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Africa's Green Revolution Drought Tolerant Maize Scam

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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, agrofuels and the Green Revolution push in Africa.

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Acronyms

H+-PPase	H+-pyrophosphatase
AATF	African Agricultural Technology Foundation
ACB	African Centre for Biosafety
AMO	Atlantic Multidecadal Oscillation
ARC	Agricultural Research Council
ARDRI	University of Fort Hare Agricultural and Rural Development Research Institute
AZEF	Arid Zone Ecology Forum
BMG	Bill and Melinda Gates
CAADP	Comprehensive African Agriculture Development Programme
CGIAR	Consultative Group on Agricultural Resources
CIMMYT	The International Maize And Wheat Improvement Center
DTMA	Drought Tolerant Maize for Africa
FAO	Food and Agriculture Organisation
GM	genetically modified
IAASTD	The International Assessment of Agricultural Knowledge, Science and Technology for Development
IRMA	Insect-Resistant Maize for Africa
ITSC	Institute for Tropical and Subtropical Crops
KARI	Kenya Agricultural Research Institute
NBI	National Botanical Institute
NRF	National Research foundation
UC	University of Connecticut
UCT	University of Cape Town
WEMA	Water Efficient Maize for Africa

Overview

Prediction of exacerbated drought in Africa due to climate change is apparently the driving force behind the establishment of the Water Efficient Maize for Africa (WEMA) initiative, another prong of the so-called "New Green Revolution for Africa". WEMA seeks to develop drought tolerant maize varieties through a program which is being presented as a panacea for solving issues of hunger on the continent using marker assisted breeding and genetic engineering. That this is being done under the guise of philanthropy sidesteps questions about the real causes of hunger, disregards issues of imbalanced global distribution of food and underplays the financial benefits to be derived by the various proponents of the scheme. The possible risks to small-scale farmers, whom WEMA targets, include loss of biodiversity through gene flow, a dependence on expensive inputs into farming, possible exposure to intellectual and property rights claims and impacts on their food security. The most effective ways of supporting small-scale farmers is through agro-ecological approaches to farming. These focus on small-scale sustainable agriculture; locally adapted seed and ecological farming that better addresses the complexities of climate change, hunger, poverty and productive demands on agriculture in the developing world.

Introduction

Maize or corn (*Zea mays* L.) is grown commercially in over 100 countries primarily for the kernel, which is processed into a wide range of food and industrial goods. On the African continent alone, maize constitutes the staple diet of in excess of 300 million people. Maize growth is sensitive to several stresses including low rainfalls and subsequent moisture stress; and there have been several calls in African countries by governments, farmers, civil society and the scientific community for solutions to the effects of drought on small-scale maize farmers and their families. Within this context, promoting the idea of a drought tolerant maize plant appears very attractive, especially in semi-arid regions of Africa and more so in the light of the current debates relating to climate change and the potential difficulties the region might face. This paper explores the meaning of drought tolerance and examines the current status of the development of drought tolerant plants both by transgenic and conventional approaches. The possible impacts of the introduction of a genetically modified (GM) drought tolerant maize on small-scale farmers in Africa is considered against the background of the underlying social and economic conditions related to hunger, including problems of distribution, access to land, wars, corruption and poverty. Further, the activities of institutions and programmes currently underway in South Africa (Monsanto field trials) and elsewhere that promote the idea and development of drought tolerant maize are examined.

What is drought?

"We have no good definition of drought. We may say truthfully that we scarcely know a drought when we see one. We welcome the first clear day after a rainy spell. Rainless days continue for a time and we are pleased to have a long spell of such fine weather. It keeps on and we are a little worried. A few days more and we are really in trouble. The first rainless day in a spell of fine weather contributes as much to the drought as the last, but no one knows how serious it will be until the last dry day is gone and the rains have come again... we are not sure about it until the crops have withered and died." – Tannehill 1947[1]

In attempting to address the challenges posed by drought it is important to understand what drought is? Most people generally accept that drought is a condition that arises when there is a deficiency in the expected levels of precipitation over a prolonged period of time; when they have a sense that the season in previous years was generally wetter. Parched land, dried crops, dust storms, and starving livestock are some of the scenes that people associate with the term drought. Unlike most hazardous weather conditions, drought is not always obvious. Drought may be several years in the making, arising from gradual loss of moisture in the soil through evaporation or the loss of surface water sources due to the lack of rainfall. However, drought is understood to be a normal feature of climate that affects all climatic zones at one time or another.

Some countries have managed the impacts of drought by effective approaches to water storage, allocation, and usage patterns, while other parts of the world have dismally failed to do so. The African continent has suffered from recurring drought and desertification, the impacts of which have been devastating on its people. Climate scientists have applied several models to drought in Africa in an attempt to understand what has caused the droughts that have beset the continent since the 1940's. One of the proposed causes is related to fluctuations in sea surface temperatures, a pattern called the Atlantic Multidecadal Oscillation (AMO).[2] Others relate drought patterns to overgrazing of livestock which prevents the land from recovering. Still others relate drought patterns to low levels of natural vegetation which contribute to greater surface albedo (surface radiation) leading to a drier, cooler climate, which in turn weakens the monsoon circulation, and less moisture comes in from the south and west.[3] Whatever the causes, drought has had and continues to have serious health, social, economic and political impacts with far-reaching consequences including hunger and famine, thirst, disease, wildfires, social conflict, war and population migration.

As early as the 1800's, calculations were made about increases in the earth's surface temperature by between 5-6°C with a doubling or tripling of the atmospheric CO_2 content.[4] Although we do not know exactly how climate change will affect regional water resources, it is clear that already-stressed water resources[5] subject to any additional stress from climate change or increased variability is very likely to exacerbate drought conditions. Some climate change models predict that the semi-arid southern parts of Africa may face reduction in available water by as much as 25%.[6] Africa relies strongly on rainfed agriculture and predictions are that the impacts of drought coupled with the impact of climate change on crop production will result in the continent being one of the worst hit areas of the world.[7] A Food and Agricultural Organisation (FAO) Report released in early 2008 predicts that a temperature increase of 3-4°C could cause crop yields to fall by 15-35% in Africa.[8] Additionally, 65 countries, largely in Africa, risk losing 280 million tonnes of potential cereal production, valued at $56 billion, as a result of climate change.[9] Other possible impacts include desertification, sea level rise, reduced freshwater availability, cyclones, coastal erosion, deforestation, loss of forest quality, woodland degradation, coral bleaching, the spread of malaria and impacts on food security.[10]

Features of African agriculture

Agriculture, from the Latin meaning "tillage of the soil", is a 10,000 year old practice that has shaped the course of human civilisation. Agriculture allowed for the establishment of permanent human settlements, greater longevity and a dependable food supply. An integral part of the lives of most people, advance in agricultural practices, especially post the Industrial Revolution, changed the face of farming. In industrialized societies average farm sizes increased substantially. However, small-scale agriculture still predominates with about 404 million of an estimated 525 million farms worldwide having fewer than two hectares of land.[11] This is certainly the case in Africa with most farmers engaged in smallholder farming systems which provide most of the food consumed, as well as a substantial share of cash crops.[12]

In the sub-Saharan region in particular, diversity is the norm where farmers typically cultivate 10 or more crops in diverse mixtures and 17 distinct farming systems are identified.[12] Many small-scale farmers practice intercropping i.e. they grow a variety of crops intermingled in the same field, often as a way of safeguarding their production from shocks such as pests, drought and as a means of maintaining the fertility and hence the productivity of the land. Small-scale farmers recognise that these intercropping approaches allow them to ensure their livelihood because intercropping measures allow farmers to spread risk in the event of crop failure, serve as a buffer to farmers who may be better able to withstand price variability, contributes to a more varied and balanced diet, maximises land use and depending on the crops planted can assist in eliminating weeds.[13]

Another widely practiced feature of African small-scale farming is seed saving where a portion of the harvested crop is set aside for the next years planting. Over years, the plants in question gradually adapt to the specific microclimate that these are planted in and unique varieties develop that are able to withstand the environmental and pest pressures exerted on them each year. Saved seed is a resource that the poorest depend on to carry them through the year. Seed related activities are also integrated with social and economic interactions, as farmers disseminate and procure seed through barter among friends, neighbours and relatives, as well as through local grain markets or traders.[14] Seed saving is not a uniquely African practice and it is estimated that about a third of humanity depends on saved seed for their survival.[15] For smallholder farmers, access to seeds can be by both and formal and informal systems (i.e., local, farmer or traditional), with the latter being more common and up to 80-90% of all seed traded worldwide being through informal systems.[16]

In certain parts of Malawi farmers have switched to planting cassava, which withstands drought much better than maize.[17] Some concerns about the widespread consumption of cassava are related to the potentially serious health implications of continued cassava consumption on both people and livestock due to the hydrocyanic acid (cyanide) contained in the plant.[18] Possible health effects include nutritional neuropathies, endemic and upper motor neuron disease as wells as headaches, nausea, vomiting and collapse. However it has been found that cyanide can be removed or substantially reduced by simple traditional processing techniques including drying, boiling, roasting, shredding or grating, and the de-watering of the pulp and fermentation of the tissue.[18]

Alternative approaches to handling maize pests are also proving useful. One of the problems of maize cultivation is attack on the plants by stem borer moths, which drill into the stems of immature plants and lay their eggs. The resulting caterpillars hatch and feed on the host plant which collapses early in growth, long before the edible ears have even ripened. The problem of stem borer attack on maize was examined in a study that started in 1994. The study found that Napier grass planted in conjunction with maize attracts stem borers, but produces a super sticky type of sap that kills the majority of the invaders' larvae when these hatch and begin to bore into the stem of the grass. Just enough of the stem borers remain to attract a parasitic wasp that is drawn to Molasses grass and feeds on the stem borer. The two grasses, when planted in conjunction with maize, aid in controlling the stem borer population. The cultivation of these two grasses has the added benefit in that the grasses provide nutritious fodder for cattle. In the study, maize yields increased by a minimum of 30% for the 1,500 farmers who have since started to interplant the grasses with their maize.[19]

Agro-ecological approaches to farming help maintain soil diversity through crop rotations that will balance certain soil nutrients in the soil and through natural, readily available inputs like compost and manure which replenish the soil. Subsistence farmers will often opt to plant and breed local maize varieties rather than buying 'modern' varieties because these represent a resource outside of the sphere of markets, which allows them to control their trade locally and maintain control of this trade within the context of their own institutional and cultural settings and arrangements.

Drought tolerance

Engineering drought tolerance

Research into elucidating the mechanism of drought tolerance in plants is underway internationally. Different plants have different genetic makeup and hence different abilities for drought tolerance. The fundamental mechanisms of stress tolerance in plants are not well understood.[20] The coding for drought tolerance in particular, is incredibly complex with up to as many as 60 genes implicated, all interacting in a subtle and complex way.

There are several programs underway internationally to genetically engineer drought tolerance in plants. A variety of wheat containing a gene from barley, which requires one eighth as much water as its conventional counterpart, is undergoing biosafety testing in Egypt in preparation for commercialization.[21] The International Maize and Wheat Improvement Center (CIMMYT) is currently evaluating a drought tolerant transgenic wheat variety which may be ready for commercialization within five years. Switching on transgenes is also an active area of research. The CIMMYT transgenic drought tolerant wheat, for example, does not do as well under conditions of sufficient rainfall as under water-deficient conditions and research is underway to switch on the drought tolerance mechanism only under conditions of water stress to reduce or eliminate yield drag.[22,23]

The University of Connecticut (UC) has engineered a drought resistant tomato by enabling transgenic tomato plants to produce more of the enzyme H+-pyrophosphatase (H+-PPase) which was shown in Arabadopsis plants to confer resistance to drought. The UC is currently studying this effect in rice, poplar trees and legumes.[24] Cornell University reported a new strategy for genetically engineering rice and other crops to make them more tolerant of drought, salt and temperature stresses, whilst improving yields.[25]

In South Africa alone, several institutions and organizations are involved in or may have units especially dedicated to the study of stress tolerance, albeit not only by genetic manipulation. These include, amongst others, The Agricultural Research Council (ARC) Institute for Tropical and Subtropical Crops (ITSC), the National Research Foundation (NRF), the Arid Zone Ecology Forum (AZEF) facilitated by the National Research Foundation, The Grootfontein Agricultural Development Institute, the National Botanical Institute (NBI) Stress Ecology Research Unit, the University of Fort Hare Agricultural and Rural Development Research Institute (ARDRI), the University of Cape Town (UCT) Plant Stress Research Unit and the University of the Witwatersrand School of Molecular and Cell Biology.

Several native South African Xerophytes e.g. *Xerophyta humilis*.[26] and *Xerophyta viscosa* (known as isiphemba or isiqumama in Zulu) have many medicinal applications including treatment for asthma, nose bleeds, general aches and as anti-inflammatory. *X. viscosa*, a so-called resurrection plant, is able to survive long periods without water and has the remarkable property of being able to rehydrate completely and resume full metabolic functions within 24 to 72 hours, depending on the species.[27] Scientists at the Plant stress Research Unit at UCT are studying X. viscosa genes that code for proteins responsible for the resurrection phenomenon. Several of the genes implicated in this drought tolerance have been identified and are being cloned into drought sensitive species of plants such as the monocot grass *Digitaria sanguinalis* and the weed *Arabidopsis thaliana*. Future plans include engineering tolerance in agronomically important crops such as wheat and maize.[25]

Engineering drought tolerance in maize

Maize or corn (*Zea mays* L.),Is grown commercially in over 100 countries primarily for the kernel, which is processed into a wide range of food and industrial goods, constitutes the staple diet of in excess of 300 million people in Africa. In Tanzania maize is the major cereal consumed, with annual per capita consumption estimated at 112.5 kg.[28] In Southern Africa, per capita consumption exceeds 100kg annually. Maize is not native to Africa and was introduced about 500 years ago.[29] Originally maize was cultivated by settlers in the region, but it soon became an important part of the diet and a means of earning some income as a cash crop by poor farmers. These local maize populations have been subjected to several hundred generations of human and natural selection in varying environments and by different cultural methods.[30] The cultivation of maize extends from the lowlands to the highlands as well as from the marginal to optimal soil fertility environments with varying degrees of success.[31] A study by CIMMYT of diversity in different maize varieties from Zambia, Zimbabwe and Malawi revealed considerable variation in phenological, morphological and agronomic characteristics and high levels of molecular diversity between varieties originating from different growing environments and between different locally and commercially bred varieties.[32] The majority of maize farmers in Africa carry out farming on small areas of land often no larger than about 3 Ha.[33]

Maize like all cultivated plants is affected by inadequate water resources and can experience drought stress leading to lower yields. In the light of the current debates relating to climate change and the potential difficulties the region might face, promoting the idea of drought-tolerant maize is very attractive.

Monsanto was granted permission in 2007 by the South African regulatory authority to conduct field trials of 4 events of its abiotic stress corn over a three year period.[34] Monsanto is also conducting studies on drought tolerant soybean and cotton.[35] In June 2009, Monsanto, in conjunction with BASF, announced the discovery of a naturally-occurring gene that can help maize plants combat drought conditions and confer yield stability during periods of inadequate water supplies.[36] Called cspB, the gene was first identified in the bacterium *Bacillus subtilis* subjected to cold stress conditions, and further research has demonstrated that cspB helps plants cope with drought stress. Monsanto hopes to make the drought tolerant plants commercially available by as early as 2010 pending the necessary regulatory approvals. Additionally, Bayer,[37] Syngenta,[38] Dow, BASF[39] and DuPont[40] all have extensive research programs in the area of drought tolerance.[41]

Wema and the new green revolution in Africa

There are several programs and funders active in Africa to promote what has been termed the "New Green Revolution in Africa". The term "Green Revolution" was coined in 1968 by then USAID Development Director, William Gaud, to describe initiatives to promote the widespread uptake of industrial agricultural technologies. [42] This was a movement that promised the benefit of increased yields through the adoption of new crop cultivars, implementation of irrigation projects and increased use of pesticides and synthetic fertilisers.

Initiated in Mexico, through the establishment of an agricultural research station, the original Green Revolution implemented primarily in South East Asia and Latin America was hailed a success. This, on the basis of increased global food production from 1970 to 1990 by 11% with more than 150 million people lifted from the ranks of the world's hungry.[43] The number of hungry in China dropped from 406 million to 189 million during this period. In China, the timing of the Green Revolution with the Chinese Revolution, which included policies of improved access to land and resultant improvement of living standards, did not allow for unambiguous attribution of reduction in hunger to the Green Revolution interventions.[44] The elimination of China from the estimation of the global impacts of the Green Revolution showed that the number of hungry people in the world actually increased by more than 11%.[45] In South America alone, per capita food supply increases of close to 8% did not prevent the number of hungry increasing by 19%.[46]

The impact of the First Green Revolution was also felt in Mexico where dwarf grain varieties, petrochemical fertilizers, and large-scale irrigation systems were encouraged and implemented. The upshot was a surge in grain yields, flooding of the markets and a plunge in global market prices. Small-scale farmers, unable to compete with larger operations, formed part of a mass migration of farmers to the urban centres. In southeast Asia alone, over a 25 year period from 1975 to 2000, the urban population increased from 20% to 35%.[47] World Bank estimates are that by 2030 half of South East Asia will reside in urban centres. The widespread promotion of the use of petrochemical based fertilisers degraded the soil and impacted on fertility by changing the physical structure of soils, making them less efficient at storing water, air, and nutrients.

This original Green Revolution, led by the Rockefeller and Ford Foundations-established Consultative Group on Agricultural Resources (CGIAR), which had such widespread impact in Asia from the 1950's to the 1980's, also targeted Africa at the time, but with little or no success. The Green Revolution by its very limited one-size-fits-all nature proved not sufficiently adaptable to Africa and African needs. In 1999, Gordon Conway, author of "the Doubly Green Revolution" announced the start of this New Green Revolution for Africa, applying the same formula of the original Green Revolution with the additional sub-revolution of using scientific and technological developments, including but not limited to biotechnology.[48] These efforts have been bolstered by the entrance of several new players including the Bill and Melinda Gates (BMG) Foundation through the Warren Buffet Foundation, the Yara Foundation and the Soros Foundation.[46] To date, these philanthropic initiatives have committed in excess of $300 million dollars [49,50,46] to the New Green Revolution developments which include:

- Crop breeding programmes, primarily in Eastern and Southern Africa;
- Promotion of farming inputs and facilitation of the use of inorganic fertilisers;
- Improved and stronger market systems, better infrastructure and training in credit and loan financing; and
- Policy and institutional interventions.

Added to the mix are United Nations initiatives, market liberalisation and deregulation drives by financial institutions, activities of large agricultural companies like Syngenta and Monsanto and the NEPAD Comprehensive African Agriculture Development Programme (CAADP).

Maize production activities in particular have been boosted by the allocation of $47 million dollars of this money to the development of a five year project called Water Efficient Maize for Africa (WEMA).[51] WEMA is an initiative by the African Agricultural Technology Foundation (AATF) and involves a partnership between the national agricultural agencies from Kenya, Uganda, Tanzania, Mozambique and South Africa; the Maize and Wheat Improvement Center (CIMMYT) and Monsanto. This forms part of the AATF's Drought Tolerant Maize for Africa (DTMA) Project.[52] According to the WEMA programme, "drought leads to crop failure, hunger, and poverty".[53] Both conventional and technological approaches are being utilised by WEMA:

- the CIMMYT is providing high-yielding maize varieties adapted to African conditions and expertise in conventional breeding and testing for drought tolerance;
- Monsanto is providing proprietary germplasm, advanced breeding tools and expertise; and
- the national agricultural research systems will contribute project governance, seed testing, production and distribution assistance.

The project rollout timeframes include the development of drought tolerant varieties by marker assisted selection in about six years and the first drought-tolerant maize transgenic hybrids by 2020.

According to a press release on the Monsanto website, multiple African seed companies will offer the new varieties to farmers who may choose to adopt them, or may elect to continue growing the varieties they currently use. Much is made of the fact that the AATF will make the newly developed varieties available royalty-free to small-scale farmers in Sub-Saharan Africa, though the terms of this arrangement are not spelled out. Regardless, Monsanto will maintain its patenting or claim of intellectual property because as Monsanto asserts, "the Patents aren't a barrier to bringing this technology to the poor. Instead, they facilitate technology innovation which benefits all farmers including the most resource-poor”.[54]

The involvement of Monsanto in WEMA paves the way for the introduction of Monsanto’s GM technology as well as expanding its potential market for fertilisers. In a global business survey conducted in 2004, Monsanto found it had about 25 million small landholder customers in the developing world. Rob Horsch, Monsanto’s vice president for international development partnerships, said that while these customers accounted for a small amount of total sales volume “it’s a large number of our total customers and it represents an important portion of our commercial future”.[55] Andrew Kimbrell, the executive director of the Center for Food Safety, describes biotech companies promoting genetically engineered crops as “... basically chemical companies selling more chemicals. They’ve been able to spread these herbicide-promoting plants around because it is more convenient for farmers who can just mass-spray their crops. But they’ve given absolutely nothing to the consumer while causing more chemical pollution and contamination.”[56]

The press on WEMA is careful not to explicitly discuss GM and focuses more on the benefits to be derived from MAS. The Seattle-based Community Alliance for Global Justice which maintains “AGRA Watch” has tracked spending of the BMG Foundation money in AGRA and in one instance, out of 23 grant projects in Kenya, 12 are involved in research and advocacy around genetically modified organisms with as much as $100 million in grants being spent in organisation which have a link to Monsanto.[57] Keith Jones of CropLife, which represents Monsanto and BASF amongst others, has stated that “GM foods are exactly the technology that may be necessary to counter the effects of global warming.”

From the announcement of the WEMA initiative in 2008, progress in rolling out the program has been rapid. To date, 13 Monsanto scientists based in South Africa and Kenya, have joined the WEMA project on a full-time basis[58] and in June 2009, the Kenya Agricultural Research Institute (KARI) announced that it was in the process of seeking regulatory approval for confined field trials of drought-tolerant transgenic maize.[59]

Risks to farmers

Impacts on food security

According to the FAO, a household’s food security is determined by food availability, access to food, stability of supply and accessibility, and the degree to which food is nutritious and safe to ingest.[60] Small-scale agriculture has maintained its dominant position in African agriculture and ensured some measure of food security for farmers engaged in this practice, even under conditions of civil unrest, disease, poverty and famine. Encouraging the use of proprietary seed makes previously independent farmers dependent on the yearly purchase of the proprietary seed and the associated agrochemicals (fertilisers, herbicides, and pesticides). The farmers’ food supply is now dependent on the external inputs from a small number of agricultural biotechnology companies.

Gene flow in maize

Gene flow is a natural process by which genes move from one location to another, either from one genome to another, or by the movement of pollen from plants into a new environment.[61] Transgenes from GM crops may flow to GM plants or to wild relatives or into new environments. Whilst it is true that the maize pollen grains are round and heavy with a high water content, which limits their dispersal range, small amounts of pollen can travel 400m or more and remain viable[62]. Dispersal of transgenes into maize landraces was first reported in 2001 in the Mexican state of Oaxaca.[63] A subsequent study questioned this finding[64] but more recent studies have confirmed their presence in Oaxaca and also found them in a new area of Mexico.[65,66] Maize is not endemic to Africa and there are no known wild relatives. However there are certain varieties prized above others, which are recognised for having particular distinctive qualities and as being a potential source of valuable traits for crop improvement. In Kenya, for example, these varieties are preferentially grown because of consumption preferences, agronomic attributes, or the subsistence orientation of production. Cultural values are also cited by subsistence farmers for planting their own varieties rather than hybrids, including the importance of colour and taste, to religious reasons for maintaining and selecting their own seeds.[67] Fears that these varieties may be contaminated by Bt genes has led the Insect-Resistant Maize for Africa (IRMA) project in Kenya to establish a collection of such varieties in the national gene bank.[68]

There is a considerable risk of gene flow when it comes to maize, especially through cross pollination and particularly in those circumstances where landholdings are fragmented; varieties are planted contiguously; and farmers recycle, exchange, or mix maize seed as is the case in most of Sub-Saharan Africa.[69] Many small-scale farmers will plant improved varieties adjacent to local varieties in an attempt to promote hybridisation between the varieties. Given the subsistence nature of a lot of these farming practices and the small acreage of small-scale farms, neighbouring farms are very close and often maize plants are within out-crossing distance of their neighbours. Traditional small-scale African farmers also practice livestock farming almost always under free-range conditions. Often, the animals are grazed communally under an open access or common property tenure system which is accompanied by widespread manure dispersal.[70]

All the risk assessment applications to the South African regulatory authority for planting transgenic maize state that wild populations with which maize could cross-pollinate are 'uncommon'. These also claim that weediness is unlikely should a seed spill or inadvertent planting occur. Despite this, the risk assessments typically detail a course of action should the transgenic maize be accidentally released to the environment. Maize plants have been shown to survive over a growing season, under comparatively colder conditions[71] than found in South Africa. Should any volunteers arise, the resulting pollen could cross-pollinate with maize in fields, producing genetic contamination. Some researchers describe the chances of cross-pollination with other maize crops as a "medium to high risk".[72]

Costs associated with expensive inputs

Whilst the Monsanto contribution is royalty-free, farmers still have to buy the seed and the inputs that accompany it including pesticides and fertilisers. In 2008, the area of Mnduka in Malawi reported a surplus in its harvest. Malawi had suffered five years of food shortages culminating in a drought in 2005 that left 4.5 million people without food. At the time of the drought, most of the farmers were already planting high-yielding hybrid maize varieties with however the requirement for expensive inputs including fertiliser. The high yielding (2500kg/hectare) grains are also less resistant to worms and weevils and seed storage for the next planting season is only effective with the expensive input of pesticides. The shift to a surplus situation was made possible, in large part, by the Malawian government subsidising the purchase of seed, fertiliser and pesticides. The surplus did not mean lower prices for locals; in just a year prices rocketed to double what they had been the previous year[73] directed by international market forces for maize outside of the control of the Malawian government. The requirement for additional inputs into the system merely added to the burden of these farmers already under pressure to produce sufficient food for their survival. The dependency created by the reliance of these farmers on the subsidy is accompanied by fear for their plight if the subsidy is withdrawn.

Patents and intellectual property rights

The approach of WEMA is to identify local species and varieties that already are able to withstand abiotic stresses and through MAS breeding and genetic engineering modify these strains to yield new varieties that are "climate ready". What they are effectively doing is isolating climate tolerant genes within these naturally available varieties and transferring them into new species all of which are then patented in the name of the developer. By 2008, many agrochemical corporations including BASF, Bayer, DuPont, Monsanto and Syngenta, had already filed 532 patent documents on so-called 'climate ready' genes at patent offices around the world.[74]

At the same time that the WEMA initiative is involved in apparently philanthropic development in Africa, its close associate[75] CropLife is involved in campaigning hard for governments in the South to enact tougher intellectual property laws to ensure that farmers pay royalties on proprietary seeds.[76] The enactment of Counterfeit Laws in certain African countries is sufficiently broad to ensure blanket protection to biotech companies. In Kenya for example, the 'Anti-Counterfeit Act', which applies to "any intellectual property right subsisting in Kenya or elsewhere in respect of protected goods", explicitly criminalises violators of plant breeders' rights.[74]

The use of royalty-free germplasm for the development of "climate ready" varieties will most likely be accompanied by intellectual property laws and seed regulations. Farmers are potentially susceptible to prosecution for violation of these especially in the event of crop flow or seed sharing and exchange with those farmers who opt not to buy WEMA developed seed. Monsanto is well known for prosecuting farmers whom it considers guilty of infringing its intellectual property and patents. Canadian Percy Schmeiser, whose field was contaminated by Monsanto-developed oilseed rape (Canola) pollen from a neighbouring farm growing the variety, was found guilty under Canadian patent law of patent infringement even though there was no way that he could have prevented the contamination. The Center for Food Safety in their 2005 report "Monsanto vs. US Farmers" revealed that Monsanto had filed 90 lawsuits against U.S. farmers in 25 states that involved 147 farmers and 39 small businesses for patent infringement. According to the report, the largest recorded judgment made thus far in favour of Monsanto as a result of a farmer lawsuit is $3,052,800.00. Total recorded judgments granted to Monsanto for lawsuits amount to $15,253,602.82. Farmers have paid a mean of $412,259.54 for cases with recorded judgments."[77] This does not include those farmers who chose to settle out of court and who are bound to silence by gag orders.

Conclusions

The UN's Food and Agriculture Organisation (FAO) estimates that every year 40% – 50% of the population of sub-Saharan Africa goes hungry and that the region "is worse off nutritionally today than it was 30 years ago".[78] The development of drought tolerant maize varieties is being presented as a silver bullet by the large biotech companies like Monsanto, DuPont and Syngenta for eradicating hunger in Africa especially in the event of predicted climate changes for the continent. Overall global food production has increased in the last 50 years with the rate of production exceeding human population growth.[79] Despite this, more than a billion people subsist on less than 1,900 calories per day and ironically, most of this number work in agriculture, largely in rural Africa and Asia.[80] In the late 1960s, Africa was a net exporter of 1.3 million tons of food a year, but now imports as much as 25% of its food requirements; a move arising more from the burden imposed by servicing international development loans and the pressure to maintain free markets.

Drought tolerance is an extremely complex phenomenon mediated by multiple genes and regulatory pathways and from the reported literature, has been shown not to be as easy to engineer into plants than more simply inherited traits governed by single genes. The successful manipulation and transfer of many complex genes, which can respond to a variety of conditions without producing unwanted toxins and allergens, is a long way off for current scientific knowledge with some geneticists admitting that even hoping for drought tolerance in the next 10 or 20 years may be too ambitious.[81] Strong economies and viable political structures have successfully responded to the advent of drought in their countries by adjusting water storage, allocation, and usage patterns.

The flaw in the argument of the biotech companies and proponents of AGRA and WEMA is the assumption that the problems lie in insufficient productivity, which will be exacerbated by drought, and that the solution lies in improved agricultural performance through biotechnology. However, the hunger and food crises in Africa are not solely caused by abiotic stresses. Undoubtedly droughts have affected the quantities of food available, but the genetic diversity of plants and animals and the diverse knowledge and practices of farming communities are the most important resources for adapting local agriculture to a changing climate. The International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD),[82] an intergovernmental report modelled after the Intergovernmental Panel on Climate and commissioned by the World Bank, was carried out over 4 years and involved the collaborative effort of more than 400 scientists. Adopted by fifty-eight countries in the global North and South (excluding the United States, Canada or Australia), the IAASTD found that agro-ecological approaches to farming that focus on small-scale sustainable agriculture, locally adapted seed and ecological farming are better able to address the complexities of climate change, hunger, poverty and the productive demands on agriculture in the developing world.[83] Farmers, in particular small-scale farmers, must be acknowledged and supported by societal and governmental structures that create an enabling environment for all to be involved in setting priorities and strategies for adaptation. An appropriate interaction with scientists focused in assisting farmers to improve conservation technologies and develop breeding strategies in a way that does not place additional burdens on communities in already straitened circumstances is essential.

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