention to develop and sell genetically engineered agrofuel sorghums – plans reminiscent of those of its rival Ceres.

Meanwhile industry giant DuPont, which has long sold sorghum seed under its Pioneer brand, cut a deal with Kansas State University to license two herbicide resistant traits for use in sorghum, one of which was taken from a Bolivian sorghum plant. DuPont's plan is to sell (non-transgenic) herbicide resistant sorghums that can be sprayed with ACC and/or ALS-type herbicides "over the top", in a similar manner as glyphosate resistant genetically engineered crops. It says these will be commercialized in 2012.[18]

Edenspace, a Kansas-based biotech-nology company whose ambition with agrofuel sorghum is similar to that of Ceres and Chromatin, has cut a patent cross-licensing deal with biotech giant Syngenta for agrofuel crops including sorghum.[19]

http://www.au.org.au/lab/wp-content/gallery/qld-trip-march/%2020080325%20Sorgum.JPG

For its part, Ceres through contractual agreements, leverages a high degree of control and far-reaching rights over the sorghum research program of Texas A&M University, including access to A&M's large collection of copies of farmers' varieties of sorghum held "in-trust" under the ITPGRFA by ICIRSAT.[20]

Consolidation of the US and international sorghum seed industry has little immediate impact on Africa, but does have long-term implications.

While the present focus of consolidation is on US-based seed production enterprises, their outlook is decidedly global: Ceres, with US and European capital, has targeted Brazil for sorghum sales. An Indian conglomerate (United Phosphorus) now owns, one-third. of the US sorghum seed market and aims to expand sorghum seed sales in Argentina, Australia, and elsewhere. Australian and Japanese capitalists are also investing in Texas companies, and similarly view their markets as global. DuPont already has global reach and another giant, Syngenta, is partnering with Edenspace to collaborate on sorghum agrofuel biotechnology.

Conspicuously absent from this gold rush are African interests. Yet CGIAR, the Alliance for a Green Revolution in Africa (AGRA), the Rockefeller Foundation, and others are promoting the use of commercial hybrid sorghums in Africa,[21] including genetically engineered types.[22] If African farmers adopt these initiatives, traditional sorghum seed saving and sharing will be replaced by dependency on commercial seed. Over time, this may become a path into the grip of a consolidated international sorghum seed industry, particularly in African countries where agriculture is more mechanized and particularly if Africa begins to grow sorghum for agrofuels.

If African farmers are drawn into commercial/ agrofuel sorghum projects, traditional sorghum seed saving and sharing will be replaced by dependency on commercial seed. Over time, this may become a path into the grip of a consolidated international sorghum seed industry, particularly in African countries where agriculture is more mechanized and particularly if Africa begins to grow sorghum for agrofuels.

Ceres' Draconian Grower Agreement

With the expansion of intellectual property over seeds in many countries in the past 20 years, the practice of imposing stringent "grower agreements" on farmers has become increasingly common, especially in the North. These grower agreements typically seek to reinforce the already considerable power of the seed company over its product. Farmers

are contractually disadvantaged and the company can easily sue them for breach of the agreement, for example, saving seed for planting the following year.

For the 2010 growing season, Ceres has put forward a particularly harsh grower agreement that it insists farmers sign before selling them seed. The Ceres agreement asserts rights to the seed that go above and beyond the strong control offered by patents and plant variety protection. First asserting that its seed is protected by various forms of intellectual property, the Ceres grower agreement then reads (in part):[23]

"Under this Limited License Agreement, GROWER MAY NOT:

Use Ceres Seed, or any parental line seed which may be found therein, or any resultant plants, seed, mutants, sports or plant tissue from any of the foregoing, for any breeding, tissue culture, sexual or asexual propagation, seed production, reverse engineering, genetic fingerprinting, molecular or genetic analysis or engineering, or research (except research on biomass (excluding any seed) grown from Ceres Seed not resulting in the reproduction of such biomass), other than the production of a single commercial crop or multi-year stand for perennials.

Sell, transfer, export, sublicense, give or supply Ceres Seed to any other person or entity for any purpose.

Save, clean, condition or sell progeny of Ceres Seed for the purpose of planting a subsequent crop."

Ceres' demands that farmers not save seed for planting are typical in the US. More unusual is its insistence that people who buy its seed cannot seek to understand what it is, through "reverse engineering", genetic tests, analysis, or research of almost any sort. The restrictions are akin to a car salesman insisting that the buyer is prohibited from looking under the bonnet. Or selling processed food and refusing to reveal its ingredients.

Ceres has not explained why it is so anxious that nobody look closely at its seeds, except to say that everything about them is a trade secret. There is significant evidence, however, that Ceres' sorghum varieties came from Texas A&M and have recent African parentage, quite possibly including seeds declared to the held in-trust for the world's farmers by ICRISAT.[24] Whatever the reason, the harsh restrictions Ceres is trying to place on farmers and its paranoia about the public finding out where its seeds come from suggest that the company has truths to hide.

In Trust Status: Does it mean anything with sorghum?

Sorghum is one of the crops listed in Annex 1 of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)[25] and is thus part of that Treaty's multilateral system of access and benefit sharing. Under Article 15 of the ITPGRFA, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has declared over 36,000

of its sorghum seed collections to be held in-trust for the world's farmers. Most of these accessions originate in Africa or have been bred from African germplasm.[26]

Sorghum seeds declared in-trust by ICRISAT include many that are the bedrock of varieties used in industrial agriculture globally. These are and will continue to be heavily used by Texas A&M and others in breeding programs. While private companies like Edenspace (which sells "Linebacker" sorghum) and Ceres (which sells "Skyscraper" varieties) are not saying where their alleged proprietary sorghums come from, there is evidence that at least some of them are scarcely removed from ICRISAT in-trust accessions. In at least one case – the US and Brazilian government patent claims on the sorghum aluminum tolerance gene – it is certain that the gene under patent claim comes from an ICRISAT in-trust farmers variety originally collected in Tanzania.

Despite the ITPGRFA, most of the institutions discussed in this paper utilize in-trust sorghum germplasm and/or its progeny in proprietary breeding programs without regard for the Treaty and its multilateral system. They can do this for two reasons:

First, much of the research is taking place in the United States, which is not an ITPGRFA Party. Second, the United States holds copies of a large proportion of the ICRISAT sorghum collection, much of which was acquired decades ago. In some cases, the US collection of African sorghums surpasses that of ICRISAT itself. For example, the US national collection includes over 3,900 sorghum accessions from Sudan alone,[27] 1,500 more than ICRISAT itself holds.

ICRISAT, which has taken a very friendly stance towards the sorghum agrofuel industry, appears uninterested in sorting out the complexities of patent claims on its in-trust germplasm when it is copied elsewhere. Contacted by the African Centre for Biosafety and Berne Declaration in regard to the patent on the aluminum tolerance gene of an in-trust variety from Tanzania, ICRISAT Director General William Dar replied by shirking responsibility for Treaty issues:[28]

> *"In these circumstances, it is unclear as to who provided the material to the research in question,"* Dar wrote, adding, *"I wish to reiterate that ICRISAT has fulfilled its role to maintain materials in the public domain and to ensure their access."*

But, of course, the aluminum tolerance gene does not remain in the public domain, as it is patented in the United States and patent claims are pending elsewhere!

ICRISAT's response implies a *de facto* policy to ignore intellectual property claims on in-trust germplasm unless somebody else (such as an NGO) proves that the in-trust seed was directly supplied to the patent claimant by ICRISAT itself. Any person that wishes to patent in-trust ICRISAT sorghum and ignore the ITPGRFA multilateral system merely needs to request ICRISAT in-trust seed from a US gene bank, and in that case, ICRISAT or its parent the Consultative Group in International Agricultural Research (CGIAR) will take no action to protect the in-trust status.

http://upload.wikimedia.org/wikipedia/commons/8/84/Sorghum_bicolor03.jpg

This problem is compounded by the fact that entities that have acquired in-trust germplasm from US collections, such as Texas A&M and the US government researchers, are filing patent claims in countries that are parties to the ITPGRFA, such as Australia, Germany, the United Kingdom, France, etc. It is also their intent, according to Patent Cooperation Treaty filings, to pursue these claims in Africa.[29]

In addition, companies like Ceres may be utilizing in-trust germplasm while refusing to admit to that fact, indicating that by industry and/or academics simply covering up the origin of germplasm they use the ITPGRFA can be ignored.

It would appear that the in-trust designation of over 36,000 ICRISAT sorghums is ultimately meaningless while ICRISAT and CGIAR remain passive in the face of these problems.

Conclusion

The combination of a rise in patent claims and international consolidation of the sorghum seed industry spells trouble for African farmers. The proprietary claims are unjust to African and other farmers who developed sorghum and its diversity. The fact that these claims are being made outside of the ITPGRFA's multilateral system of access and benefit sharing allows improper claims over unaltered germplasm and denies resources from that system to promote the conservation and development of sorghum in and for Africa.

With the sorghum seed industry consolidating on other continents, donors such as the Gates and Rockefeller Foundations as well as multinational seed companies, are encouraging Africa to abandon traditional sorghum seed saving and sharing. In its place, they say a system dominated by commercially produced hybrid seed will be more productive. If Africa moves in that direction, however, it may find its sorghum production systems ripe for exploitation by the same agrochemical and seed interests that are presently consolidating elsewhere. This will result in the loss of African control over sorghum germplasm, even in Africa itself.

Climate change and agrofuels will continue to drive increased commercial interest in sorghum while those issues remain high on the global agenda and sorghum's unique usefulness is not eclipsed by other crops. Sorghum is currently on course to go the way of maize, soya, and other highly proprietary crops, particularly in agrofuel applications.[30] If Africa is passive and does not assert its sovereignty, it may see very little benefit from the growing interest in this African heritage crop.

References

1. The patent applications indicated in this chart exclude a number of others previously presented in ACB publications, including claims on the sorghum aluminum tolerance gene. For information on these patents please refer to: Hammond E (2009). **Africa's Granary Plundered**. African Centre for Biosafety. December and African Centre for Biosafety (2009). **Patents, Climate Change and African Agriculture: Dire Predictions**. September. Both available at: http://www.biosafetyafrica.net. See also: Mande M and A Elinaza. 15 February 2010. **US, Brazil seek patent to Tanzania sorghum**. The East African. http://www.theeastafrican.co.ke/news/-/2558/861208/-/pv8ocdz/-/index.html (accessed 6 June 2010).
2. Publication numbers prefaced with "US" are United States applications. Those beginning with "WO" are international Patent Cooperation Treaty (PCT) publications. Here, where a PCT application has been published, it is used to reference the patent family. If no PCT application has been published, then the US publication number is used. PCT claims are also filed in national and regional jurisdictions. More information can be found on in the WIPO Patentscope database (http://www.wipo.int/patentscope/en/) and by searching for the patent subject in national patent data.
3. Hammond E. 2009. **Africa's Granary Plundered**. African Centre for Biosafety. December.
4. US Department of Energy. Joint Genome Initiative (DOE JGI). 2010. **Sorghum bicolor (Cereal grass)**. http://www.phytozome.net/sorghum#D1 (accessed 7 June 2010).
5. DOE JGI. 2010. **Why Sequence Sorghum?** http://www.jgi.doe.gov/sequencing/why/3060.html (accessed 7 June 2010).
6. Texas A&M University. 7 March 1977. **Release of A&B Tx 622, 623, and 624 – Female grain sorghum lines and their maintainers**. Memorandum obtained under the Texas Public Information Act in request AR-2010-007 to Texas A&M Agrilife.
7. US Department of Agriculture, Agricultural Research Service (USDA ARS). 2010. **PI 276837**. http://www.ars-grin.gov/cgi-bin/npgs/acc/display.pl?1206925 (accessed 7 June 2010). The zerazera sorghum has no recorded name. Its ICRISAT designation is IS 12661. Also used are the US designations SC170 (Texas A&M, partially photoperiod converted) and PI-276873 (USDA ARS). It has been suggested that this sorghum was originally collected from lowland Ethiopian farmers by researchers from Alemaya University (now Haramaya University). See: McGuire S. 2005. **Getting Genes: Rethinking seed system analysis and reform for sorghum in Ethiopia**. (PhD diss.). Wageningen University.
8. Internationally, plant variety protection is the subject of the International Convention for the Protection of New Varieties of Plants, commonly called the UPOV treaty.
9. Hammond E (2009).
10. Advanta. 5 February 2010. **Advanta US, Inc. acquires Crosbyton Seed Company**. http://www.advantaus.com/pdfs/advanta%20acquires%20crosbyton.pdf (accessed 6 June 2010).
11. NuFarm. 5 August 2009. **Nufarm acquires leading US sorghum seed companies**. http://www.nufarm.com/system/inc/generic/fileDownload.php?downloadFile=/assets/12980/1/2009-08_US_Seed_Companies.pdf (accessed 6 June 2010).
12. Pearson M. 29 December 2010. **Nufarm Says Sumitomo Chemical to Acquire 20% Stake**. Bloomberg. http://www.bloomberg.com/apps/news?pid=20601087&sid=a0rhlGnGturI (accessed 6 June 2010).
13. Mendel Biotechnology. 2008. **Mendel Biotechnology and MMR Genetics Announce Sorghum Biofuels Collaboration**. 16 June. http://www.mendelbio.com/newsevents/index.php#aa
14. Monsanto. 2008. **Monsanto Company and Mendel Biotechnology Announce Cellulosic Biofuels Collaboration**. 28 April. http://monsanto.mediaroom.com/index.php?s=43&item=596
15. Owned by United Phosphorus of Mumbai, India.
16. Anonymous. 12 February 2008. **DuPont, K-State Partner on Herbicide-Tolerant Sorghum Hybrids**. Kansas Farmer. http://www.kansasfarmer.com/story.aspx/dupont/kstate/partner/on/herbicidetolerant/sorghum/hybrids/9/15720 (accessed 6 June 2010).
17. Chromatin. 28 April 2010. **Chromatin, Inc. Acquires Sorghum Partners, Inc. (SPI) and Milo Genetics, LP**. http://www.chromatininc.com/news-article.php?articlenumber=38 (accessed 6 June 2010).
18. Anderson K. 12 May 2010. **Coming soon: Inzen herbicide-tolerant grain sorghum** (Interview with Wayne Schumacher of DuPont). Brownfield Agricultural News. http://brownfieldagnews.com/2010/05/12/coming-soon-inzen-herbicide-tolerant-grain-sorghum/ (accessed 6 June 2010).
19. Edenspace. 19 May 2010. **Edenspace-Syngenta Collaboration in Energy Crop Feedstocks**. http://www.edenspace.com/news/2010/20100519.html (accessed 6 June 2010).
20. Hammond E (2009).
21. For an overview of ICRISAT thinking on African sorghum seed systems, see: Mgonja J and R. Jones. 2009. **Sorghum Seed Systems**. Presentation to From technology to product development for the African farmer. BecA-ILRI Hub and Syngenta Foundation for Sustainable Agriculture. Nairobi. 29 April 2009. http://www.syngentafoundation.org/__temp/Sorghum_seed_systems.pdf (accessed 6 June 2010).

22. African Centre for Biosaety. 2007. Tainting Africa's Heritage. 10 January.
23. Ceres. 2010. **Ceres Seed Use Agreement**. http://www.bladeenergy.com/seedagreement.aspx (4 June 2010).
24. Hammond E (2009).
25. The text of the treaty can be found at Url: http://www.planttreaty.org/texts_en.htm
26. To browse ICRISAT's collection, visit http://singer.cgiar.org and click on Institutes / Collections, then ICRISAT, then ICRISAT Sorghum.
27. Erpelding JE et al. 2005. **Variation in anthracnose resistance within the Sudanese sorghum germplasm collection**. PGR Newsletter Issue No. 141.
28. Dar W. 20 May 2010. Director General of ICRISAT. Personal communication.
29. Databases accessible over the internet do not provide data on national and regional patent applications in Africa (and large parts of Asia and Latin America). National and regional patent offices must be consulted to determine the status of the applications in those places.
30. Agrofuel applications are likely to develop in North America, South America, and Asia, whether or not Africa itself develops a large crop-based ethanol industry.

PO Box 29170, Melville 2109, South Africa
www.biosafetyafrica.net