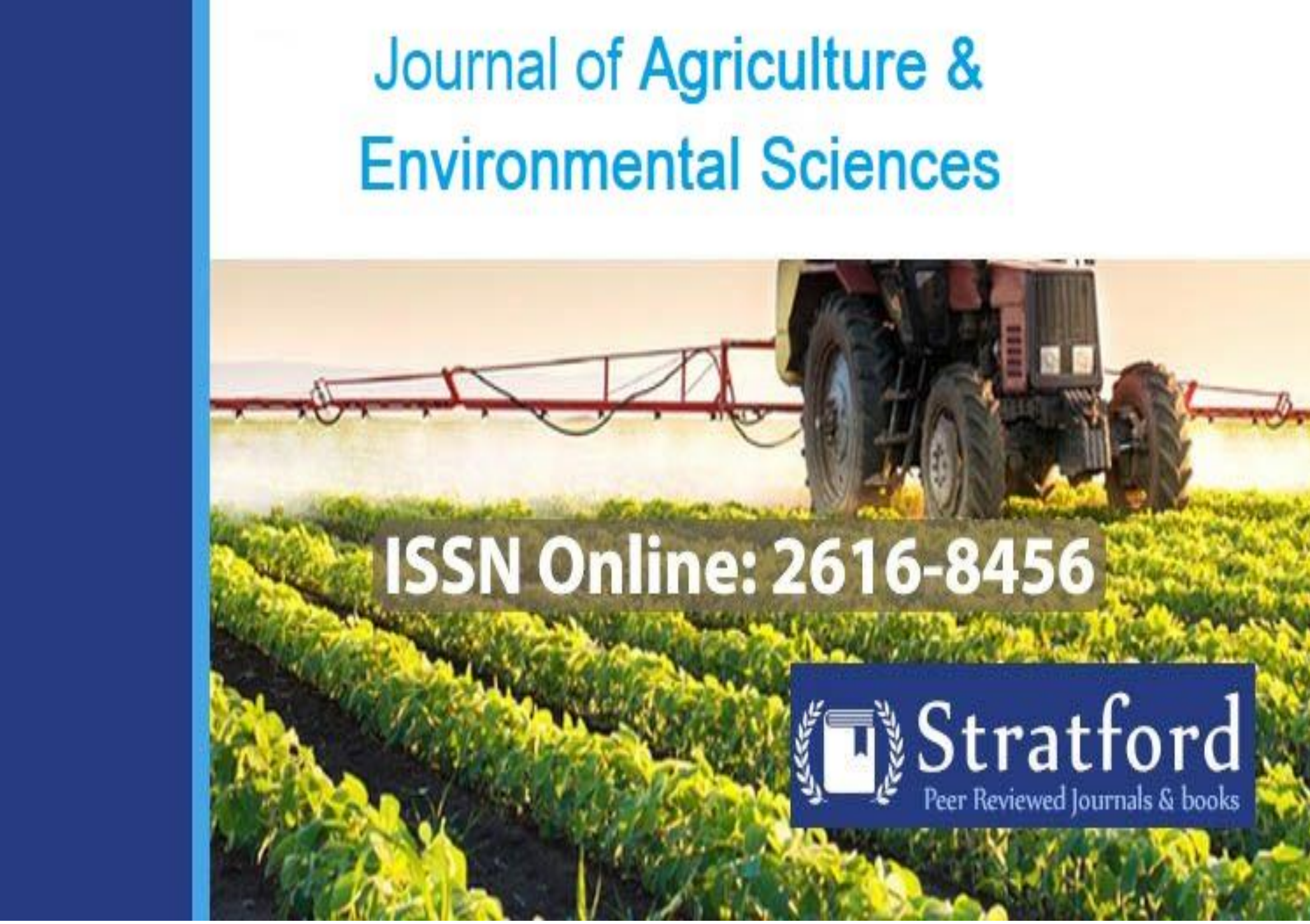

Beyond the Label: Choosing Low-Impact Farming by Crop, Context, and Country

Ben Henson

ISSN: 2616-8456

Stratford Peer Reviewed Journals and Book Publishing
Journal of Agriculture & Environmental Sciences
Volume 9||Issue 2 ||Page 116-125|| April |2025|
Email: info@stratfordjournals.org ISSN: 2616-8456

Beyond the Label: Choosing Low-Impact Farming by Crop, Context, and Country

Ben Henson

SACPP Farm Services Ltd / SSA Farm Services Inc

Email address: blhenson@sacpp.org

How to cite this article: **Henson, B. (2025). Beyond the Label: Choosing Low-Impact Farming by Crop, Context, and Country. Journal of Agriculture & Environmental Sciences, 9 (2), 116-125. https://doi.org/10.53819/81018102t3123**

Abstract

This paper examines the limitations of labeling systems such as "organic," "non-GMO," and "regenerative" in evaluating the true environmental and agronomic impact of farming systems. Using crop-specific case studies—maize, French beans, blueberries, dry beans, and cotton—the analysis applies metrics like Environmental Impact Quotient (EIQ), pesticide risk, soil disturbance, and carbon footprint to compare systems across different contexts. The final section highlights a breakthrough in wheat breeding—Biological Nitrification Inhibition (BNI)—as a scalable, label-defying innovation. Findings support a metrics-first approach to sustainability assessment and call for a shift in both policy and consumer engagement.

Keywords: *Beyond the Label, Low-Impact Farming, Crop, Context, Country*

1.0 The Illusion of Easy Answers

The world wants simple answers. Organic is good. GMOs are bad. Chemicals kill. Natural is safe. But on the ground, where food is actually grown, none of it is that simple. Labels like organic, regenerative, GMO-free, pesticide-free, no-till, and carbon neutral have become moral shorthand—and often marketing tools. But the real impacts of a farming system aren't decided by its branding. They're decided by what it does to the land, the water, the air, and the people working it. Metrics like yield per acre, environmental impact quotient (EIQ), pesticide risk (PRT), carbon footprint, and soil disturbance are all part of a more honest assessment. Take tillage, for instance. It's a mechanical, chemical-free method of weed control often associated with organic systems—but it also releases stored carbon, damages soil structure, and increases erosion risk. And then there are the absurdities: spinach labeled "non-GMO," as if it had been genetically modified in the first place. (It hasn't.). If you take off the labels and instead ask, "Which practice has the lowest impact on the environment, soil, water, and farmer livelihood?" the answer shifts with every crop, region, and season.

Farmers don't farm ideals. They farm realities—weeds, pests, disease, margins, rainfall, labor shortages, and markets. And in both the global North and South, the least impactful system isn't always the one with the most marketing appeal. This essay explores how metrics like the Environmental Impact Quotient (EIQ) and the Pesticide Risk Tool (PRT) can offer a clearer view of sustainability. When paired with yield stability and economic access—especially in food-insecure regions—these tools reveal that the best system is rarely ideological. It's practical.

1.1 Maize: A Case Study in Tradeoffs

Maize is a staple crop cultivated across diverse agro-ecological zones worldwide. Its production systems range from smallholder farms in Sub-Saharan Africa to large-scale industrial operations in North America. The choice of pest and weed management strategies significantly influences the environmental impact and sustainability of maize cultivation.

Pest and weed management approaches in maize production vary considerably. Conventional systems typically rely on a combination of pre-emergent herbicides (e.g., atrazine, metolachlor) and post-emergent applications. Insect pests like the fall armyworm (*Spodoptera frugiperda*) are managed using synthetic insecticides, including pyrethroids and organophosphates. In contrast, Bt maize is genetically engineered to express *Bacillus thuringiensis* (Bt) toxins, providing inherent resistance to specific insect pests. Bt maize has been shown to reduce the need for chemical insecticides, particularly against the European corn borer and fall armyworm. Roundup Ready maize, engineered for glyphosate tolerance, allows for post-emergent weed control without pre-emergent herbicides, simplifying weed management but raising concerns about glyphosate-resistant weed populations. Organic maize systems depend on mechanical weeding, crop rotation, and natural pesticides such as neem extracts. While avoiding synthetic chemicals, these systems often face challenges in effectively managing pests like the fall armyworm.

The Environmental Impact Quotient (EIQ) provides a standardized measure to assess environmental impact of pesticide use, considering factors like toxicity to non-target organisms, persistence in the environment, and potential for groundwater contamination. Conventional maize systems typically have an EIQ of around 22, with average yields of 4.5 t/ha, moderate soil disturbance, and a carbon impact of approximately 280 kg CO_2-eq/t. Bt maize and Roundup Ready maize systems show lower EIQ values of around 15, with higher average yields of 5.0 t/ha, low soil disturbance, and reduced carbon impacts of about 210 kg CO_2-eq/t. Organic systems, despite their chemical-free approach, often have higher EIQ values of approximately 28, coupled with lower yields of 2.8 t/ha, high soil disturbance, and elevated carbon impacts of around 350 kg CO_2-eq/t. Self-grown or low-input systems have the lowest EIQ at 6, but also the lowest yields at 1.8 t/ha, making them suitable for subsistence farming but not commercially scalable.

Studies show that Bt maize significantly reduces chemical insecticide use, improving environmental safety and lowering EIQ values (Kovach et al., 1992). Both Bt and Roundup Ready maize maintain yields while enabling conservation tillage, enhancing soil carbon retention (Zhang et al., 2022). Research in Sub-Saharan Africa highlights the labor burden of organic systems and the role of synthetic options in pest control (Day et al., 2017). Comparative studies also demonstrate that mechanical weed control in organic systems increases carbon release and soil disturbance.

Each maize cultivation system presents unique tradeoffs. Conventional approaches offer higher yields but rely on synthetic inputs with associated environmental concerns. Bt and Roundup Ready maize provide efficient pest and weed control respectively but require careful management to

https://doi.org/10.53819/81018102t3123

prevent resistance issues. Organic systems emphasize environmental sustainability but may face challenges in productivity and pest management. Self-grown or low-input approaches are suitable for small-scale, subsistence farming with minimal environmental impact but limited scalability.

1.2 Organic Blueberries: A Model for Low-Impact, High-Value Perennial Production

Blueberries (*Vaccinium* spp.) are among the most amenable fruit crops to organic production, especially in regions like the Pacific Northwest and the Northeast U.S. Their perennial nature, adaptability to acidic soils, and relatively low pest pressures make them suitable for organic management. Moreover, consumer demand for organic blueberries has been strong, providing economic incentives for growers.

Organic blueberry production emphasizes cultural and biological controls for pest and disease management. The use of organic mulches like sawdust or pine needles helps suppress weeds, retain soil moisture, and maintain soil acidity. Soil fertility in organic systems often utilizes composted manures or plant-based fertilizers to meet nutrient requirements. While blueberries have relatively few pest issues, challenges like the spotted wing drosophila (*Drosophila suzukii*) have emerged. Organic growers employ strategies such as timely harvesting, netting, and approved organic insecticides like spinosad to manage these pests.

Research indicates that well-managed organic blueberry systems can achieve yields comparable to conventional systems. For instance, a 10-year study by Oregon State University found that organic blueberries grown on raised beds with appropriate mulching and fertilization strategies produced yields similar to conventional methods. In terms of environmental impact, organic blueberry production tends to have a lower Environmental Impact Quotient (EIQ) due to reduced reliance on synthetic pesticides. Life Cycle Assessments (LCA) have also shown that organic blueberries have a lower carbon footprint compared to other berry crops, primarily due to lower input requirements and sustainable farming practices.

Studies analysing the carbon footprint of various berry crops found that organic blueberries had one of the lowest carbon footprints per kilogram of fruit produced. The organic approach offers lower environmental impact, comparable yields, and meets consumer demand for organic produce, though it requires careful management of soil fertility and pest control. Conventional methods may provide potentially higher yields and established pest control methods but come with a higher

https://doi.org/10.53819/81018102t3123

environmental impact due to synthetic inputs. This analysis underscores that, for certain crops like blueberries, organic farming can offer a sustainable and economically viable alternative to conventional methods, provided that best practices are followed.

1.3 Organic Dry Beans: A Low-Impact, Resilient Legume

Dry beans are a staple legume crop valued for their protein content and soil-enriching properties. They are particularly well-suited to organic farming due to their nitrogen-fixing ability, relatively low pest pressures, and adaptability to diverse climates. In regions like the U.S. Upper Midwest and parts of Canada, organic dry bean production has gained traction among both small-scale and commercial growers.

Organic dry bean cultivation emphasizes preventive and cultural practices for pest and weed management. Crop rotation with cereals or other crops disrupts pest and disease cycles. Mechanical weeding tools like rotary hoes and inter-row cultivators manage weeds without chemicals. Planting cover crops suppresses weeds and enhances soil health. Encouraging natural predators and using approved organic pesticides when necessary also plays a role in pest management. While these methods can be effective, they require careful management and may be labor-intensive.

Studies comparing organic and conventional dry bean systems have found that organic systems generally have lower environmental impacts per area unit, including reduced greenhouse gas emissions and lower potential for biodiversity loss and ecotoxicity (Nature). Organic dry bean yields can be comparable to conventional yields under optimal conditions, though they may be lower in some cases due to weed pressure and nutrient availability (Ag & Natural Resources College). Organic practices often lead to improved soil structure and increased microbial activity, enhancing long-term soil fertility.

Research from Michigan State University found that certain dry bean varieties performed well under organic management, with yields approaching those of conventional systems (Ag & Natural Resources College). A study indicated that organically grown common beans had higher protein content and levels of beneficial micronutrients like iron and zinc compared to conventionally grown beans (Frontiers). Life cycle assessments have shown that organic dry bean production can

https://doi.org/10.53819/81018102t3123

result in a lower carbon footprint per kilogram of beans produced, primarily due to the avoidance of synthetic fertilizers and pesticides (MDPI).

The organic approach offers lower environmental impact and improved soil health with potential for comparable yields, though it requires meticulous management and may result in lower yields under suboptimal conditions. Conventional methods provide higher yields and established pest and weed control methods but come with greater environmental impact and reliance on synthetic inputs. This analysis underscores that, for crops like dry beans, organic farming can offer a sustainable and economically viable alternative to conventional methods, particularly when best practices are employed.

1.4 Bt Cotton vs. Organic Cotton: A Case of Metrics Over Labels

Cotton is a globally significant crop, both economically and environmentally. The debate between Bt (*Bacillus thuringiensis*) cotton and organic cotton often centers around environmental impact, pesticide use, and sustainability.

Bt cotton is genetically engineered to express proteins from the *Bacillus thuringiensis* bacterium, providing inherent resistance to specific insect pests, notably bollworms. This genetic modification reduces the need for chemical insecticides. Studies have shown that Bt cotton cultivation significantly reduces the Environmental Impact Quotient (EIQ) compared to conventional cotton. For instance, research in India indicated that Bt cotton had an EIQ field rating of 16.23, substantially lower than the 157.76 rating for conventional cotton, marking an 89.5% reduction in environmental impact due to decreased pesticide use. Bt cotton has demonstrated higher technical efficiency and yield compared to non-Bt varieties, contributing to increased farm income and reduced pesticide-related health risks for farmers.

Organic cotton is cultivated without synthetic pesticides, fertilizers, or genetically modified organisms (GMOs). Instead, it relies on natural methods like crop rotation, composting, and biological pest control. The most widely used pest control agents in organic cotton include botanical insecticides like pyrethrins, and mineral-based fungicides such as copper sulfate and sulfur. While permitted under organic standards, these substances are not inherently low-impact. Pyrethrins are broad-spectrum and can be toxic to beneficial insects like bees. Copper sulfate, though naturally derived, is persistent in soil and can accumulate to levels that impair soil biota

https://doi.org/10.53819/81018102t3123

and pose risks to aquatic ecosystems. Sulfur has low toxicity to humans and animals but may cause irritation and requires protective handling. The Environmental Impact Quotient (EIQ) of these substances varies, but in many cases, organic pesticides like copper can have higher EIQ scores than some synthetics used in conventional systems. This reveals a key challenge in using the term "organic" as a proxy for environmental sustainability. Organic cotton yields can be lower due to pest pressures and restricted input options, although practices like cover cropping and biological controls may offset some losses over time.

Bt cotton and organic cotton differ in several key aspects. Bt cotton uses genetic modification while organic cotton does not. Bt cotton shows reduced pesticide use due to built-in pest resistance, while organic cotton avoids synthetic pesticides and uses natural methods. Bt cotton demonstrates lower EIQ with significant reduction in pesticide-related harm, while organic cotton's environmental impact is variable and depends on specific practices. Bt cotton typically achieves higher yields and efficiency, while organic cotton may have potentially lower yields depending on pest pressure. Bt cotton has a neutral to positive effect on soil health with less pesticide runoff, while organic cotton has a positive effect on soil health enhanced through organic practices.

This comparison illustrates that while both Bt and organic cotton aim to reduce environmental impact, their approaches and outcomes differ. Bt cotton leverages genetic engineering to minimize pesticide use, while organic cotton emphasizes natural inputs, which can still carry significant environmental costs. Evaluating sustainability requires a nuanced understanding of metrics like EIQ, soil health, and yield—not just branding.

Bt cotton systems in India showed an EIQ rating of 16.23 compared to 157.76 for conventional—an 89.5% reduction (Singh et al., 2011). In high bollworm regions, Bt cotton has reduced insecticide use by up to 95%, improving worker safety and ecological health. Bt cotton delivers higher yields and technical efficiency compared to non-Bt and organic systems (Kouser & Qaim, 2011). Organic cotton avoids synthetics but relies on pyrethrins and copper, both of which can carry high EIQ scores and non-target risks.

1.5 Subbarao's Wheatfield: The Breakthrough That Defies the Label

Modern wheat production has a nitrogen problem. Despite decades of breeding and billions in subsidies, wheat's nitrogen-use efficiency (NUE) remains stuck at around 33%. That means two-

https://doi.org/10.53819/81018102t3123

thirds of the fertilizer applied either leaches into groundwater or escapes as nitrous oxide—a greenhouse gas nearly 300 times more potent than carbon dioxide.

But nature had a solution all along. *Leymus racemosus*, a wild relative of wheat, releases root compounds that suppress nitrifying bacteria. These bacteria normally convert ammonium (NH_4^+) into nitrate (NO_3^-), the leaky form of nitrogen that fuels both groundwater pollution and climate emissions. The process is called Biological Nitrification Inhibition (BNI).

Through precision breeding, Dr. G.V. Subbarao and his team at JIRCAS transferred a chromosomal segment from *Leymus* into elite wheat cultivars like MUNAL and ROELFS. The result is BNI wheat—a plant that performs all the functions of top-performing varieties while naturally inhibiting soil nitrification.

Field trials have demonstrated several measurable impacts of BNI wheat. Soil nitrate decreased by 30% in the rhizosphere of BNI wheat. Nitrous oxide emissions were reduced by 25% compared to non-BNI lines. Nitrogen uptake increased by up to 58% under low-N conditions. Biomass and yield showed 50% more biomass without fertilizer and 10–14% higher grain yield with standard inputs. The grain quality-maintained baking and protein standards throughout.

BNI wheat changes the game in several key ways. Plants absorb ammonium more efficiently than nitrate, reducing their energy load and increasing resilience under stress. Retaining ammonium in the root zone alters pH and microbial dynamics in ways that favor nutrient retention and long-term fertility. Unlike management-intensive interventions, BNI is bred into the seed, allowing it to scale with the crop. Perhaps most importantly, it accomplishes all this without genetic engineering, synthetic inputs, or label-friendly marketing. It's not "organic." It's not "GMO." It's just better wheat.

BNI wheat doesn't just close the nitrogen loop; it rewrites the questions we ask about sustainability. Instead of "Is it certified?" we might ask, "Does it leach nitrate?" Instead of "Is it natural?" we might ask, "What does it leave in the soil?" In a world chasing 2050 climate goals and facing nitrogen regulation from the EU to Sub-Saharan Africa, BNI wheat offers a solution that speaks the language of data, not ideology. It reminds us that nature, when understood and stewarded well, can still surprise us.

https://doi.org/10.53819/81018102t3123

1.6 Conclusion

The search for sustainable agriculture too often gets hijacked by simplistic labels—organic, conventional, GMO-free, regenerative. Yet none of these categories, standing alone, can tell us whether a farm builds soil, protects pollinators, preserves water quality, or meets the economic needs of farmers.

Commercial-scale organic farms run the full spectrum—from deeply ecological operations to those using organic certifications as a marketing tool while relying on frequent copper sprays and aggressive tillage. Similarly, *Bacillus thuringiensis*—a cornerstone of both organic and GMO systems—can be sprayed, bred into plant roots, or genetically encoded, with outcomes that depend far more on context than label.

And then there's the wheatfield that could change the world.

Subbarao's BNI wheat, bred not through genetic engineering but by tapping into the allelopathic powers of wild grasses, suppresses nitrification in the soil. It reduces nitrate leaching and nitrous oxide emissions, improves nitrogen-use efficiency, and increases yields—all while maintaining grain quality. It's not "organic." It's not "GMO." But it may be the most environmentally sound wheat ever bred.

This blurring of boundaries isn't a failure of the food system—it's its evolution. The future of sustainable agriculture lies not in ideology, but in innovation measured by outcome. Metrics like EIQ, carbon footprint, soil disturbance, and yield per hectare offer a clearer lens than any slogan ever will.

When we shift the question from "Is it organic?" to "What's its impact?"—we begin to build a food system grounded in biology, ecology, and accountability. The wheatfield, the bean patch, the berry row, and the cotton field each have their own truths. And it's our job—as scientists, farmers, and eaters—to listen to those truths, not just the labels.

References

Day, R., Abrahams, P., Bateman, M., Beale, T., Clottey, V., Cock, M., ... & Witt, A. (2017). Fall armyworm: impacts and implications for Africa. *Outlooks on Pest Management*, *28*(5), 196-201. https://doi.org/10.1564/v28_oct_02

Kovach, J., Petzoldt, C., Degni, J., & Tette, J. (1992). A method to measure the environmental impact of pesticides.

Kouser, S., & Qaim, M. (2011). Impact of Bt cotton on pesticide poisoning in smallholder agriculture: A panel data analysis. *Ecological Economics*, *70*(11), 2105-2113. https://doi.org/10.1016/j.ecolecon.2011.06.008

Singh, V. K., Upadhyay, P., Sinha, P., Mall, A. K., Jaiswal, S. K., Singh, A., ... & Kole, C. (2011). Determination of genetic relationships among elite thermosensitive genic male sterile lines (TGMS) of rice (Oryza sativa L.) employing morphological and simple sequence repeat (SSR) markers. *Journal of Genetics*, *90*, 11-19. https://doi.org/10.1007/s12041-011-0018-5

Takemoto, K. (2021). Optical manipulation of molecular function by chromophore-assisted light inactivation. *Proceedings of the Japan Academy, Series B*, *97*(4), 197-209. https://doi.org/10.2183/pjab.97.011

Zhang, X., Davidson, E. A., Mauzerall, D. L., Searchinger, T. D., Dumas, P., & Shen, Y. (2015). Managing nitrogen for sustainable development. *Nature*, *528*(7580), 51-59. https://doi.org/10.1038/nature15743