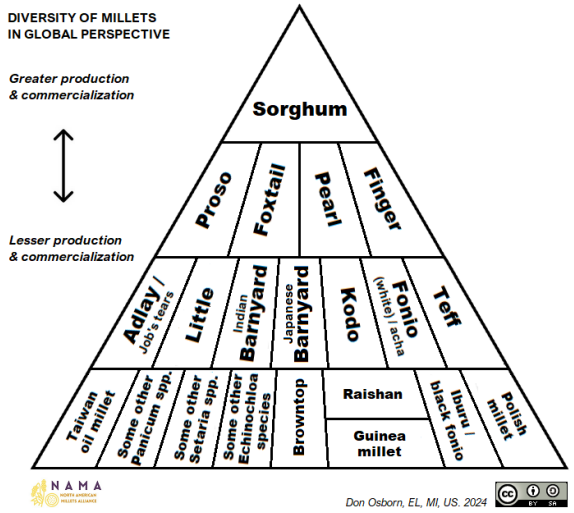


A “Millets Triangle”

Visualizing millets as a group, with one re-usable schematic

Don Osborn, PhD

North American Millets Alliance, 31 March 2025

Version 3.0

Many millets: A challenge for messaging

- There are almost 20 different cultivated species we call “millets”
- “Millets” is not a botanical category, but rather a “folk taxonomy” that groups diverse species by use and a more or less arbitrary set of characteristics (e.g., they tend to have small round grains)
- Millets were domesticated in various regions, mostly in Asia & Africa
- Some millets are produced worldwide for grain or fodder – notably sorghum, pearl millet, foxtail millet, proso millet, & finger millet
- Others are grown regionally or locally, often little known elsewhere
- **How to communicate such complexity as simply as possible?**
- **Can it be done in a single diagram?**

Organization of this presentation

1. Conveying millets' complexity: Quick overview of approaches
2. The Millets Triangle: A simplified schematic & the organization of data within it
3. Other examples of uses: Using the Millets Triangle to convey information about millets
4. Conclusion: Thoughts about future development of the Millets Triangle concept

1. Conveying millets’ complexity

Quick overview of several approaches

Lists, tables, charts & diagrams

- There are 2 main approaches to meaningfully summarizing the diversity of millets on a single diagram
  1. A visually scannable **list**, with selected information for each millet, presented either line-be-line or incorporated into a table
  2. An “at-a-glance” **image** (diagram or chart) using names and perhaps images of millets (as plants or grains), arranged so as to communicate some set of relationships to each other and/or to our use of them
- The focus here will be on #2
- The following four slides feature examples of:
  - a list (per #1) in table format, including various information about millets
  - a tree chart (per #2) showing botanical relationships of millets in context
  - a map (also per #2) showing probable centers of domestication of millets
  - a pie chart (again, #2) comparing annual grain production of millets

A list of millets

A list of millets, with botanical relationships (all in the *Poaceae* family), & geographical origins

COMMON NAME	SPECIES	TRIBE	SUB-FAMILY	CENTER OF ORIGIN
Sorghum	*Sorghum bicolor*	Andropogoneae	Panicoideae	Africa
Job's tears / adlay millet	*Coix lacryma-jobi*	Andropogoneae	Panicoideae	Southeast Asia
Taiwan oil millet	*Spodiopogon formosanus*	Andropogoneae	Panicoideae	East Asia
Pearl millet	*Pennisetum glaucum*	Paniceae	Panicoideae	African Sahel zone
Foxtail millet	*Setaria italica*	Paniceae	Panicoideae	East central Asia
Proso millet	*Panicum miliaceum*	Paniceae	Panicoideae	Central and east Asia
Little millet	*Panicum sumatrense*	Paniceae	Panicoideae	South Asia
Sonoran panic grass	*Panicum hirticaule*	Paniceae	Panicoideae	Western North America
Indian barnyard millet	*Echinochloa frumentacea*	Paniceae	Panicoideae	Southeast Asia
Japanese barnyard millet	*Echinochloa esculenta*	Paniceae	Panicoideae	East Asia
Browntop millet	*Brachiaria ramosa*	Paniceae	Panicoideae	Southeast Asia
Guinea millet	*Brachiaria deflexa*	Paniceae	Panicoideae	West Africa
White fonio	*Digitaria exilis*	Paniceae	Panicoideae	West Africa
Black fonio	*Digitaria iburua*	Paniceae	Panicoideae	West Africa
Raishan	*Digitaria compacta*	Paniceae	Panicoideae	South Asia
Polish millet	*Digitaria sanguinalis*	Paniceae	Panicoideae	East Europe
Kodo millet	*Paspalum scrobiculatum*	Paspaleae	Panicoideae	Africa (grown as crop only in Asia)
Finger millet / ragi	*Eleusine coracana*	Cynodonteae	Chloridoideae	East central Africa
Teff	*Eragrostis tef*	Eragrostideae	Chloridoideae	Horn of Africa

NB- The common names of the 5 most cultivated millets worldwide are in **boldface**.

DO, EL, MI, US 2022/12/7

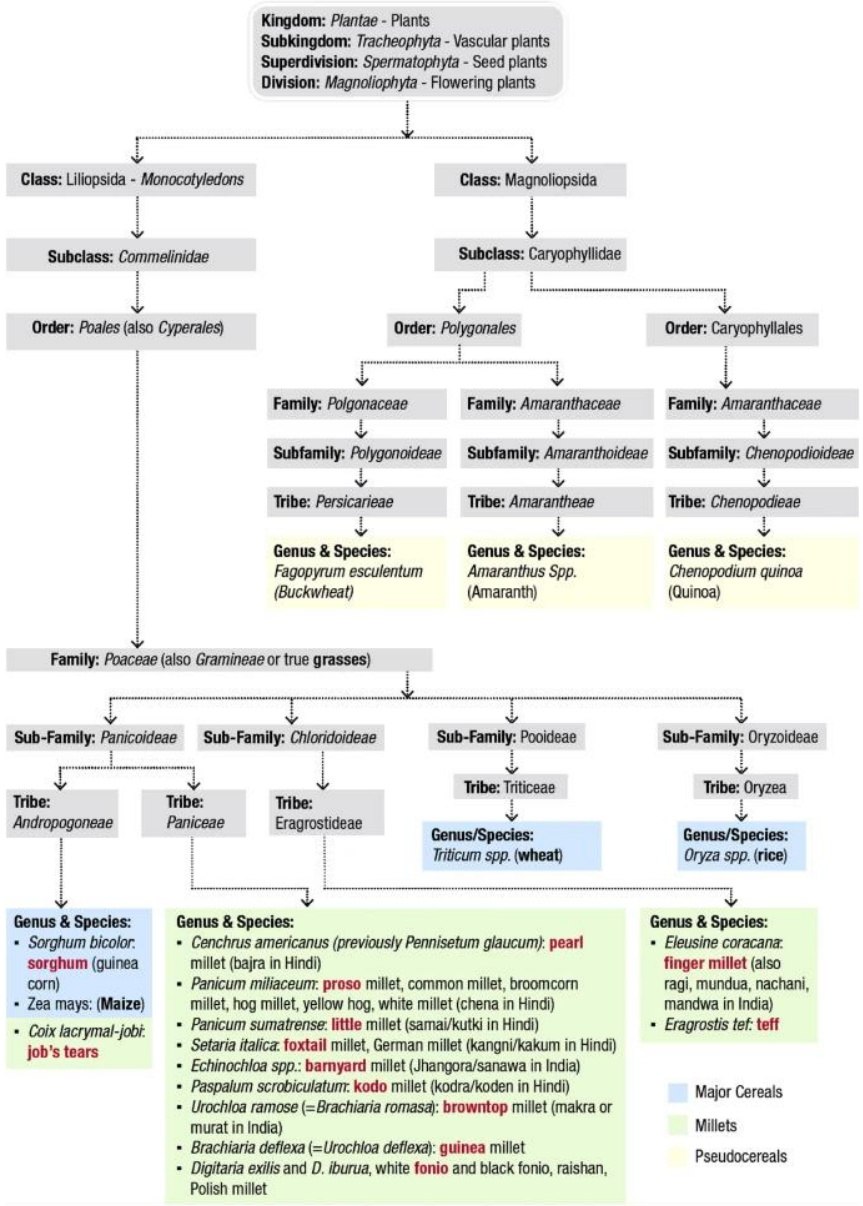
A tree chart, showing botanical relationships

While a list can convey a lot of information in text format, a chart or diagram can convey selected information & relationships in a particular context

The diagram at right (courtesy of Joanna Kane-Potaka) shows millets, other grains, & pseudo-cereals in botanical taxonomy

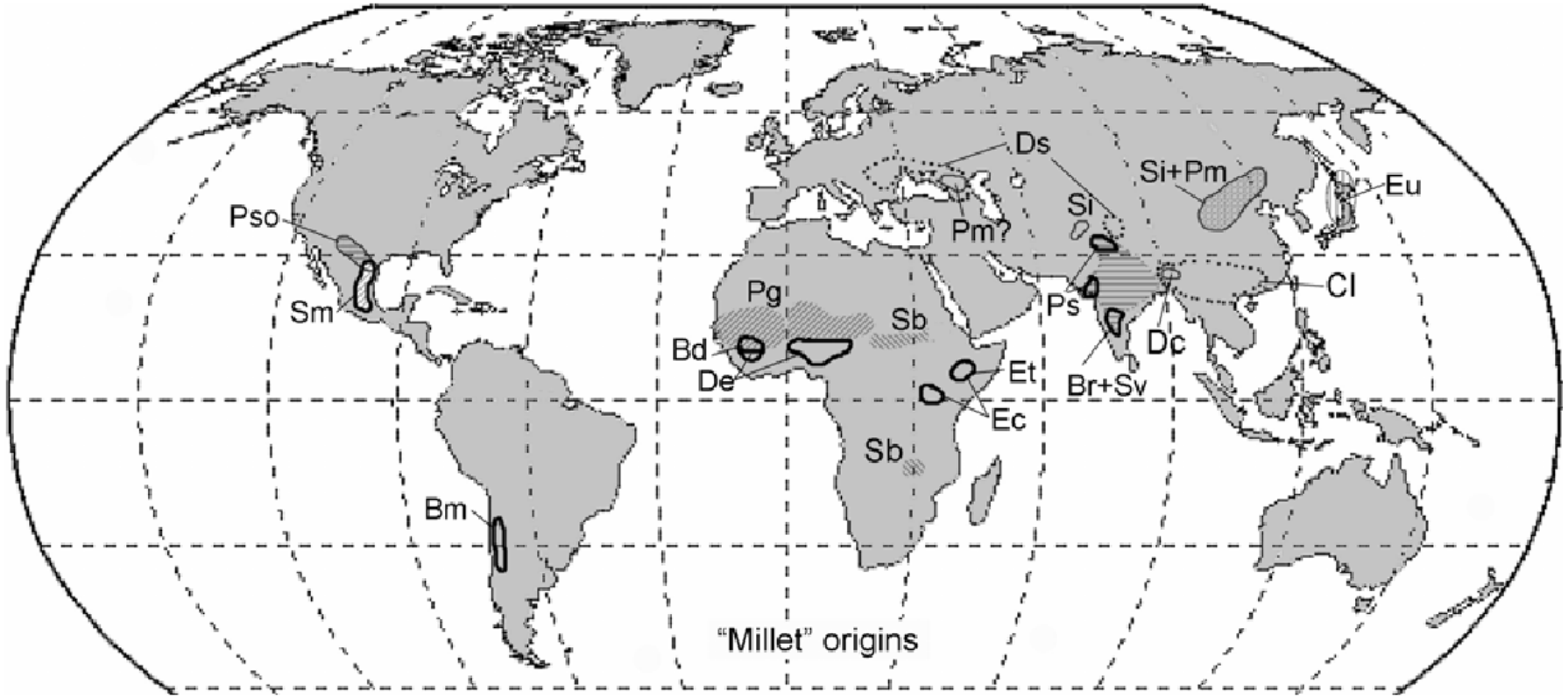
Millets can be understood as a "folk taxonomy," as it groups species from more than one part of taxonomic tree

(There are some minor differences in classification between this diagram & the previous list)



Source: Kane-Potaka, J., "Fig. 2. Taxonomical classification of small millets and other major cereals and millets, and pseudo-cereals" in Vetriventhan, M., Azevedo, V.C.R., Upadhyaya, H.D. et al. "Genetic and genomic resources, and breeding for accelerating improvement of small millets: current status and future interventions." *Nucleus* 63, 217–239 (2020). https://doi.org/10.1007/s13237-020-00322-3

A map, showing geographic origins



Source: S. Weber, D. Fuller. "Millets and their role in early agriculture." *Pragdhara*. 2007;18:69–90.

Figure 1. The map of likely centres of origin for "millets." Millets abbreviated: Pso:

"Pso: Panicum sonoran; Sm: Setaria cf. macrostachya; Bm: Bromus mango; Bd: Brachiaria deflexa; De: Digitaria exilis; Pg: Pennisetum glaucum; Sb: Sorghum bicolour, including Southern African zone where the race kafir may be an independent domesticate; Ec: Eleusine coracana; Et: Eragrostis tef; Ds: Digitaria sanguinalis; Pm: Panicum miliaceum, a separate Western origin remains unconfirmed; Si: Setaria italica; Ps: Panicum sumatrense: Br: Brachiaria ramosa; Sv: Setaria verticillata; Dc: Digitaria cruciata; Cl: Coix lachrymal-jobi; Eu: Echinochloa crus-galli var. utilis. The striped zone in India indicates the broader Indian millet zone within which several domestications remain to be better localized (Paspalum scrobiculatum, Echinochloa colonum, Setaria pumila), in addition to possible multiple domestications of Brachiaria ramosa."

A pie chart, illustrating relative annual production of millets

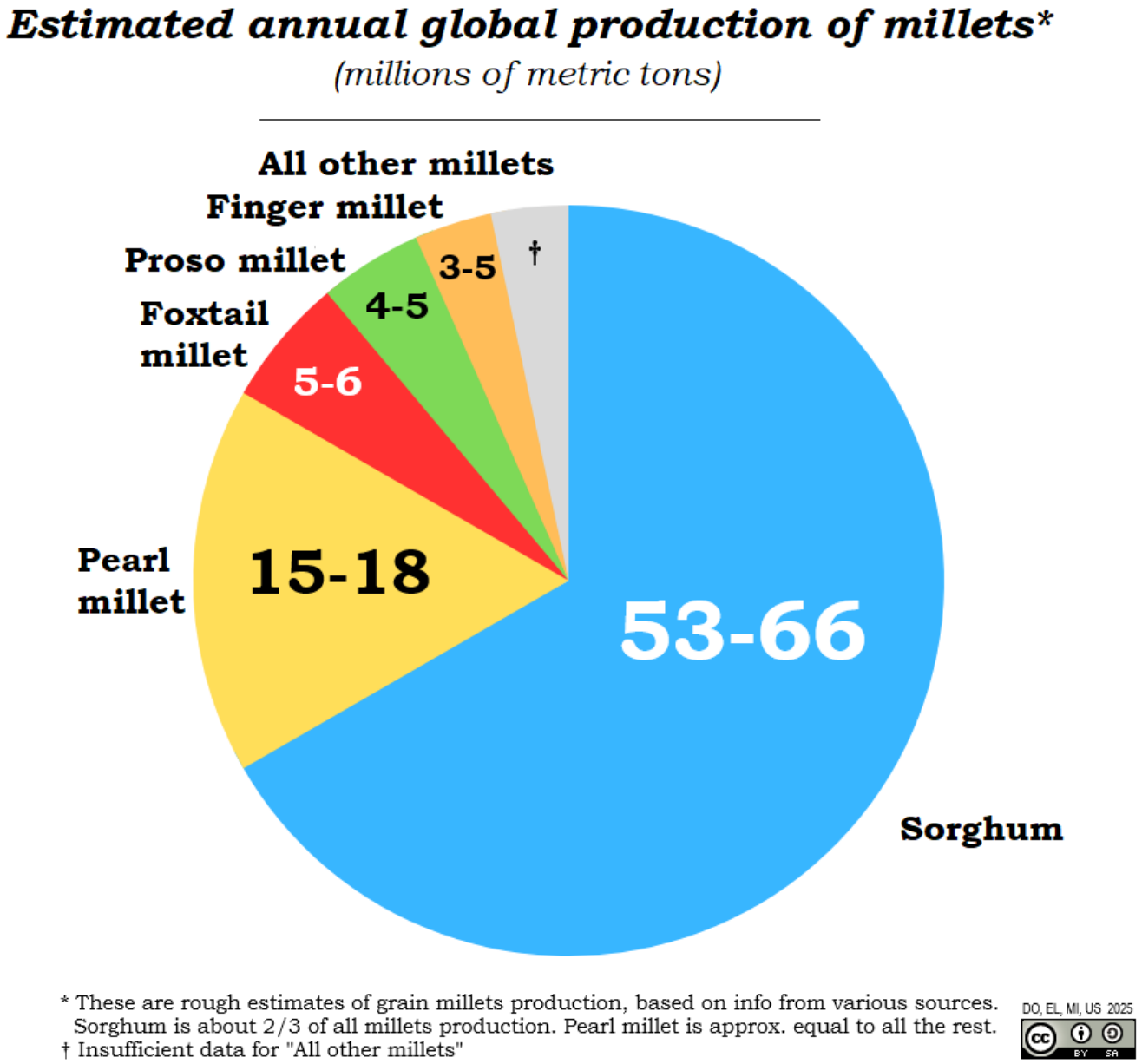
The diagram at right uses some estimates of global annual production of grain millets.

Sorghum is around 60 million metric tons (MMT) per year, & accounts for ~2/3 of total production

Other millets often grouped together as “millet” have been estimated at ~30 MMT. Pearl millet production accounts for about half of that

The next three millets – foxtail, proso, & finger, in that order – plus others account for the rest

These are approximations from several sources over a number of years. The production of various millets – as well as their availability & uses – will vary by country & locality



Combining info on millets in one diagram?

- Each approach can carry significant information
  - Lists, tables, & text generally, can be comprehensive & detailed
  - Images, which can illustrate relationships, tend to focus on certain aspects at the expense of others – such as in the two examples above
- This project seeks to convey several kinds of information in a single schematic – namely, relative production levels, botanical relationships, and geographic origins
- Understanding the plurality of millets is facilitated by recognizing that there is some order to this diverse group on these 3 respects
- Beginning with the levels of production, this effort uses a triangle divided into cells (this 2024 version is the third since 2022)

2. The Millets Triangle

A simplified schematic & the organization of data within it

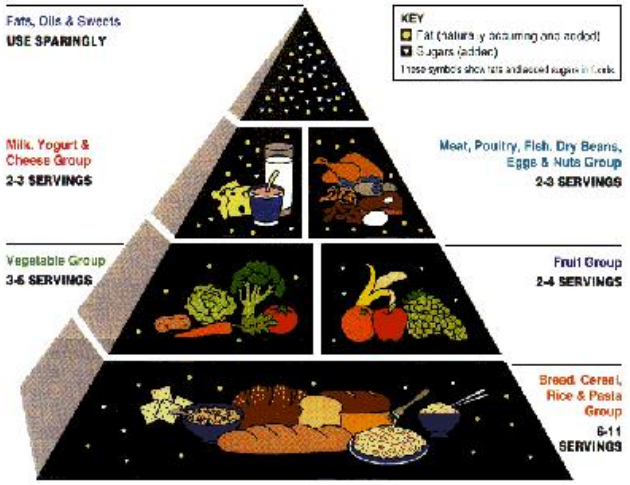
A “triangle” of millets

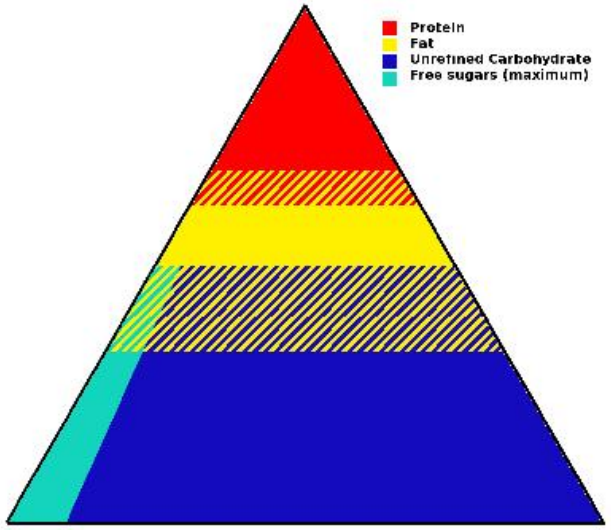
A simple framework to convey various facts about millets

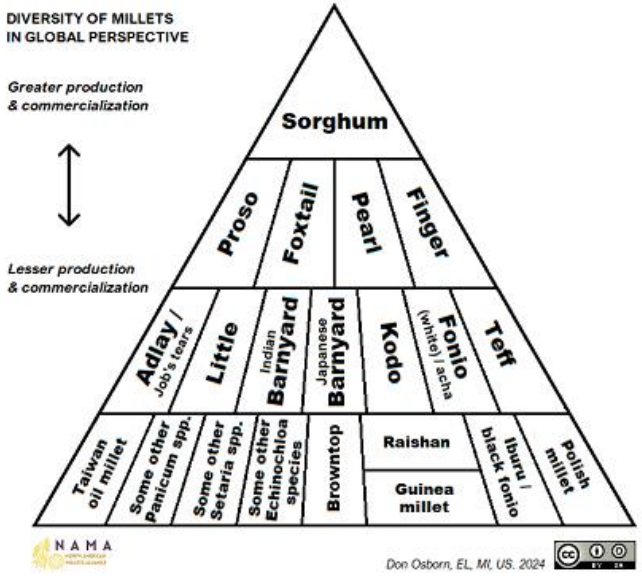
Organizing principle is relative production levels: The few most produced at top tiers of triangle, with less produced millets on lower tiers

“Triangle” (as in pool or billiards rack, *top left*), not “pyramid” (as in food pyramids, *t.r.* & *b.l.*), as there is no vertical hierarchical relationship other than numbers

The resulting **millets triangle** (*b.r.*) is also organized to integrate info on botanical & geographic relationships, as we will see in the following slides







Internal organization of the millets triangle

The placement of names of millets in the cells of the triangle is not random, but rather was done with several criteria in mind:

- Vertical organization reflects levels of production (as already noted)
- Organization with regard to botanical relationships
  - All the millets are in the botanical family *Poaceae*, like other cereal grains
  - Species of the same botanical sub-families & tribes are in adjacent cells, to the extent possible given the vertical organization
  - Species of the same genus in adjacent cells, again, to the extent possible
  - *Botanical hierarchy: … > Family > Sub-family > Tribe > Genus > Species*
- Alignment by geographical origins (Asia to the left, Africa to the right)

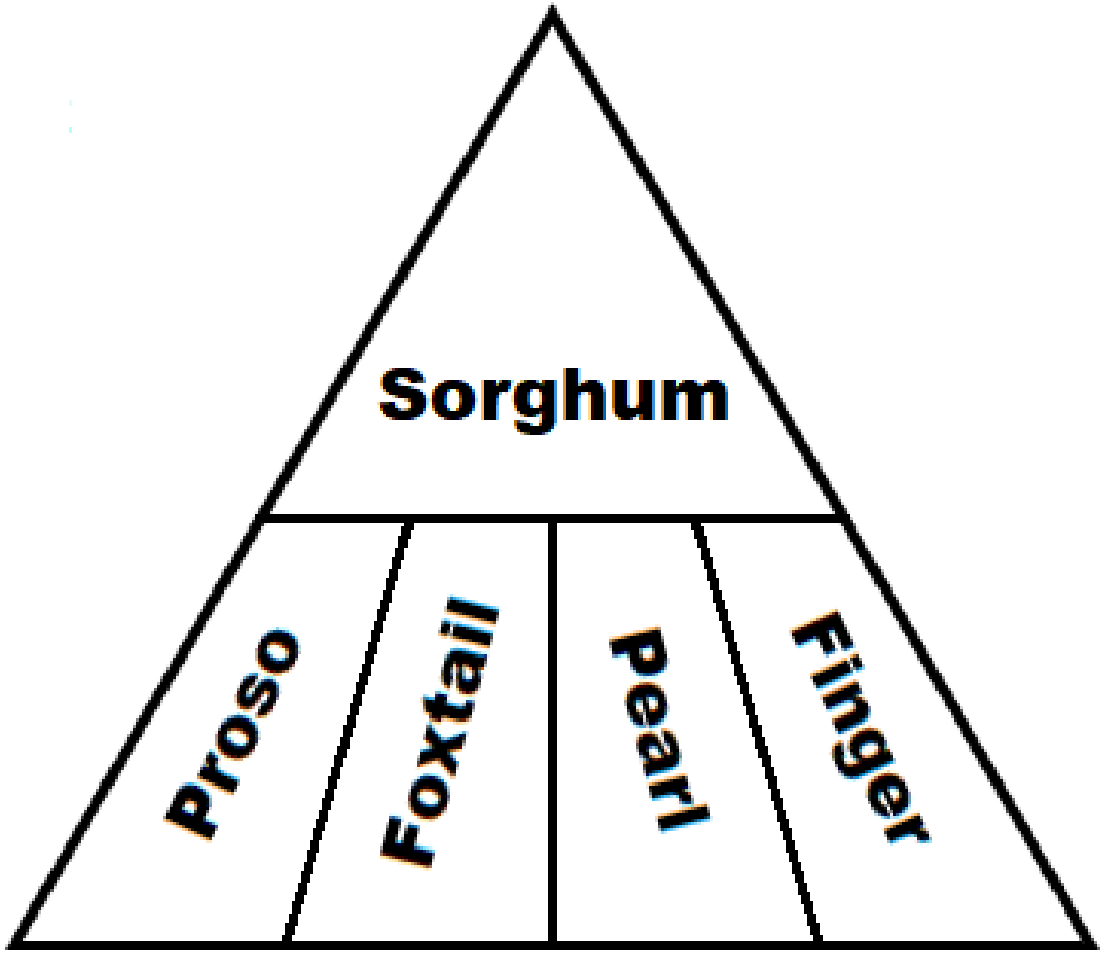
Top 5 millets

We begin at the top with the most grown & consumed millets

Sorghum is by far the most produced worldwide (~60 million metric tons of grain per year)

The next 4 millets are each significant in more than one world region

- Pearl millet (15-18 million mt)
- Foxtail millet (5-6 million mt)
- Proso millet (4-5 million mt)
- Finger millet 3-5 million mt)

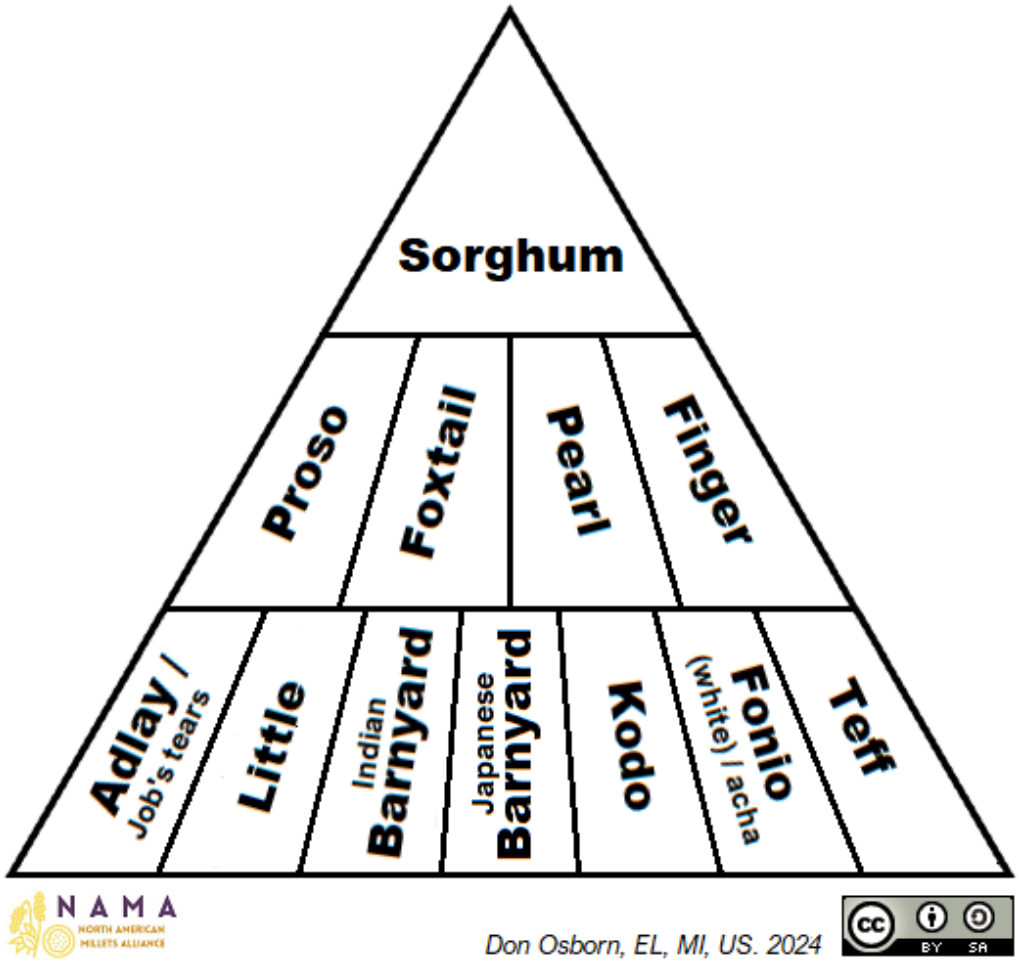


More millets

Adding a third level with millets produced at a high level in one world region

These also are traded within and to some extent beyond these regions

Since exact figures for these millets are hard to come by, the selection here (and in the fourth level, shown on next slide) are somewhat subjective at this time



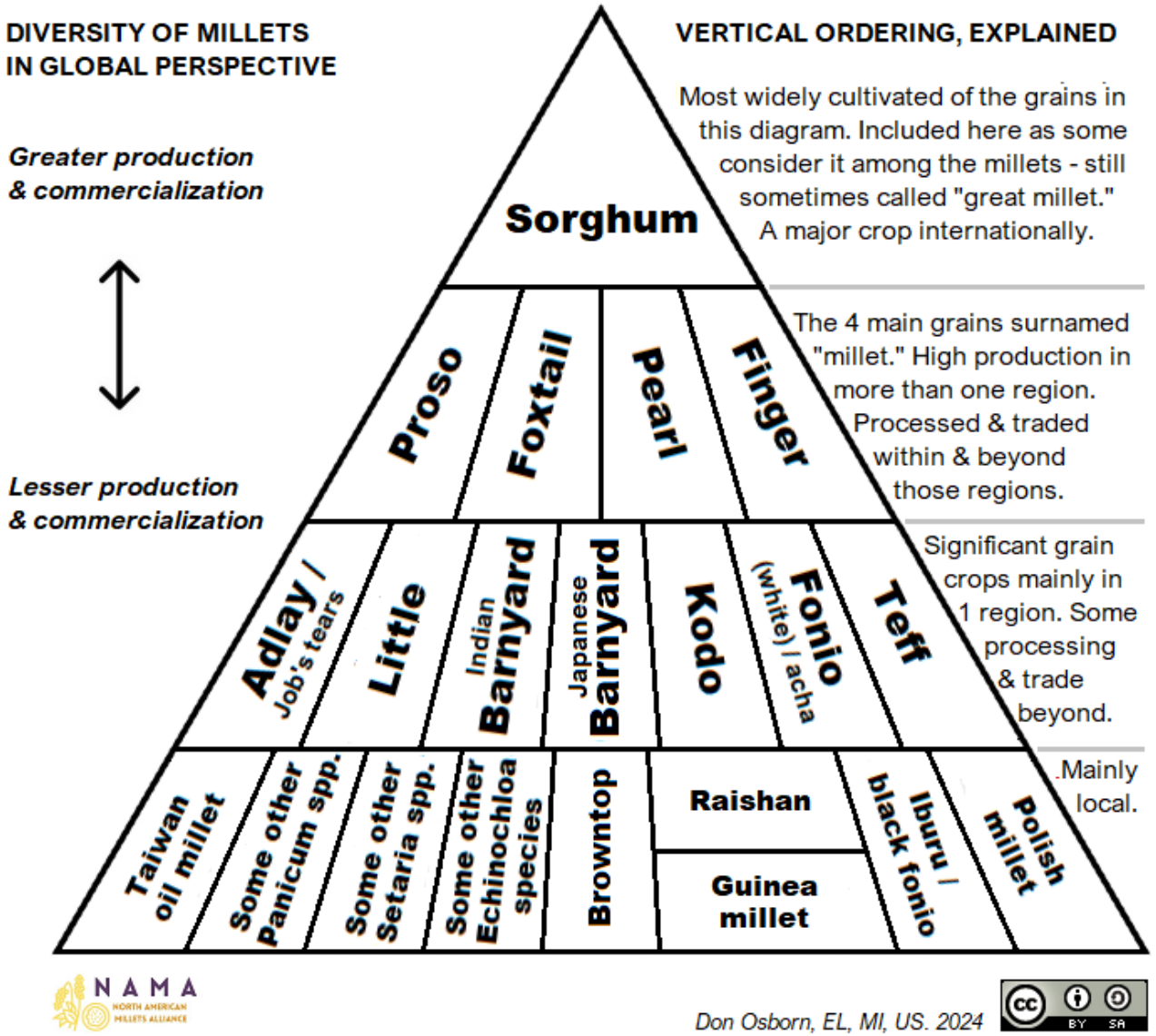
“Millets triangle”

The triangle is complete with addition of the fourth level

These are millets of smaller, generally local production

Cells for *Panicum* spp., *Setaria* spp. & *Echinochloa* spp. are included to account for other species in these genera, once or currently grown for food

Cells for raishan & Guinea millet are horizontal to keep two genera & continental origins in adjacent cells (explained in later slides)

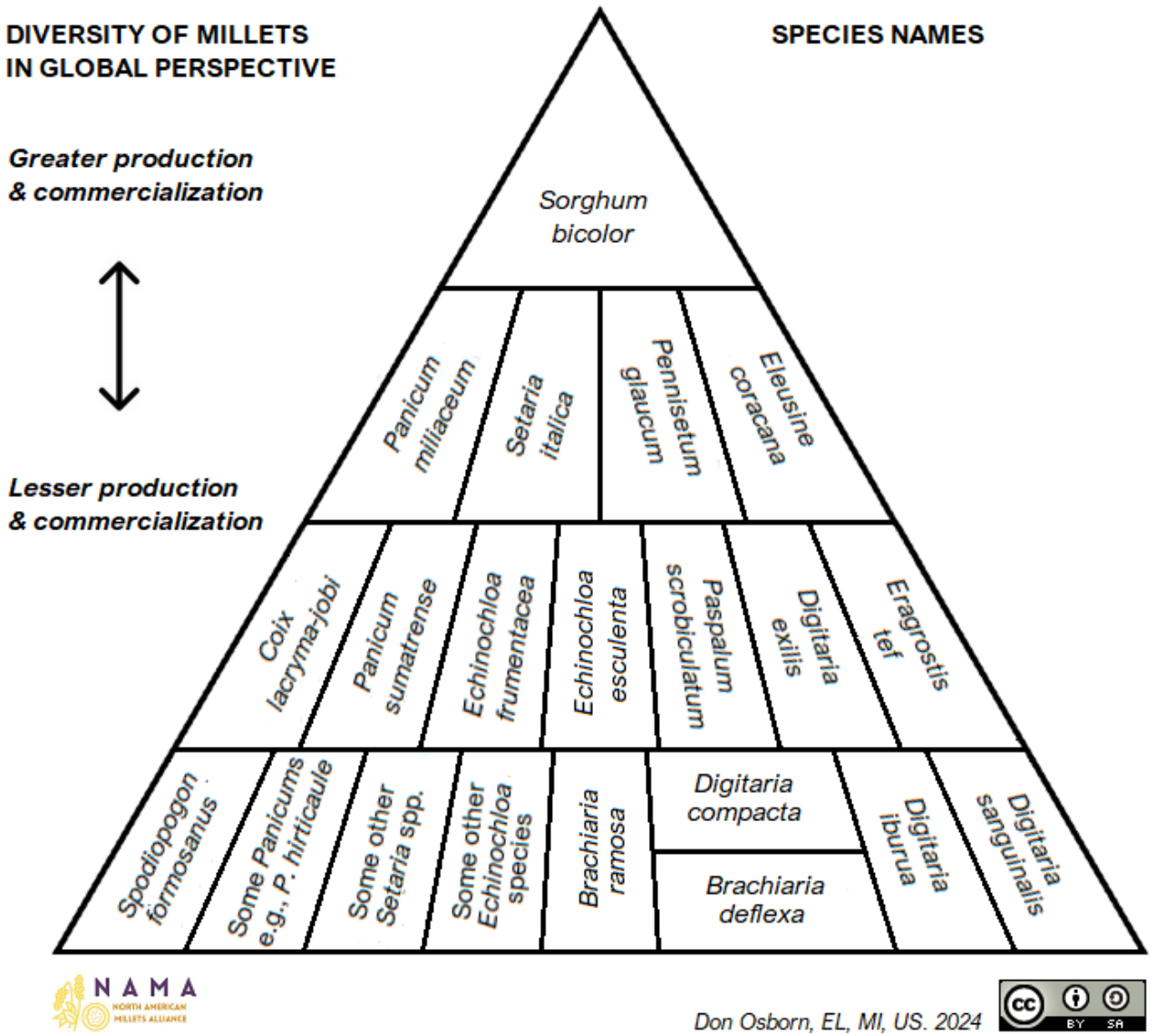


Species names

Here are the species names (*Genus species*) for the common names shown in the main version of the triangle.

Note: 4 cells from genus *Digitaria*, 3 each from *Panicum* & *Echinochloa*, and 2 each from *Setaria* & *Brachiaria* (or *Urochloa*).

In the next 3 slides each of these genera, in turn, are highlighted using the millets triangle.

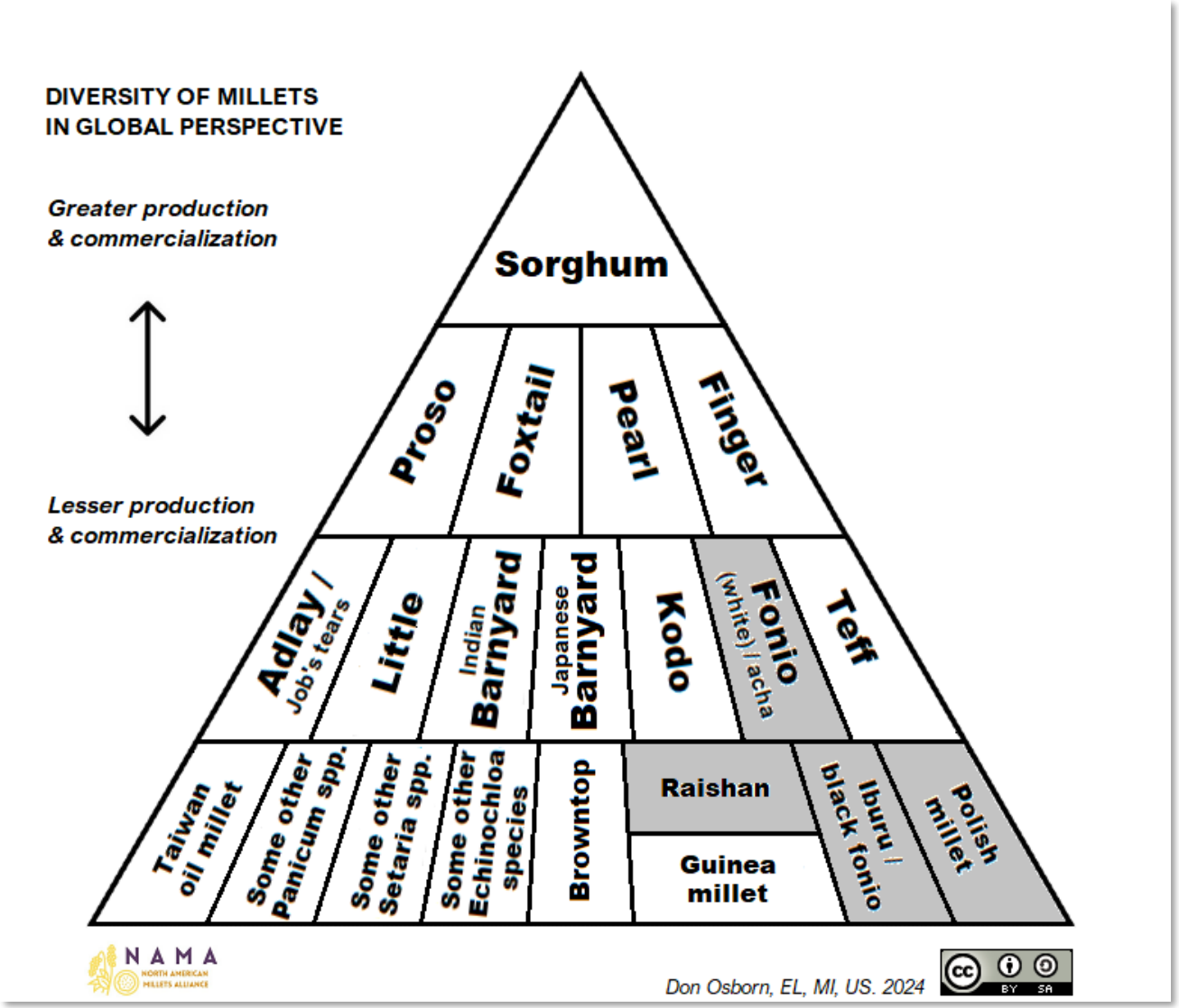


4 *Digitaria* species

Shading or color-coding of cells in the triangle is used to convey information at a glance.

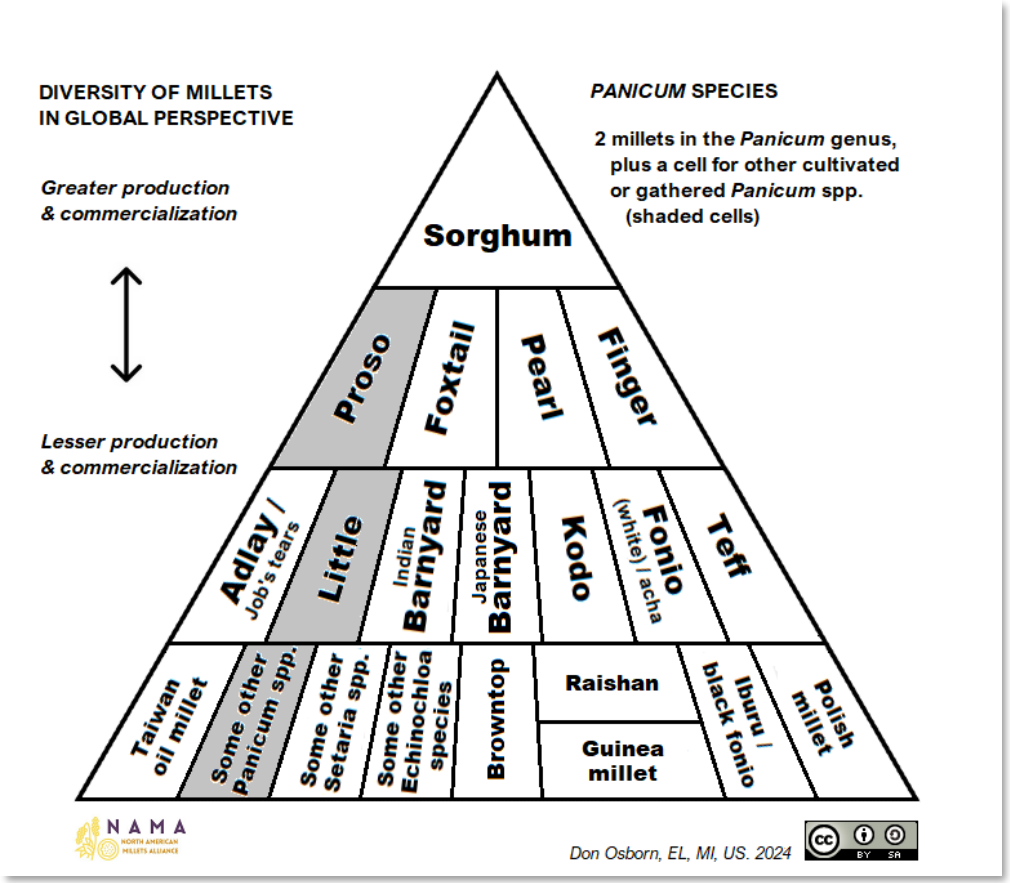
Here, 4 *Digitaria* species are spotlighted:

- Fonio (or white fonio; a.k.a. acha), *D. exilis*
- Black fonio (a.k.a iburu), *D. iburua*
- Raishan, *D. compacta*
- Polish millet or sikiya, *D. sanguinalis*

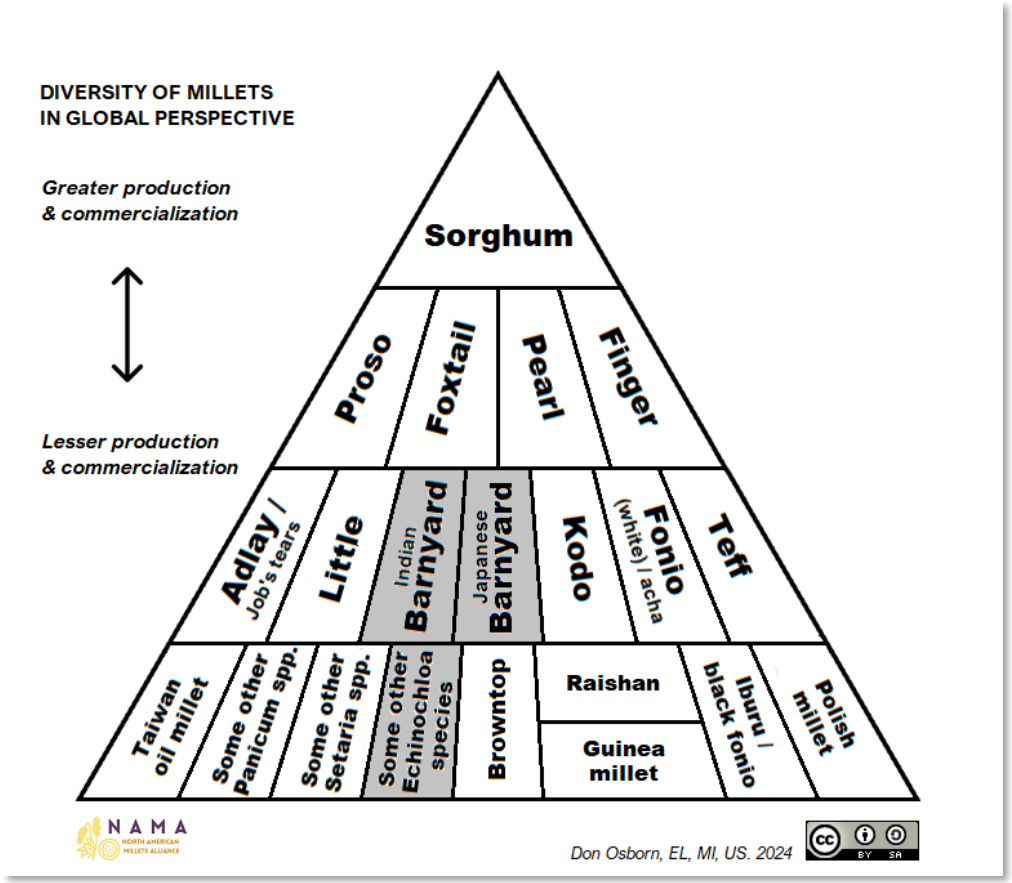


Panicum & *Echinochloa* species

2+ *Panicum* species

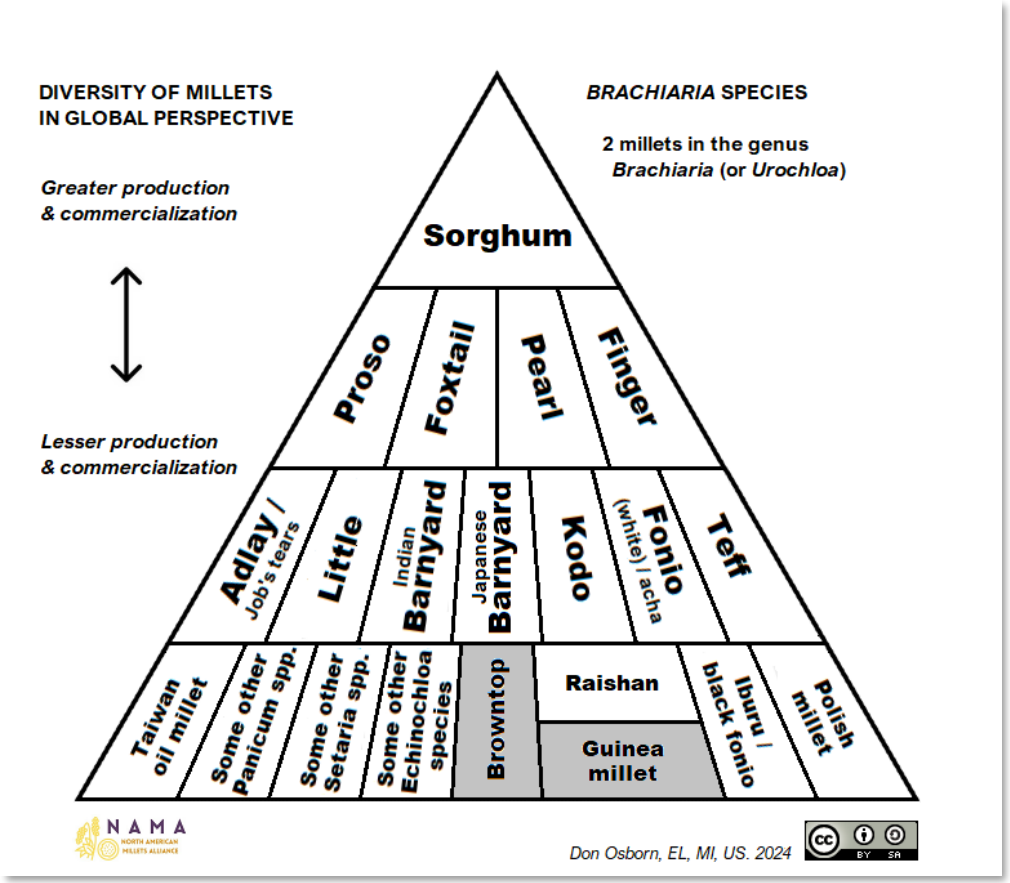


2+ *Echinochloa* species

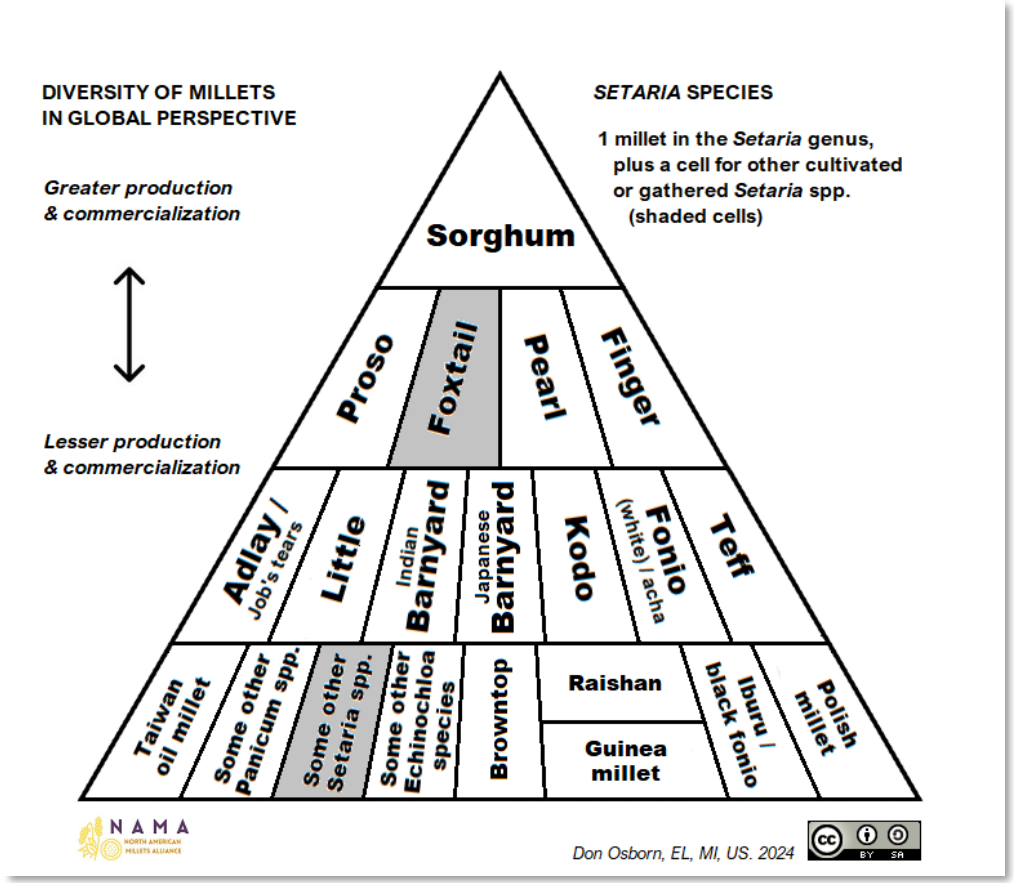


Brachiaria (or *Urochloa*) & *Setaria* species

2 *Brachiaria* (or *Urochloa*) species



1+ *Setaria* species

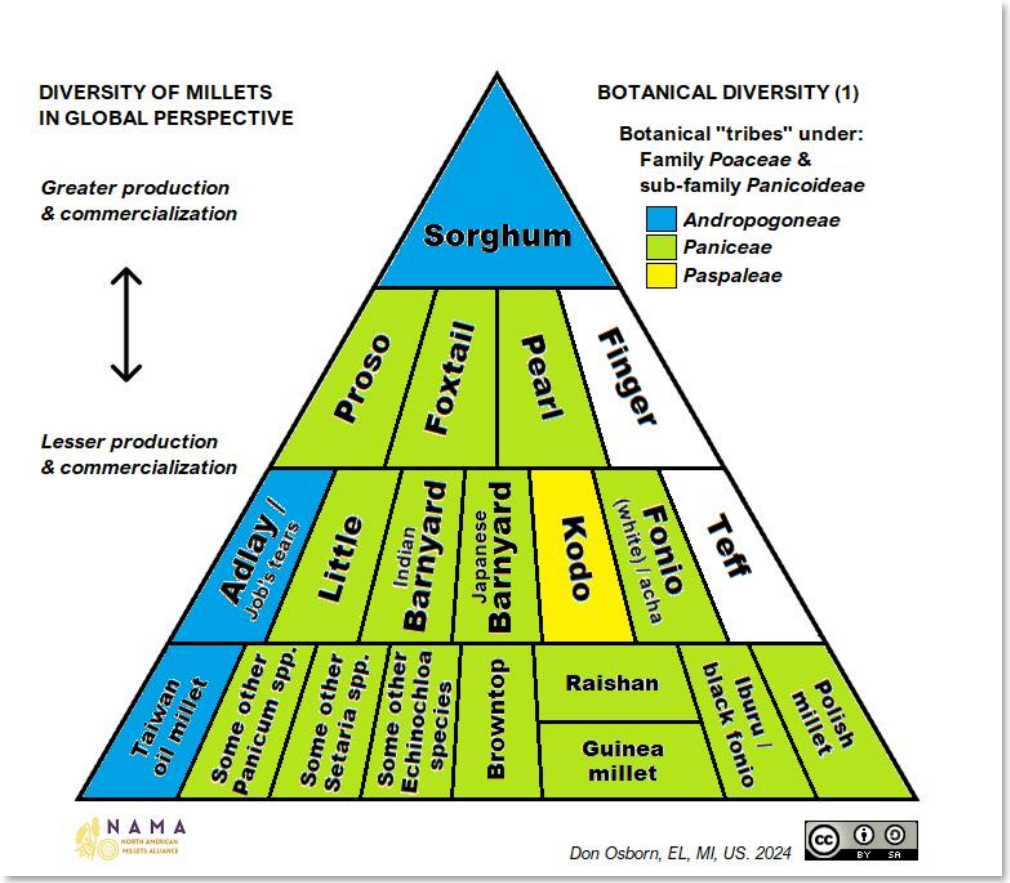


Botanical taxonomy (& “folk taxonomy”)

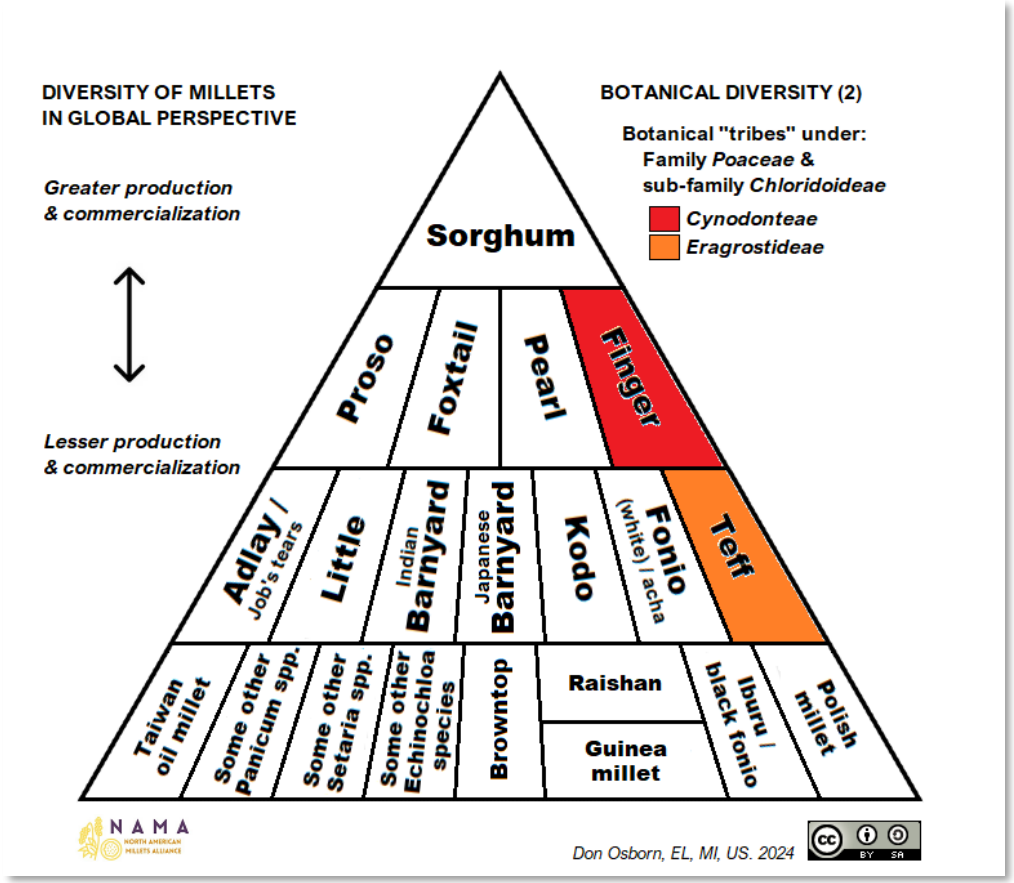
- In botanical taxonomy the genera and species of millets discussed above also belong to
  - 2 sub-families of the family *Poaceae*, and
  - 5 “tribes” of those sub-families
  - *Botanical hierarchy: … > Family > Sub-family > Tribe > Genus > Species*
- What makes them all “millets” is a matter of history, culture, & languages – making it a kind of “folk taxonomy” focused on some shared characteristics, and their utility as crops & foods
- Taking this grouping as it is, however, we find it helpful to understand their botanical categories and relationships, and to account for these to the extent possible in the millets triangle

2 sub-families (& 5 “tribes”) of *Poaceae*

Sub-family *Panicoideae* (3 tribes)



Sub-family *Chloridoideae* (2 tribes)



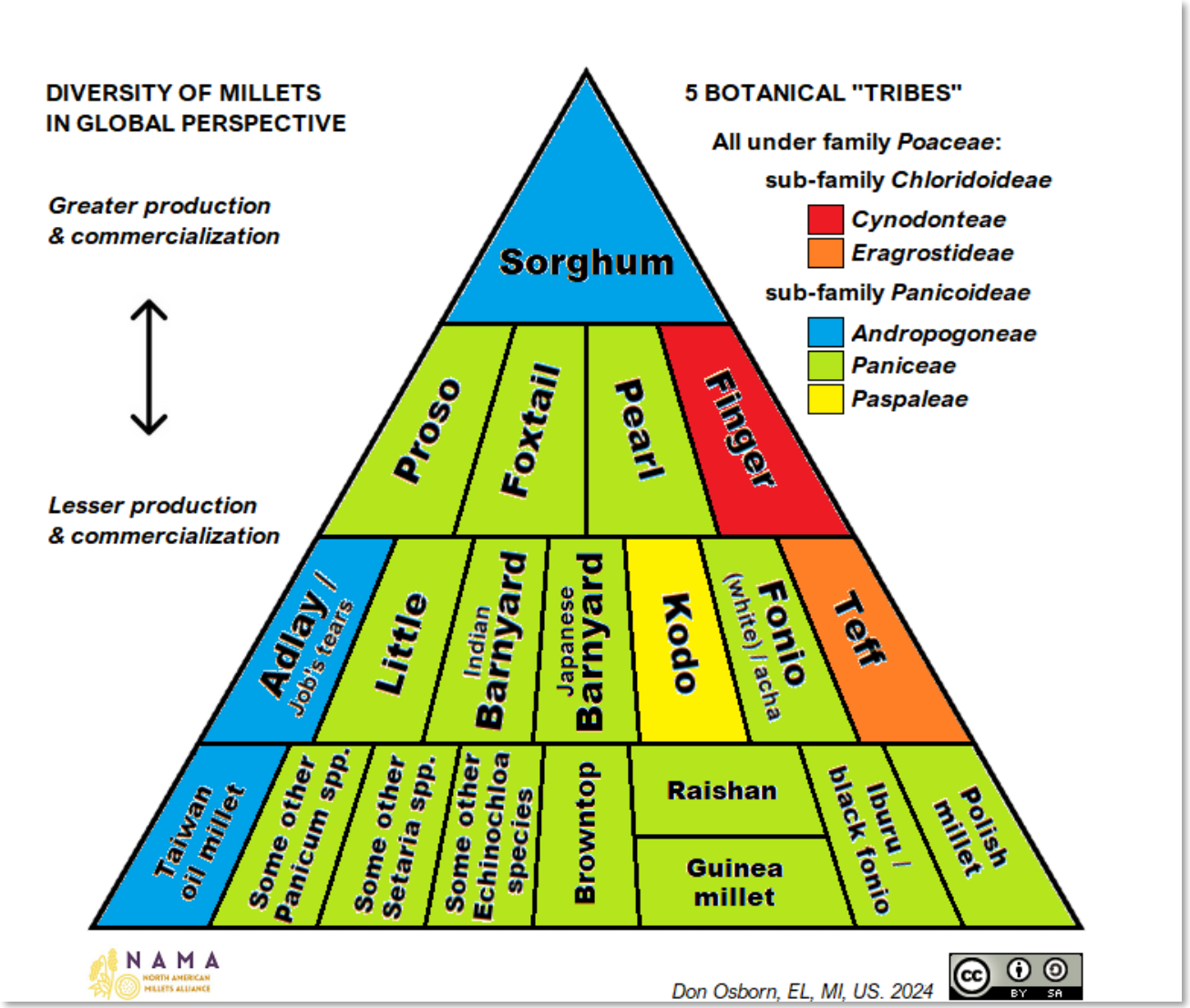
Botanical diversity in one triangle

The information presented In the two diagrams in the previous slide can be combined, as shown on the right.

The millets triangle is structured to facilitate understanding of some basic relationships among millet species.

It can also be used to convey a greater or more focused amount of information on any given parameter.

Color-coding, as in the examples in this presentation, or other visual identifiers such as lines, stipple, and cross-hatching, can be used with an explanatory key to show groups of, and relationships among, the various millets.



Origins of millets by continent

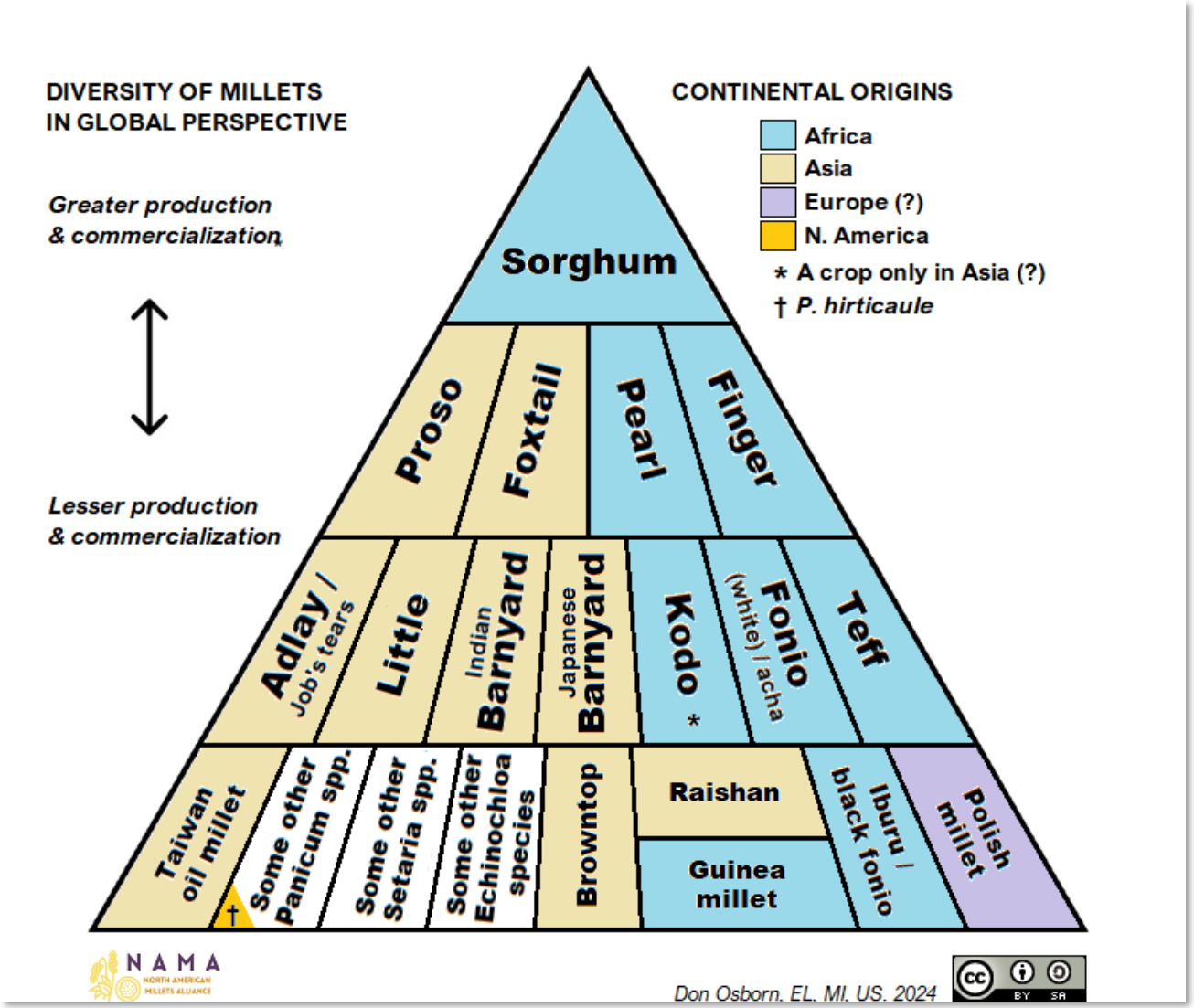
The millets triangle is also organized with the millets of Asian origin to the left, and those of African origin to the right.

As a general rule, these were domesticated in their continent of origin, and are still cultivated there (even as some millets are also cultivated in other world regions).

The only exception is kodo millet (*Paspalum scrobiculatum*), which is from Africa but apparently cultivated as a crop only in Asia.

Digitaria sanguinalis was (is?) a small-scale crop in central Europe (Polish millet), & is also a crop in one district of Madhya Pradesh, India – sikiya. Were there two centers of domestication?

Panicum hirticaule is native to parts of North America, and was apparently managed and cultivated for grain since ancient times. A variety is still grown on a very limited scale.



3. Other examples of uses

Using the millets triangle to convey information about millets

A reusable schematic

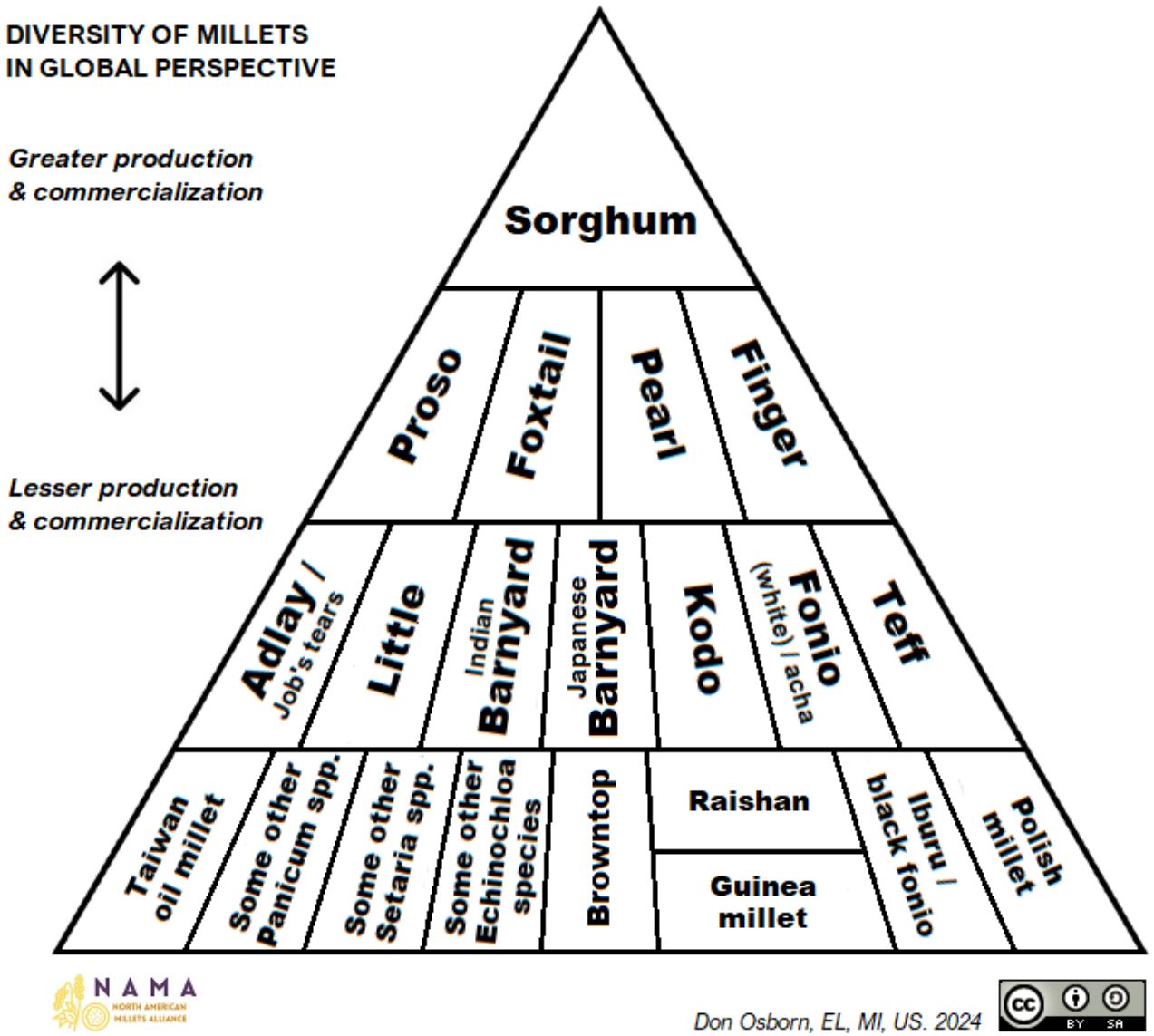
The main mode of use foreseen for the millets triangle is – as illustrated above – shading or color-coding cells to convey various information.

For example: Which millets are used for what? Or grown where?

The diagram could of course be localized to other languages.

The structure, selection of species, or organization could also be modified.

Other examples follow.

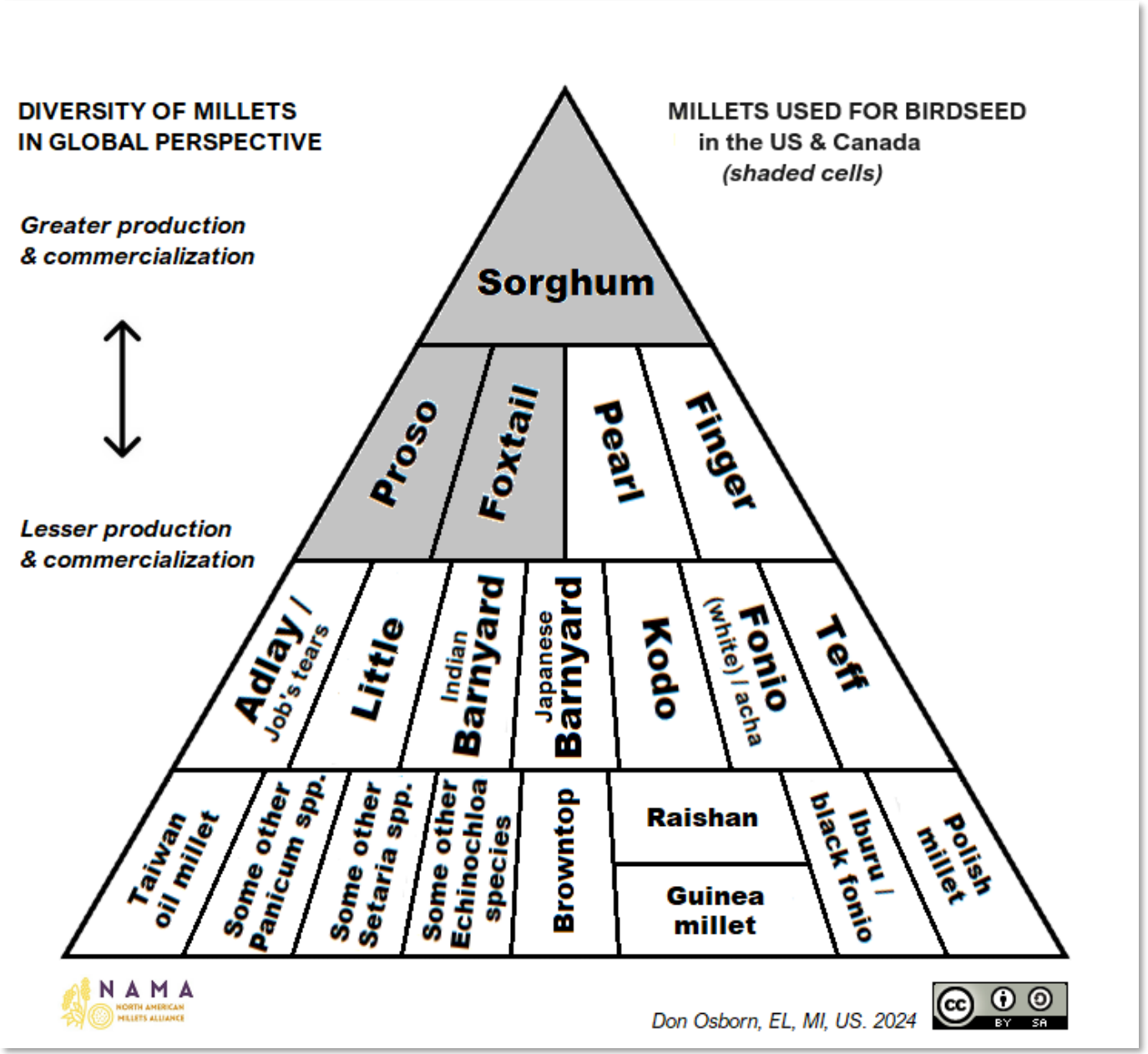


Millets for birdseed

Many people associate “millet” with birdseed. This is, in fact, one important market.

Millets commercialized in North America for birdseed include:

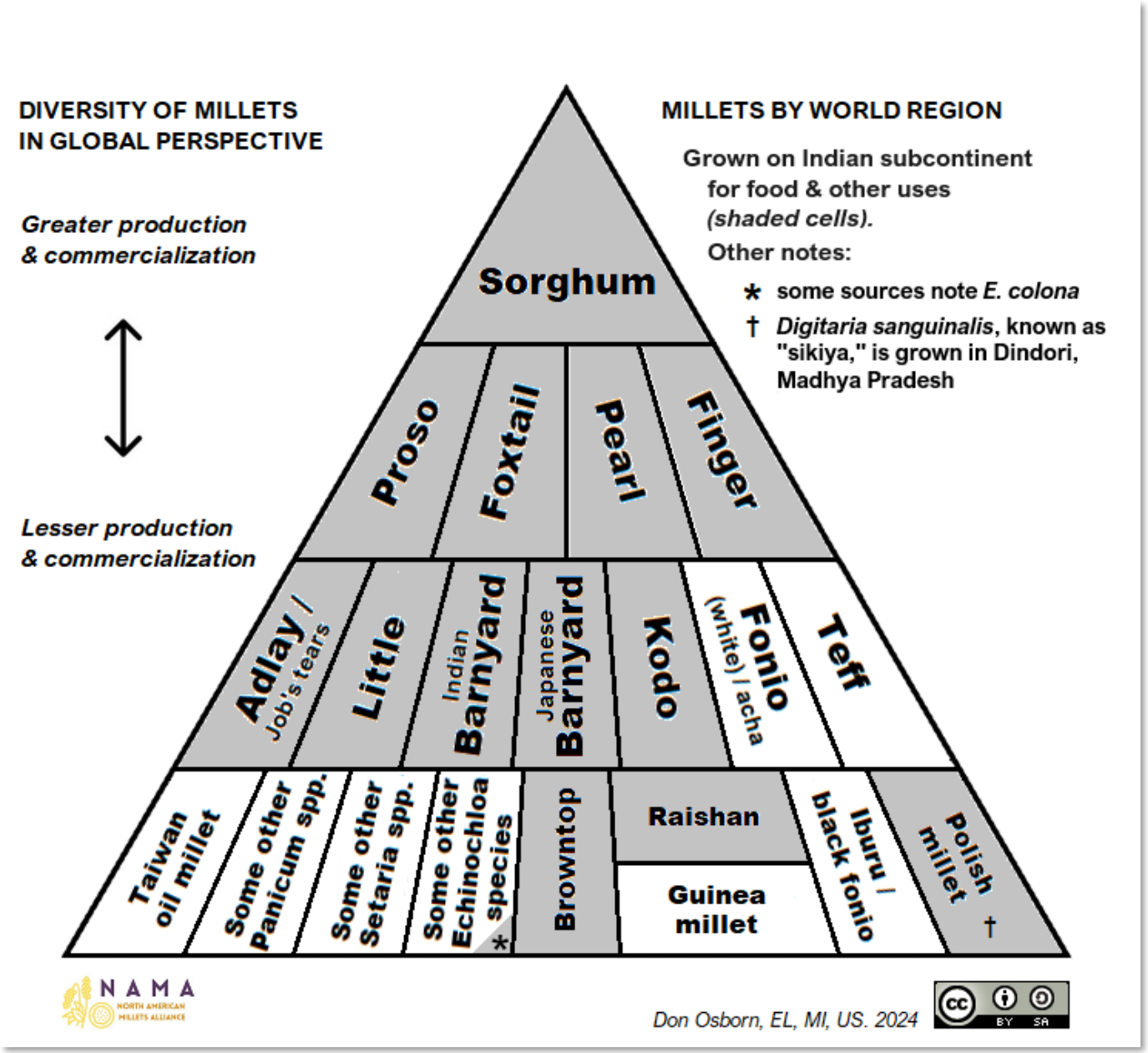
- Proso, of which more than one variety, used in mixes for wild & domesticated birds
- Sorghum, also included in some mixes
- Foxtail, often sold as grain heads or “sprays” for domesticated birds



Millets grown in India & neighbors

India by itself is the largest producer of millets & is kind of a “crossroads” of millets domesticated in the region, and from Africa & other parts of Asia. It grows, consumes & exports these diverse millets.

Some sources note “8 millets” in this region, but all together there is more like a dozen.



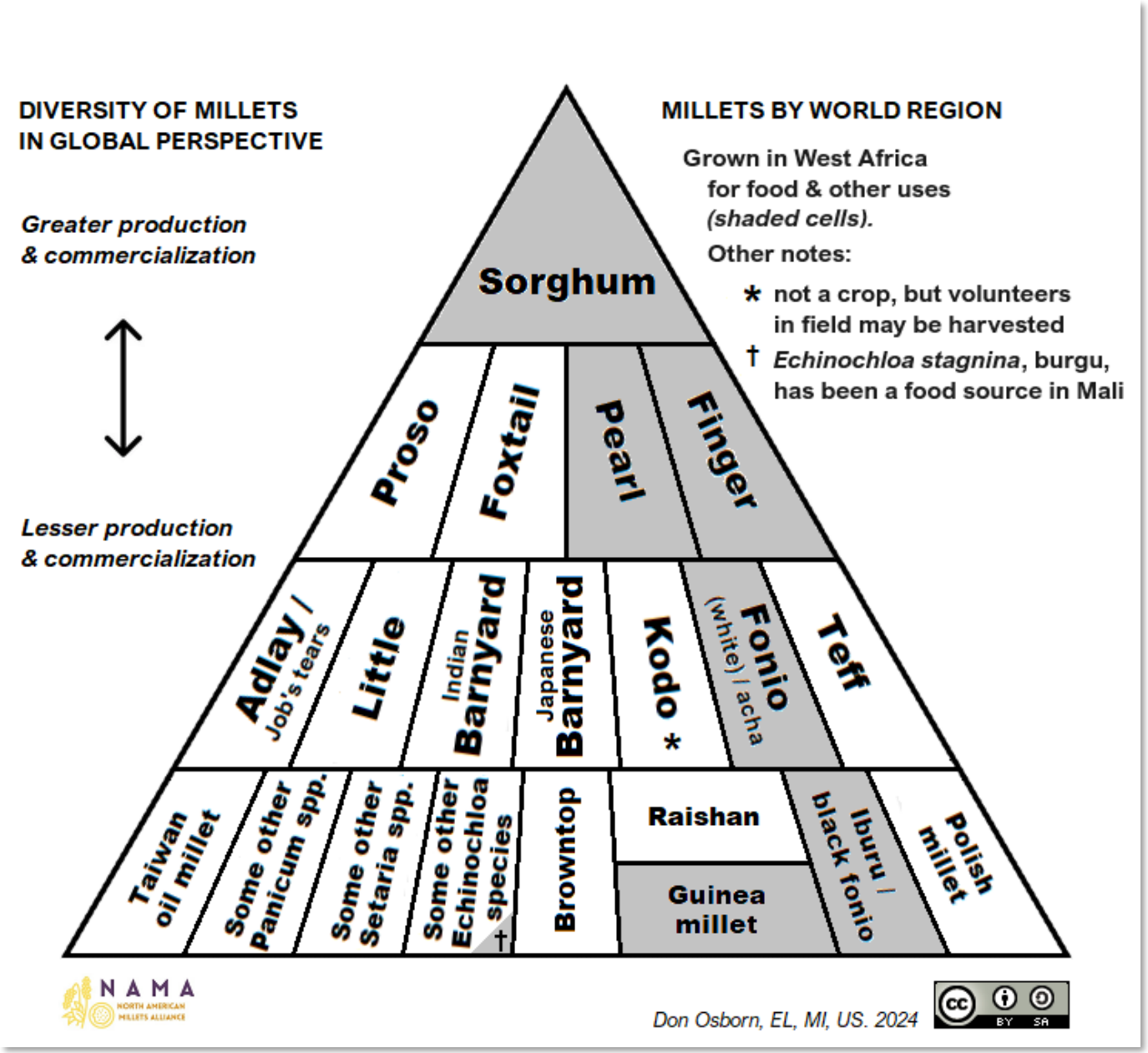
Millets grown in West Africa

West Africa – especially the Sahelian zone – grows a lot of pearl millet and sorghum.

Finger millet is grown in some parts of Nigeria, and fonio (or acha) is a crop in various parts of the region.

Black or iburu fonio & Guinea millet are grown in limited areas.

Burgu is primarily for forage.

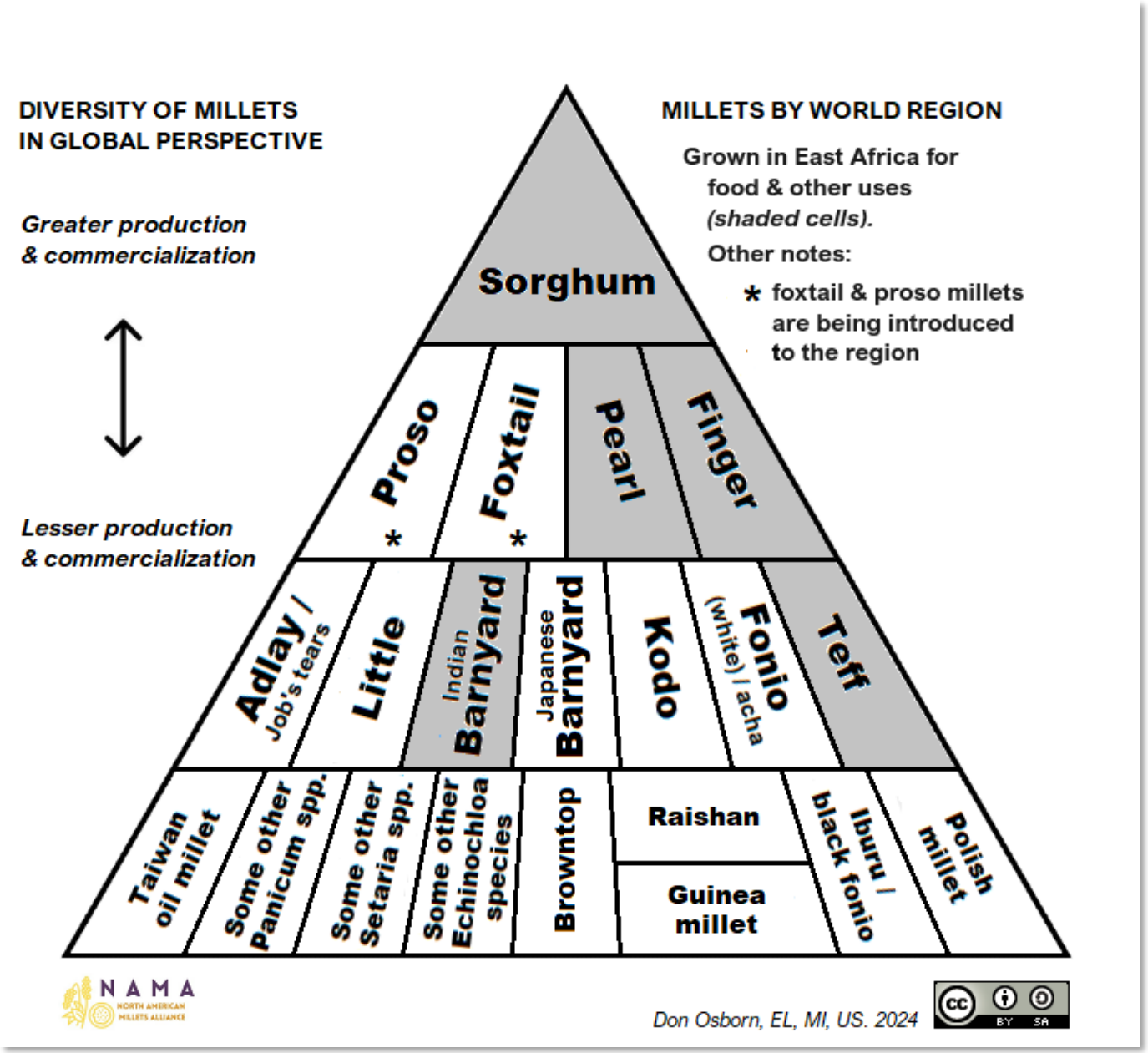


Millets grown in Eastern Africa

East Africa & the Horn of Africa are the origin of the 2 millets in the Chloridoideae sub-family – finger millet & teff, respectively.

Pearl millet and sorghum are also grown, as are varieties of Indian barnyard millet.

A China/FAO project is introducing foxtail & proso millets to Uganda.

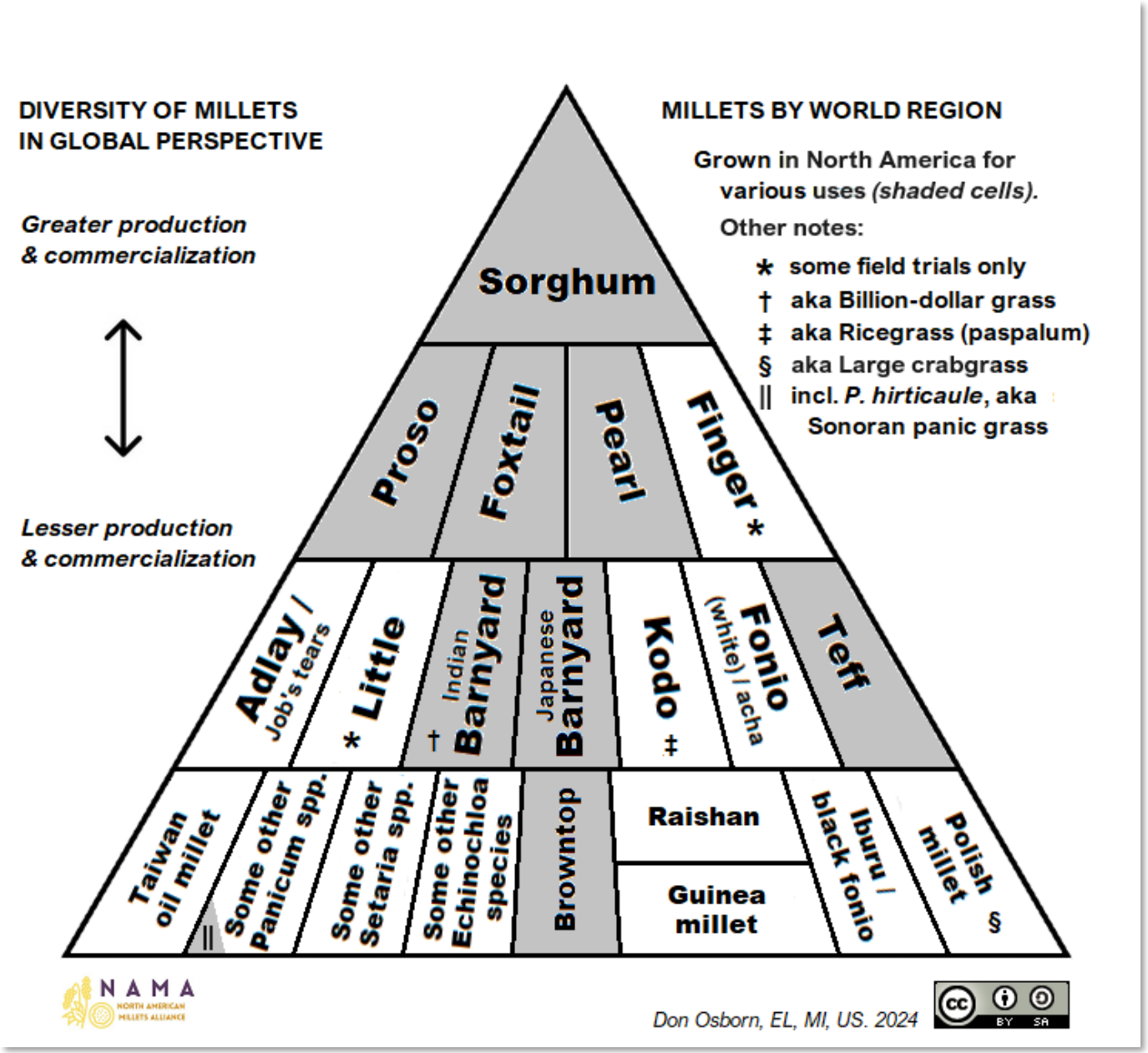


Uses of millets in North America, I

At least 8 millets are grown on farms in the US, Canada, & Mexico, with much of this variety in the US.

A ninth – *Panicum hirticaule* – is an indigenous species grown on a very limited scale by Native Americans in NW Mexico.

Notes added to diagram for other information.

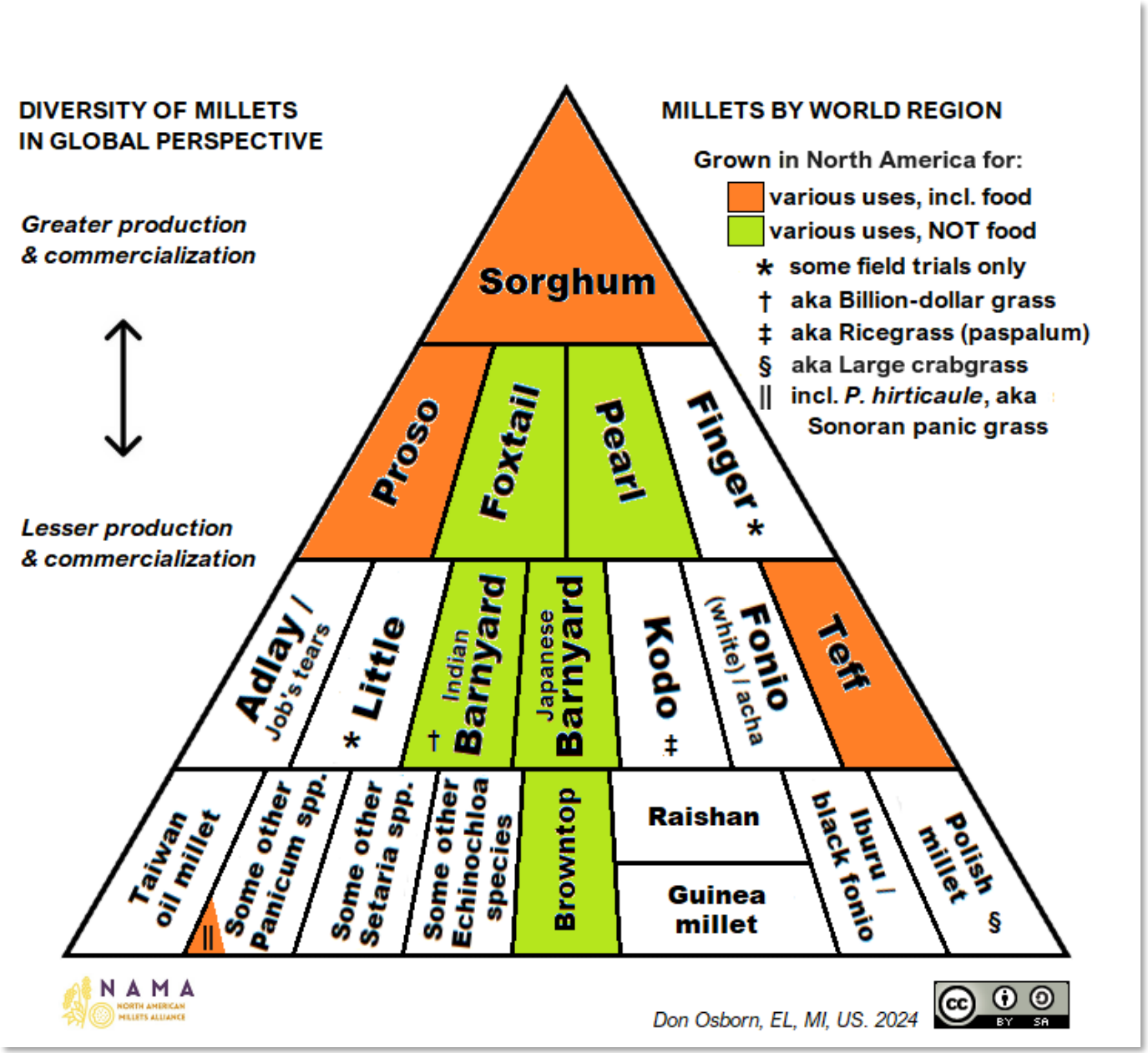


Uses of millets in North America, II

Unlike in much of Asia & Africa, some millets are not grown for food in this region. Color-coding the cells helps clarify this issue.

All colored cells (green & orange) indicate being grown for some or all of a range of uses on farms (forage, feed) & wildlife.

Orange indicates also being grown for food-grade grains (for human food).

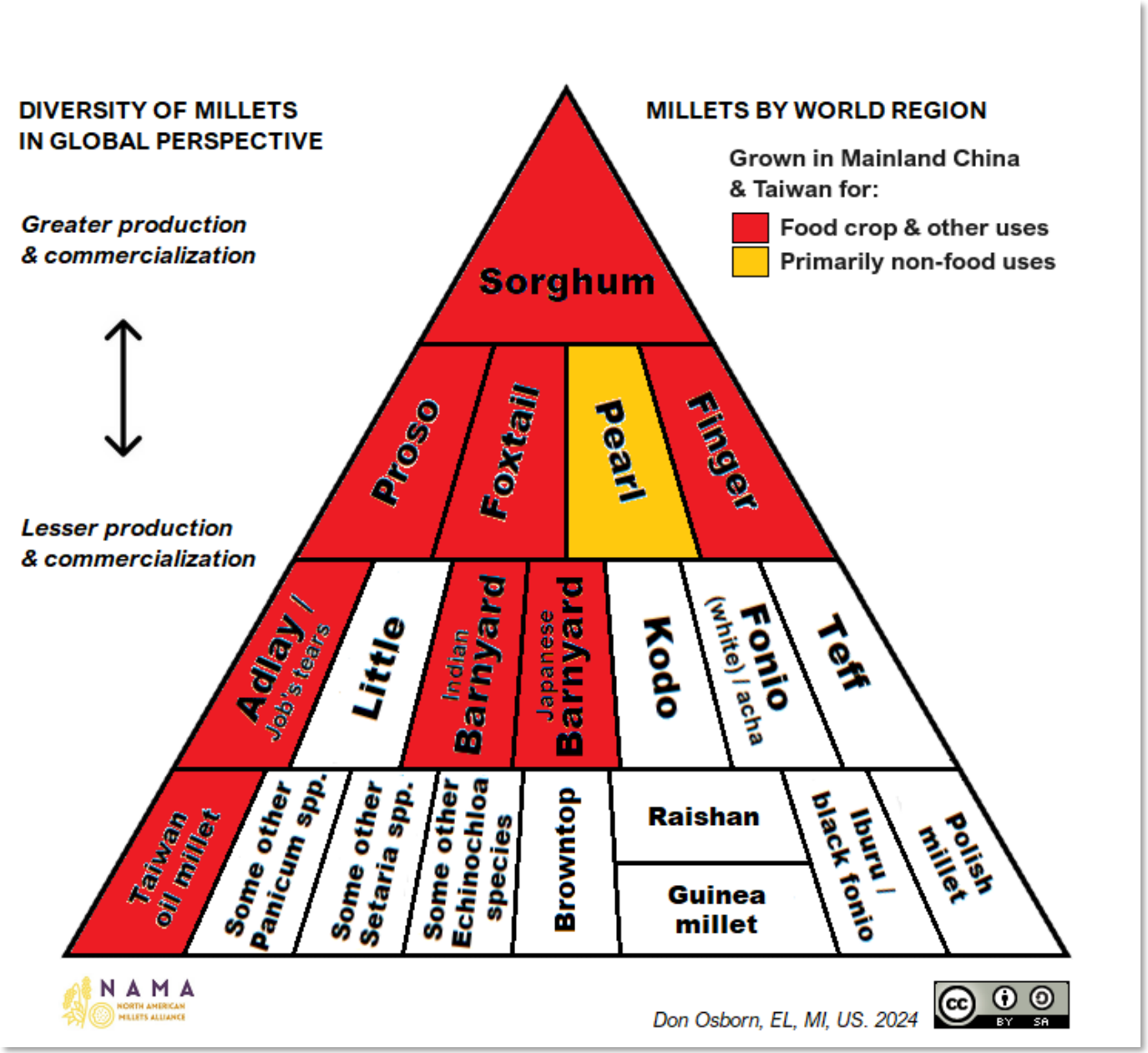


Millets in Mainland China & Taiwan

Three millets have been domesticated in mainland China (foxtail, proso, & adlay or Job's tears), and one (Taiwan oil millet) in Taiwan.

Also grown are barnyard millets, sorghum, finger millet, & pearl millet.

All are grown for food except pearl millet, which is apparently used for forage.

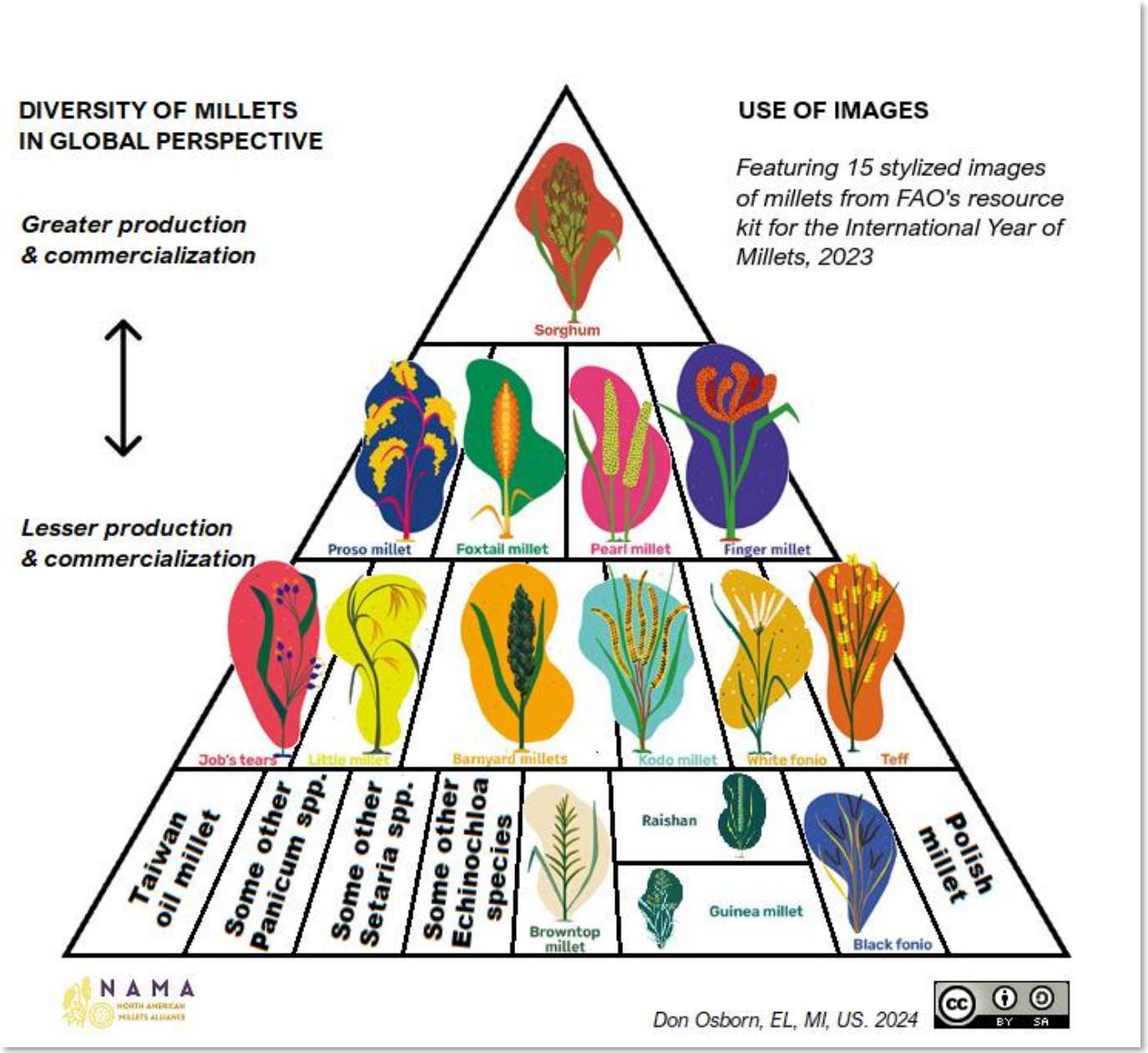


Millets triangle with images

For the International Year of Millets in 2023, the UN FAO commissioned a set of 15 stylized illustrations of millets

Here, these images are placed in their corresponding cells in the millets triangle

One could similarly put other images or photos to display the diversity of millets



4. Conclusion

Thoughts about future development of the Millets Triangle concept

Summary and look forward

- The millets triangle as presented here is not a final or fixed product
- It is free to use and adapt for commercial or non-commercial ends
- Anyone is invited to develop it further (CC-BY-SA), with the hope that such development will help further understanding of the place and potential of millets in agriculture and food
  - The present examples were done with a very basic image editor (so the shading of cells is rather crude), and a text rotation utility
  - Someone with design skills & good image software could do much better
- An ideal direction for development would be a dynamic online version enabling users to call up various views, or generate new ones based on their own questions or parameters

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Thank you!

A "Millets Triangle," Ver. 3.0
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