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CROSS-BORDER PERILS CREATE CROSS-BORDER PARTNERSHIPS

How U.S. Leadership in Research Can Fight Threats to Global Agriculture

In the last fifty years, U.S. public investments in agriculture sciences have sparked revolutionary developments in disease prevention.

New technologies continue to protect U.S. farmers and consumers from pests and diseases both within and outside the United States. The effectiveness of these efforts has permitted the United States to achieve high farm yield, low prices, and new and safer trading opportunities, while also improving the diets of millions of people across the globe.

The United States plays a critical leadership role in creating global partnerships for agricultural research into pests and diseases[1]. However, diseases that affect global agriculture still risk human and animal health, political stability, and economic vitality in both the developed and developing world and represent roadblocks to feeding 10 billion people by 2050. Below are several examples that illustrate why the United States must continue to lead in research and development to address agricultural pests and diseases. Successful efforts to arrest or eliminate these complex pest and disease challenges do not happen overnight and will require a long-term commitment among nations and research institutions. In an ever-shrinking world, diseases in one location threaten global production and human health. The time for investment is now.

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Avian Flu

"Avian flu" encompasses 27 subtypes of influenza that are typically found in Southeast Asia. Of these types, the two most relevant and dangerous are H5N1 and H7N9.

These two types of bird flu are typically transmitted from live birds to humans, most often to workers on poultry farms or in live bird markets, the latter of which are especially common in East Asia where most cases of the disease appear. Currently these pathogens are almost solely endemic to birds, with outbreaks decimating flocks within 48 hours. They can be further exacerbated by man-made ecology like factory farms where close proximity and unhygienic conditions can speed its spread[2].

Avian flu is one of only a few diseases that could metastasize into a global pandemic, according to the Centers for Disease Control and Prevention (CDC). Both serious strains also have a high human mortality rate. Since 2003, 860 cases of H5N1 have resulted in 454 deaths worldwide[3]; since February 2013, 1625 cases of H7N9 have caused 623 deaths worldwide[4]. Some countries, such as China, have developed an H7N9 vaccine, but flu viruses are known to rapidly change and evolve. Even if it is used, a vaccine may not be as effective as anticipated[5].

Avian flu also poses severe risks to the East Asian economy. Since infected poultry are carriers, culling is the most effective reaction to an outbreak, resulting in the crippling of egg and meat production. A 2005 FAO report, following an outbreak in Southeast Asia, found that the economic losses totaled $10 billion over the region as a whole. In Vietnam specifically, the average opportunity cost of culling a bird ranged between $69 and $108, in a country where half the population survives on less than $2 a day[6].

In January 2014, a Canadian citizen returning from China fell ill and died from the H5N1 virus, marking the first known human case in North America. In addition, some strains endemic to the continental U.S. have been discovered, and the USDA actively monitors populations for breakouts, especially those with the potential to impact domesticated birds and humans. The spread of Avian Flu demonstrates the need for more research into vaccines, prevention, and control protocols to protect against this serious threat. **While Avian flu has not yet been introduced to North America on a large scale, failure to act could rapidly lead to a cascade of human and economic costs.**

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Aflatoxin

Aflatoxins are carcinogens produced by mold growing on rotting vegetation, often corn, cottonseed, and nuts. These particles can contaminate both grains and the meat of animals that eat them, potentially spreading to humans. Because people in sub-Saharan Africa consume high quantities of crops that are susceptible to aflatoxin contamination, they are especially vulnerable to exposure. One serious outbreak in Kenya in 2004 killed 125 people[8]. It is estimated that 26,000 Africans die each year due to liver cancer caused by chronic exposure to aflatoxin[9]. Broader health effects such as immune suppression with higher rates of illness and child stunting have also been associated with exposure.

However, aflatoxin is not solely a problem in the developing world; mass globalization means that contaminated imports and exports can cause aflatoxin scares. In 2013, infected Serbian cattle feed transmitted aflatoxins into milk produced in the Netherlands and Germany, which went to market in Croatia, Romania, and Serbia, causing national health crises in those countries[10]. In order to prevent the spread of the toxin, the Danone Company alone blocked 75 tons of dairy products from reaching supermarket shelves in Romania[11].

Once milk, meat, or grain is infected, the only option is to destroy and discard the product, resulting in potentially dire economic consequences. It is estimated that an outbreak in the United States corn industry alone could cause economic losses totaling as much as $1.68 billion annually[12]. Small-scale farmers can be hit especially hard, as aflatoxins are often difficult to detect, and although the toxins can be neutralized preemptively with fungicides and care when storing grain, these strategies are not yet options typically available in the developing world.

As no known cure exists for aflatoxin, early detection and proper food storage are the foremost methods of aflatoxin prevention[13]. While products such as Aflasafe, developed by Agricultural Research Service (ARS) researchers at USDA for use in the United States and later adapted for use in Africa through international research partnerships, promote the growth of a fungal strain that displaces the toxin-producing species, they are not yet widely available[14]. Although more research is needed, current genetic study is focused on developing strains of crops that are themselves resistant to mold in the first place, as well as mapping the genetic makeup of these molds to better understand them and guard against infection[15]. Should this research be successful, it has the potential to effectively eliminate the possibility of contamination, thus dramatically reducing the risk of aflatoxin scares in the future and saving lives.

Fall Armyworm

Indigenous to the tropical and subtropical Americas, "armyworm" is the general name for a species of moth caterpillars that can destroy crops, invading fields like its namesake. Fall armyworm reproduces rapidly and in great numbers and can migrate up to 100 kilometers each night. The insect is especially common in Mexico and southeastern states such as Florida and Georgia. There is no specific crop that fall armyworm targets; instead, over 80 kinds of plants can be affected, from tobacco to cotton to potatoes to corn, with the worm eating leaves and boring through fruiting bodies[16].

The USDA has been researching this pest since the 1920s with good results to date: while armyworm is a perennial problem, insecticides and preventative measures protect American foodstuffs from debilitating attack today. However, in 2016, fall armyworm was discovered in Nigeria and had spread across Africa by early 2017. The worm is especially dangerous to maize, a staple crop for 300 million African smallholder families, as it can eat away at leaves and burrow into ears, destroying the fruiting body completely. In addition, armyworm is seasonal in the United States, as winter temperatures kill off many of the insects each year. In Africa, however, generations are continuous, as favorable weather allows for their spread year-round[17].

The Centre for Agriculture and Biosciences International (CABI) estimates that, if left uncontrolled, maize yield alone could experience losses of as much as 53 per cent and total up to $6.1 billion across 12 African countries[18]. Not only would this seriously harm fledgling economies; it would also cause profound food shortages in a region with a rapidly-growing population. In addition, potential spread to Europe and Asia would cause economic and trade disruptions on a global scale.

Currently, African farmers are advised to minimize and carefully target the use of insecticide due to cost, lack of control, and the concern that the worm could build up resistance that would render the chemicals useless. Instead, a global coalition composed of the United States Agency for International Development (USAID), the International Maize and Wheat Improvement Center (CIMMYT), and the CGIAR Research Program on Maize, in collaboration with national and international research and development partners, has recommended proven biological techniques that are more feasible and sustainable for smallholder farmers in Africa, such as increasing plant diversity to encourage insect-eating birds and bats; using "trap crops" to draw army worms away from the main production crops; and improving overall plant health to withstand attack.

Countermeasures used widely and successfully in the Western Hemisphere are also set for deployment in Africa, including the introduction of predatory insects, bacteria, and fungi that are harmless to the field but prey on armyworm. In addition, genetic engineering shows promise: a strain of water-efficient corn is currently undergoing field testing in Kenya, Uganda, and Mozambique for its innate toxicity to fall armyworm and other insects[19].

Although the fall armyworm is just beginning to take root in Africa, scientific research into control measures abounds thanks to extensive studies. Lessons from years of U.S. research can be applied and adapted to the African context. Successful implementation of these practices will mean the difference between mass starvation and upheaval and continued growth in Sub-Saharan Africa.

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Foot and Mouth Disease

Although foot and mouth disease (FMD) is a nonlethal viral infection, its effects can spur economic catastrophe. While the disease is not usually dangerous to people (although humans can be carriers), FMD negatively impacts the overall health of sheep, cattle, pigs, and other livestock by causing blistering sores in the mouth and on legs, thus impairing meat and milk production. A vaccine is available in limited quantities for only one strain of a total of seven that currently exist, and there is no known cure[20]. It is highly contagious and can be spread via air and contaminated materials[21]. As a result, when animals contract the disease, they and any potentially infected livestock are culled, and their carcasses burned or buried.

FMD is most common in the developing world, where infrastructure, preventative care, and practices to prevent its spread are sparse. For small-scale farmers in these areas, an outbreak is especially devastating. In contrast, North America has largely been "FMD-free" since the 1950s, when Canada suffered an epidemic. Meticulous vaccination and active monitoring have prevented widespread outbreaks since then.

The only place in the United States authorized to study live FMD viruses is the Department of Homeland Security's Plum Island Animal Disease Center, off the coast of New York. For the past 50 years, state-of-the-art biocontainment technology has allowed for safe research without risk of wider contamination. Research into FMD is difficult: with dozens of variations and sub-strains, no single vaccination addresses all kinds. Importantly, USDA's ARS, along with a global consortium of FMD research institutions, continues its research with the goal of preventing future outbreaks of this devastating disease through scientific inquiry[22]. In addition, USDA's Animal and Plant Health Inspection Service follows screening and monitoring procedures to prevent outbreaks[23].

However, many countries do not practice similar policies. Blood tests cannot distinguish between infected animals and vaccinated animals, so FMD-free countries do not import livestock with any antibodies against the disease. In response, most countries tend to adopt policies of non-vaccination to improve their cattle exports[24]. Unfortunately, these practices have spurred two dramatic epidemics since 2000. In 2001, more than 2000 confirmed cases in the UK led to $3 billion in losses and 6 million culled cattle[25]; Wales alone culled 5700 sheep[26]. In 2011, South Korea culled 3 million head of cattle and pigs[27], resulting in an estimated loss of $2.8 billion[28]. These extreme economic costs underscore the critical need for additional research to improve detection in order to prevent the need to cull entire herds in the face of a potential outbreak.

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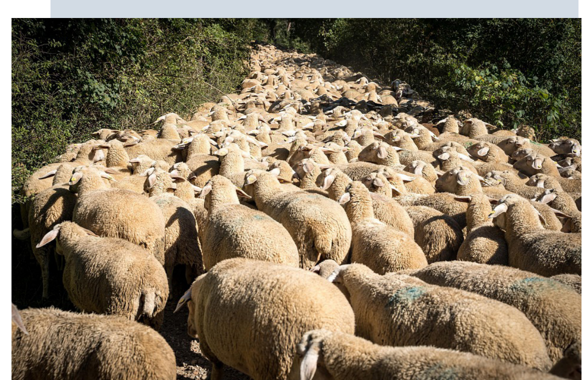

Wheat Blast

Wheat blast, a fungal infection, causes grains of wheat to wither and shrivel less than a week after symptoms first appear – farmers' crops can fail seemingly overnight with little time to react. This emerging disease is a dangerous threat to the production of one of the most important global staple crops.

According to the International Maize and Wheat Improvement Center (CIMMYT), this fungus was first observed in South America in 1985 and has since spread throughout the region, causing a 30% plummet in wheat production in Brazil in 2009. However, in 2016, the pest made an unexpected jump of some 10,000 miles to the Southeast Asian nation of Bangladesh, decreasing overall wheat production there by 3-5%. This outbreak, in a country already struggling with food security challenges and childhood stunting, underscores a sobering reality: in an interconnected world, plant pathogens can appear in new environments without respect for natural or national borders and with little warning[29].

Due to the complex genetic and physiological makeup of wheat blast, research into it is an uphill battle. Despite thirty years of study, scientists still do not fully understand the main sources of the pathogen or how to reliably prevent infection, as traditional fungicides are only partially effective. However, USDA's National Institute of Food and Agriculture (NIFA)-funded research is making important headway in managing and understanding this disease – critical research that could save American crops should wheat blast make its way to North America[30]. **Even an outbreak the size of Bangladesh's, wherein only a small fraction of the crop was affected, could result in the loss of $405 million to American farmers[31].** Thus, research to combat wheat blast abroad would serve as a first line of defense against a potential infection at home.

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Endnotes

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