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VIEWPOINT

Plowing: Dust storms, Conservation Agriculture, and need for a "Soil Health Act"

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The dust storm tragedy on I-55 in central Illinois on May 1, 2023, a reminder of the Dust Bowl era of the 1930s, necessitates urgent policy intervention to replace plow tillage with Conservation Agriculture (CA) involving no-tillage with crop biomass mulch, cover cropping, and complex crop rotations. System-based CA has co-benefits including control of soil erosion by wind (dust storm) and water, low risks of non-point source pollution including algal bloom, adaptation and mitigation of climate change, reduced incidence of drought-flood syndrome, sustained productivity, high farm income, and improved soil health. The current farm bill already contains a Clean Water Act, Clean Air Act, and Growing Climate Solutions Act that can all be complemented and more effective with a healthy soil. The forthcoming farm bill should have provision to reward farmers for ecosystem services at a nominal rate, e.g., US$50 ac^{-1} yr^{-1} (~US$123.46 ha^{-1} y^{-1}), through a proposed "Soil Health Act" to further CA as a solution to climate change and other environmental issues. Restoring soil health through CA is a win-win option and a major contribution to mitigating future climate extremes and food security.

Ninety years after the Dust Bowl we should not need reminding that agriculture's job is to feed people without degrading the environment, not create chaotic catastrophic events due to poor utilization and resource management. Unfortunately, the recent I-55 dust storm catastrophe in central Illinois, United States, in May of 2023 did just that and caused the loss of 8 lives, hospitalization of 37 others, loss or damage to 72 vehicles, and triggered associated environmental degradation (figure 1). This disaster was caused by low April rainfall—roughly half of normal amounts—and high winds that blew across freshly tilled fields and lofted loosened topsoil into the air. The tragedy captures one of the more visible unintended consequences of frequent intensive tillage when farmers plow in the fall, and till again one or two times before spring planting. Less visible consequences include soil erosion by runoff, as well as decreased soil, water, and air quality—and the loss of the soil organic matter that is at the heart of soil health. Soil dust from both tilled and bare fallow farmlands pose severe risks to public health and transportation safety, and this recent catastrophe illustrates the unintended consequences of soil mismanagement and the need for both farmer education and farm policy reform.

Dust storms are a major catastrophe; they degrade the local soil and surrounding environmental quality and the health and well-being of humans and ecosystems. The increased frequency and intensity of dust storms associated with climate extremes and the associated deaths has become alarming. Tong et al. (2023) report that in most years windblown dust causes loss of life comparable to hurricanes, thunderstorms, and wildfires, with a total of 232 deaths from windblown dust events in the United States from 2007 to 2017. On November 29, 1991, the largest single dust-related highway incident in US history occurred on Interstate 5 in the San Joaquin Valley, California, where 164 vehicles collided, resulting in 17 deaths and injuring 151 additional people (Tong et al. 2023; Pauley et al. 1996). In most cases, similar crash sites are "situated near farmland, which constitutes a major dust source across the United States" (Tong et al. 2023; Lambert et al. 2020). Enhanced soil management will be required with widespread adoption of CA practices that preserve, protect, and restore our soil. Enhanced management of our agricultural soils will contribute to the welfare of humanity along with environmental quality and food security.

CAUSES AND SOLUTIONS OF SOIL DUST STORMS

Soil erosion from both wind and water continues to be a national and global problem (Montgomery 2007a, 2007b). Dust fatalities are most frequent over the southwestern United States due to three primary factors: dry weather, windy conditions, and bare or tilled soil surfaces contributing to severe soil dust storms (Tong et al. 2023). Farmers have little or no control over dry weather and windy conditions. Farmers must understand the main management decisions that affect dust storms are the soil surface conditions and tillage. Lal et al. (2007) discuss the importance of transitioning from intensive moldboard plow tillage to no-tillage as the first step to minimize soil loss and degradation. Adding cover crops to continuous no-tillage in CA systems offers many economic and environmental benefits in addition to erosion control, including increased organic matter, nitrogen (N) fixation, and water infiltration. The improved soil structure enables better air and water exchange, improved soil microbiota, and sustained or increased yields through healthier soils. Over the decades since the

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Figure 1
A dust storm led to near blackout conditions along I-55 in Illinois on Monday, May 1, 2023. Photo source: WICS-TV, Springfield, Illinois.

Photo credit: WICS-TV Springfield, Illinois

1930s Dust Bowl, many catastrophic dust storms (Tong et al. 2023) have shown that there are seasonal agricultural sources that emit soil dust when the cropland is dry and not covered by vegetation, or when affected by agricultural operations (Hill et al. 2019). They will continue to occur as long as tillage remains a common practice on farm fields.

WE HAVE BEEN SLOW TO LEARN CONSERVATION LESSONS

Historical lessons from impacts of intensive agriculture and plow tillage provide modern civilization learning opportunities that lead to the future. The Dust Bowl of the 1930s is the most often cited historical example of large-scale wind erosion and dust storm activity with the core covering much of the US Great Plains. Most severe dust storms, often referred to as "black blizzards," occurred between 1933 and 1938, with maximum activity during spring plowing (Faulkner 1943). "Black Sunday," the single worst day of the Dust Bowl, was April 14, 1935. When the drought and dust storms showed no signs of letting up, many people abandoned their land and exited the Great Plains in the largest migration in American history. These tragic experiences highlighted the need for soil conservation practices and eventually led to the development of the Soil Conservation Service (SCS) that evolved into NRCS (Natural Resource Conservation Service) in 1994. No-tillage is now a major pillar in a regenerative system that allows nature to work and natural drainage channels to open with plant roots and earthworm activity. While NRCS has advised farmers to reduce tillage since the Dust Bowl era, progress has been slow due to 10,000 years of "tillage tradition" and advice to adopt "conservation tillage" or other forms of reduced tillage that do not provide minimum soil disturbance.

SUSTAINABLE AGRICULTURE

There are many different perceptions about the meaning of sustainable agriculture (Du Pisani 2006), but the United Nation's current global development and environmental goals of sustainable development require principles of science to protect and maintain the environment and the associated ecosystem services dependent on our soils (Keesstra et al. 2016). From an agricultural perspective, sustainable development implies a multidimensional approach to managing agroecosystems encompassing productivity, environmental, economic, and social components of sustainability.

No-tillage as a single practice produces mixed results with regard to yields and economic and environmental benefits. However, the combination of no-tillage, cover crops, and crop diversity that form the three pillars of CA systems have been shown to make a major contribution to sustainable agriculture development globally (Lal 2015; Montgomery 2017; Kassam 2020; Reicosky and Kassam 2021; Duiker 2022; Kassam et al. 2022). Indeed, several researchers (Lal 2017; Montgomery 2017) suggest adopting CA for erosion control, to improve soil and water management outcomes, protect the environment, sequester carbon (C) in soil (Lal 2004), and achieve food security.

Though the CA component of minimum soil disturbance broadly refers to the physical disturbance of the soil, it can also include chemical disturbance. When CA farmers "restore fertility to the land, this helps feed the world, cool the planet, reduce pollution, and return profitability to family farms" (Montgomery 2017; Kassam et al. 2022). Many climate-smart agriculture practices are incorporated into CA systems to decrease agriculture's C footprint. The key to CA lies in understanding that it is not a rigid, highly structured farming practice and that the three primary principles are applicable around the globe. Rather, its implementation depends heavily on improved management skills and the context and nature of each farm to which it is applied, the specific crops being grown, and the prevailing farming conditions that likely require more education. As there is no "cookie-cutter" recipe, this makes farmer education central to successfully implementing CA.

The concepts of soil health and soil as a living system are also slowly becoming more widely understood. For example, the visible presence of earthworms in the soil is understood to be a positive sign of biological activity. Montgomery and Bilké (2016, 2022) and Montgomery et al. (2022) reviewed why good health—for people and for plants—depends on soil microbial life and showed why understanding, cultivating, and nurturing beneficial soil microbiomes holds the key to transforming agriculture and medicine. This transformation to a new type of agriculture will require new concepts and practices that lead to a better understanding and ultimately food security. The concept of soil health unites the farmers, consumers, scientists, environmentalists,

and policymakers working to incorporate agricultural conservation practices.

EDUCATION IS NECESSARY FOR TECHNICAL SOLUTIONS TO WIND EROSION

Stakeholder education is needed as we work toward global food security transforming our food production systems. The importance of soil biology is slowly being understood and accepted, illustrating the concept and complexity of a living soil system (Montgomery and Bilké 2016). The unknown risks in new ecological management systems require new management skills as new technology and equipment evolves. Measurement of biological properties and processes requires more sophisticated data collection to make improved management decisions. Farmer education can be enhanced in developing independent, farmer-led networks with farmers as mentors and teachers. Successful farmers have practical credibility sharing their successes at conferences, field days, and other programs organized to educate farmers, crop consultants, agricultural business representatives, ag science teachers, and professors. In that way, these farmers also help educate the educators and policy groups. Experienced farmers with positive attitudes and credibility, along with a little passion, are more effective at communicating with and teaching other farmers. They can also share their fields for on-farm research and demonstration projects.

The entire agriculture community needs understanding of the interrelationships between the three primary principles of CA for truly sustainable production. The development of farmer-led networks and peer learning training, which may be more effective than traditional forms of education, should be encouraged to ensure the continuation of sustainable production (Shin et al. 2017). The combination of social science principles and enhanced communication skills may help with the understanding and acceptance of policy decisions. The best method for getting more conservation on the land and protecting our natural resources for future food security may be an alternative path in which farmers are educated, learn how to apply science principles, and do some of their own on-farm research. Farmer-led mentors, farmer-led networks, and peer learning training should be encouraged (Pape and Prokopy 2017; Ranjan et al. 2019). Further education may be required for the three interconnected CA principles to be broadly accepted and integrated as a sustainable agriculture system by young farmers.

Given the ecological complexity of the living soil system, our challenge is to find reasonable ways of educating the farmer and the consumer of the soil biological complexity that exists as the foundation of our food security. This major educational process must continue as more innovative ideas and concepts around soil health evolve for CA and other types of regenerative agriculture, including eco-intensification, C farming, and agroforestry. Farmers' frustrations with policy regulations may require a social science emphasis for clear and effective communication and education.

POLICY AND EDUCATIONAL CHANGES/IMPLICATIONS

Wind erosion and dust storms have been an agricultural issue in the semiarid central US Great Plains since settlers first plowed prairie grasslands to produce food and fiber. Subsequent research and policy development has resulted in some progress; however, recent climate extremes suggest the need for continued development for a workable solution. Currently, important policy decisions are being included in the new farm bill, a package of legislation passed roughly once every five years that has a tremendous impact on agricultural production and farming livelihoods. The farm bill should emphasize stakeholder education and project funding to get more CA implemented on agricultural ecosystems. Current crop insurance policy reinforces marginal farming practices, and as a result does not encourage adoption of improved practices that prevent soil erosion from water and wind. Basing crop insurance on CA with three primary principles would reduce environmental degradation. These improved management practices are required for more resilient soils that provide a level of environmental quality and consistent crop yields. In particular, the farm bill needs to include a proposed "Soil Health Act," which rewards farmers for adoption of CA systems emphasizing cover cropping through payments for ecosystem services at a nominal rate, e.g., US$50 ac^{-1} yr^{-1}. The payment value is based on the price of crop residues returned, cost of cover crop seed, and the cost of additional fertilizer in the formation of stable humus. In addition, previous governments have paid US$50 per C credit for injecting 1 tn (~0.907 t) of carbon dioxide (CO_2) into geological strata. With cover crop and residue return rate of CO_2 sequestration being about 1 C credit ac^{-1} yr^{-1} (~2.47 C credits ha^{-1} y^{-1}), farmers using these practices should be paid the same price. The Soil Health Act will complement present policy including the Clean Air Act and Clean Water Act, and the Agriculture Resilience Act designed to improve soil health and protect farmland for future generations.

Farmer organizations, many farmer-led and farmer-mentored, such as the No-Till Farmer, Ohio No-till Council, Pennsylvania No-Till Alliance, and No-Till on the Plains, etc., should be funded to organize events for education of farmers, consumers, consultants, and policy groups on benefits of CA practices. Practice and land use-based payments to farmers for ecosystem services, similar to the Conservation Reserve Program in the Farm Bill of 1987, are needed to promote the adoption of CA (Palm et al. 2014).

SUMMARY

The severity of recent drought in parts of the Corn Belt resulted in large amounts of wind erosion, suggesting the lessons from the "Dust Bowl Days" have not been retained by all. The recent soil dust cloud catastrophe in central Illinois is another wakeup call suggesting that agriculture needs to implement more sustainable production practices. The combined unique conditions of dry soils, strong winds, and recent soil tillage caused the tragic loss of human life. This catastrophe and several other verified dust storm incidents should provide strong justification for the need to incentivize adoption of soil health practices and CA widely across the United States. Policy implications for the

new farm bill programs that promote conservation innovation through payments for ecosystem services, training, and new ideas, along with farmer and consumer education programs, including a proposed "Soil Health Act," are essential. Investing in adopting farming practices that can stop the dust from blowing would pay dividends for generations.

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