For the catalog of **Whole Grain Connection wheat seeds** (*see pages 9 and 10)*

Notes to assist with

Landrace Wheat Varietal choice

Introduction

The Whole Grain Connection is a non-profit enterprise founded in 2000 by Monica Spiller to promote whole grain foods and sell old fashioned wheat seed predating 1880, which was the beginning of refined flour milling.
The realization was that organic farmers could use an interesting cash cover-crop of landrace wheat instead of simply ploughing under a nondescript grain cover-crop, provided they could manage all stages of handling and marketing even when small-scale grain infrastructure may not be locally established.
The wheat varieties in the catalog were selected during various stages in a personal odyssey to learn about the use of wheat in whole grain bread and wheat agriculture. Ultimately the selections were made by demonstrating that they could be grown successfully under dry farmed organic conditions in California. This revealed the concept of climate matching Old World landrace wheat varieties with local climates in the New World. No wheat varieties are native to the American continent.

How to order wheat seed from the Whole Grain Connection

Initially make a phone call: Monica Spiller at 650 938 2865 or e-mail barmbaker@aol.com for availability and advice. Seed is $2.00 - $3.00/pound, sold in 25-pound bags.

With the end goal of 100% whole wheat products, there is no restriction on the type of wheat that can be milled into flour; stone milling and modern impact milling are suitable for any wheat variety. The farmer chooses a variety absolutely for the conditions on their farm and not at first for the miller or baker to suit their needs. In the end this means that the miller and baker will receive the highest quality product well suited to the region. There is an ethnic cuisine already established for every kind of wheat. This makes more sense than the currently preferred requirement for the commodity wheat farmer to choose a hard-red variety specifically bred for the refined flour miller and also necessarily bred for the region; these modern varieties are upgraded every few years because they often do not hold their disease resistance. The result has been that the commodity farmer, miller and baker rarely develop full familiarity with a variety before moving on to the next one from the breeder's lab.

When the ultimate goal is for fresh stone milled 100% whole wheat flour, the breeder is given a different set of characteristics desired in the developed wheat, including appropriateness for organic farming. The miller is no longer the dictator to the organic wheat farmer or the 100% whole grain baker who can mill the grain for themselves.

Classifying versatile and varied wheat

(Wheat is self-pollinated. Wheat head = spike. Rachis = stem of the spike.)

Ploidy **–** number of sets of chromosomes. Wheat has 7 chromosomes in each set.

Simplified modern nomenclature:
Diploid wheat has two sets of chromosomes: 2 x 7 = 14 chromosomes. *Triticum monococcum*. eg einkorn*

Tetraploid wheat has 4 sets of chromosomes: 4 x 7 = 28 chromosomes. *Triticum turgidum*. eg. emmer*, durum, khorasan, cone, rivet, pollard (large seeds generally)

Hexaploid wheat has six sets of chromosomes: 6 x 7 = 42 chromosomes. *Triticum aestivum*. eg spelt*, bread wheat, club wheat (smaller seeds generally)

* *hulled wheat types*

Hulled vs Free-threshing wheat
The hulled wheats are not free-threshing. Hulled wheats possess a weak *rachis* such that the *spikes* (heads) break apart during threshing into *spikelets.* The grain stays inside the spikelets. Hulled wheats can be planted in the form of the spikelets to shield seed from soilborne diseases. Broadcasting with a spreader is conveniently used to plant spikelets followed by rolling in the seed or harrowing. Specialized planters would be preferred for planting spelt spikelets to a depth of 1-1.5 inches. However, the bare grain can also be used for planting provided it has been dehulled without damage to the germ. Storage as cleaned spikelets gives increased protection from insect and rodent attack during storage. A special de-huller is required to dehull einkorn, emmer and spelt. Rice dehullers usually work well for these hulled wheat types. (hull = husk = chaff)
Note that pearling machines are not appropriate for the production of hulled wheat seed or whole grain, since the pearling process removes a significant amount of bran and germ.

***Hardness*:** hard vs soft is a measured physical hardness. This is useful to know because hard wheat makes a sandy flour and soft wheat a velvety flour when stone or impact milled. Durum wheat is the hardest wheat of all and, at home, it is best milled to a flour With an impact mill.

Bearded vs beardless: bearded (awned) wheat heads deter birds and animals; beardless wheat heads are conveniently cleaner and easier to thresh free of chaff.

Club wheat vs lax wheat: compact club wheat is useful in windy regions to reduce self-threshing in the field when ripe heads bounce against each other. Lax wheat heads, with widely spaced spikelets, are usually long and more fragile in the wind than denser heads.

***Spring vs Winter habit types*:**
Spring habit types come to fruition after a short season of continuous growth usually in a steadily warming season. Shortest season spring types are likely the most drought tolerant. They are suitable for spring planting after severely cold winter, or as in California planting in the fall to make use of a warm rainy winter. Spring habit shows immediate upright growth.

Winter habit types require a long total time in the ground and grow best after fall planting and initial establishment with prostrate growth, followed by a prolonged dormant time under snow; they grow upright in the warmth of spring and come to fruition during summer, but they cannot tolerate severe winters such as in Minnesota, the Dakotas, and Canada. Winter habit types show prostrate initial growth. *It appears that in California, winter habit types can be planted until Valentine's Day, so that they are above ground and well established before the Spring Equinox; planted later they do not come to fruition satisfactorily by the end of summer.*

Defining Landrace, heirloom, modern, hyper-modern and heritage wheat types:

Landrace wheat has been grown for hundreds of years maybe millennia in a particular region in the Old World without modern breeding or genetic interference. Landrace types were in use before refined flour milling was invented, therefore they are likely good flavored and interesting for whole grain end use

Heirloom wheat: a variety that has been passed along in a family or by farmers that is of interest; usually it is modern and developed 50 or more years previously, but it can be any interesting variety handed down.

***Modern wheat*:** Developed since the revelation of Mendel's Laws of inheritance in the late 1800s. Coincidentally refined flour milling of hard red wheat was introduced in the 1880s. As a result breeders made purposeful crosses to make hard-red wheat varieties for refined flour milling, and make them suitable for growing in a wide range of climates, beyond the Mid-West. *Hyper-modern* wheat was introduced by breeders after the 1950s when wheat genes were modified by mutation to produce very short stature wheat suited to modern conventional agriculture. *Hyper-modern* wheat is bred for a combination of suitability for refined flour milling, with suitability for conventional agriculture.
A few *modern* breeders such as Steve Jones are breeding for organic farming and whole wheat milling and end use.

Heritage wheat: is any reliable wheat that seems to have stood the test of say 50 years or more and is being grown currently. *Heritage wheat* can include any of the above *landrace, modern, hyper-modern* and *heirloom* varieties.

Red wheat vs. white wheat or purple!
Modern commodity wheat grain is classified as "red" or "white". The classification is quite distinct because the modern "red" wheat varieties have been specifically bred to be of a particular hardness and type, which has a bran color that is usually dark and called "red". Modern white wheat bred to have light colored bran is called "white". It is less popular with the refined flour millers because it is generally softer and yields less refined flour than the (hard) red varieties, e.g. only 66% vs 76% refined flour respectively. However, makers of cookies, cakes and noodles really like this kind of soft wheat flour, hence its continued existence.

"Hard white wheat" is usually a modern invention i.e. white wheat that is suited to more efficient refined flour milling. Modern hard white wheat is popular for lighter

colored whole wheat products. However, some lesser-known landrace white wheat varieties are naturally quite hard.

The distinctly "red" modern wheat types can usually resist pre-harvest sprouting in the field after ripening in wet summer weather.
The distinctly "white" modern wheat types are generally grown in areas with completely dry summer conditions during ripening. If "white" types are grown in regions with wet summers they are likely to sprout in the ear while still in the field, so reducing their ability to make a well risen bread. The fault is recognized using the "Falling Number" lab. test.

Landrace wheat types are much more varied in their bran color than modern commodity wheat. There are many landrace varieties with a color intermediate between the two extremes of "red" and "white". Since bran color, or kernel color, seems to be associated with ability to resist preharvest sprouting in the field it is likely that the depth of bran color suggests the degree of resistance to pre-harvest sprouting.

Wheat with a purple bran color e.g. Ethiopian purple durum wheat is also seen among the landrace varieties.

The USDA Small Grains Collection, www.ars-grin.gov uses an in-house color-coding system from their in-house colorimeter that is in no way connected to the commodity "red" and "white" designations. See:
https://npgsweb.ars-grin.gov/gringlobal/descriptordetail.aspx?id=65016

From this you can see that the color numbering system for wheat kernels in their collection corresponds with color and shade rather than an absolute correlation from dark to light. It might not be possible to say with any certainty which landrace wheat bran colors correspond with resistance to preharvest sprouting in the field. However, varieties described with a kernel color of 8-amber or 8-white are likely the most susceptible to preharvest sprouting in the field; they should be avoided for planting in regions with a rainy or humid summer.

Kernel color can differ from year to year; this can be due to the natural variation that occurs from season to season due to the growing and storage conditions. Thus, in some years kernel color for a variety will register as 7-tan while in other years 8-amber or 8-white will be observed.

Bran color variation is also of interest to whole wheat bakers since the color of the finished whole wheat products will mostly depend on the color shown by the wheat kernel bran.

Information source for landrace and well-established varieties

USDA Small Grains Collection, Aberdeen, Idaho, is a seed bank established for breeders and provides on-line information, and small amounts of varieties for all researchers. We need to show gratitude and respect for this work, by making educated choices of varieties to trial. www.ars-grin.gov

Planting advice for organic dry-farming wheat

When to plant: In California for dry-farming wheat, planting times are governed by likely rainfall (without risk of flooding) i.e. late November through March. Occasionally planting can be as late as May when a hefty rain might be forecast and there is still substantial moisture remaining in soil from the previous rainy season. If there is a risk of flooding rains after planting in the late fall, farmers now consider planning for a second planting early in the New Year.
In irrigated desert regions planting time is according to a warm enough starting temperature after coldest season. Irrigation is mainly for the first month of growth to establish plants with known drought tolerance, such as the durum type.

Planting is best timed so that soil will be moist enough for about 4 weeks while plants are established; it can be ready in the soil before a major rain forecast.

Amount to plant:
Small scale: plant at the rate of a seed every 2-3 inches in rows 8 inches apart, at a depth of 1-1.5 inches.
Full scale: 75 -100 pounds per acre. Use lowest amounts when a really wet growing season is anticipated. (Farmer in Arizona planted at 14 pounds per acre and obtained reasonable yield, due to maximized tillering in enough space!) Lowest amounts are also appropriate when soil is poor and water likely to be limited – discretion is needed! Dense planting to exclude weeds is risky because the crop could lodge due to intense growth.
Also note the extreme difference in seed sizes between hexaploid (small kernels) and tetraploid (large kernels) varieties. To account for this, seed can be planted at the rate of ***number of seeds per acre***, by making use of the value for "1,000 kernel weight" of the seeds being planted. The "thousand kernel weight" is a value that varies each year according to the conditions of growth. During a trial at UC Davis in 2018, the seeding rate was set at 900,000 kernels per acre for a wide range of wheat varieties. Only one variety was calculated to be planted at 100 pounds per acre. By taking into account seed size, the range was from 57 to 100 pounds per acre. The result was that all plots were nicely covered; neither sparseness nor significant lodging was seen.

Note that landrace wheat and varieties developed before 1950 produce large tall plants that never should be planted as densely as *hyper-modern* short-stature wheat, otherwise they will choke each other and lodge. In drought conditions it is possible to plant more densely and so help shade out weeds or conversely less densely to provide enough moisture for each plant. Discretion is needed! Best to manage weeds with a known understory crop such as small native clovers and grasses and weed suppressing cover crop rotations. The "not so regenerative" way would be to disk ahead of planting to minimize weed growth. Later planting (January /February) in the Sacramento Valley allows for reduced weed growth.
Plan crop rotations with wheat carefully, to avoid carryover seeds that harvest with the wheat e.g. *vetch seed is a nuisance* to remove from Sonora or other small grained wheat. Using a color sorter to remove foreign seed from a crop is expensive, and un-necessary with careful planning of crops in rotation.

Irrigation
Irrigation is discouraged since the quality of the grain is best when grown with minimal water. Yield is certainly enhanced with greater irrigation, but grain protein is often reduced.
In desert climates irrigation may be available and used: especially at planting time and during initial plant establishment. However, irrigation should be halted after the crop heads fill, and it should be minimized.

Avoiding problems such as weeds, fungal disease and lodging
Weeds can be considerably controlled with judicious and continuous rotation of cover crops, by mowing the wheat crop before weeds go to seed, and by grazing the wheat crop. Because these landrace wheat varieties grow tall it is often possible to mow or graze them back down to about 6 inches, provided they have not begun to head; this takes down weeds too. The final plants may not be so tall and lodging may be reduced by this practice.
Fungal disease can be minimized by never growing wheat or a related crop in the same field until 3 years have elapsed, always planting clean seed, and clearing the field of any residual plant material harboring disease.
Lodging is minimized by avoiding dense planting. It should be possible for the wind to blow between the plants.

Yield expectations for dry farmed landrace wheat:
It is said that the farmers in the 1800s grew two crops of wheat in a year. But I would suggest, not in the same field! In a favorable (lucky!) year, one planting could be done in early December and another from January through March. This concept is useful if land is available and the first planting is at risk from flooding…….
Yields in California in the hey-day of dry-farmed wheat from 1860 – 1880 seem likely to be comparable with landrace wheat planted now (although they did have the advantage of highly fertile and freshly cleared lands): the yield range was 1,000 to 4,500 pounds per acre with about 2,000 pounds per acre as normal. This compares well with yields seen for dry-farmed landrace wheat today. The trick is to find a variety that truly suits your farm location and weather. Soil should of course be reasonably fertile! In general, there can be no comparison with conventional wheat farming yields, where the wheat is grown with irrigation, fast release fertilization and dense planting.

Climate matching choices for landrace wheat varieties

Climate matching reduces the possibility of disease.
Basically, to choose a variety we need to know whether spring vs winter habit type is suitable and whether the summer is rainy such that a red wheat should be grown.

There are Old World regions and corresponding landrace wheat varieties matching every North American & Canadian climate zone.
https://en.wikipedia.org/wiki/K%C3%B6ppen_climate_classification

Köppen climate zone	***Climate***	***Carleton's* wheat regions in USA***
A	**Tropical**	n/a
B	**Dry**	
	Desert	Irrigated (spring) wheat district (Wyoming, Montana, Southern Idaho, Utah, Nevada, Arizona, New Mexico, Colorado)
C	**Temperate**	Soft (red and white) wheat district (NY, PA, NJ, Maryland, Delaware)
		Southern wheat district (Kentucky, Virginia, NC, Georgia, Alabama, Arkansas, Missouri)
	Mediterranean	White wheat district, Pacific coast (California, Oregon, Washington, Northern Idaho)
D	**Continental**	Semi-hard winter wheat district (Ohio, Illinois, Michigan, Wisconsin)
	Very cold winter	Hard (red) Spring wheat district (Minnesota, North & South Dakota, Wisconsin, Iowa, Nebraska, Montana, Colorado)
	Cool winter	Hard (red) Winter wheat district (Kansas, Missouri, Iowa, Nebraska, Oklahoma)
		Durum wheat district (Durum was not much grown in 1900) **
E	**Polar**	n/a

*USDA Bulletin "The Basis for the improvement of American wheats" by Mark Alfred Carleton. *December 10, 1900*.
http://wholegrainconnection.org/sitebuildercontent/sitebuilderfiles/carlton24basisforimprovem24carl.pdf

Note when reading old literature from USDA: they describe varieties as suitable or not for the miller as the main reason for "improvement" – they are referring to the refined flour miller, and this is not relevant to the reasons used for making heritage varietal choices, which are instead chosen by making use of climate matching. Landrace varieties are ready made for our changing climate.

** Durum wheat is generally drought tolerant and suited to *Mediterranean* and *Continental* climates.

Reference Literature
Useful history of many old varieties including list of synonyms:
USDA Bulletin #1074 "Classification of American Wheat Varieties" by J. Allen Clark. *November 8, 1922.*
http://wholegrainconnection.org/sitebuildercontent/sitebuilderfiles/clarkusdabulletin1074cat87212876.pdf

Useful botanical description of wheat in 1921, predates modern breeding, most varieties described are landraces:
The Wheat Plant, By John Percival. 1921

https://ia902909.us.archive.org/27/items/wheatplantmonogr00percuoft/wheatplantmonogr00percuoft.pdf

Landrace wheat position paper, by Monica Spiller. 2008
http://wholegrainconnection.org/sitebuildercontent/sitebuilderfiles/Landracewheat0808.pdf
Or alternatively this smaller link that omits cover photo. Scroll past first blank pages:
http://wholegrainconnection.org/sitebuildercontent/sitebuilderfiles/Landracewheatbw2008.pdf

Note the above links are to very large files that take a long time to download. I suggest printing out copies or excerpts for future reference.

The Whole Grain Connection Seed Catalog – List of seeds

All are spring types with exceptions noted.
*Availability limited

Tetraploid Wheat *(Triticum turgidum)*

Common name	*Name*	*USDA Accession number*	*Bearded (+) or beardless (-)*	*Seed color code*	*Region or country of origin*	*Koppen climate zone (approximate)*
	Triticum turgidum					
	subsp. *dicoccon*					
Winter Emmer	**Escandia*** (winter)	PI 191093	+	8-white /amber	Asturias, Spain	Csa
	subspecies *turgidum*					
Pollard wheat	**Maparcha**	PI 125343	+	7-tan	Laghman, Afghanistan	BSh
Cone wheat	**Akmolinka**	PI 438971	+	7-tan	North Kazakhstan	Dfb
	subsp. *durum*					
Durum	**Durum-Iraq**	PI 481581	+	7-tan	Iraq	BSh
Durum	**Blue Beard Durum**	unknown	+	7-tan?	Iran (Jim George / UC Davis)	Dsa
Purple Durum	**Ethiopian Blue Tinge Durum**	unknown	+	5-purple	Ethiopia (Dan Jason)	Cwb

Hexaploid Wheat *(Triticum aestivum)*

Common name	*Name*	*USDA Accession number*	*Bearded (+) or beardless (-)*	*Seed color code*	*Region or country of origin*	*Koppen climate zone (approximate)*
	Triticum aestivum					
	subsp. *spelta*					
Spring Spelt	**Silanes** (Spanish spelt)	PI 348428	+	7-tan	Asturias, Spain	Csa
Winter Spelt	**Stalden** (Swiss spelt) (winter type)	PI 347864	-	7-tan	Bern, Switzerland	Cfb
Spring Spelt	**Oviedo***	PI 348431	+	7-tan	Asturias, Spain	Csa
Spring Spelt	**La Pola***	PI 348456	+	7-tan	Asturias, Spain	Csa
Spring Spelt	**Asturien***	PI 591891	+	8-white /amber	Asturias, Spain	Csa
	subsp. *aestivum*					
White wheat	**Sonora**	CItr 3036	-	8-white /amber	Durango, Mexico	BSk
White Wheat	**Wit Wolkoring**	PI 479660	-	7-tan	South Africa	Csa
White wheat	**Chiddam Blanc de Mars**	PI 185403	+	8-white /amber	France & England	Cfb
White wheat	**India-Jammu**	PI 57906	-	7-tan	Jammu & Kashmir	Bsk
White wheat	**Foisy**	CItr 5246	-	7-tan	Oregon 1865 (by Mr Foisé)	Csb

Other available landrace varieties, from other sources
Khorasan / Kamut® *T. turgidum subsp. turanicum* (Afghanistan) (spring)
Red Fife *T. aestivum subsp.aestivum* (Russia to Canada) (spring)
Turkey Red *T. aestivum subsp.aestivum* (Russia to Kansas) (winter)
Spelt *T. aestivum subsp.spelta* (Amish from Switzerland?) (winter)
Einkorn *Triticum monococcum* (from Turkey?) (spring or winter type?)
Emmer *Triticum turgidum subsp. dicoccon* (spring or winter)
Kyperounda *Triticum turgidum subsp. durum* (from Cyprus) (spring)