



# ALBERT LEA SEED

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## **Triticale** (*Triticale hexaploide* Lart.)

### **Description**

- Triticale (pronounced: trit-ah-kay-lee) is a hybrid cereal grain produced when durum wheat is pollinated with rye pollen.
- Approximately 11,500 to 13,000 seeds per pound
- No official bushel weight exists for triticale. 52 - 56 pounds per bushel is average.
- Triticale can yield 30 - 80 bushels/acre.

### **Management Considerations**

- Triticale yield, stress tolerance, and disease resistance (except ergot) are typically greater than wheat.
- Triticale is generally superior to wheat for pasture, silage, hay, and for grain used for feed.
- In general, triticale has superior drought resistance compared to barley, wheat, and oats.
- Triticale may have some allelopathic effect which can inhibit the germination and growth of small seeds but effect is not as high as winter rye.
- Triticale does not possess the grain traits of wheat so its greatest market potential is as animal feed either forage or grain.
- Winter triticale is as winter hardy as winter wheat but less than winter rye.
- When winter triticale is spring-seeded, vernalization will not occur so plants will remain vegetative (will not produce seed) and can be used for grazing.
- Winter triticale matures about five days later than winter wheat and about two weeks later than fall rye under similar growing conditions.
- Select fields with good drainage, sandy loam to heavy clay soil textures. Avoid fields that had cereal crops and forage grasses in the previous year to reduce risk of disease.

### **Optimum Planting Dates**

- Spring triticale should be planted as early as practical.
- Winter triticale should be planted in the fall on dates similar to winter wheat but even more care should be taken to leave surface residue to catch snow.
- Optimum dates for direct seeding winter triticale in Minnesota:

Location	Date
South of I-90	September 20 – October 10
Between I-90 and I-94	September 10 – September 30

### **Seeding Recommendations**

- Prepare the seedbed similarly to that for oats, barley, or wheat.
- Triticale should be seeded using a standard grain **drill about ½ to 1½ inch deep**.
- **Plant about 100 – 120 pounds per acre**. Use lower rate for grain production and higher rate for forage. Triticale does not tiller as much as wheat.
- Set grain drill 10 - 20 percent greater than for wheat as the seed is bigger and lighter in weight.

### **Fertilization** *(Please contact your fertilizer professional for your specific needs)*

- Basic agronomic practices are similar for winter wheat, winter triticale and fall rye.
- Fertilizer applications should be based on soil tests.
- Ensure adequate levels of phosphate (40 lb/acre) and potash (80 lb/acre) are applied in the fall.
- Nitrogen should be applied 1/3 fall and 2/3 spring providing a minimum of 100 pounds/acre of actual N for best forage production and highest protein levels.

### **Weed and Disease Control** *(This is not intended as a recommendation or endorsement of any specific product but as a list of possible controls. Please contact your chemical professional for your specific needs and always read and follow label directions)*

- Select fields with low weed seed density if possible. Plant early in a well prepared seed bed for rapid germination.
- Seeding early results in a more competitive stand establishment and provides a jump-start on the weeds.
- Triticale is slightly more susceptible to ergot than wheat. Use crop rotation and tillage to reduce incidence.
- Bromoxynil (Buctril) is registered for broadleaf weed control in triticale. No herbicides are registered for grass weed control, so the crop needs to be planted on relatively weed-free fields. Triticale grows slower than wheat in the spring and grassy weeds could be a problem.

### **Harvest Considerations**

- Optimum harvest stage for forage is when the plant is at the flag leaf or boot stage before head emergence. Protein content at this stage will vary between 14 – 19%. Generally, forage yields and palatability will be higher than for either wheat or rye.
- Triticale grain generally matures later than wheat or rye and has a higher protein content which makes it a good home-grown feed option. Attention must be paid to ensure that ergot levels are less than 0.1%. Newer varieties have fewer ergot problems. Combining standing grain rather than swathing first is advisable because triticale is more susceptible to sprouting in the swath than wheat.
- In high fertility situations, lodging can occur. Under such conditions, plan to harvest early.

## EINKORN

### Origin and Taxonomy

Einkorn is thought to have originated in the upper area of the fertile crescent of the Near East (Tigris-Euphrates regions). Wild einkorn *Triticum boeoticum* includes both the single grain *T. aegilopoides* and the two grain *T. thaoudar* and *T. urartu*. Cultivated einkorn is *T. monococcum*, and like wild einkorn has the genome constitution AA (Table 1). In cereal crops the head (inflorescence) if unbranched is called a spike. The spike consists of flowers (spikelets) arranged on the rachis (which is an extension of the stem). The flowers (spikelets) arise from nodes along the rachis which are called rachilla. The spikelet is enclosed by bracts, the glumes, or chaff. The kernels within the spikelet are enclosed in bracts, the lemma, and palea. As an example, kernels of free threshing wheats thresh free of the bracts; barley threshes free of the glumes, while lemma and palea make up the hull of the kernel; einkorn, emmer, and spelt thresh with the complete spikelet intact. A classification and description of *Triticum* sp. is outlined by Briggles and Reitz (1963). The wild and cultivated einkorn are differentiated by the brittleness of the rachis. The rachis of wild einkorn is brittle and the spikelets readily disarticulate when mature, whereas the rachis of cultivated einkorn is less fragile and remains intact until threshed.

Einkorn along with emmer and spelt are often referred to as "the covered wheats," since the kernels do not thresh free of the glumes or the lemma and palea when harvested (Fig. 1). In contrast to the free threshing wheats, the spikes of einkorn disarticulate at threshing (the seed head breaks apart into intact spikelets). The spikes disarticulate with the rachilla apex attached to the base of the spikelet. Einkorn has long narrow glumes which are awned. Cultivated einkorn generally has one kernel per spikelet.

Einkorn became widely distributed throughout the Near East, Transcaucasia, the Mediterranean region, southwestern Europe, and the Balkans, and was one of the first cereals cultivated for food.

Harlan (1981), cites information suggesting that wild einkorn grain was harvested in the late Paleolithic and early Mesolithic Ages, 16,000-15,000 BC. Confirmed finds of wild grain remains have been dated to the early Neolithic (Stone Age) 10,000 BC. (Helmqvist 1955; Zohary and Hopf 1993). Cultivated einkorn continued to be a popular cultivated crop during the Neolithic and early Bronze Age 10,000-4,000 BC giving way to emmer by the mid-Bronze Age. Einkorn cultivation continued to be popular in isolated regions from the Bronze Age into the early 20th century. Today, einkorn production is limited to small isolated regions within France, India, Italy, Turkey, and Yugoslavia (Harlan 1981; Perrino and Hammer 1982).

### Agronomy and Production

Historically, einkorn was cultivated in cool environments on marginal agricultural land through the Mid-east and southwestern Europe. Einkorn is still cultivated in harsh environments and poor soil in Italy (Perrino and Hammer 1984). Einkorn selections produced protein and yield equal to or higher than barley and durum wheat when grown under adverse growing conditions (Vallega 1979). Evaluations of 15 einkorn accessions grown in Italy indicate that the yields were significantly lower than that of modern wheats when grown under intensive cropping management (Vallega 1992). However, in this study several progeny of selected einkorn crossings (while lacking in several desirable agronomic traits) produced yields comparable to the modern wheats. Eighty einkorn PI accessions from (NSGGRF) have been evaluated for yield, straw characteristics, and date of heading at the Southern Agricultural Research Center, Huntley, Montana (SARC) from 1992 to the present. The yields of einkorn ranged from 4160 to 120 kg/ha, 1992; 1290 to 130 kg/ha, 1993; 2160 to 220 kg/ha, 1994; and 2400 to 720 kg/ha in 1995. The 1995 yield range represents 25 final PI accession selections (based on yield record and straw strength) of

which five produced total yields higher than oats and three higher total yields than the barley and wheat included in the trial. Einkorn grain yields in comparison to spring wheat under dryland cropping were dependent upon growing season environment (Table 2). The protein content of einkorn when threshed in the hull varied from 10% to 26% higher, and the grain from 50% to 75% higher than the protein content (12.5% to 13.5%) of the hard red wheats. Agronomic production practices for spring grains would be applicable to einkorn, which has a tendency to mature later than spring wheat. Einkorn may be most suitable for cropping in lower moisture environments similar to the northern Great Plains area of Montana. The einkorn accessions tested had only moderate straw strength, averaged 109 cm in height, and would be susceptible to lodging in high moisture environments. The susceptibility to diseases is unknown and may be expressed in high moisture environments.

## Marketing and Utilization

In the U.S., einkorn production is presently limited to evaluations of PI accessions for agronomic yield and quality traits, and or germplasm sources for plant breeders to improve protein and disease resistance in the development of modern wheats. However recent studies in Europe and Canada emphasized the nutritional quality of einkorn. Grain protein of einkorn accessions and progeny of einkorn crossings were consistently significantly higher than modern wheats (Vallega 1992). The data also indicate that given the significant increase in yields of the progeny and the higher grain protein, progeny lines produced significantly more protein/ha than the modern wheats. The amino acid composition of einkorn was found to be similar to wheat, irrespective of very large variations in total grain protein among the einkorn accessions tested (Acquistucci et al. 1995). The composition and nutritional characteristics of a selected spring einkorn were compared to spelt and hard red spring wheat grown in Canada (Abdel-Aal et al. 1995). The einkorn accession was considered more nutritious than the hard red wheat, based on the higher level of protein, crude fat, phosphorous, potassium, pyridoxine, and beta-carotene. The gluten of the einkorn accession had a gliadin to glutenin ratio of 2:1 compared to 0.8:1 for durum and hard red wheat. Flour and dough characteristics of gluten from 12 einkorn accessions were compared to durum and common wheats (D'Egidio et al. 1993). The einkorn flours were characterized by high protein, high ash, a very high carotene content, and small flour particle size when compared to the modern bread wheats. Dough characteristics of the einkorn accessions were significantly inferior to the modern wheats. The gluten strength was similar to that of soft wheats, but remained sticky, with a low water retention capacity. While breads made from einkorn were considered to be inferior to emmer or spelt breads (LeClerc et al. 1918), Bond (1989) states that breads made from einkorn in France had a light rich taste which left common bread wheat products tasteless and insipid by comparison. Bond also indicated that similar to ancient civilizations the einkorn grains were used in various food dishes such as soups, salads, casseroles, and sauces. The consideration that flour from *T. monococcum* may be non toxic to individuals with celiac disease (Favret et al. 1984, 1987) as cited by D'Egidio et al. (1993), and Abdel-Aal et al. (1995) suggest that given the nutritional advantage of einkorn and possible consumption by individuals allergic to common wheats, an increased interest will be given to the diploid wheats.

## EMMER

### Origin and Taxonomy

The sites of origin of emmer are considered to be similar to einkorn, within the regions of the Near East (Nevo 1988). Wild emmer *T. dicoccoides*, like wild einkorn is distinguished by the brittleness of the rachis, which disarticulate when mature. The rachis of cultivated emmer *T. dicoccum* is less fragile and tends to remain intact until threshed. The genomic constituents of emmer are described in [Table 1](#). The genomic constitution AA of emmer is thought to be derived from *T. monococcum*. Various sources of the BB genome have been suggested, *T. speltooides*, *T. searsii*, and *T. tripsacoides* (Morris and Sears 1967; Kimber and Sears 1987). Emmers are predominantly awned with spikelets consisting of two well developed kernels. Emmer glumes are long and narrow with sharp beaks.

The use of emmer as a cereal food is considered to be contemporary with that of einkorn. Similar to einkorn, the earliest civilizations initially consumed emmer as a porridge prior to developing the process of bread making.

Remnants of wild emmer in early civilization sites date to the late Paleolithic Age 17,000 BC (Zohary and Hopf 1993). Cultivated emmer emerged as the predominant wheat along with barley as the principal cereals utilized by civilizations in the late Mesolithic, and early Neolithic Ages 10,000 BC (Helmqvist 1955; Harlan 1981; Zohary and Hopf 1993). Cultivated emmer dispersion and use by early civilizations greatly exceeded that of einkorn. Due to the addition of the BB genome cultivated emmer could be grown in a wider range of environments including regions having high growing season temperatures. Cultivated emmer became the dominant wheat throughout the Near and Far East, Europe, and Northern Africa from the Neolithic (Stone Age) through the Bronze Age 10,000-4,000 BC. Emmer utilization continued through the Bronze Age 4,000-1,000 BC, during which the naked wheats, primarily the tetraploid species slowly displaced emmer. However, emmer continued to be popular in isolated regions such as south central Russia into the early 1900s. Presently emmer remains an important crop in Ethiopia and a minor crop in India and Italy (Harlan 1981; Perrino and Hammer 1982).

### Agronomy and Production

Several thousand hectares of emmer were grown throughout the midwest and western states in the early 1900s (Martin and Leighty 1924). During this period 5 cultivars and 3 selections were identified and evaluated for yield and quality traits. Emmer yields exceeded yields of barley, oats, and wheat cultivars in years which were characterized by less than favorable growing seasons, and produced equal or lower yields when growing conditions were more suitable for cereal production. Three hundred and 50 PI accessions from the NSGGRF were evaluated for yield and straw strength beginning in 1987 at the SARC. During the past nine years emmer yields (as threshed) averaged from 3,700 to 225 kg/ha. The yields of emmers in comparison to barley, oats, and spring wheat were variable, dependent upon growing season environments and locations. Higher yielding emmer PI accessions would equal barley yields and out yield oats in growing seasons which were less ideal for grain production. Advanced selections of emmer PI accessions produced grain kernel yields ranging from 48% to 74% of spring wheat under dryland cropping ([Table 2](#)). Emmer PI 254148, a black-chaffed accession with moderate height and straw strength outyielded barley in low moisture years and consistently outyielded oats in a five year study conducted from 1988-1992 at SARC (Schulz-Schaeffer et al. 1995).

Agronomic practices for emmer production are similar to oats. Emmer test weights are similar to oat test weights (360-440 kg/m<sup>3</sup>) when grown under dryland cropping at the SARC. Emmer seeding rates are

similar to oats, (76 kg/ha) in low rainfall and 100 kg/ha in high rainfall regions. Emmer should be swathed prior to threshing to prevent head shatter losses.

### **Marketing and Utilization**

Presently limited amounts of spring emmer are grown in scattered areas throughout Montana and North Dakota. Two unidentified emmer selections, Cenex emmer and common emmer are grown and available in limited quantities from a small number of seed grain dealers. Emmers marketed and grown in Montana and North Dakota are often mistakenly referred to as spring spelt. The Cenex emmer selection significantly out yields the common emmer which is usually sold by individual farmers. The emmers are grown for grain and used as cattle feed, replacing either oats or barley in feedlot rations. Protein levels of emmer as threshed ranged from 5%-35% higher than oats or barley, while the protein of the grain kernels ranged from 18.5%-21.5% in trials grown in Montana.

Milling and baking studies conducted by LeClerc et al. (1918) indicated that while emmer flour was satisfactory to produce a good loaf of bread, the quality was not equal to breads made from common wheat. Breads produced from whole grain flour of emmers grown at SARC were heavy textured with a pleasing taste that was milder than breads made from rye flour. A recent study at the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) in Mexico evaluated 137 emmer accessions using gel electrophoresis to identify selections which contain glutenin fractions known to contribute to bread quality (Pena et al. 1993). Evaluation of over 800 lines of wild emmers resulted in the identification of lines which had high protein and high molecular weight sub-units characteristic of gluten having good bread baking quality (Blum et al. 1984). Presently breeding and selection for superior emmer cultivars is being conducted at the Northwest Plant Breeding Co., Pullman, WA (C. Konzak, pers. commun. 1995).

## SPELT

### Origin and Taxonomy

The origin of spelt is controversial. While general agreement exists on the origin, extent, and utilization of wild and cultivated einkorn and emmer, archaeobotanists and cereal geneticists have proposed two primary hypothesis for the origin of spelt. One hypothesis suggests a single site of origin in the geographic region of present day Iran. The second suggests two independent sites of origin, the Iranian region and a southeastern European region. Suggested dates for the Iranian origin range from the mid-late Neolithic (Stone Age) 6,000-5,000 BC (Zohary and Hopf 1993). Some authors (Dorofejev 1971; Belea 1971) discuss the possibility of a much later independent European origin, others using genetic markers (McFadden and Sears 1946; Kuckuck 1964); seed protein profiles (Johnson 1972); and genes for resistance to rust (Kema 1992); cite data for support of a common origin such as the Iranian region. While the majority of evidence indicates the single site of origin, possible evidence for both sites are reviewed by Harlan (1981), Kema (1992), and Zohary and Hopf (1994) who reviewed 19 and 21 references by Zohary and Hopf respectively, specific to the origin of cultivated crops. The majority of evidence indicates that the origin of spelt must have occurred when either wild or cultivated emmer (AABB) dispersed to regions where *T. tauschii* (*Ae. squarrosa*) (DD) was an indigenous wild grass species.

The genomic constitution of *T. spelta* is described in [Table 1](#). Similar to the advantage of emmer AABB over einkorn AA, the addition of the genome DD contributed by the wild grass *T. tauschii* resulted in increasing the adaptation of spelt to an even wider range of environments. Spelt represents the hexaploid series of the *Triticum* genome constitution (AABBDD) which like the diploid and tetraploid einkorn and emmer is characterized as a "covered wheat," the kernels do not thresh free of the glumes, lemma, and palea. The spelt spikelets contain two well developed kernels, and are characterized by glumes which have wide square shoulders and short obtuse beaks. The spelt spikelets are most often awnless, however many awned selections also exist. While the rachis of the spelt seed head like cultivated einkorn and emmer is fragile, the point at which the spikelet disarticulate is distinctly different. In contrast to einkorn or emmer, which break apart with the rachilla attached to the base of the spikelet, spelt spikelets break apart with the rachilla remaining attached to the face of the spikelet rather than at the spikelet base ([Fig. 1](#)).

Spelt was widely distributed from the Near East origin during the Bronze Age (4,000-1,000 BC), throughout the Balkans, Europe, and transcaucasia. Some of the earliest recordings of spelt appear in the Bible (Exodus 9:30, Isaiah 28:25, and Ezekiel 4:9). The first reference to spelt is found in the "Edict of the Roman Empire Diocletian," in 301 (Flaksberger 1930). Along with the free threshing wheats, spelt may have played a role in the first politically established welfare system in Rome, beginning in 59 BC when after food riots, grain was distributed free to the Roman citizens (Harlan 1981). The wide distribution of spelt was facilitated by the northern and southern route migrations of early civilizations westward. Spelt production continues to be a major cereal crop in isolated regions throughout southeastern Europe, primarily in Germany and Switzerland.

### Agronomy and Production

U.S. production of emmer and spelt peaked in the early 1900s and declined steadily thereafter. The first recorded U.S. production information on emmer and spelt, records 233,000 ha, primarily in the states of North and South Dakota, Kansas, Nebraska, and Minnesota. Limited production of spelt also occurred in Wisconsin, Michigan, Iowa, Illinois, Indiana, Montana, Wyoming, and Texas. Production decreased rapidly during the next ten years to 68,000 ha in 1919. This included predominantly winter spelt and spring emmers. Martin and Leighty (1924) documented the production and utilization of the "covered

wheats" einkorn, emmer, and spelt in the U.S. and cited over 70 publications dating from 1899 to 1924. Five spelt cultivars were known to be grown in the U.S. during the 1900s. Martin and Leighty (1924) review 52 studies conducted from Texas to Canada on the yield of emmer and spelt in comparison to barley, oats, and wheat. The inconsistent yield potential and higher protein advantage of spelt could not compete with the progress of breeding programs which improved the yields and quality of barley, oats, and the free threshing wheats. Factors such as limited availability of adapted cultivars, low test weight 465-310 kg/m<sup>3</sup> in addition to time and expense of dehulling (for grain use) also contributed to the loss of interest in the covered wheats.

Environmental conditions, particularly growing season precipitation, significantly affected the yield competitiveness of spelt. Winter spelt often outyielded spring oats and barley when early growing season temperatures are cold and moisture is limited. Studies conducted in Germany indicate that the hull of spelt provided an advantage to the seed germination (Ruegger et al. 1990a) and provided protection against soil borne pathogens (Riesen et al. 1986), in conditions unfavorable to germination. Rates of C<sup>14</sup> assimilation into developing spelt and wheat kernels were evaluated by Ruegger et al. (1990b). Results indicated that low temperatures had less effect on C<sup>14</sup> assimilation into the spelt kernels as compared to wheat.

Yields and agronomic traits varied significantly among the spelt PI accessions grown under dryland at the SARC. Studies (1990-1995) of 1000 PI accessions indicated wide variations in yield (7000-1000 kg/ha), test weight (462-315 kg/m<sup>3</sup>), days to heading (154-166 days), plant height (97-140 cm), and kernel protein content (15.8-19.2%). Winter spelt data (average of the five highest yielding selections) is compared to winter wheat ([Table 3](#)). Spelt yields are given as harvested with the kernel in the hull, and kernel yield only as estimated for a 60% kernel weight thresh out. Percent kernel weight thresh out during the 4 year study ranged from 55%-75%, thus 60% is a conservative estimate. Yield percentage of spelt grain in comparison to the hard red winter wheat check varied from 55%-97% during the 4 year study. Total harvested yields (hull and grain) of spelt grown in Montana were often higher than the total weight of wheat grain harvested. The protein content of the covered wheats when threshed in the hull varied from 10%-26% higher than the protein content (12.5%-13.5%) of hard red wheats, thus offering a potential feed advantage when used for livestock growing rations. However, if used for high concentrate fattening rations, the feed-to-gain ratio is less than barley or maize due to the high percentage of fiber (hull portion) of the covered wheats. Feeding studies with dairy cattle and poultry indicated that the feed value of spelt was similar to oats (Arscott and Harper 1962; Ingalls et al. 1963). Yields and protein content of winter spelt harvested for forage were significantly higher than traditional hay barley or spring oat cultivars (Stallknecht and Gilbertson 1995).

In Montana, some cattle producers in regions of low growing season precipitation, plant spelt in preference to spring oats due to the yield advantage of the winter spelt. Spelt production has however varied significantly. In 1987, 200 Montana farms grew 7300 ha, compared to 1992 when spelt production was recorded as 25 farms and 700 ha (Census of Agr. 1992). Limited spelt production occurs in Pennsylvania, Michigan, Indiana, Kansas, and North Dakota. At present, major spelt production in the U.S. centers in the Midwest, specifically Ohio, which has over 12,000 ha.

'Champ' (a spelt/wheat cross) developed by Ohio State University (Lafever 1988) was the first spelt cultivar released in the U.S. Lafever also released 'GR900', a head selection from a mixed spelt population. Lafever has continued to develop spelt cultivars, for Sunbeam Extract Co. (H. Lafever pers. commun. 1995). Six advanced spelt lines, developed by Sunbeam Extract Co., were included in a yield trial conducted at the SARC in 1995. These lines produced 25%-40% greater yields than the highest yielding spelt PI accessions or spelt cultivars included in the 1995 trials. Northwest Plant Breeders Co., Pullman, Washington is also involved in the development of potential spelt cultivars (C. Konzak pers. commun. 1995). Proprietary European cultivars of spelt, utilized specifically for human food are presently



grown in the U.S. for Arrowhead Mills, Texas, and Purity Foods, Michigan (B. Cater pers. commun. 1995; D. Stinchcomb pers. commun. 1995). Foundation and certified seed of Champ, GR900, and an old standard German cultivar, 'Oberkulmer' are available from Frenchs Inc., Waheman, Ohio (L. French pers. commun. 1995).

General information and practical production guides are available for producers interested in spelt production (Lafever and Campbell 1976; Oplinger et al. 1990). The suggested seeding rates for spelt in the Midwest are 90-112 kg/ha. Information generated at SARC, indicated no differences in spelt yields when planted at 67 or 100 kg/ha on dryland or at 100 or 134 kg/ha under irrigation. Seeding of the large hulled spelt seed can be accomplished by use of grain drills which have adjustable openings of sufficient size to accommodate the large pointed seed, and allow for the planting of adequate seeding rates. Smooth drop tubes are desired to prevent seed from lodging and plugging the tube. Midwest studies suggest lower nitrogen fertility rates for spelt in comparison to wheat to compensate for susceptibility to lodging. However, SARC studies have identified selections with excellent straw strength. The advanced semi-dwarf types from Sunbeam Extract Co. have excellent resistance to lodging under higher nitrogen levels which increase the yield potential of spelt. Spelt harvest is generally accomplished by swathing the grain when the stem has not completely turned color. Delayed harvest can result in significant head shatter at maturity.

Studies on the nutritional aspects of spelt report wide variability in the chemical constituents of the grain. Ranhotra, et al. (1995) present data which show few differences between a hard red wheat cultivar and a Canadian spelt selection. The grains were evaluated for gluten traits, chemical composition, amino acid composition, and protein efficiency. The data suggests possible validity to the claim that spelt may be easier for humans to digest than wheat. Recent studies have reported variations in protein, lysine, vitamins, crude fat, minerals, and gliadin/glutenin ratios among spelt selections (Abdel-Aal et al. 1995; Ranhotra et al. 1995, 1996a). A study was initiated by SARC in 1994 to evaluate the performance of three spelt selections, and two hard red wheat cultivars for yield, protein, lysine, fiber, and carbohydrate content over five environments in Montana and North Dakota (Ranhotra et al. 1996b). Results indicate that while variable among locations, the protein content of all spelt selections grown at all locations was consistently higher (18%-40%) than that of the hard red wheats. Lysine content was lower in spelt compared to the wheat, and was inversely related to percent protein. The inverse relationship between percent protein and lysine content of spelt has been reported previously. Variations in protein and lysine content and the inverse protein/lysine relationship were recorded for 164 spelt selections grown over a three year period in Belgium (Clamot 1984). The results on nutritional constituents of the preceding study indicate that variations in the protein content of the grain for a given species is highly dependent upon cropping practices and environmental conditions.

## **Marketing and Utilization**

Spelt is the only "covered wheat" species grown and marketed in the U.S. for human food. Stimulated by market promotions, spelt planted for human consumption increased from less than 40 ha to over 3200 ha between 1987 and the present. Organic and commercial spelt are grown under contract and graded for test weight and percent protein (B. Carter pers. commun. 1995; Stinchcomb pers. commun. 1995). Spelt products are available through organic health food outlets as grain, whole grain and white flours, and processed products. Processed products include assorted pasta, cold and hot cereals, and pre-packaged bread, muffin, and pancake mixes. Baking qualities of spelt cultivars available in the early 1900s were evaluated by LeClerc et al. (1918). The authors reported that good loaves of bread could be produced from spelt flours. Evaluations of spring spelt accessions for bread and pasta products have been conducted in Canada (Hucl et al. 1995). Results indicated that spelt flours treated with an oxidant produced loaf

volumes similar to bread wheats. The Canadian researchers anticipate releasing a spring spelt cultivar in 1996.

The suggested attributes of spelt relative to wheat are ease of digestion, taste, and that individuals with certain allergies to common bread wheats can consume spelt. The success of The Berlin Natural Bakery, Berlin, OH, a major commercial bakery of spelt products is based on the attributes given to spelt (H. Graves pers. commun. 1995). In Europe spelt harvested in the hard dough stage and roasted is called "Grunkern," and is considered a "gourmet" food to be used in breads, cereal, soups and casseroles.

# Oats

## General Information

Oats (*Avena sativa* L.), while difficult to process, are relatively simple to grow in the northeast. They do very well in cool, moist climates, grow quickly, and are able to tolerate mild frosts. Oats have been eaten for centuries and have traditionally thrived in the cool climates of Scotland, Ireland, Germany, and Scandinavia. Because oats were well-known as animal feed before they were milled for human consumption, the first producers of oatmeal for humans were actually ridiculed. Now, however, oatmeal is considered a healthy and elemental part of many people's diets.

There are both hulled and hull-less varieties of oats available. In addition to grain for human and animal consumption, oats are often grown in the north as a cover crop primarily for weed control and soil improvement. However, they are a delicious cereal crop that is high in nutrition as well (oats generally contain between 12 and 22% protein). Oats for human consumption, or milling oats, should be plump and heavy. Some growers have found that heirloom varieties, like 'Rodney,' are more productive and can combat weeds better than their shorter-stemmed contemporaries. The most commonly-grown species of oat in northern climates is common white oats, which tolerate cool weather better than the red oats sometimes grown in the southern United States.

## Planting

In our northern New England climate, oats are planted in early spring, at a depth of about 1-2 inches, and harvested in mid-summer. Compost or manure should be applied in the fall preceding planting, and oats should be planted in moderately fertile, well-drained soils. Oats require more water than other cereals, however, and will do well in seasons with adequate rainfall. It is recommended that in the autumn prior to planting, oat growers disc and ridge their soil to aerate and warm the soil more quickly in the spring; this will help reduce the chances of damage caused by phytotoxins (harmful toxins in soil residue). A general rule of thumb for the northeast is that oats will do well in the same sorts of soils preferred for potatoes.



Because oats do well in cool weather and can tolerate light frosts, they should be planted as early as possible, once the ground is workable. They will germinate more quickly than most cereals, compete against early weeds and take advantage of spring moisture in the soil. Usually oats are planted with a grain drill at a rate of about 2.5 bushels/acre (80 lbs/acre). Seed can also be broadcast and then gently tilled or culti-packed, but the seeding rate may need to be increased to 3 bushels/acre (96 lbs/acre) to allow for the same germination. Thin-hulled varieties of oats generally produce higher yields (and groat percent, or the percentage of the entire kernel's mass that is usable groat), and can contain more protein as well. In a small-scale or home garden, preparing and planting oats can be done with a rotary tiller. Work the soil in the fall preceding

planting, hand-broadcast the seed when the soil warms up in the spring, and then gently till the seedbed again to bring the seeds into contact with soil.

Although oats do grow well in fertile soil, they grow without heavy fertilizing, and can in fact be adversely impacted by high additions of nitrogen. Once the growing season has begun, the color of the plants will help indicate the fertility of the soil; dark green oats signify soils that are too high in nitrogen and will be more likely to lodge, or fall over, whereas light green plants will indicate that the nitrogen in the soil is inadequate and will possibly yield poor-quality oats. (If your oats are not high-quality enough for milling, they can often be used as animal feed instead.)

## Cultural Practices

Rotating cereal grain crops is an efficient way to control weeds. In addition, oats are often planted with red clover, which will crowd out weed populations and can be left in the ground for another year of growth. This will ultimately improve soils by adding nutrients to the field while reducing potential for erosion. Clover can either be inter-seeded at the same time as oats with a grain drill or broadcast after the oats have established themselves. If broadleaf weeds are a problem in the field used for oats, growers can plant their oats and then blind-harrow with a light-weight harrow before the oats emerge to kill upcoming weeds. Legumes like clover can then be broadcasted once the oats are in the three- or four-leaf stage. If necessary, oats can be cultivated with a tine-weeder to knock down weeds, but the oats themselves will compete fiercely with weeds further into the growing season. In small gardens or plots, oats can be planted in rows and cultivated to minimize weeds.

If the oats are harvested as a cereal crop, their stalks can be chopped and left on the ground, and the stubble will catch snow and protect the soil through the cold northeast winter. Because the roots and stalks of oats are rich in carbon, they can then be turned into the soil the following



spring to improve soils. Oats are often used in this way as a “catch crop” for their ability to take up excess soluble nutrients, which are re-released once the plant is tilled into the soil and broken down.

Leaf or crown rust can present a problem for oat growers, but rust-resistant varieties are now available, and removing any potential hosts (such as wheat, triticale, and wild grasses) from the edges of fields will also minimize damage. Rust has proven to be more of a problem in southern and central areas of the United States, but northern growers should be aware of its existence. Likewise, aphids have been known to enjoy oats. To minimize diseases and pests, rotate crops and avoid planting oats in the same field year after year, or immediately following a crop of other grains.

## Harvesting & Storing

When ripe, healthy oat plants should mature into a solid yellow color. They should not be harvested for grain until they are very ripe, unless they are to be windrowed. For milling, growers should choose a variety of oats with a plump kernel and, ideally, a test weight of at least 38 lb/bushel. A test weight any lower than 30 lb/bushel indicates that the harvest contains

shriveled oats with little potential for both germination and nutrition. As oats are evaluated by processors for milling quality, the important characteristics of good oats are generally high test weight, bright groat color, high groat percent, low oil content, and high protein and beta-glucan content.

Usually, oats can be harvested about 12 weeks after they are planted. In areas where weeds are prevalent, it may be beneficial to swath, or cut, the crop before combining. Weeds will certainly make harvesting more difficult, and the weed seeds and chaff can be difficult to separate from the oats. Swathing the crop first, and then windrowing oats, will allow further ripening and drying, as long as conditions are dry. Some combines have pickup attachments that can harvest these windrows, and many northern growers use this method, insisting that oats ripen slowly and unevenly on the plant.

Oats should have 12 to 12.5% moisture for harvesting and storage, and should be harvested only when conditions are dry. In some cases, further aeration will be required once the oats are harvested. To keep oat quality high, it is important to keep your crop free of insects and mold, and carefully dry and store the crop.

Oats can be threshed and winnowed just like wheat, but the further processing necessary for human consumption is a rather difficult process. Oat groats have a hard, tight hull around them, and this must be removed before eating. De-hulling oats is a complicated process, generally done either with a compressed-air or impact de-huller. For large-scale growers it may be difficult to find processing facilities. There are hull-less varieties of oats, *Avena nuda* L., but some growers in the northeast avoid “naked oats” because of their low yields and high desirability to birds (others suggest that because the plants are not usually strong enough to support a hungry bird’s weight, bird damage is not a serious problem).



When oats were first harvested for human consumption, they were hulled with stone mills, winnowed to remove the hulls and debris, and ground into course flour, which, then required three or four hours of cooking time in order for the lumpy, pasty oatmeal to be eaten. Now, processors heat oats to make the hulls brittle and easier to remove, then remove the hulls from groats with impact or compressed air de-hullers. The groats can then be used as is (although they take much longer to cook this way) or sprouted. They can be rolled and flaked or steel-cut for oatmeal. Oats are sometimes steamed for a longer shelf life, which stabilizes the lipase enzyme (problematic because of oats’ relatively high fat content). However, in cool climates, many suggest that steaming may be an unnecessary step for small-scale growers, unless the oat variety is very high in oils and causes concern over rancidity.