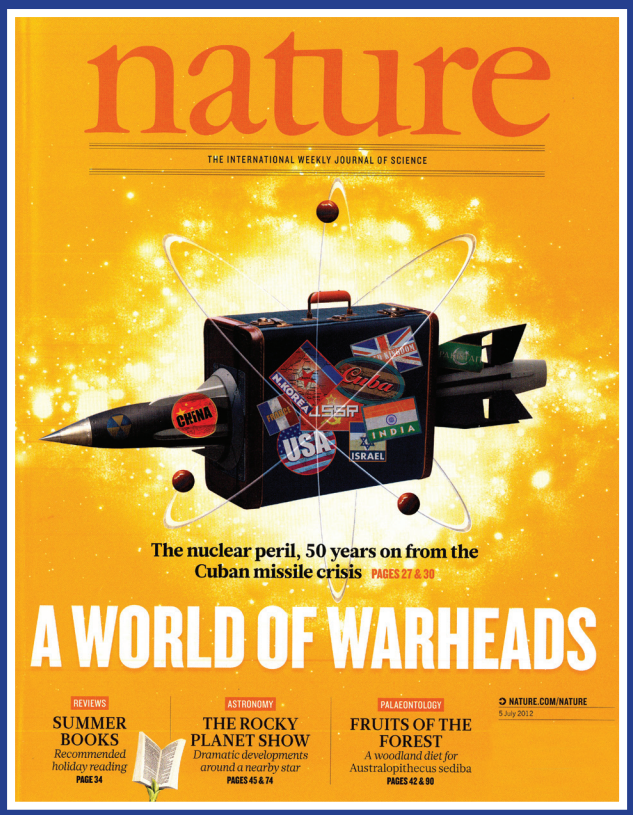
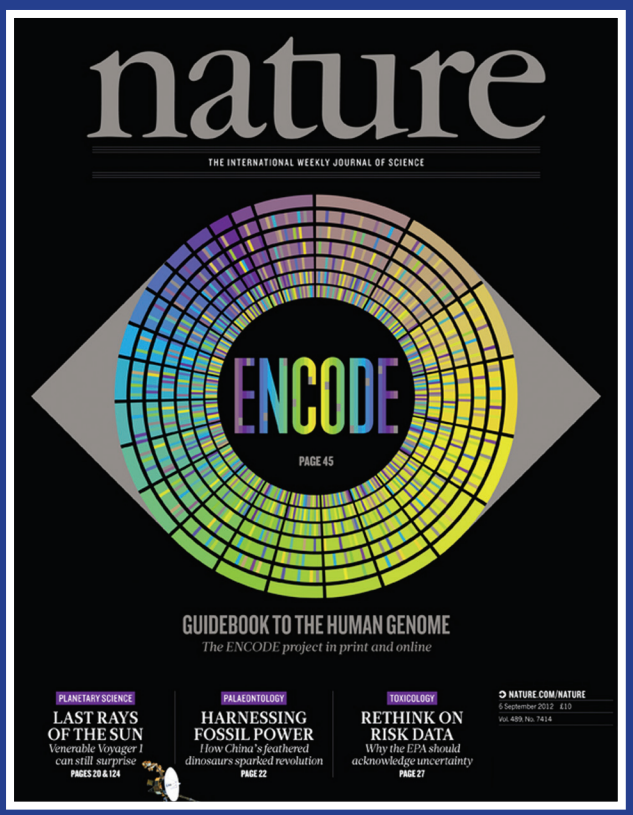
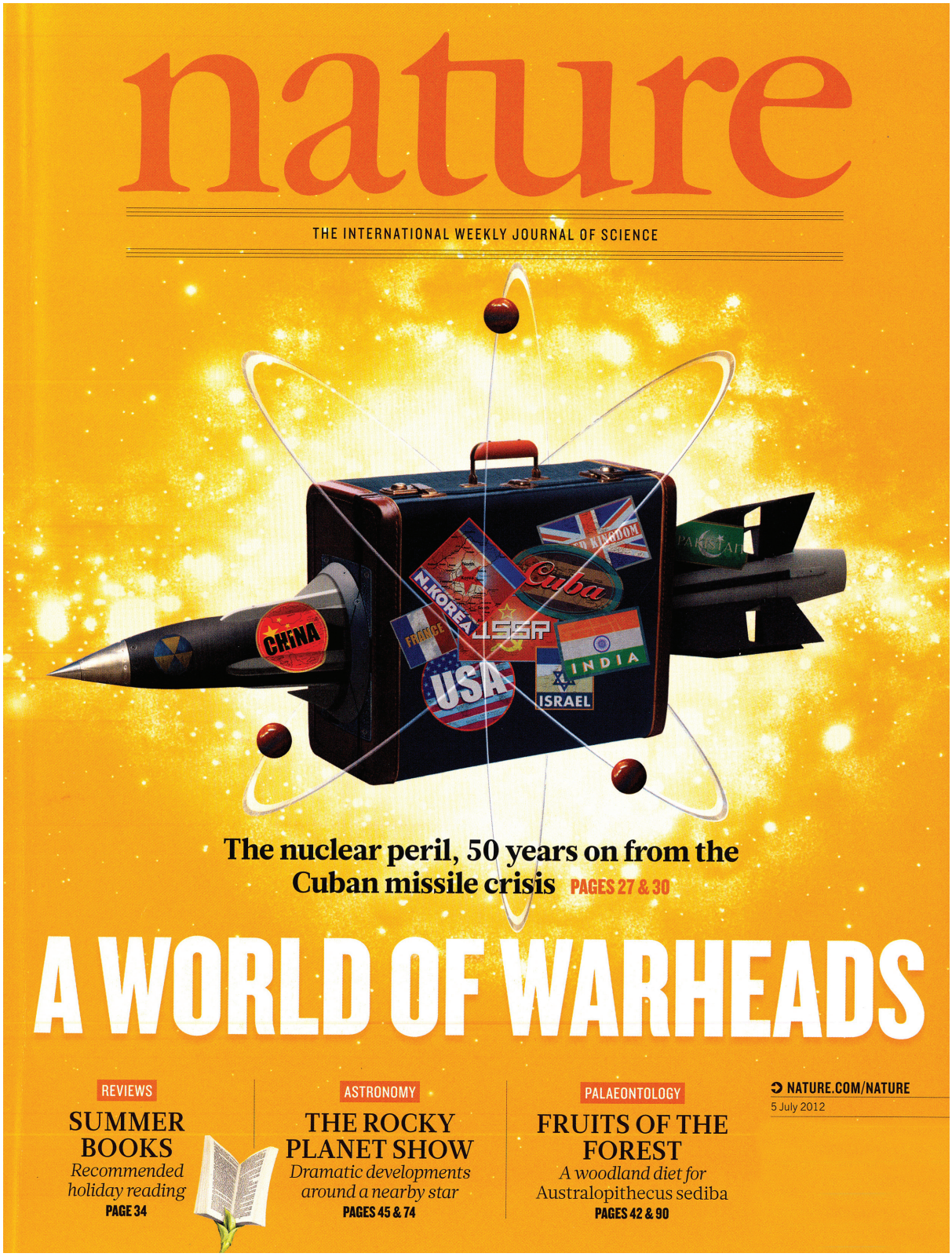
THE HOWARD G. BUFFETT FOUNDATION 2012 NATURE MAGAZINE PUBLICATIONS







In Support of Conservation Agriculture for Smallholder Farmers

Written by Howard G. Buffett

Originally published in *Nature Magazine* | 07.05.12

In Support of Conservation Agriculture for Smallholder Farmers

BY HOWARD G. BUFFETT

I have been farming for 35 years and currently manage or operate farms in Arizona, Illinois, Nebraska and South Africa totaling more than 14,000 acres. Farming seems to be the only profession where others think they know how to farm better than farmers. I would never presume to tell a banker how to collateralize a loan or a scientist how to develop a peer-review study, yet I have observed everyone from bankers, politicians, bureaucrats and academics tell farmers how they should farm. Their advice is usually derived from books, small research plots, extrapolations or philosophical revelations about what will work and what will fail for farmers. As a result, billions of development dollars have been misguided.

Every year I face new challenges on my farms, every year I must adjust and adapt and every year I learn enough to write a new chapter in a book. I learn it from experience, frustration and failures. However, one thing that has provided consistent success on our farms and for millions of farmers, both large and small, across the world is conservation-based agricultural production techniques.

FARMING IS RESEARCH

Since I operate a private foundation focused on addressing hunger and achieving food security through agricultural development, I also farm to learn about what works and what doesn't work in different contexts. We partner with Southern Illinois University, Penn State, Purdue, Texas A&M and other organizations to achieve meaningful results. Our foundation research farms use oxen with no-till planters and roller crimpers. We also use 400 horsepower tractors with 60 foot planters. We farm two acre fields and 320 acre fields. Our research plots are adapted in size to reflect real field conditions. The first time I learned the importance of this was in Mozambique—the research station was consistently producing six tons of maize per hectare yet the average in the country was less than one ton per hectare; the research success was not transferring to farmers.

Farming is a challenging business—farms are susceptible to all types of weather, are at the mercy of volatile markets and subject to a myriad of crop pests and diseases. There is one common denominator that commercial farmers require to be competitive and what every small farmer in developing countries must have to feed their families; it is healthy soil. And how you farm determines the health of all soil.

SOIL IS LIFE

The human body requires air, water, food and sunlight. Plants require the same. Most people think of agriculture as growing food, but it is actually a complex biological process and it is often site-specific. I have farms 15 miles apart in Central Illinois that require different techniques even between these fields. Why? Because of different soil types, topography, drainage, soil organic matter, Ph, and cation exchange levels. Scientists study these soil characteristics, but farmers, who have access to the information, know them in each of their fields.

The idea behind agricultural science is obvious: to provide answers about soil and resource preservation while increasing our productivity. But these answers do not always transfer from one part of the world to another, or from one field to the next.

One principle that does transfer and hold true is that productivity is directly related to soil health. Our farms with four percent organic matter will consistently outyield our farms with two percent organic matter—there are rare exceptions, but not many. No-till increases organic matter and carbon levels, which improves soil structure; it enhances water percolation and retention capacities; and it sequesters Co_2-reducing GHG levels in the atmosphere. It also provides numerous other benefits, all of which support healthy soil.

Therefore, some basic principles, such as the use of conservation agriculture, hold true. How those principles are understood and how we achieve better results by applying this knowledge in different contexts requires an understanding of soil quality, climate, pests, disease, and labor, as well as access to animals, mechanization, chemicals, fertilizer, seeds, infrastructure, markets, and the economic status and culture of the general population.

Viewing it this way no longer makes farming look so simple.

---

1 Horowitz, John, Robert Ebel, and Kohei Ueda. United States. Department of Agriculture. 2010. *"No-Till" Farming Is a Growing Practice.* Web. <http://www.ers.usda.gov/publications/EIB70/EIB70_reportsummary.pdf>.

BUSINESS AS USUAL MINDSET

To bring tens of millions of small-scale farmers out of poverty, and for commercial farmers to meet future global demands for food production, requires us to improve our farming methods. Forty years ago, many laughed at U.S. farmers who were pioneering conservation-based practices such as no-till and strip-till. Today it is practiced on 35 percent[1] of all U.S. crop acres and is a central component of Brazil's success in achieving world-class status in agriculture. So why are some trapped in the same place U.S. farmers were 40 years ago? Mindset.

Resistance to change is a killer for any innovation. Examine some of the greatest innovators, from Borlaug to Jobs, and you will see they have faced great opposition and hurdles in their efforts to change people's acceptance of new ideas. Gandhi articulated this phenomenon perfectly: "First they ignore you, then they laugh at you, then they fight you, then you win."

Conservation agriculture has been ignored, laughed at and fought against; but now it is winning. It is winning across the globe. Yet there are still a few fighting, arguing why it cannot work or isn't applicable instead of looking for appropriate applications of the basic principles.

Big problems are not solved without looking beyond our current thinking—just ask any scientist or crop breeder, they will tell you they can achieve something better than what we have. They prove it over and over.

Do you use the same computer you used ten years ago? Do you rely on the same phone you had five years ago? Of course not. Knowledge and technology have provided new solutions—farming is no different.

SEPARATING MYTH FROM REALITY

The fact is, some of the challenges facing the adoption of conservation agriculture for smallholder farmers are symptoms of other problems. These problems need to be addressed with or without conservation agriculture. Africa suffers from some of the most weathered and abused soils in the world. There are areas in Central America where soils have been beaten and wasted away by hurricanes. These soils cannot be restored by simply applying synthetic fertilizer, nor will they ever reach their potential from improved seeds without the proper support systems. We—and others —have invested millions of dollars in our own research to find solutions to these and other problems.

Let me address ten common myths of conservation agriculture when applied to smallholder farmers.

My response is based on our experience, over many years, across multitudes of soils, weather, equipment and observations. In future editions, we will provide information from others who have also critically examined this issue.

Myth #1: Minimum or no-till cultivation practices require more labor, do not sequester enough carbon, and in some cases can be harmful to soil structure.

On our farms, no-till uses less labor and decreases weed pressure—this is true for our large operations and small operations. (On our commercial farm it also significantly reduces equipment costs and fuel use.) Some argue that no-till doesn't sequester as much carbon as originally estimated—that is like saying a child failed his exams by receiving a B instead of an A—not everything is defined by perfection. Tillage promotes accelerated volatilization that releases Co_2. Therefore, the less soil is tilled, the less carbon is released into the atmosphere—that is good for the soil and the environment. Tillage is what harms soil structure; carbon builds soil structure.

Myth #2: Retention of high levels of crop residue for ground cover mulch is not realistic for smallholder farmers because they are not able to produce sufficient biomass or must use biomass to feed higher value livestock.

It is true that the residue of some crops is used for feed, but this is not always a result of best practices. The bottom third of the stalks of crops such as sorghum or millet can have negative nutritional value for animals, but offer good organic material for soil. However, without the proper training, these old habits will not change. There has also been little research in Africa to determine the value of simply leaving the root balls in place and planting between the old rows.

In South Africa, two oxen pull a roller crimper. I first learned of this process years ago in Mozambique when I visited two farmers who had constructed a homemade crimper from an old oil barrel.

In some cases it will be a challenge to overcome the issue of competition for residue, in other places it is not an issue at all. Therefore it is like everything else in life, you do it where it works and you make adaptations where necessary. In terms of increased biomass, as yields increase, biomass will increase—no one should be advocating for accepting current yield levels.

Myth #3: Smallholder farmers in the developing world cannot access or afford the herbicides they need to combat weeds without significant additional labor.

Our experience with our African development projects, on our Africa farm, our research in Ghana and on our farms in the United States is that no-till reduces labor, weeds, equipment costs and fuel. As our no-till commercial fields mature, we often use less herbicide. This year is a case in point: the only fields where we applied herbicide twice was where we tilled the ground to replant corn—the no-till did not require additional herbicide application.

We have also experienced limited weed pressure in our small oxen-powered fields using cover crops without herbicide.

There is huge potential to use cover crops to balance the use of herbicides. It would be difficult to broadly scale cover crops in Africa today, but who is advocating that Africa's—or anyone else's—resources remain where they are today? Conservation agriculture faces the same challenges all agricultural improvements face where there has been a lack of investment and research over many years. Continuing to advocate approaches that are beyond the financial capacity of poor farmers, rely on fossil fuel hydrocarbon price volatility or that continue to degrade soil is irresponsible. We need to invest in affordable, context-appropriate long-term solutions.

Myth #4: In much of the developing world, there is limited availability of seeds and too high a need for subsistence food crops to justify investment in productive cover crop plant varieties.

Arguing that cover crops will not work because the seeds are not available is like planning our future as if today's constraints are permanent. Our foundation is investing in developing improved seeds and seed access in various ways across Africa so farmers have new options.

We also need to look at the use of edible cover crops such as cowpeas to support poor farmers—this approach could yield multiple benefits. If we take the attitude that we cannot solve the seed access issue, farmers would never make progress.

Smallholder farmers need solutions, not people who will keep them poor. They need access to all kinds of improved seeds from cover crops to open pollinated varieties to hybrids.

We deliberately left a section of land without cover crops to determine weed pressure.

Inset: The area crimped by the oxen/crimper combination is examined for weeds—within the square pictured, zero weeds were located.

Myth #5: Small farm plot areas, limited dietary demand and long time horizons to realize benefits limit adoption of crop rotation and intercropping practices.

The idea that small farm plots cannot realize the benefits of crop rotation and intercropping practices due to long time horizons is misguided; millions of smallholder farmers currently use these practices! It also implies that the process is affected by the size of the field. Do hybrid seeds yield less per acre on two acres than on fifty acres? Of course not!

Hundreds of years ago, the Milpas of Guatemala, the Aztecs of Mexico and the Iroquois of North America survived by using symbiotic relationships between crops and by using rotations, an important aspect of conservation agriculture. Penn State recently published a paper[2] on the importance of these approaches. The benefit of farming practices are not determined by size but by activity, and conservation agriculture has many faces as these native production systems demonstrate.

There is hope for smallholder farmers but they need context-specific research, alternatives to rebuild soil and reliable extension services. If U.S. farmers had decided that farming would never improve, we would be a very poor and hungry nation. If farmers are provided the opportunity and support, they will be successful. This is not a challenge unique to conservation agriculture.

Myth #6: Benefits are highly sensitive to a wide variety of local environmental, climatic and socioeconomic conditions, making adoption of conservation agriculture a more complex and riskier approach.

Conservation agriculture actually provides a risk management strategy that most other farming approaches cannot because it provides resiliency for farmers, relies less on external inputs, conserves soil and water, and reduces costs and labor. In addition, for smallholder farmers to rely on a system that depends exclusively on herbicides has its own risks, including carry over impact affecting crop diversity in subsequent years and off-site movement affecting the environment—both can be addressed by training.

Herbicides are important, but their use requires training for proper handling and application—and that already assumes herbicides are available and affordable, which is not the case for many smallholder farmers.

Myth #7: The time and training required for adoption of conservation agriculture is impractical for solving the immediate and future need.

If the farmers I met in Fufuo, Ghana, or Estelí, Nicaragua accepted the attitude that new ideas are too impractical to implement, their children would starve. They have improved their lives because of conservation agriculture, improved seeds and training. When you begin with limited resources, of course the challenges are great. However, try telling the smallholder farmers in Brazil that it is impractical to use conservation agriculture, or tell the thousands of farmers benefiting from the World Food Programme's Purchase for Progress pilot effort in Central America that no-till practices take too much time to adopt, they will have one answer: "it has worked for me and for my family."

My most encouraging experiences have been with small-scale farmers when I have returned to visit and they are excited to show me the success of their changes. Sometimes they have changed their seed spacing or seeds per hole. Oftentimes they have switched to no-till or minimum till—and their yields have improved. Conservation agriculture is already a solution for millions of farmers.

Myth #8: Synthetic fertilizers will solve productivity problems for smallholder farmers, therefore there is no need for conservation agriculture.

Synthetic fertilizer will often contribute to increases in crop yields. However, this can be a stop-gap measure without the support systems to address water quality, soil fertility, desertification and long-term productivity gains. Cover crops and other conservation-based practices complement and supplement synthetic fertilizers. Cover crops stabilize nitrogen in the soil, scavenge nutrients for crop use, add organic matter, build soil structure, address compaction issues and affect permeability. In poor soil, and in extreme cases, "dead soil," the soil will not respond to synthetic fertilizers and biological activity must be reestablished. Cover crops also provide resiliency to distribution or financing interruptions to synthetic fertilizer systems. To imply a country and their farmers will never achieve the capacity or sophistication to have these same choices and opportunities is like advocating for agricultural colonialism.

---

2 Postma, Johannes A. and Jonathan P. Lynch. United States. Pennsylvania State University. 2012. *Complementarity in root architecture for nutrient uptake in ancient maize/bean and maize/bean/squash polycultures*. Web. <http://aob.oxfordjournals.org/>

Myth #9: In cases where smallholders begin to adopt conservation agriculture, as soon as external funding and technical support is discontinued, many farmers revert to previous conventional farming methods.

This myth has some truth to it—smallholder farmers do often adopt various agricultural practices until external funding and technical support are discontinued (the NGO model). In fact, this is why we no longer fund these standard development projects. What this demonstrates is a failure in process and resources, in capacity-building and long-term commitment, not a failure in the farming method. Conservation agriculture did not fail these farmers: we failed these farmers, governments failed these farmers, NGOs failed these farmers, donors failed these farmers. The fact that these farmers originally adopted conservation agriculture with the proper training and support only proves that the system is viable. It is why we advocate for a commitment to the system, not just the farming method. There is a long list of agricultural projects that never used conservation agriculture as part of their approach and expended huge sums of money only to see failed outcomes.

Myth #10: The challenge of changing the 'mindset' of millions of poor farmers requires an enormous effort to redefine the culture of agriculture.

I refuse to accept the premise that because it is difficult we should not do it. Is overcoming poor governance less difficult than conservation agriculture? Is eliminating malaria less difficult than conservation agriculture? Is preserving the world's natural resources less difficult than conservation agriculture? When did we start making decisions based on the degree of difficulty instead of what is the best solution for the goals we want to achieve?

TREATING DIRT LIKE SOIL

The future for many farmers will depend on the long-term viability of soil. Conservation agriculture is a diverse and proven method to deliver results. Farming is a biological process—the principles of conservation agriculture are consistent with nature's methods.

I have farmed in many conditions with many soil types. I have farmed everything from beach sand, silt loams, to heavy clays. I have watched my crops destroyed by cut worm and been forced to replant hundreds of acres. I have seen soybeans cut to shreds and shattered by hail just before harvest and I have hauled 10,000 bushels of corn from a bin, spoiled by aflatoxin—a costly lesson I will never forget.

I have deep ripped in South Africa while avoiding aardvarks and I have seen deer devastate my corn in Illinois.

There is nothing about farming that is normal or consistent. There is no average year and what works one year may not work well the next.

There is one reason our foundation will continue to advocate on behalf of conservation agriculture in every format we can: we want to see millions of farm families succeed. And we want to see this achievement driven by good science and practical applications. We know that farming can be compatible with preserving our natural resources, but we must be innovative and think long-term. We must serve the millions of farmers who need our support with bold ideas that will bring about change—not with philosophies or models that are outdated and have for decades failed to change the lives of millions of smallholder farmers living in extreme poverty. It's time for a new mindset, new thinking and responsible risk-taking to bring about productive change.

Best practices benefit large farm operations and small operations. Cover crops and other techniques which improve soil health, build soil structure, break up pest cycles, reduce soil erosion, improve water quality, sequester carbon and reduce synthetic inputs are not limited to field sizes or farmer profiles.

THE HOWARD G. BUFFETT

About the Howard G. Buffett Foundation

Established in 1999, the Howard G. Buffett Foundation's primary mission is to improve the standard of living and quality of life for the world's most impoverished and marginalized populations. The Foundation's focus is on international programs that operate in challenging environments, including conflict and post-conflict countries. The Foundation has supported more than 100 agricultural projects in over 40 countries and more than 35 nutrition projects in over 20 countries. The Foundation believes achieving global food security requires all countries—including the United States—to adapt its agricultural practices and policies to meet long-term agricultural needs and successfully address hunger and malnutrition.

GHANA IS A BEACON

Africa's farmers have largely missed out on the conservation agriculture trend that's swept many of the world's breadbaskets. But what's happening in Ghana shows that these techniques can deliver big benefits to smallholder farmers on that continent as well.

In February 2007, I traveled on a deeply-rutted red-dirt road to Fufuo, a village in Ghana's Ashanti region, with agronomist Kofi Boa. He was teaching smallholder farmers how to get more food from their plots by moving away from their traditional slash-and-burn practices. In Ghana, as in much of Africa, farmers have traditionally found room for growing crops by using a cutlass to chop down the brush and trees on a hectare or so of tribal land. Then they burn the residue to expose the ground for planting seeds. What is left over from the harvest usually gets torched as well. After two or three years of producing crops, the soil is so depleted of nutrients that sputtering harvests force farmers to hack out another plot from the bush. In some parts of Ghana, farmers must leave their depleted plots fallow for up to ten years so that the soil recuperates.

This system scars the land and consumes so much labor that farmers often don't have time to cultivate enough land to lift their families out of poverty. Making matters worse, the appetite of Africa's growing population is forcing farmers to give the land less time to recover before planting their crops again. It is little wonder that Sub-Saharan Africa's corn yield per hectare is now just one-third of the world average compared to about two-thirds of the world rate in 1960.

In Fufuo, however, the farmers told me that their corn yields have climbed since they began adopting conservation practices. Other than poking holes in the ground to plant seeds, they have stopped breaking the soil and have stopped viewing plant residue as trash. In Fufuo, farmers can buy the weed-killer glyphosate, which they spray from backpacks onto their plots in order to knock down weeds before the planting season. That gives their corn plants time to grow big enough leaves to rob any weeds of sunlight. Unchained from the hoe, the farmers now have time to produce other crops and raise chickens. Among other things, the extra money they are making is paying school fees for their children.

A study released in 2002 found that in normal growing seasons no-till farmers in Ghana reported 45% higher corn yields than farmers who had never tried the method. The yield advantage grew to 48% in a dry year.[1] Similar yield advantages on no-till with mulch plots in Ghana have been reported by Boa-Amponsem et al (1998), Aflakpui et al (2006) and Kombiok et al (1995). The higher corn yields in the no-till fields were attributed to a significant reduction in weeds, lower erosion and enriched soil moisture.

The 2002 study also found that smallholder farmers in the Ghana survey who adopted the no-till method reduced the labor involved with field preparation and planting by 22%. The time spent removing weeds from their plots declined by 51% to an average of 4.3 man-days per hectare from 8.8 man-days per hectare.

Our foundation provided $1.6 million for a four-year CARE project to introduce conservation agriculture practices such as zero-tillage and cover crops to thousands of farmers in northern Ghana, where growers have complained of shrinking crop yields and many farming families struggle with food shortages four to five months of the year. By the time the project ended in June 2011, according to CARE, the corn farmers who had adopted conservation agriculture practices were seeing yields averaging 140% more than the 2008 baseline.

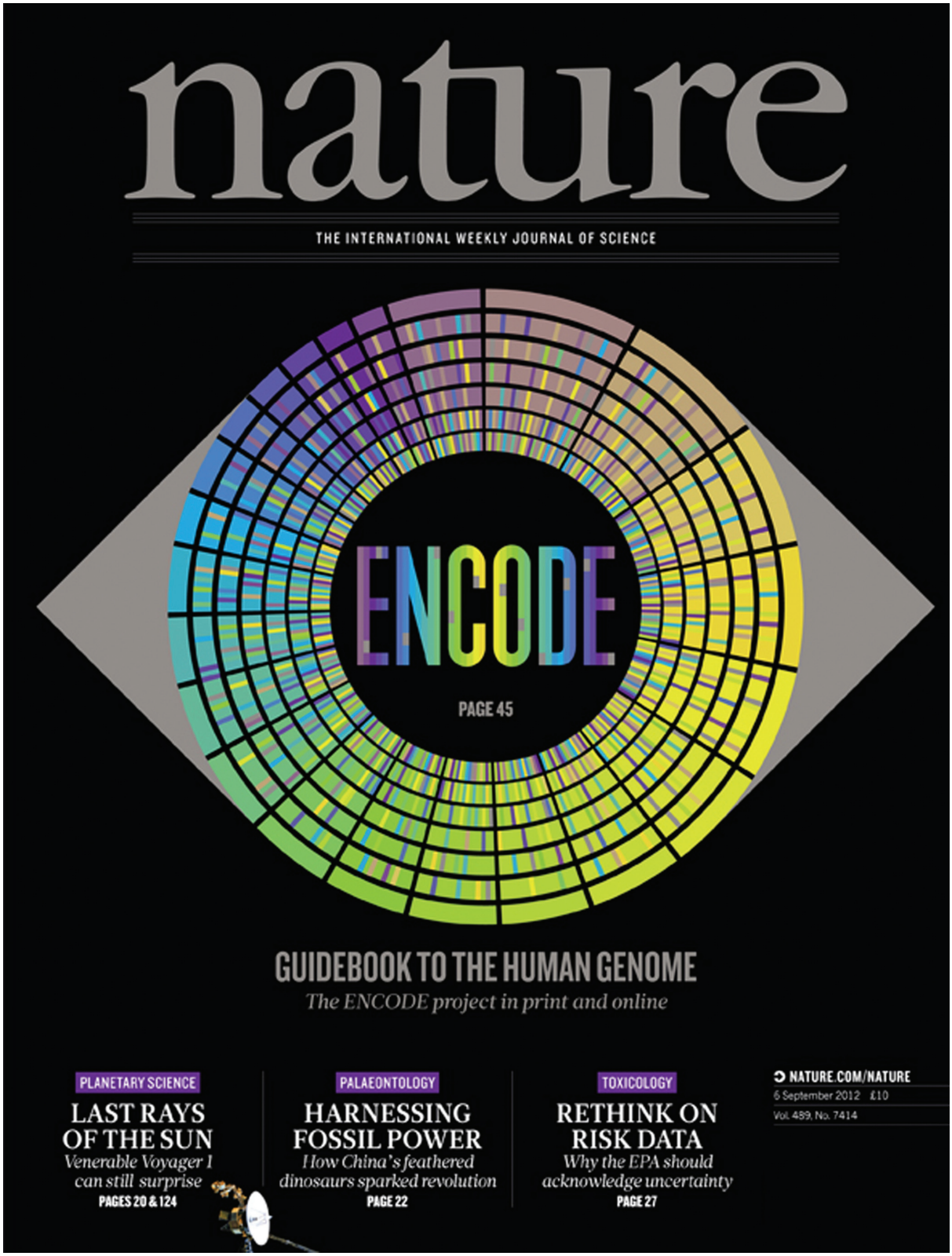
My experience in Ghana tells me that it's time to stop the sniping in the scientific community over conservation agriculture.

What we need to do is put more resources into figuring where it would work best in Africa, and how to tweak these practices for the growing conditions that vary widely across that continent.

At our foundation's research farm in South Africa, for instance, studies are underway on the ability of cover crops to suppress weeds, bank water and improve soil microbiology. We held a conservation agriculture workshop at the farm earlier this year for managers of African seed companies and we're testing equipment such as a no-till planter that can be pulled by oxen or a small tractor.

I think Ghana is on to something big.

1 Ekboir, J., K. Boa, and A.A. Dankyi. 2002. *Impacts of No-Till Technologies in Ghana*. Mexico D.F.: CIMMYT



Ten Truths About Conservation Agriculture and Smallholder Farmers
Written by Howard G. Buffett
Originally published in *Nature Magazine* | 09.06.12

Ten Truths About Conservation Agriculture and Smallholder Farmers

BY HOWARD G. BUFFETT

In the July 5, 2012 issue we provided examples on what we have learned during our 20-year experience working in conservation agriculture in both large and small systems. Now we want to share with you what others have learned.

There are growing numbers of smallholder farmers throughout the developing world who are successfully implementing conservation agriculture practices adapted to specific local conditions and existing crop and livestock production customs. As a result, farmers are using a wide variety of reduced tillage techniques and various means to protect soils with organic ground covers. It is clear conservation agriculture, like all agriculture practices, offers no single "silver-bullet solution" that satisfies every farm condition. The constraints and availability of natural resources, local climatic conditions, socio-economic policies and other factors all have a role in shaping a farmer's approach. However, conservation agriculture offers unique and critically-needed solutions to many of the challenges all farmers face, requiring us to make every effort to develop its full potential.

A rigorous scientific understanding of the success factors involved in conservation agriculture for smallholder farmers is only now being established. Consequently, much of the evidence that demonstrates conservation agriculture's potential for this group of farmers is drawn from a limited number of sub-scale development initiatives and underfunded research by scientific institutions and civil society organizations.

We do not have all of the answers but there is no question we need more public and private sector support for research in this area. There are many promising signs that investing in conservation agriculture practices will lead to improved farmer livelihoods, increased food security and enhanced local and global environmental quality. Examples of how it is being successfully implemented, and the scientific research that is providing solutions to key issues, are discussed in the following overview of conservation agriculture's basic truths and their applicability to smallholder farmers.

Truth #1: Smallholder farmers who adopt integrated conservation practices can realize a higher return on investment in terms of labor savings, net income and improved soil quality.

- The Food and Agriculture Organization of the United Nations (FAO) studied nearly 5,000 smallholder farmers who adopted conservation agriculture practices in four different regions of Tanzania and Kenya following their participation in farmer field schools. Farmers who adopted conservation agriculture substantially reduced their labor inputs while also improving their crop yields from 26%-100% or more over a period of three to ten years. Farmers who used appropriate direct seeding equipment (e.g. a manual 'jabber') could plant a field of 0.4 hectares in three to four hours as compared to conventional tillage where three people working with hand hoes needed an entire day. (Shetto, et al. "Conservation Agriculture as Practiced in Tanzania: Three Case Studies." 2007.)

- With conservation agriculture's reduced labor and time requirements for planting new crops, farmers are better able to sow seeds during the optimal planting 'window.' Studies indicate that for each day that seeding is delayed past the optimal planting period, harvested crop yields can be reduced by 1-1.5%. (Olaf Erenstein, "Zero Tillage in the Rice-Wheat Systems of the Indo-Gangetic Plains." IFPRI Discussion Paper # 00916. International Food and Policy Research Institute. Washington D.C. 2009.)

- With the encouragement and support of the Ministry of Agriculture and several non-governmental organizations (NGOs), many smallholder farmers in Ghana have replaced their reliance on traditional 'slash and burn' cultivation methods with no-till and crop residue mulching practices that include the use of herbicides to control weeds. The International Maize and Wheat Improvement Center (CIMMYT) and the Crop Research Institute conducted field surveys of farmers in 30 different villages to determine the relative labor requirements of the two systems. These surveys found that the overall family labor inputs were 27% lower for those farmers who adopted conservation agriculture and their maize crop yields were 57% greater than those achieved by farmers who continued to rely on slash and burn practices. (J. Ekboir, et al. "Impact of No-Till Technologies in Ghana." CIMMYT Economics Program Paper 02-01. 2002.)

- The World Food Programme's (WFP) Purchase for Progress (P4P) program has reported that participating Nicaraguan smallholder farmers' adoption of conservation agriculture practices has enabled them to reduce their production costs by 40%. (Ken Davies, WFP/P4P Coordinator. 2012.)

- The carbon sequestration potential of conservation agriculture practices is variable. However, many studies have shown that soil organic carbon (SOC, aka carbon) levels under no-till are much higher in the first 10 centimeters of topsoil than in soils under conventional tillage (e.g. approximately 75% higher at a five cm depth and 40% higher at a 10 cm depth). SOC levels are similar at 20-30 cm depths for both systems. Models indicate that total SOC under conservation agriculture could be 10-30% greater than for conventional tillage. (Robert, et al. Soil Carbon Sequestration for Improved Land Management. FAO. 2001.)

- A meta analysis of 67 long-term agriculture experiments that compared soil carbon sequestration rates between no-till and conventional tillage practices found that the transition from tillage to no-till practices could continually sequester an average 480 kg C/ha/year over a period of 15-20 years until the SOC levels reach a stable equilibrium. (T. West and W. Post. "Soil Organic Carbon Sequestration Rates by Tillage and Crop rotation: A Global Data Analysis." Soil Science Society of America Journal. 66. 2002.)

- Ratan Lal, the Director of the Carbon Management and Sequestration Center at Ohio State University has reported that the SOC levels of natural ecosystems have been significantly depleted by historical land misuse and poor management of soils. Lal notes that if farmers adopted "recommended management practices" that include conservation agriculture with no-till farming, residue mulching, cover cropping, crop rotations, appropriate use of both organic and inorganic fertilizers and other related land stewardship techniques, approximately 100 to 1000 kg C/ha/year could be sustainably sequestered until a new equilibrium level of SOC is achieved over a 25-50 year period. (Lal. "Beyond Copenhagen: mitigating climate change and achieving food security through soil carbon sequestration." Food Security. Springer. 2010; and M. Jarecki and R. Lal. "Carbon Management for Soil Carbon Sequestration." Critical Reviews in Plant Sciences/ Vol. 22. 2003.)

Truth #2: A combination of education and site-specific analysis will help balance competing uses for crop residue.

- An International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) study of the dual use (soil conservation vs. livestock feed) of crop residues in Niger indicated that the nutrient content of some crop residues is unevenly distributed throughout the plant segments (e.g. stalks, stems, panicles, etc.). In such crop residues the lower structural biomass has very little nutritious value as livestock feed. It is believed that for some crops (e.g. millet), nearly 40% of total residues could be more valuable in contributing to overall farm productivity and farmer income if used as ground cover for soil conservation that increase crop yields rather than as fodder for livestock. (Powell and Fussell, "Nutrient and Structural Carbohydrate Partitioning in Pearl Millet." Agronomy Journal. Vol. 85, July, 1993.)

- The Consultative Group on International Agricultural Research (CGIAR) Systemwide Livestock Programme's analysis of economic trade-offs between using crop residues for ground cover mulches or for fodder in West Africa found that optimum returns were possible with varying levels of crop residue retention across different locations and crop varieties. In some cases the majority of residues should be used for soil cover and nutrient recycling; in other cases using a majority of residues for fodder provided farmers with the highest return. (IITA et al. "Balancing livestock needs and soil conservation: Final Report." 2011.)

- In some communities, farmers protect their crop residue mulches from free grazing livestock by discussing the importance of organic ground cover for crop productivity with village governing organizations and their neighbors. In some areas community self-governance groups prohibit free grazing livestock practices, resulting in residues being retained for mulch. (CA-SARD Project. CA Cases from Tanzania.)

- Farmers have cultivated livestock fodder crops on field contours and set aside areas and then harvested these crops as 'cut and carry' feed for corralled livestock. These practices have resulted in crop residues being available for use as mulch and enabled farmers to effectively collect manure for use as organic fertilizer. (Bolliger et al. "Taking Stock of the Brazilian Zero-Till Revolution: A Review of Landmark Research and Farmers' Practice." Elsevier. 2006.)

A farmer in Ghana collects and spreads leaves and crop roots onto his soil to increase organic matter. When I asked him why he was doing this, he replied, "to give my soil life." All farmers understand the importance of healthy soil.

Truth #3: Diverse varieties of cover crops, crop rotations and substantial residue retention can reduce reliance on herbicides.

- As farmers gain experience in growing cover crops that control weeds, weed pressures can be reduced. Ground cover residues and green manure crops can also suppress weed infestations in later years to a level that enables farmers to use a fraction of the herbicides that were originally needed. (Steiner, et al. "Weed Management in Conservation Tillage Systems." African Conservation Tillage Network. Information Series #8.; and Kofi Bofa. Ghana. personal communication. 2012.)

- In long-term field trials in Malawi, CIMMYT researchers found that the use of cover crops and green manures over a period of seven cropping seasons could control weeds without the need for further applications of herbicides. (Bram Govaerts. CIMMYT. personal communication. 2012.)

- Multi-year crop rotations with different plant varieties have significantly reduced the need for herbicides to control weeds. A study in Iowa of Low External Input (LEI) farming practices compared conventional two-year corn/soybean rotations with three- and four-year rotations of corn with N-fixing crops. The study found that over a four-year period the longer rotations significantly reduced the need for herbicides (i.e. by 76% and 82% respectively) and synthetic fertilizers (i.e. by 59% and 74% respectively). The rotational crops' allelopathic biochemical and ground cover competition properties may explain the superior weed control results. (M. Liebman, et al. "Agronomic and Economic Performance Characteristics of Conventional and Low-External Input Cropping Systems in the Central Corn Belt." Agronomy Journal. Vol. 100. 2008.)

Truth #4: Efforts to identify crops adapted to local conditions, building capacity of farm organizations and improving smallholder access to key inputs are gaining traction.

- Since 2006, the Program for Africa's Seed Systems (PASS) has provided technical and financial support to local research institutions for the development of their institutional capacity and scientific breeding of high-yielding, disease resistant maize, cassava and rice varieties. PASS also links research institutions with local seed companies and provides direct loans and equity investments to emerging seed companies where necessary. These efforts ensure farmers are aware of improved seeds, can access them and get the extension services they need to improve yields. To date over 60 independent seed companies have been created (with another 40 planned by 2017) and over 9,000 agro-dealers have been trained and networked, resulting in 373,283 MT of seed sold to African farmers. In 2010, 21 MSc and 10 PhD students supported by PASS graduated, helping to build critical technical and research capacity. Our foundation has supported the expansion of PASS's efforts into Sierra Leone, Liberia and South Sudan. (AGRA Annual Report, 2010.)

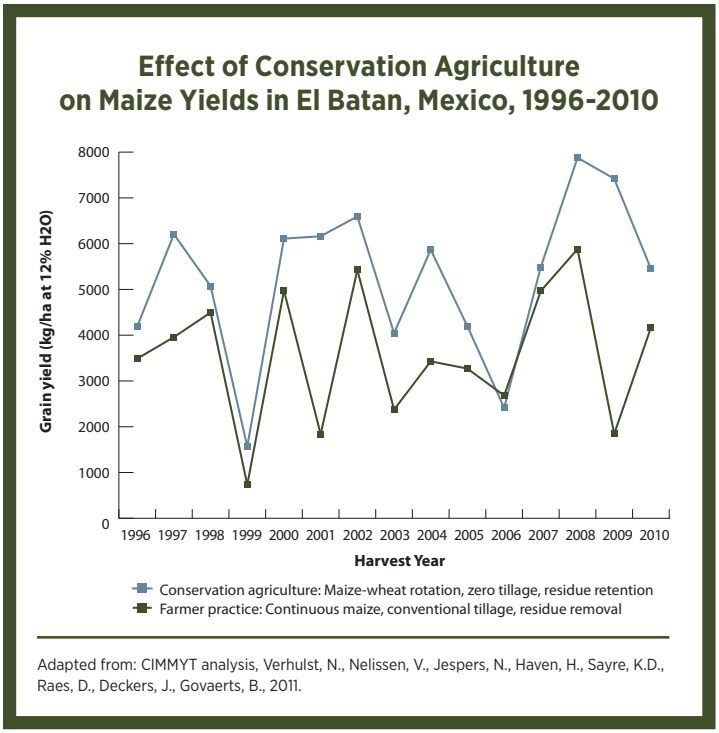
- NGOs and agricultural research institutions are developing and propagating green manure cover crops and N-fixing plants and woody legumes that are adapted to African agroclimatic conditions. In addition, Farmer Field Schools are encouraging farmers to establish local seed banks in which a variety of rotational and cover crop seeds and seedlings are produced and exchanged within the community. (Eotuleo Farmer Field School: CA-SARD Project. CA Cases from Tanzania.)

- The World Food Programme's P4P is a 21-country pilot project to source commodities for WFP's food assistance efforts from local smallholder farmers. As part of the program in Central America, P4P provides conservation agriculture extension services to participating farmer organizations. One element of this training introduced N-fixing bean varieties to women farmers in Guatemala. By adding these legumes to their intercropping and crop rotation practices, the farmers improved the nutrition of their diets, introduced an additional source of income from the sale of these beans and naturally produced N fertilizer for their fields. (WFP. P4P January Update 2011.)

- CARE International's Hillside Conservation Agriculture Project (HICAP) in Tanzania encouraged participating farmers to cultivate N-fixing cover crops (e.g. pigeon pea, lablab and cowpeas) that could be harvested for sale as starter seeds to other farmers. The HICAP project also facilitated seed distribution to farmers in the area to support Farmer Field Schools and demonstration plots. (CARE HICAP Project Annual Report to HGBF. 2012.)

Truth #5: Many smallholders who adopt conservation agriculture experience increased crop yields.

- Long-term conservation agriculture field research in Mexico demonstrates that conservation agriculture practices for maize and wheat production consistently achieved higher yields over conventional practices from the first year onward. In the initial year of the study conservation agriculture maize and wheat yields were respectively 20% and 33% greater. Conservation agriculture yields for both crops were particularly better during drought years when conservation agriculture's enhanced soil moisture retention properties had a positive impact on grain production. (Erenstein, et al. "Adapting No-tillage Agriculture to the Conditions of Smallholder Maize and Wheat Farmers in the Tropics and sub-Tropics." No-Till Farming Systems. Eds. T. Goddard, et al. Bangkok: World Association of Soil and Water Conservation. 2008.)



Adapted from: CIMMYT analysis, Verhulst, N., Nelissen, V., Jespers, N., Haven, H., Sayre, K.D., Raes, D., Deckers, J., Govaerts, B., 2011.

- Immediate crop yield improvements were achieved by farmers participating in CARE International's farmer field school demonstration project in Tanzania. These farmers had an average yield gain of 87% over the conventional control plot yields in the first year. (CARE International HICAP Project report to HGBF, 2012.)

Truth #6: Conservation agriculture's focus on soil health, reduced erosion and an emphasis on crop diversity reduces the exposure of smallholders to crop failures.

- Long term field research by CIMMYT indicates that zero tillage with retention of residues significantly improves soil moisture levels and enables crop yields that are far greater than those from conventional practices during extended dry periods. (Verhulst, et al. "Conservation agriculture as a means to mitigate and adapt to climate change…" 2011.)

- The Tropical Soil Biology and Fertility Institute of The International Center for Tropical Agriculture (CIAT-TSBF) led a multi-institutional research study of mixed crop-livestock systems in Mozambique that evaluated smallholder intercropping of maize with pigeonpea and cowpea legumes. This intercropping practice provided farmers with improved surface cover of their fields, valuable N-fixing soil inputs, increased resilience to low rainfall conditions and better food security. (Rusinamhodzi, et al. "Productivity of Maize-Legume Intercropping under No-Till in Central Mozambique." Regional Conservation Agriculture Symposium. Johannesburg, South Africa. 2011.)

- Ghanaian farmers surveyed by CIMMYT affirmed that they benefited from reduced risks as a result of their adoption of conservation agriculture. (Ekboir, et al. "Impact of No-Till Technologies in Ghana." CIMMYT. Economics Program Paper 02-01. 2002.)

In Mozambique we discovered farmers using a homemade roller crimper to control weeds, protect seedlings from the heat and "provide food for their soil," as one of the farmers told me.

Truth #7: Investing in conservation agriculture requires a long-term commitment to achieve widespread adoption.

- In Brazil, conservation agriculture is a well-established practice, but it took a tremendous commitment first by early adopters, and then by government and extension agents to encourage widespread adoption. Local land user clubs were invaluable to changing farmers' mindsets by promoting the concept and helping each other in their conservation agriculture adoption efforts. The most innovative conservation agriculture farmers continually share their knowledge of best practices with their neighbors. They also share modifications to direct seeding equipment adapted to local soil and crop residue conditions. (Bolliger et al. "Taking Stock of the Brazilian Zero-Till Revolution: A Review of Landmark Research and Farmers' Practice." Elsevier. 2006; and Ribeiro, et al. "Comprehensive inventory and assessment of existing knowledge on sustainable agriculture in Latin America." CIRAD. 2007.)

- Catholic Relief Services' (CRS) conservation agriculture development project in Zimbabwe has been a multi-year effort to introduce farmers to conservation agriculture practices and support their adoption. An initial 650 farmers adopted conservation agriculture practices in the first year (2004/2005) and 54,416 farmers were practicing conservation agriculture at the end of five years. (Mutsindikwa, et al. "Conservation Agriculture "a winners' choice."" CRS-Zimbabwe. FAO. CA Regional Workshop. 2011.)

Truth #8: Plants use synthetic fertilizer more efficiently when combined with conservation agriculture practices.

- A team of soil scientists assessed the efficiencies of improved crop yield gains with inorganic fertilizer inputs when applied to soils with higher levels of organic carbon. The study team concluded that "for efficient nutrient utilization, inorganic fertilizer must be combined with organic matter, water harvesting, conservation agriculture and controlling soil erosion in site-specific integrated soil fertility management strategies." Their recommendations clearly identify the important role of conservation agriculture practices in enabling smallholder farmers to maximize the benefits of their use of synthetic fertilizer inputs. (Bationo, et al. "African Soils: Their Productivity and Profitability of Fertilizer Use." African Fertilizer Summit. Nigeria. 2006.)

- In the absence of conservation agriculture, if fertilizer use is stopped (because of lack of availability or affordability), production levels will likely fall, soil quality will not have been improved, and farmers will still lack the skills needed to sustainably build soil health to achieve long-term productivity. (Dorward, et al. "Towards 'smart' subsidies in agriculture? Lessons from recent experience in Malawi." Natural Resources Perspectives 116. Overseas Development Institute. September 2008; and Jayne, et al. "Fertilizer Subsidies in Eastern and Southern Africa." COMESA African Agricultural Markets Programme. Policy Synthesis #2. 2009.)

Truth #9: Investment in farmer organizations helps farmers develop the skills and confidence to encourage and support the adoption of new practices like conservation agriculture.

- Cooperative groups of local farmers convincingly demonstrate best practices and serve as mentors to their peers. They are also better able to finance, purchase and share tools, exchange improved seeds and agree to follow livestock management programs that protect residues and cover crops for uses that improve soil health and crop yields. Where local communities have been technically and organizationally developed, the eventual discontinuation of external assistance has not led to widespread farmer rejection of productive conservation agriculture practices. (Penning de Vries, editor. "Bright Spots Demonstrate Community Success in African Agriculture." IMWI Working Paper 102. 2005.)

- It is critical to focus on enhancing farmer skills, knowledge and opportunities to directly participate in research and testing of techniques and technologies that best leverage local resources. By building farmers' individual and collective capacities to manage integrated conservation agriculture practices, their skills and experiences mature and they will become less reliant on remotely sourced inputs and provisions of external funding. (Agriculture at a Crossroads. IAASTD. Island Press. 2009.)

Truth #10: Smallholder farmers themselves must participate as partners in the research, development and demonstration efforts to advance conservation agriculture adoption.

- In the early 1990s, most maize and wheat farmers in the Yaqui Valley of Mexico were burning their crop residues. With the technical assistance of CIMMYT and other agricultural development organizations' field demonstrations of raised bed maize cultivation methods, improved irrigation techniques and mentoring support, in the span of one decade nearly all farmers had changed their practices and now retain their residues for soil conservation purposes. (Verhulst, et al. "Conservation agriculture as a means to mitigate and adapt to climate change, a case study from Mexico." Designing Agricultural mitigation for smallholders in developing countries. Wollenberg L. editor. Earthscan. 2011.)

- In the span of forty years, Brazil has undergone a remarkable transition from relying on traditional and conventional tillage practices to today's condition where it is a major agricultural producer with 75% of cropland under no-till or reduced tillage. While this transformation substantially relied on innovating and expanding large scale farming operations, it also included adoption by hundreds of thousands of smallholder farmers. This farming revolution was accomplished with strong and persistent support from government and private sector investment in developing techniques, technologies and cropping practices to promote soil fertility and control erosion while producing profitable agricultural outputs. These efforts included focused research programs, development and commercialization of no-till technologies, extensive field training and other initiatives. (Bolliger, et al. "Taking Stock of the Brazilian 'Zero-Till Revolution.' " Elsevier. 2006.)

With long-term investment, and a commitment to research, innovation, and developing a support system to encourage the adoption of conservation agriculture, it is clear the developing world can transform its approach to farming to be more productive and more sustainable for current and future generations.

THE HOWARD G. BUFFETT

About The Howard G. Buffett Foundation

Established in 1999, The Howard G. Buffett Foundation's primary mission is to improve the standard of living and quality of life for the world's most impoverished and marginalized populations. The Foundation's focus is on international programs that operate in challenging environments, including conflict and post-conflict countries. The Foundation has supported more than 120 agricultural projects in over 40 countries and more than 50 nutrition projects in over 30 countries. The Foundation believes achieving global food security requires all countries—including the United States—to adapt its agricultural practices and policies to meet long-term agricultural needs and successfully address hunger and malnutrition. To learn more, visit www.thehowardgbuffettfoundation.org.