

Science & Society

Renaming Indigenous crops and addressing colonial bias in scientific language

William Dwyer,¹
Carol N. Ibe,^{2,3} and
Seung Y. Rhee^{1,*}



Indigenous crops, commonly known as orphan, forgotten, or neglected crops, are understudied, but have important roles in the diet and economy of the communities that cultivate them. Here, we review potential benefits of Indigenous crop research and highlight the importance of an anticolonial framework to prevent exploitation of these unique resources.

Establishing and sustaining global food security is one of the greatest challenges of our era. An estimated 2.3 billion people worldwide suffer from malnutrition or lack of year-round access to adequate nutrition¹. Current agri-food systems are centered around a small number of input-intensive crops [maize (*Zea mays*), wheat (*Triticum aestivum*), and rice (*Oryza sativa*)] and, consequently, are vulnerable to economic shocks and extreme climate events, both of which are predicted to increase in frequency with climate change. Securing a stable food supply for the Earth's growing population will require an increase in the yield of staple crops and a concerted effort to diversify existing agricultural systems. Understudied Indigenous crops, or 'orphan crops', represent a massive, largely untapped, reservoir of nutritional and genetic potential, which may prove an effective solution toward the achievement of both goals.

The phrase 'orphan crop' describes a category of crops that are not traded globally in significant quantities, despite often having a major role in supporting the diet and economy of local communities. Orphan crops include a range of cereals, grains, fruits, legumes, and roots. Uniquely adapted to their environments, these crops are often highly nutritious, tolerant of marginal growing conditions, and boast vast reservoirs of genetic diversity [1]. Orphan crops exist across the globe, but are mostly cultivated by smallholder farms throughout Africa, Asia, and South America, where they provide essential nutrients, ecological services, and important sources of revenue to local communities.

Some orphan crops are widely cultivated and have long records of domestication [2], but their proper integration into modern agricultural systems has historically been hindered by a lack of scientific research. With only a fraction of the resources and breeding programs that are available to major crops, the development of orphan crops has lagged far behind the required level to mainstream their cultivation. However, a growing interest in orphan crops over the past decade is sparking investment in research, technology, and infrastructure [3]. Several studies recently identified targets for genetic improvement [4–6], speed breeding programs [7], farmer training [8], and market interventions [1] designed to accelerate the integration of orphan crop species into global agri-food systems.

Orphan crops may be understudied, but they are far from neglected (Figure 1). For example, teff grass (*Eragrostis tef*) is the most widely cultivated crop in Ethiopia in terms of area coverage, production volume, and cash crop value [9]. Millet (*Panicum miliaceum*) varieties are grown and consumed across Africa, where they provide a key supply of carbohydrates to millions of consumers [9,10]. The leguminous Bambara

groundnut (*Vigna subterranea*) and cowpea (*Vigna unguiculata*) supply a steady source of protein to sub-Saharan Africa and help replenish soil nitrogen contents by virtue of their association with soil-dwelling rhizobia [11]. *Amaranthus*, a genus of (mostly) South American crop species, formed the basis of Aztec agriculture until the arrival of colonizers precipitated the decline of amaranth production and the subsequent collapse of Indigenous food systems [12].

A variety of synonyms have been introduced to describe orphan crops [5]. Some, such as 'forgotten' crops, 'lost' crops, 'neglected' crops, and 'underutilized' crops, assume a Western perspective and ignore the rich relationship between the crops and the communities that cultivate them. Other terms, such as 'ancient' crops and 'minor' crops, suggest inferiority compared with mainstream (or major) crops. 'Promising' crops and 'crops of the future' convey enthusiasm, but both have the detrimental effect of reducing the value of the crops to their sole potential for their improvement and integration into Western food systems. We propose the phrase 'understudied Indigenous crops', or more simply 'Indigenous crops', as a starting point to address flaws in these commonly used terms and to prompt discussion regarding how these important crops should be studied.

Words profoundly shape perception and material outcomes over time [13]. We believe the term 'orphan crop' warrants scrutiny, because it suggests a reliance upon scientists from developed nations to foster the crops into modern agroindustrial systems. Describing understudied Indigenous crops as orphaned overlooks the role of local communities in the continued stewardship of these plants. By contrast, the significance of the word 'Indigenous' extends past its literal meaning of 'native to a place'. It recognizes the generations of farmers that enabled domestication of the crops and emphasizes the importance



Trends in Plant Science

Figure 1. Examples of Indigenous crops. (A) *Vigna subterranea*, the Bambara groundnut, is a legume cultivated throughout Africa and is one of the most important sources of protein throughout the continent. A valuable intercrop species, groundnut can support the growth of other crops by enriching soils through nitrogen fixation. Bambara groundnut is resistant to high temperatures and impoverished soils, and is suitable for cultivation up to 1600 m above sea level [15]. Equipped with a recently published genome, plant breeders and scientists are attempting to improve Bambara groundnut varieties to address food security concerns in semiarid Africa. (B) *Eragrostis tef*, or teff grass, is a cereal crop in the grass family and a key supply of carbohydrates throughout the horn of Africa. Teff is the most important crop in Ethiopia in terms of area coverage, production volume, and cash crop value. It exhibits tolerance to drought, water logging, and pest epidemics. Several breeding programs, some in partnership with local and international institutions, are currently seeking breakthroughs in teff improvement to enhance available varieties and increase production yields [9]. (C) *Amaranthus caudatus* is an herbaceous plant native to the American tropics and an important source of carbohydrates, protein, and fiber in South America, and in India and Africa, where it has been naturalized. *Amaranthus* species have been widely cultivated for millennia, with archeological evidence suggesting amaranth formed the basis of Aztec agriculture. *A. caudatus* tolerates a variety of growth conditions and, by virtue of its C4 photosynthesis, requires little water input. The plant is resistant to high salinity, marginal soils, and drought.

of the knowledge of local communities in future efforts to understand these unique crops and promote their cultivation. Beyond simply suggesting a change in naming conventions, we hope our proposed term can bring concerns surrounding Indigenous crop research to the forefront and open the floor for conversation and debate.

With their unique adaptations and stress resilience traits, Indigenous crops have captured the attention of Western scientists and plant breeders. Developments to buffer agroindustrial crop systems against climate change are urgently needed, particularly as current yields struggle to keep up with the demands of a growing population. Indigenous crops offer a promising avenue to address these challenges. However, it is crucial that all research endeavoring to develop Indigenous crop varieties recognizes the sovereignty of countries of origin over their biological and genetic resources (Figure 2). Indigenous crop researchers,

particularly those from developed nations, should acknowledge science's history of colonial harm and continuously strive to abolish the inequitable exploitation of resources from countries of origin.

Approaching Indigenous crop research through an anticolonial framework requires investments in both biological research and local capacity building. While initiatives such as the African Orphan Crops Consortium (AOCC) are helping raise awareness of Indigenous crops by publishing genetic resources, many international efforts lack the capacity-building investment to train local farmers and scientists in the use of those resources [6]. Grassroots organizations, such as the JR Biotech Foundation, use a bottom-up, training-based strategy to empower local communities and bridge skill deficiency gaps hampering innovation in regions of the world with fewer scientific resourcesⁱⁱ. Only in tandem with investments in the local infrastructure and human capacity

of the countries of origin can Indigenous crop research deliver tangible solutions toward food security to communities suffering from malnutrition.

Indigenous crops could also help diversify agriculture in developed countries that currently supply half of the world's calories with just three staple crops: maize, wheat, and riceⁱⁱⁱ. Despite their high yields, these crops tend to be grown in input-intensive, genetically uniform, monoculture fields, making them vulnerable to extreme weather events, resource depletion, and environmental degradation. Introducing Indigenous crops to farm fields could bolster the resilience of agricultural systems to environmental shocks by supplying new genetic diversity, particularly in parts of Asia and Africa where Indigenous crops abound but marginal field conditions cannot support the optimal growth of temperate crops [8].

Indigenous crops could further improve agricultural systems with their genomic reservoirs of resistance genes and alleles. Through synthetic biology approaches, these resilience traits can be introduced in other crops to improve their resistance to a range of stresses, from pests and nutrient deficiency to suboptimal climatic conditions. Some Indigenous crops, such as the African eggplant (*Solanum aethiopicum*), have already been used as genetic donors to improve the resistance of Solanaceae species to disease caused by pathogenic fungi [14]. Probing the genomes of Indigenous crop species and understanding the molecular basis of their unique resilience traits could help rectify the loss of genetic diversity in major crops and more broadly address food security concerns around the world.

Beyond the colonial-trodden terminology that describes Indigenous crops lie deep, ancestral roots and cultural bonds tying the crops with the communities that originally identified, cultivated, and curated



Figure 2. An anticolonial framework for Indigenous crop research. Scientists studying Indigenous crops should consider these guidelines to ensure that the benefits of their work are accessible and useful to the communities of origin of the crops. Indigenous crops could transform food markets and strengthen food webs threatened by climate change. Efforts to achieve food security should prioritize vulnerable regions of the world, such as those that lack access to staple crops. This list is non-exhaustive; it is meant as a starting point to prompt discussion surrounding the equitable use of Indigenous crop materials (seeds, tissue, and germplasm) and Indigenous knowledge in research, agriculture, stewardship, and global food markets.

them. To these communities, Indigenous crops are not neglected, orphaned, forgotten, or underutilized; they are part of daily living. In circumstances in which global staple crops remain unaffordable to households in low-income, food-deficit countries, Indigenous crops are the go-to crops for food, feed, medicine, and traditional practices. Enhancing and conserving Indigenous crops as primary food sources in their custodian communities is vital to address the widespread starvation battering the continent^{iv}.

Indigenous crops offer a unique opportunity to diversify, improve, and safeguard

agricultural systems around the world. Breeding Indigenous crops, encouraging their widespread use, and leveraging their resilience genes through synthetic biology approaches could help address the rapidly worsening global food security crisis. However, approaching Indigenous crop research from an anticolonial perspective is imperative to put an end to the scientific harm done to vulnerable and historically exploited communities. Western scientists should consider the negative repercussions of using language such as 'orphan crop' and advocate instead for terminology that recognizes the contributions of scientific thought from a diversity of

backgrounds. Therefore, the study of Indigenous crops, beyond its myriad potential impacts on food systems and sustainable agriculture, presents a chance to rectify the wrongs of colonial science and empower the nations and communities that have most suffered in its grip.

Acknowledgments

We thank S. Brady, T. Long, members of the Rhee lab, and the Plant Cell Atlas community for helpful discussions. This work was carried out, in part, on the ancestral land of the Muwekma Ohlone Tribe, which was, and continues to be, of great importance to the Ohlone people.

Declaration of interests

C.N.I. is the founder and president of the JR Biotek Foundation. S.Y.R. is a scientific advisor for the Foundation.

Resources

- ⁱwww.unicef.org/press-releases/un-report-pandemic-year-marked-spike-world-hunger
- ⁱⁱwww.jrbiotekfoundation.org
- ⁱⁱⁱwww.fao.org/faostat/en/
- ^{iv}www.oxfamamerica.org/explore/research-publications/dangerous-delay-2-the-cost-of-inaction/

¹Department of Plant Biology, Carnegie Institution for Science, Stanford, CA 94305, USA

²JR Biotek Foundation, Bowie, MD, USA

³John Innes Centre, Department of Crop Genetics, John Innes Centre, Norwich, NR4 7UH, UK

*Correspondence:
srhee@carnegiescience.edu (S.Y. Rhee).

<https://doi.org/10.1016/j.tplants.2022.08.022>

© 2022 Elsevier Ltd. All rights reserved.

References

- McMullin, S. *et al.* (2021) Determining appropriate interventions to mainstream nutritious orphan crops into African food systems. *Glob. Food Sec.* 28, 100465
- Lu, H. *et al.* (2009) Earliest domestication of common millet (*Panicum miliaceum*) in East Asia extended to 10,000 years ago. *Proc. Natl. Acad. Sci. U. S. A.* 106, 7367–7372
- Marks, R.A. *et al.* (2021) Representation and participation across 20 years of plant genome sequencing. *Nat. Plants* 7, 1571–1578
- Njaci, I. *et al.* (2022) Chromosome-scale assembly of the lablab genome - a model for inclusive orphan crop genomics. *bioRxiv* Published online May 21, 2022. <https://doi.org/10.1101/2022.05.08.491073>
- Tadele, Z. (2019) Orphan crops: their importance and the urgency of improvement. *Planta* 250, 677–694
- Hendre, P.S. *et al.* (2019) African Orphan Crops Consortium (AOCC): status of developing genomic resources for African orphan crops. *Planta* 250, 989–1003

7. Chiurugwi, T. *et al.* (2019) Speed breeding orphan crops. *Theor. Appl. Genet.* 132, 607–616
8. Mabhaudhi, T. *et al.* (2019) Prospects of orphan crops in climate change. *Planta* 250, 695–708
9. Chanyalew, S. *et al.* (2019) Significance and prospects of an orphan crop tef. *Planta* 250, 753–767
10. Habiyaemye, C. *et al.* (2016) Proso millet (*Panicum miliaceum* L.) and its potential for cultivation in the Pacific Northwest, U.S.: a review. *Front. Plant Sci.* 7, 1961
11. Sanginga, N. *et al.* (2000) Phosphorus use efficiency and nitrogen balance of cowpea breeding lines in a low P soil of the derived savanna zone in West Africa. *Plant Soil* 220, 119
12. Ma, X. *et al.* (2021) A chromosome-level *Amaranthus cruentus* genome assembly highlights gene family evolution and biosynthetic gene clusters that may underpin the nutritional value of this traditional crop. *Plant J.* 107, 613–628
13. Loftus, E.F. and Palmer, J.C. (1974) Reconstruction of automobile destruction: an example of the interaction between language and memory. *J. Verbal Learn. Verbal Behav.* 13, 585–589
14. Toppino, L. *et al.* (2008) Inheritance of *Fusarium* wilt resistance introgressed from *Solanum aethiopicum* Gilo and *Aculeatum* groups into cultivated eggplant (*S. melongena*) and development of associated PCR-based markers. *Mol. Breed.* 22, 237–250
15. Kole, C. (2007) Pulses, Sugar and Tuber Crops. Springer