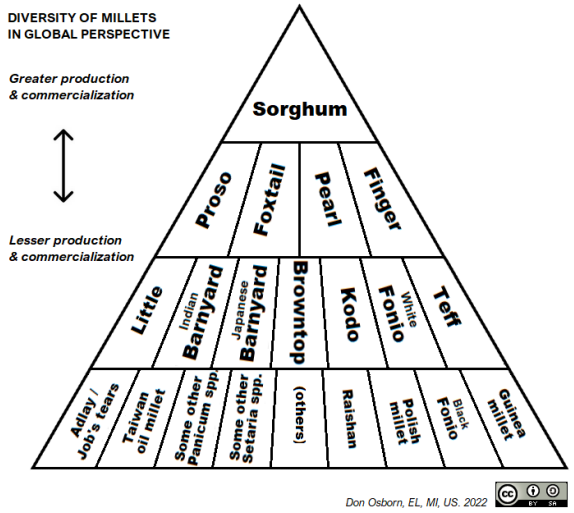

A “Millets Triangle”

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

Don Osborn, PhD

North American Millets Alliance, 28 July 2023

Version 1.0

Many millets: A challenge for messaging

- There are almost 20 different cultivated species we call millets (including sorghum & teff)
- “Millets” is not a botanical category, crossing sub-families & “tribes”
- Millets were domesticated in diverse 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, & little known elsewhere
- How to communicate such complexity?
- Can it be effectively communicated in a simple diagram?

Conveying millets’ complexity

Quick overview of approaches

Lists, tables, charts & diagrams

- There are 2 main approaches to meaningfully summarizing the diversity of millets in an “at-a-glance” image
  1. A list with selected information for each millet, presented either line-be-line or incorporated into a table (the latter of which in digital format, might be sortable by items of information included)
  2. A diagram or chart using names and/or images of millets (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 two slides feature examples of a list (per #1) & a chart (per #2)
- The diagram dubbed the Millets Triangle is then introduced

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**.

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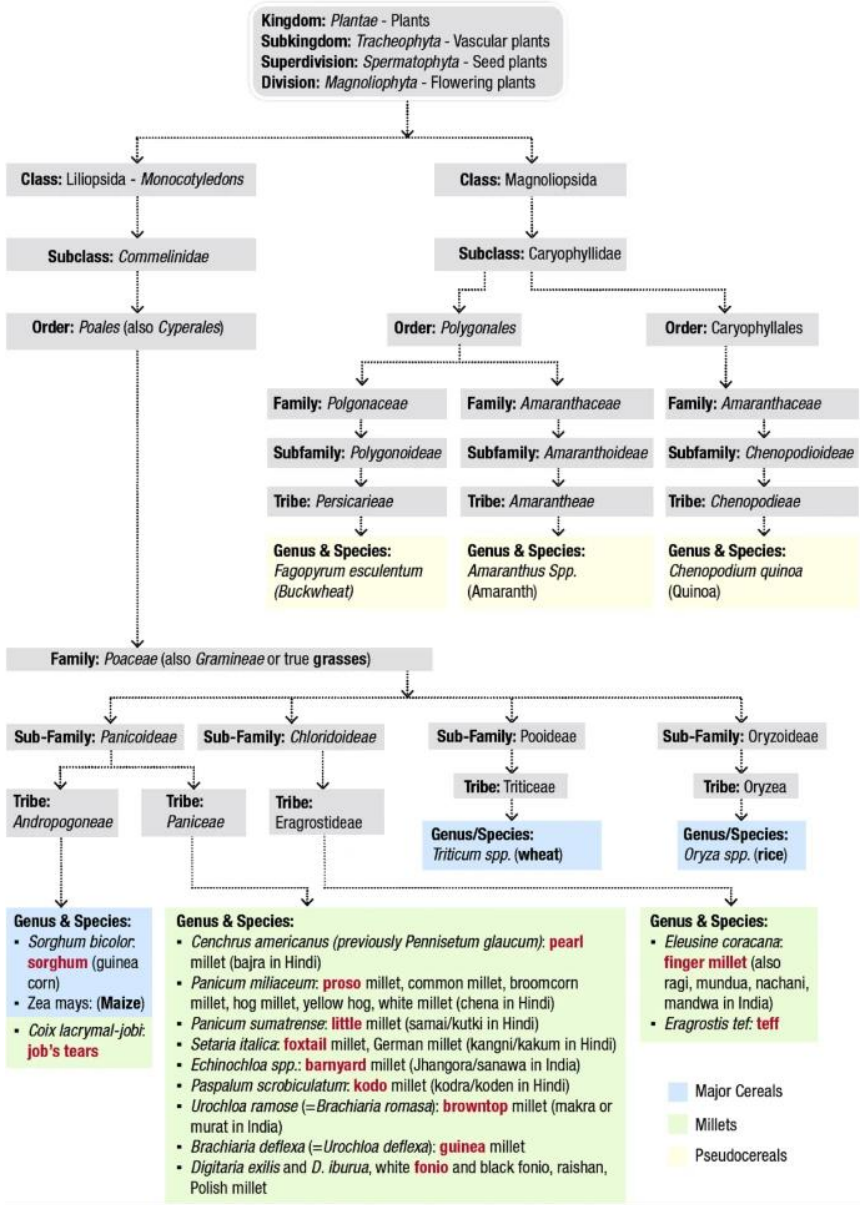
Chart showing botanical relationships

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 Joanne Kane-Potaka) shows millets, other grains & pseudo-cereals in botanical taxonomy

Millets are found in 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

The Millets Triangle

A simplified schematic & the organization of data within it

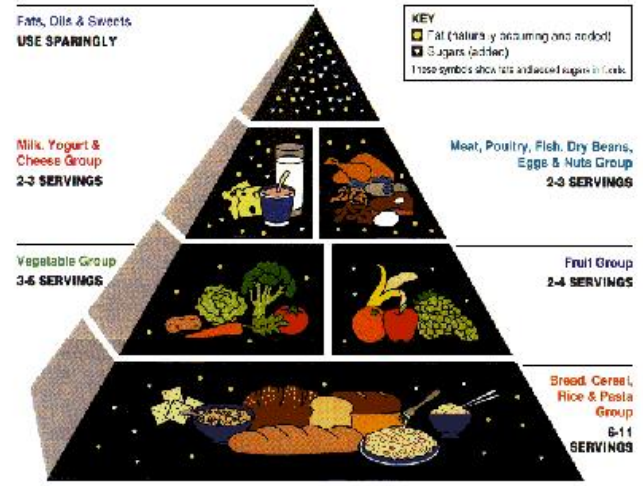
A “triangle” of millets

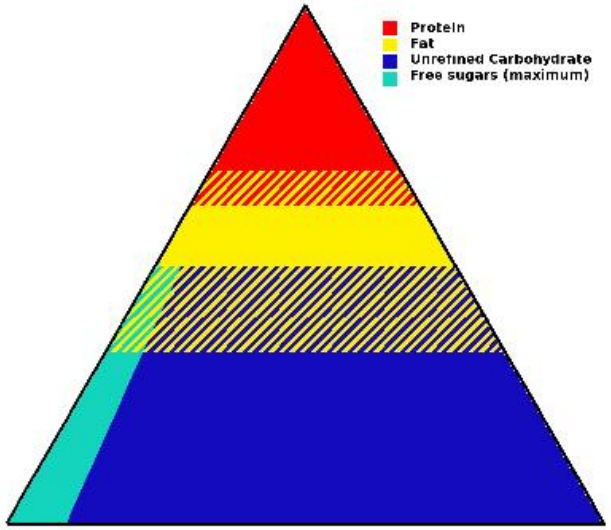
A simple framework to convey various facts about millets

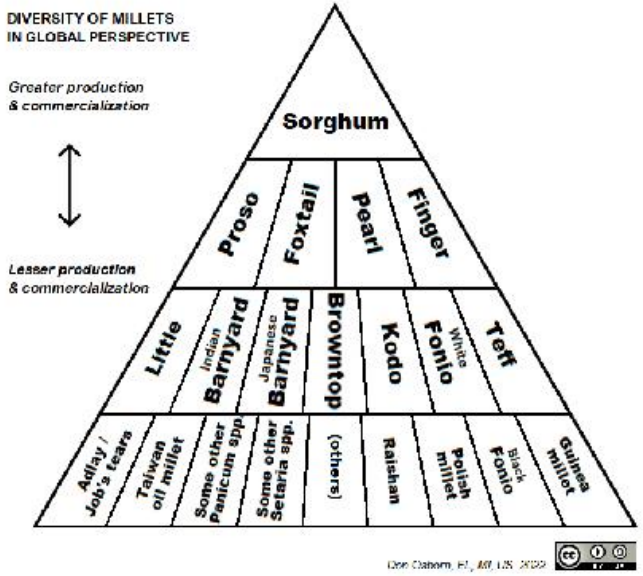
Organizing principle is relative production levels: The few most produced at top tiers of triangle, with less produced millets on lower tiers

“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 millets are in the botanical family *Poaceae*, like other cereal grains
  - Species of the same botanical sub-families & tribes in adjacent cells, to the extent possible
  - 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)

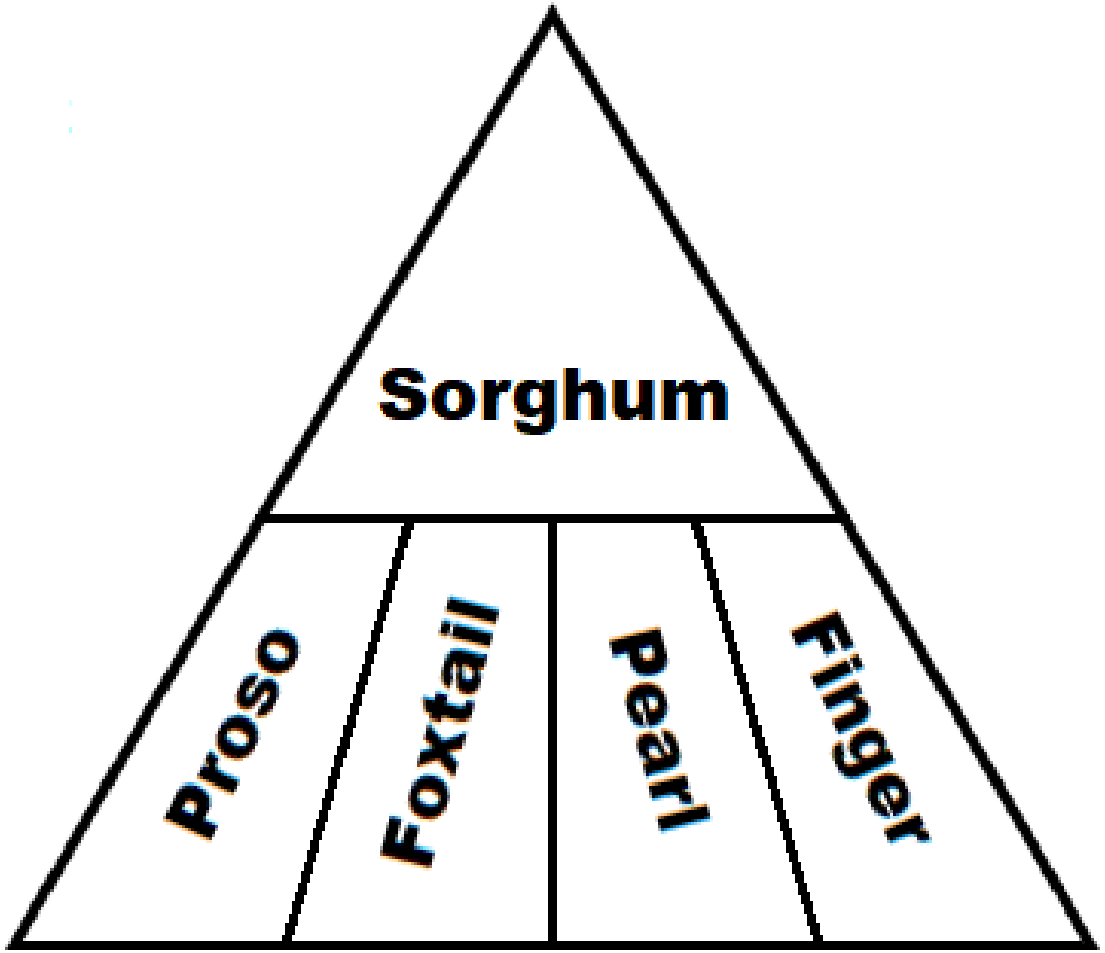
Top 5 millets

At top 2 levels are the most grown & consumed millets

Sorghum is by far the most produced worldwide (~60 million Mt of grain / year)

The next 4 millets are each significant in >1 world region:

- Pearl (~14 m Mt)
- Foxtail (~5 m Mt)
- Proso (~4 m Mt)
- Finger (~3 m Mt) millets



“Millets triangle”

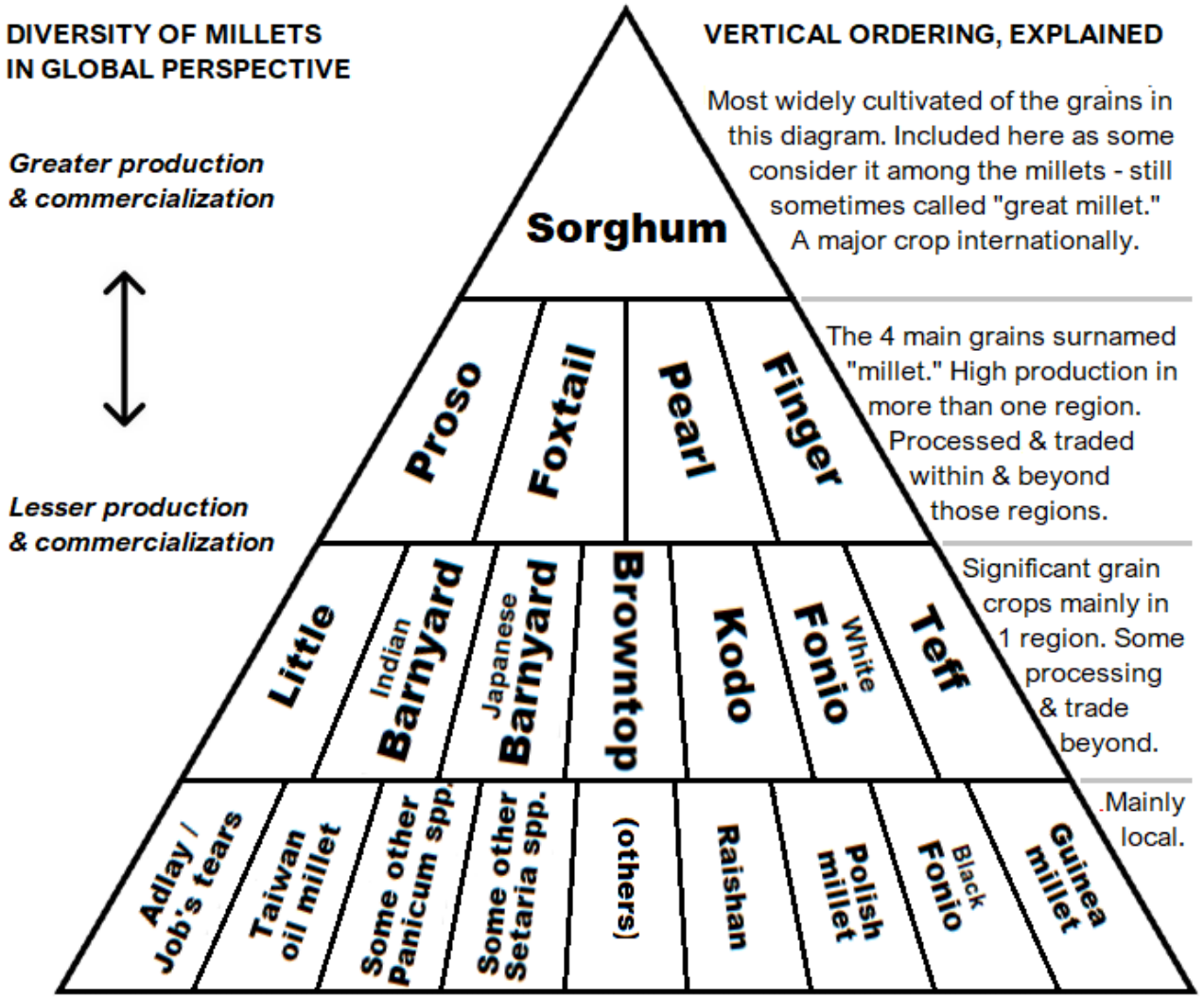
Expanding the triangle to include less widely cultivated millets on 3rd & 4th levels

On the 3rd level, most grain production is in one region

At bottom, smaller production & generally more local

Panicum spp. & *Setaria* spp. Included to account for several of these once used as food by Native Americans

Arrangement of lower 2 levels may change with better data

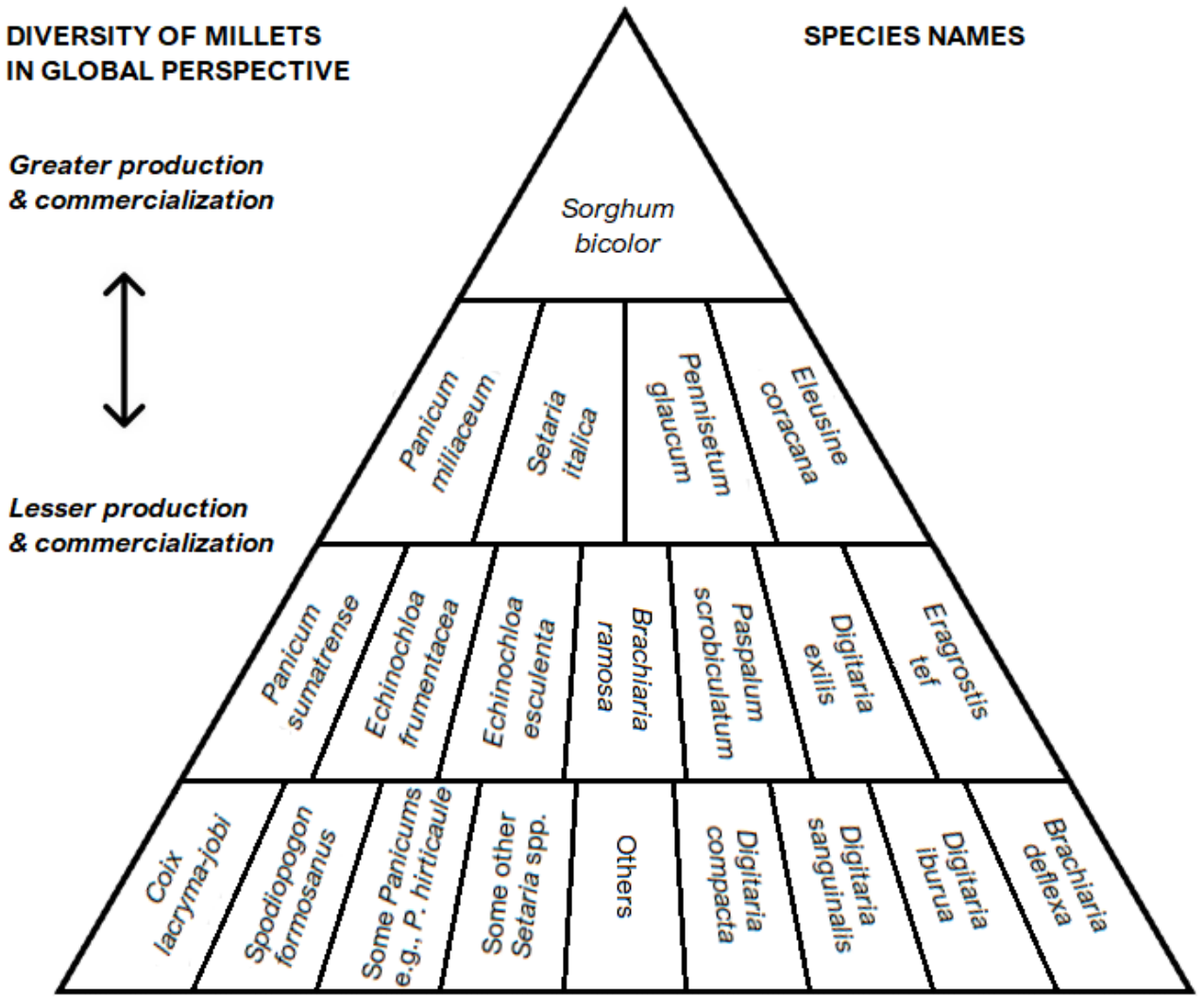


Species names

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 from *Panicum*, and 2 each from *Setaria*, *Echinochloa*, & *Brachiaria* (or *Urochloa*).

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

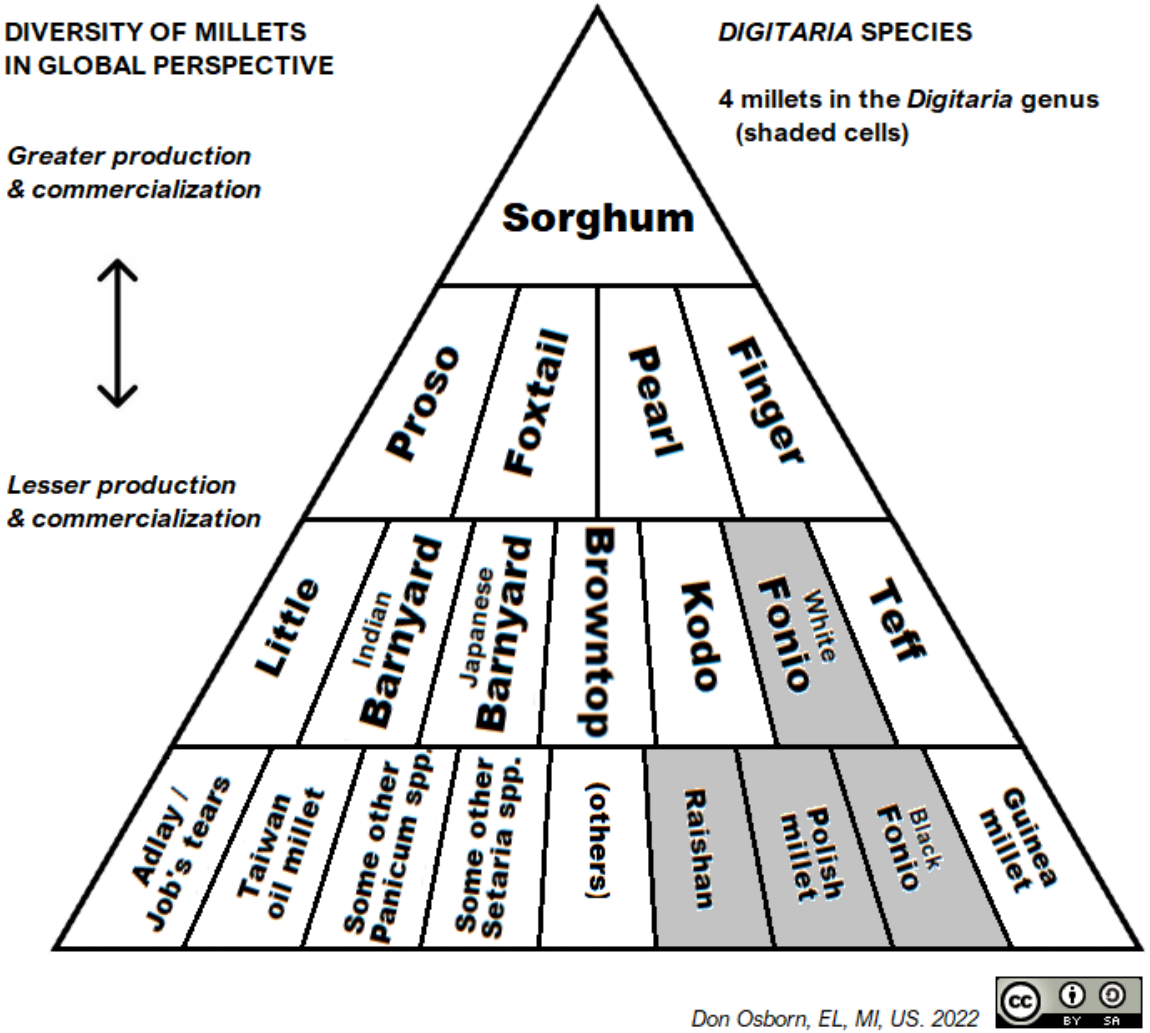


Digitaria species

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

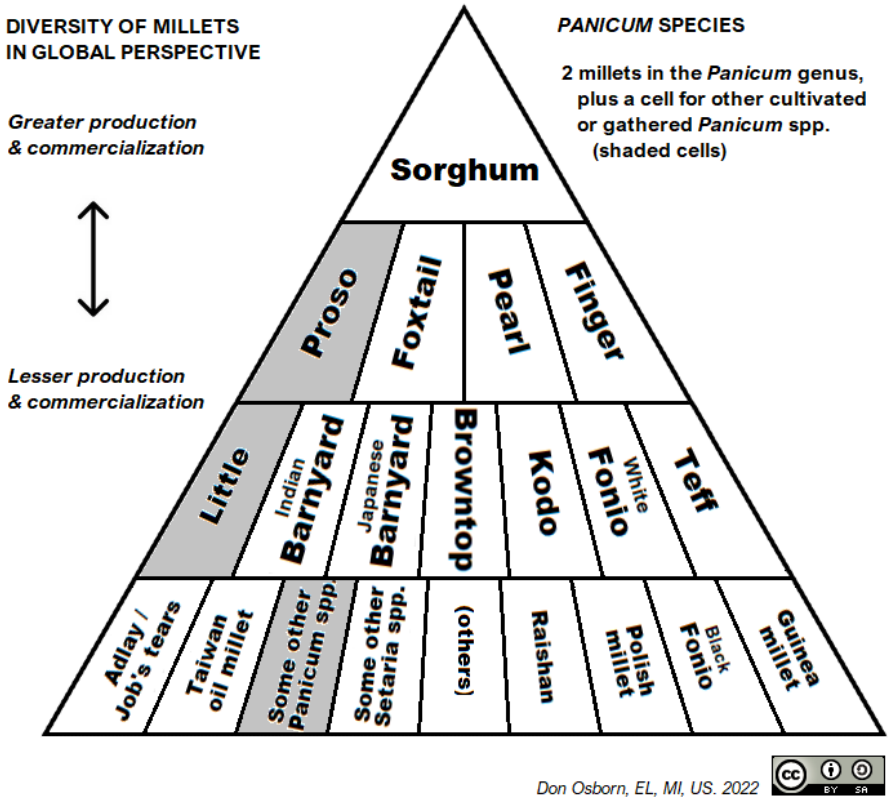
Here, 4 *Digitaria* spp. are spotlighted:

- Fonio (or white fonio), *D. exilis*
- Black (or iburua) fonio, *D. iburua*
- Raishan, *D. compacta*
- Polish millet, *D. sanguinalis*

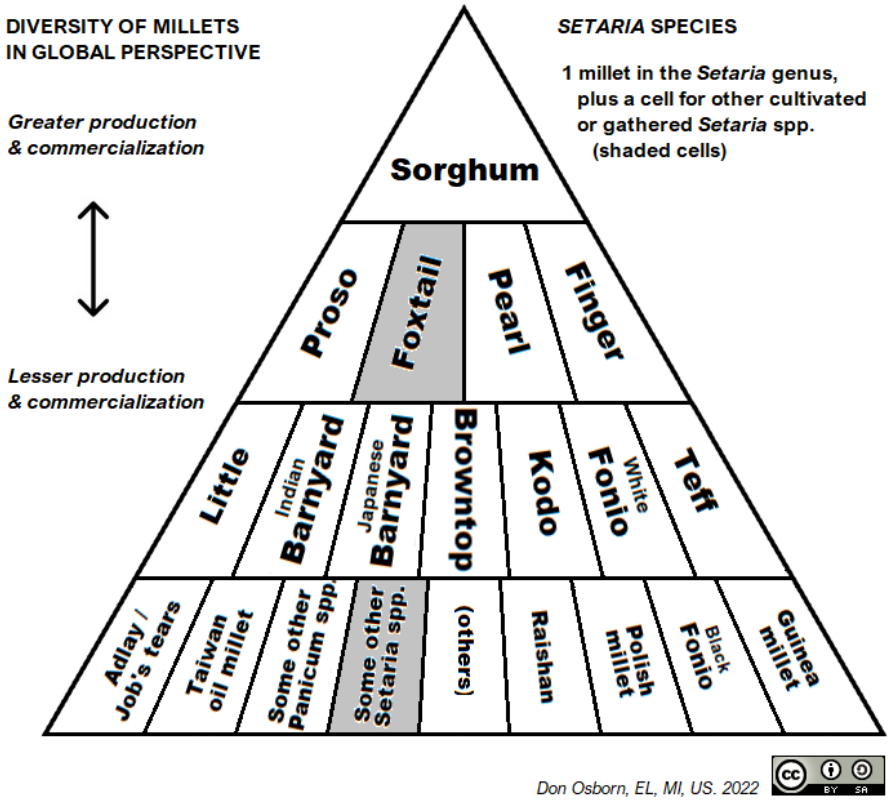


Panicum & *Setaria* species

2+ *Panicum* spp.

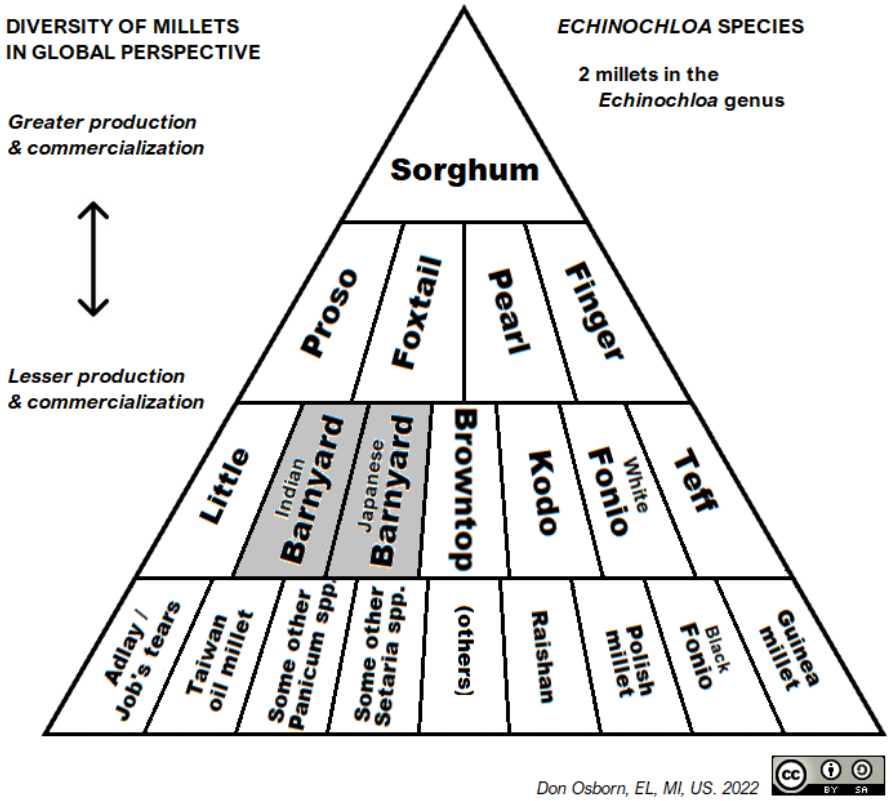


1+ *Setaria* spp.

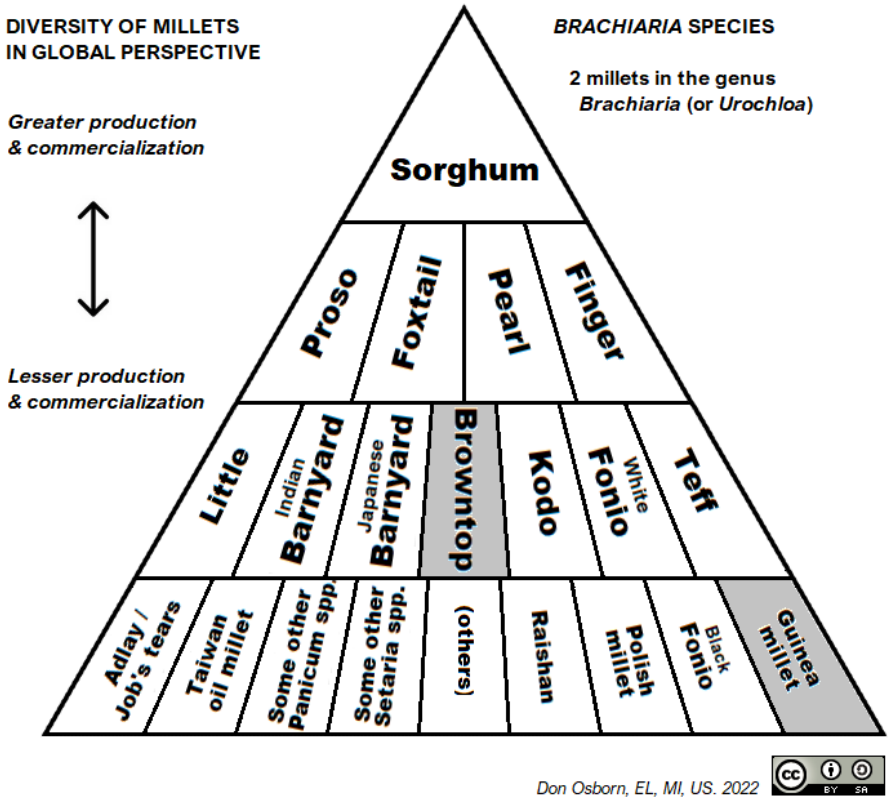


Echinochloa & *Brachiaria* (or *Urochloa*) spp.

***Echinichloa* spp.**



***Brachiaria* (or *Urochloa*) spp.**

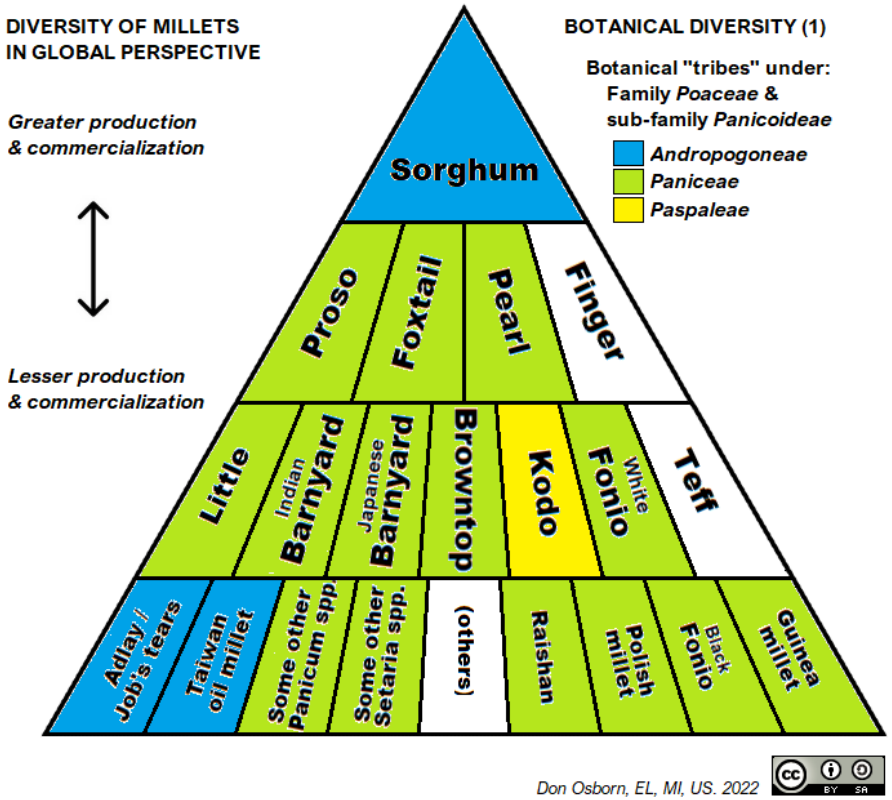


Botanical taxonomy (& “folk taxonomy”)

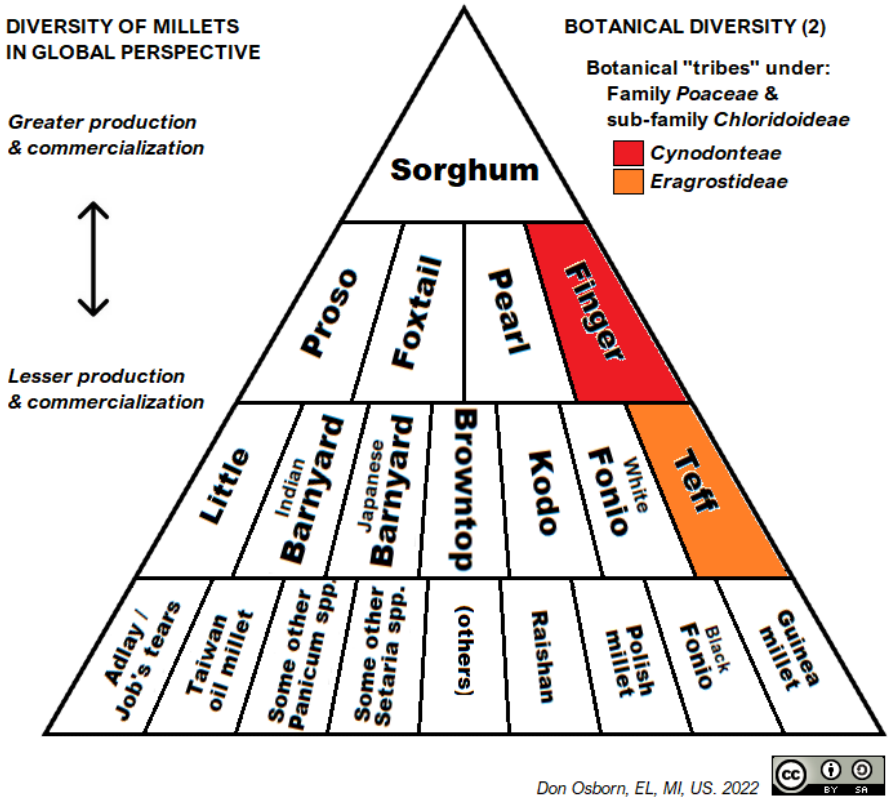
- In the botanical taxonomy above genera and species, millets are also found in
  - 2 sub-families of the family *Poaceae*, and
  - 5 “tribes” of those sub-families
  - *Botanical hierarchy: … > Family > Sub-family > Tribe > Genus > Species*
- What makes them all “millets” is a matter of history going back to early agriculture, and languages – a separate discussion from this one
  - However, we find it useful to think of “millets” as a kind of “folk taxonomy,” focused on some shared characteristics, and their utility as crops & foods
- In any event, it is helpful to understand their botanical relationships, and account for them 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)



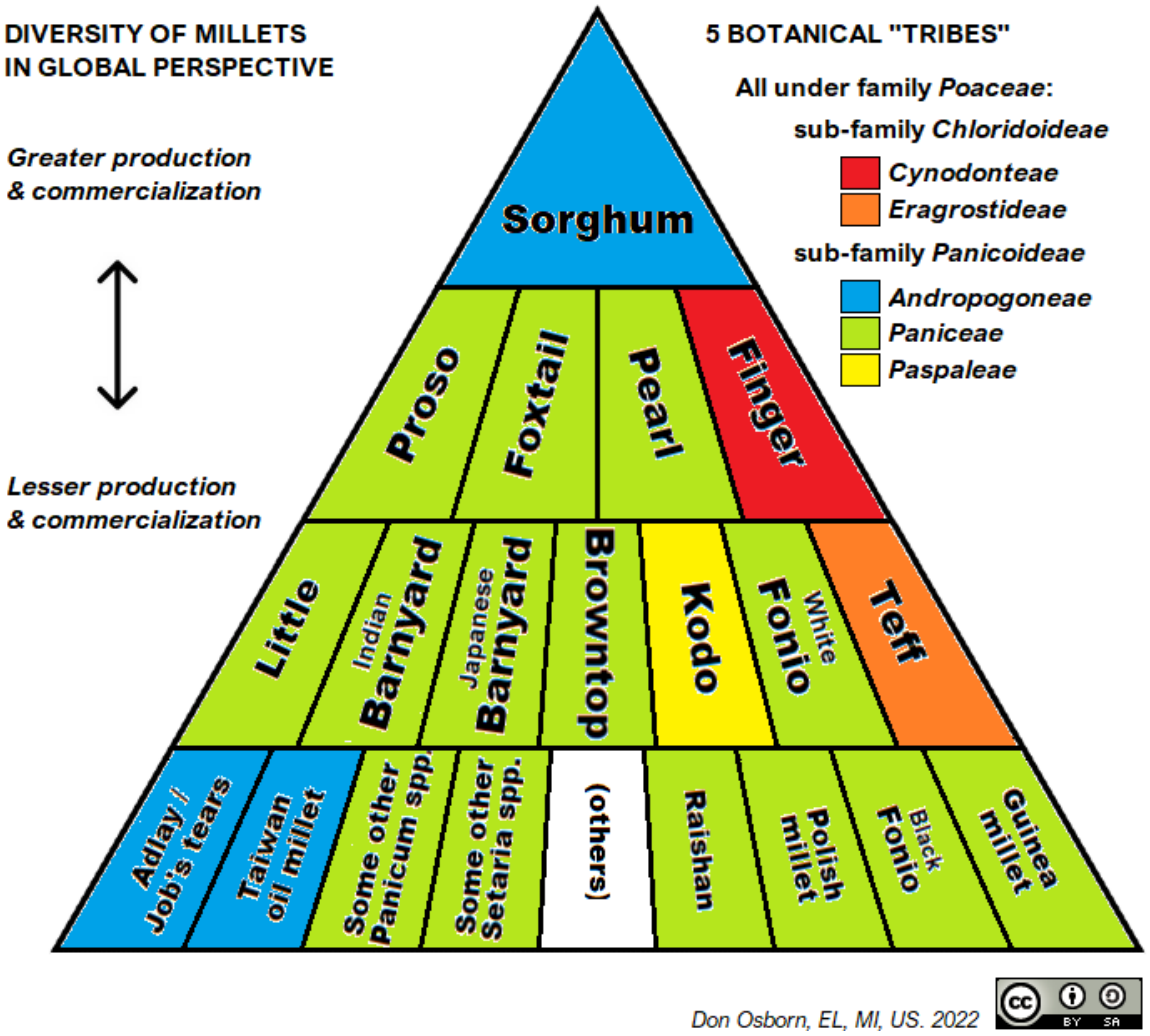
Botanical diversity in one triangle

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

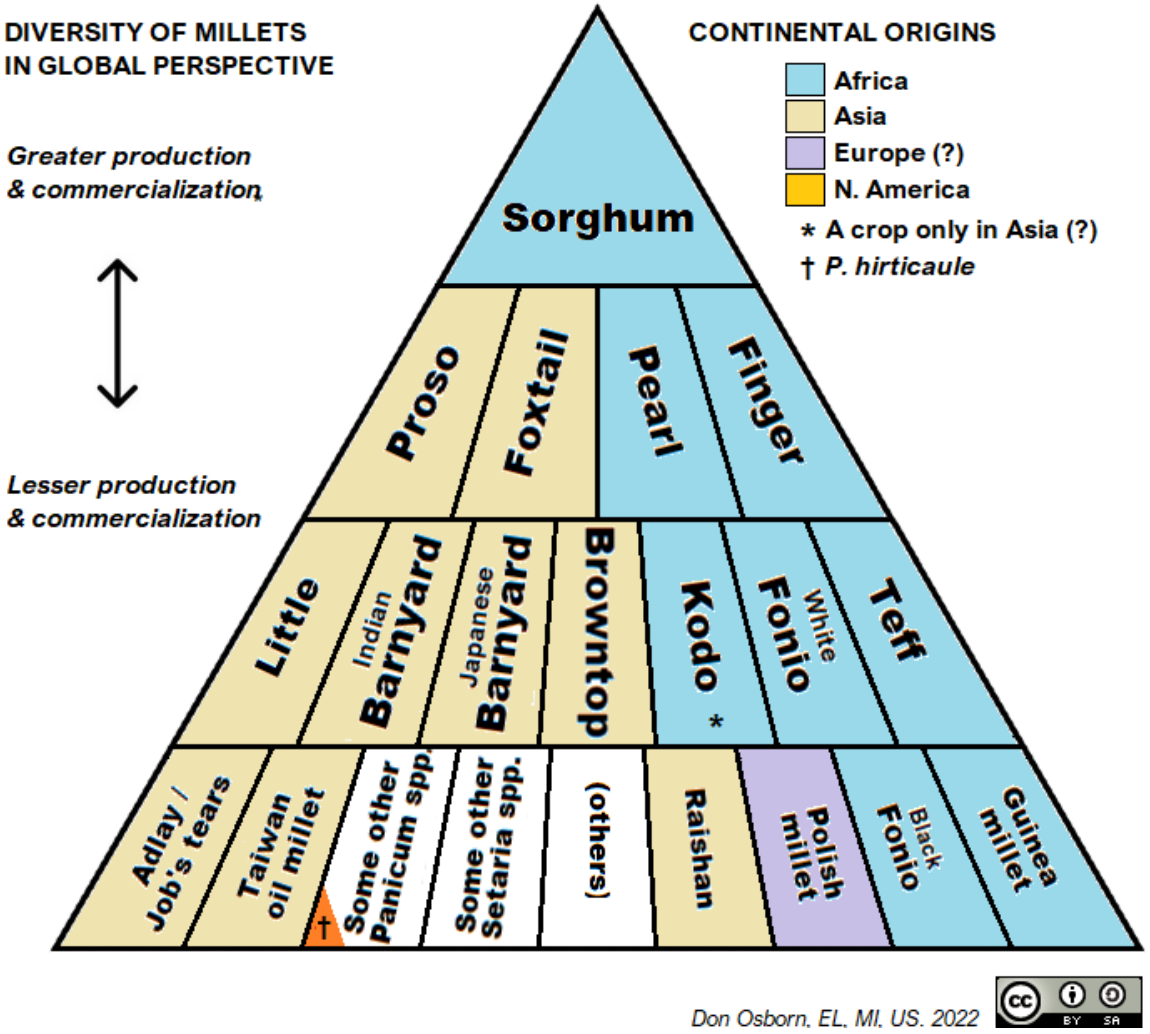
The millets triangle is also organized with the millets of Asian origin to the left, and those of African origin to the right.

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.

Polish millet (a common name for *Digitaria sanguinalis*) is apparently from Europe and was (and is?) cultivated for grain and fodder.

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.



Other examples of uses

Using the millets triangle to convey information about millets

(this section to be expanded in updated versions of the presentation)

A reusable schematic

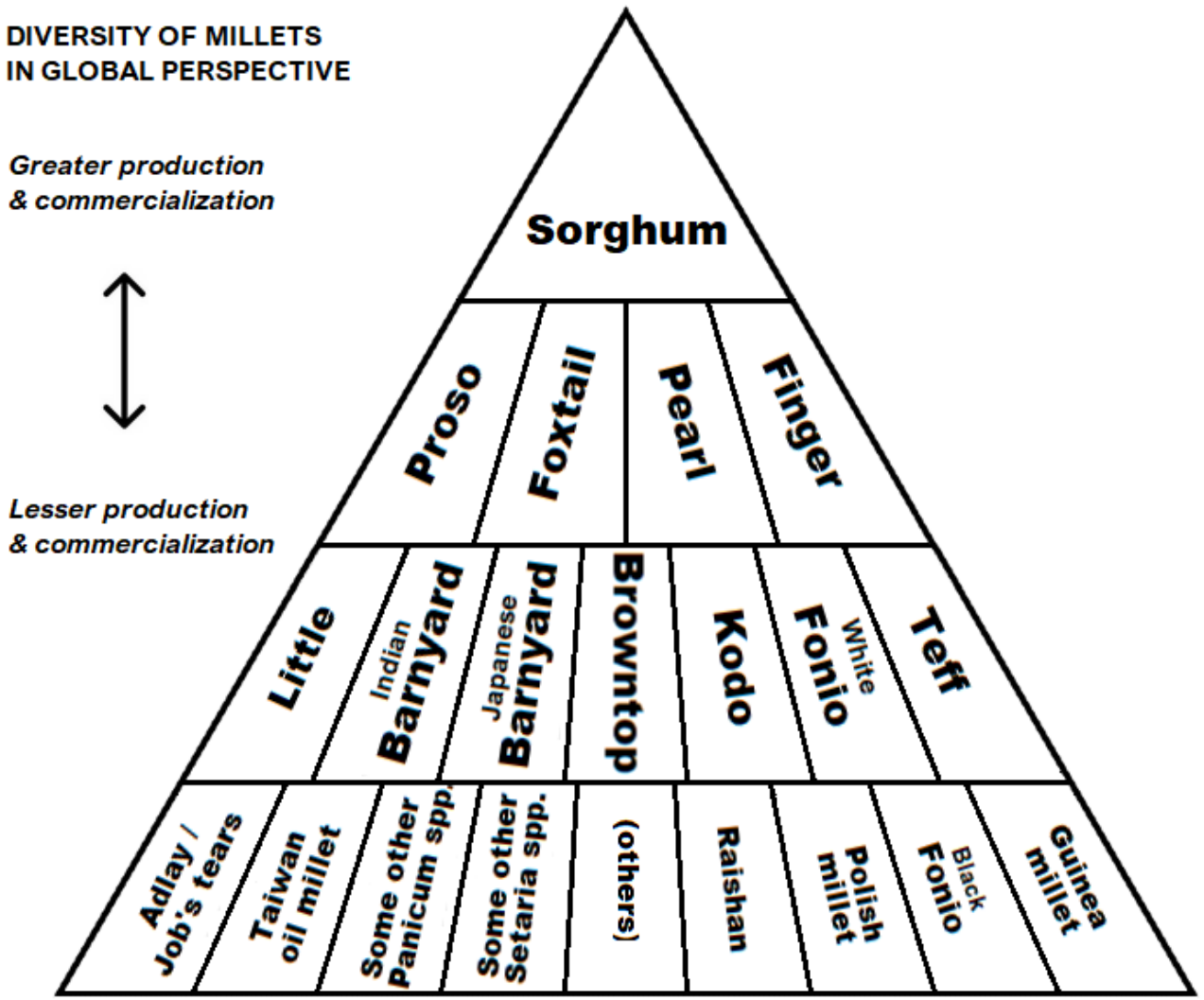
The main mode of use foreseen for the millets triangle is – as illustrated above – shading or color-coding cells to convey various information.

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.



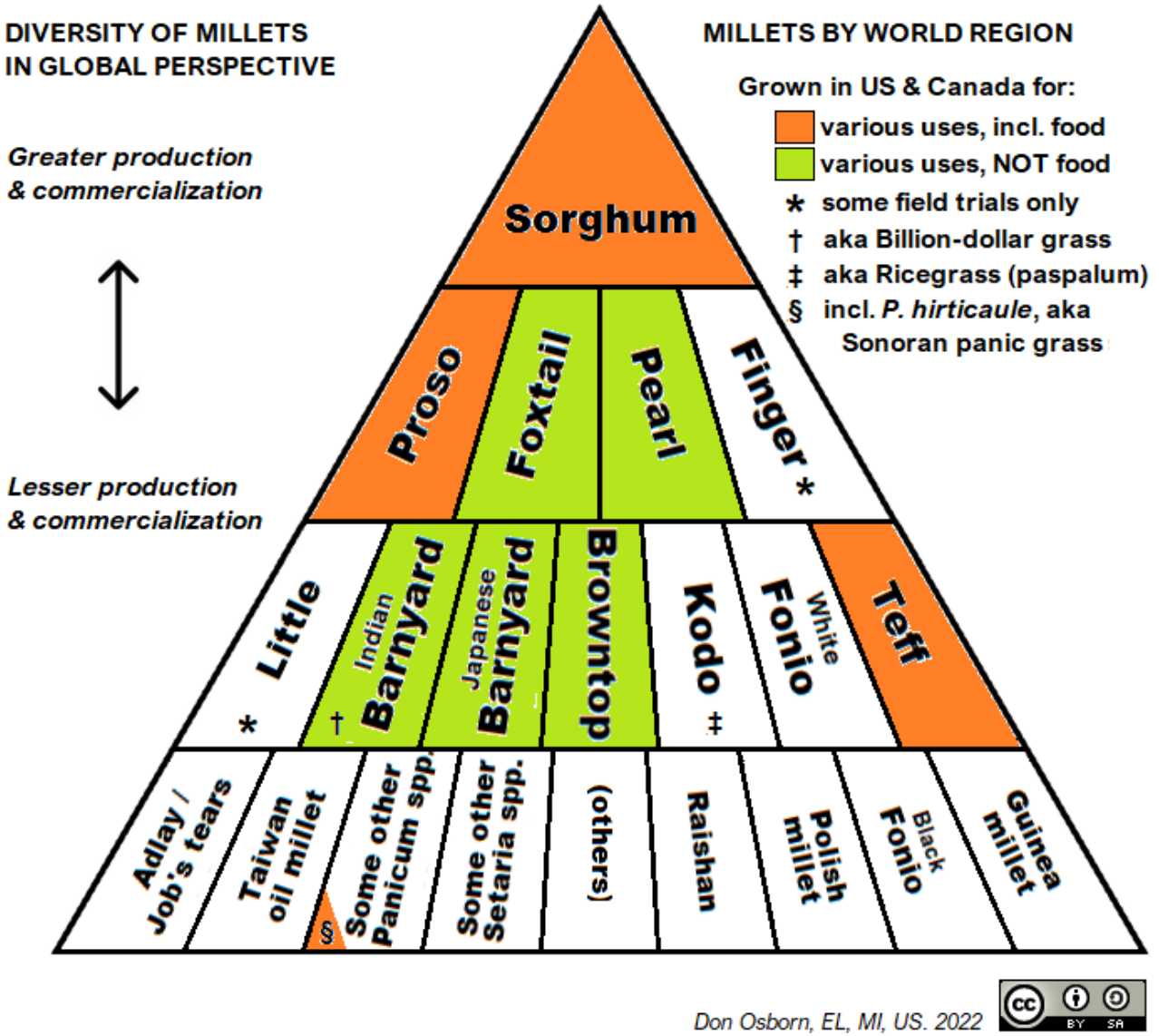
Uses of millets in the US & Canada

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).

Additional information about specific uses of various millets could also be incorporated.

Notes added where these can provide details or exceptions.

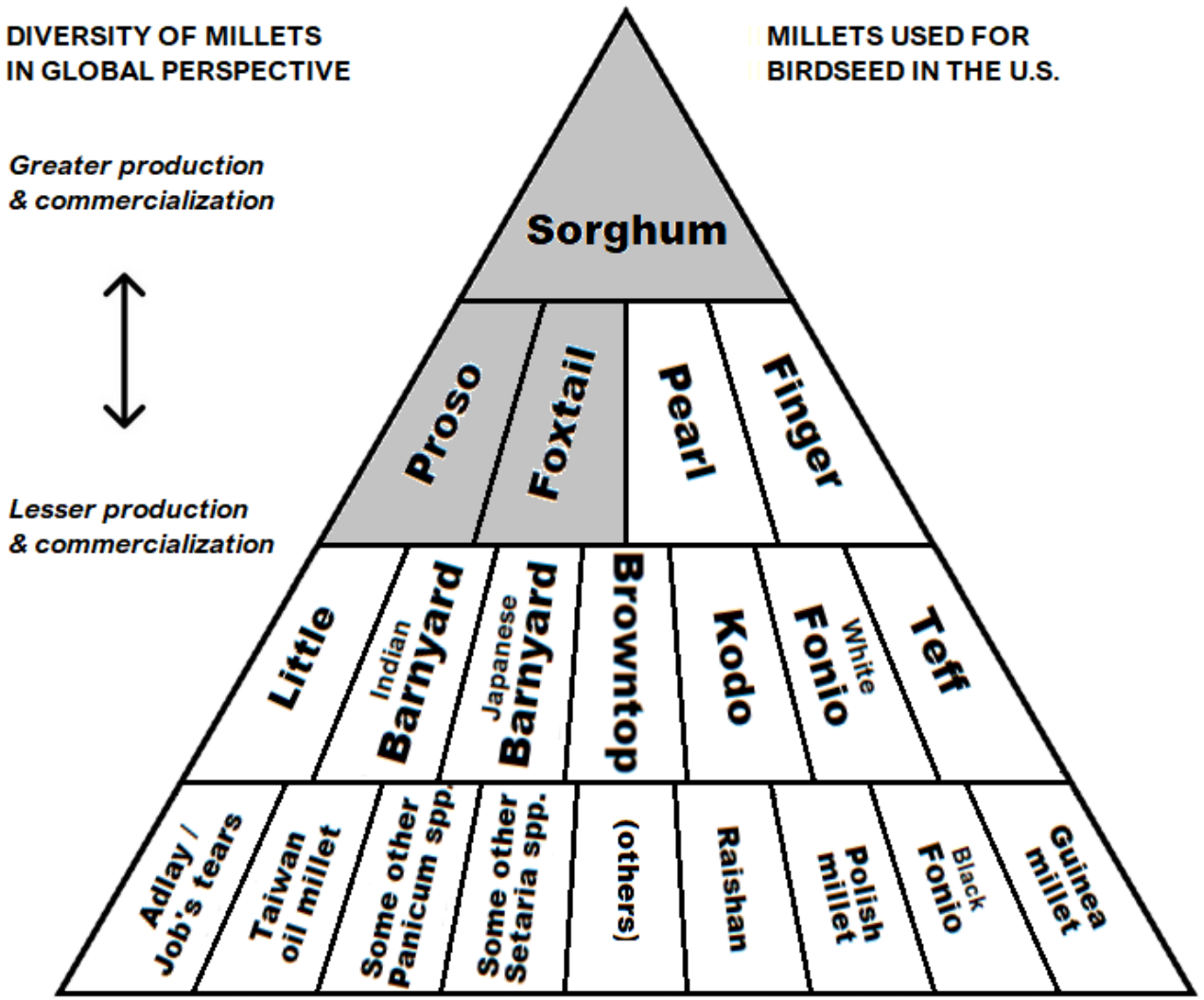


Millets for birdseed

Many people in North America associate “millet” with birdseed. It is, in fact, an important market.

The millets used for birdseed:

- Proso, of which possibly 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



Conclusion

… and 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 & 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

NAMA
NORTH AMERICAN
MILLETS ALLIANCE

Thank you!

DO, EL, MI, US
don@milletsalliance.org