FOOD

IMPROVED RICE CULTIVATION

Vietnamese poet Phan Van Tri writes of rice grains: "They leave rice fields to travel far and wide: who doesn't count on them for sustenance? . . . Time after time, their forebears saved the realm—for centuries their breed has fed our folk." Rice has, in fact, been part of human life for thousands of years. Most likely domesticated in China first, today the grain is nearly universal—white, brown, and sticky; noodles, cakes, and vinegar; pilaf, paella, and porridge. Rice provides a full one-fifth of calories consumed worldwide, more than wheat or corn, and is the essential staple in the daily diet of 3 billion people, many of them poor and food insecure.

Presently, rice cultivation is responsible for at least 10 percent of agricultural greenhouse gas emissions and 9 to 19 percent of global methane emissions. Flooded rice paddies are perfect environments for methane-producing microbes that feed on decomposing organic matter, a process known as methanogenesis. Higher ambient temperatures where rice is cultivated increase emissions, which suggests that methane releases from rice paddies will increase as the planet gets hotter. Methane does not persist in the atmosphere as long as carbon dioxide does, but over a century, its global warming potential is up to thirty-four times greater. Thus, the world faces a multifaceted challenge: to find and adopt ways to produce rice that are efficient, dependable, and sustainable, meeting the growing demand for this staple food without causing warming.

It "was discovered almost by accident." That is how French Jesuit priest and agronomist Henri de Laulanié described the origins of the System of Rice Intensification (SRI), a key approach to improve rice production, which he and smallholder farmers developed on Madagascar in the 1980s. Under atypical time constraints, a group of agricultural students transplanted rice seedlings much earlier than usual. It was an unanticipated first step toward a holistic system that lowers the inputs required for rice production—seeds, water, and fertilizer—while dramatically increasing crop yields.

Three decades later, the *New York Times* described SRI as emphasizing "the quality of individual plants over the quantity" and applying "a less-is-more ethic to rice cultivation." Thanks in large part to the evangelizing efforts of Norman Uphoff, of Cornell University, that ethic is now practiced by 4 million to 5 million farmers around the world, especially in Asia. They include Sumant Kumar, a farmer in the village of Darveshpura in northeast India, who achieved a world-record yield of 24.7 tons of rice on his 2.5-acre (1-hectare) plot in 2012—eclipsing the 4.5 or 5.5 tons that are typical for a piece of land that size.

SRI is not the only approach to sustainable rice production, but it seems to be the most promising. Kumar and his friends engaged in a simple set of practices knit together in a compelling way:

1. *Planting.* Rather than bedding out three-week-old seedlings by the handful—bunched close together—SRI calls for transplanting single seedlings when they are eight to ten days old and using a square grid that gives each one wider berth. Doing so creates more access to sunshine and canopy space aboveground, and more room for the roots to spread below.
2. *Watering.* Most conventional rice fields are continuously flooded, enabling methanogenesis, but SRI specifies more purposeful, intermittent watering. Temporary draining midway through a growing season or alternating between wet and dry conditions is more favorable to soil microbes and root systems that like to breathe, while disrupting the waterlogged conditions that methane-producing microbes favor. Research shows mid-season drainage alone reduces methane emissions by 35 to 70 percent.
3. *Tending.* Weeds can be a challenge in the absence of flooding, which SRI addresses with a rotating hoe used by hand, also aerating the soil. In tandem, applying organic compost helps to enhance soil fertility and carbon sequestration. Reducing or avoiding synthetic fertilizers protects both soil and waterways.

It all adds up to creating the ideal environment for rice to grow, fed with more sunshine, more air, and more nutrients. The result: plants that are larger and healthier, with stronger root systems, aided by more abundant, thriving soil microorganisms. Not only are yields 50 to 100 percent higher than conventional rice production, but seed use drops by 80 to 90 percent and water inputs by 25 to 50 percent. This reduction in water use makes SRI not just a means of mitigating global warming but also a good approach for adapting to a warming world. SRI plants also prove more resistant to drought, flooding, and storms—phenomena heightened by climate change.

While these practices improve the productivity of a farmer's land, labor, and capital, the labor inputs required can be higher than in conventional rice cultivation, mostly in the early years, when a farmer is learning SRI. As Uphoff explains, "It's not intrinsically labor-intensive; it's initially labor-intensive." Farm incomes can double when SRI gets adopted. Despite its spread to some forty countries and millions of smallholder farms, some scientists dispute yield and income claims, citing insufficient peer-reviewed research. That body of literature is growing, but SRI may continue to face this challenge, at least in the near term. SRI's defenders suggest that the grassroots, democratic, and holistic nature of the movement may actually be the reason for critique. Farmers, those most intimately in dialogue with the earth, are the innovators and experts—not agribusiness, nor academia. SRI disrupts the mechanistic, chemically intensive approach to food production upon which so many companies depend for their income.

SRI is not the only means for achieving improved rice production. There are four general and increasingly common techniques, best used in combination, that focus on water, nutrients, plant varieties, and tillage. Mid-season water drainage and alternate wetting and drying improve aerobic conditions. More balanced application of both organic and inorganic nutrients reduces methane emissions while supporting yields. Rice varieties or *cultivars* that are less water-loving can be used in more aerobic environments. Techniques for seeding rice without tilling the ground also have positive effect.

The advantage and the burden of SRI and other improved rice-production techniques is that they hinge largely on behavior change, shifting the way farmers manage their plants, water, soil, and nutrients. On one hand, that means it is exceedingly doable for smallholder farmers, who need not buy anything before putting SRI into practice (a striking difference from conventional approaches to agricultural intensification). The main technical challenge they face is controlling water application. On the other hand, many rice farming methods have been in place for centuries; they are embedded in families, villages, and cultures. Shifting entrenched customs requires a comprehensive approach to cultivate necessary knowledge and skills, help farmers see what results are possible, and implement incentives that make the prospect of change compelling. In SRI's early days, de Laulanié and his collaborators founded an educational organization, Tefy Saina, meaning "to improve the mind" in Malagasy. There is a message in that name: On-the-ground knowledge sharing and peer-to-peer training continues to be indispensable. Deepening and spreading those efforts can help low-emissions rice cultivation take root worldwide. It was not de Laulanié's original purpose, but his work may prove to be indispensable in tackling global warming.

IMPACT: *Our analysis includes both SRI and improved rice production, which involves improved soil, nutrient management, water use, and tillage practices. SRI has been adopted largely by smallholder farmers and has much higher yield benefits compared to improved rice production. We calculate that SRI can expand from 8.4 million acres to 133 million acres by 2050, both sequestering carbon and avoiding methane emissions that together total 3.1 gigatons of carbon dioxide or its equivalent over thirty years. With increased yields, 477 million additional tons of rice could be produced, earning farmers an additional $678 billion in profit by 2050. If improved rice production grows from 70 million acres to 218 million acres over thirty years, another 11.3 gigatons of carbon dioxide emissions can be reduced. Farmers could realize $519 billion in additional profits.*