or panicles appear. Barley flowers more nearly at the
time of head emergence. Symptoms of freeze injury at
heading and flowering are nearly identical.

The flowering stage is the most temperature sensi-
tive. Small differences in temperature, duration of ex-
posure or other conditions can cause large differences
in amount of injury. Usually, light freezes at this stage
will result in an appearance of more-random damage
than at other stages. More-severe freezes usually cause
the entire head to be sterile. It is common for the awns
to bend at nearly 90-degree angles from the rachis as
they mature (Fig. 7).

Milk — Zadoks scale 71-77

Developing cereal kernels normally grow to full size
about 2 weeks after flowering. Maximum grain weight,
however, is not reached until 3 to 5 weeks after flow-
ering, the length of time depending on temperature and
variety.

If young kernels fail to develop after freezing tem-
peratures, they likely have been injured. Injured ker-
nels may be white or gray and appear rough and
shriveled instead of light green and plump. If the freeze
is followed by cool weather, symptom appearance may
be delayed a week or more.

Injured kernels may initially grow to normal size, but
they produce light, shriveled grain at maturity. Their
contents may be off-color and liquid instead of viscous.
The rachilla or short stems that hold the florets in the
head may also be darkened. Often, damaged forets are
easily stripped from the rachillas.

Cereals frozen at the milk stage often shatter easily
at maturity, and the shriveled kernels produce low test
weight grain. Germination percentage is usually reduced
as a result of freeze injury.

Dough — Zadoks scale 83-89

Kernel development is completed during this stage.
Cereal kernels frozen at this stage are likely to have
slightly reduced test weights and to appear shriveled
or wrinkled. Yield reductions are usually minor. The
embryo (germ) has a higher moisture content than other
kernel parts, and its complex of cellular contents and
structures makes it more vulnerable to freeze damage.
Seed germination and barley malt quality may be
reduced.

Management of freeze-injured cereals

Making the best decisions concerning the crop re-
quires accurate assessment of damage. Except in rare
cases, freezing in any given field usually injures only
a part of the cereal crop. Damage may be worse in low
areas or on a slope where the crop is at a more-
susceptible stage of maturity.

Late tillers that may not normally produce grain of-
ten develop rapidly after main tillers are killed by a
freeze, particularly when damage occurs in early growth
stages. If after-freeze conditions are favorable, these
tillers can account for appreciable yield. Most often,
however, late tillers have significantly reduced yields
and the grain is poorly filled, giving low test weights.

Efforts to force wheat to retiller after the initial crop
was cut due to freeze or hail damage have been gener-
ally unsuccessful if the crop was in the boot or later
stages of growth. Barley and oats may retiller more than
wheat.

Harvest for grain

When damage assessments indicate that adequate
yields can be obtained, leaving the crop for grain har-
vest is often the producer’s best choice. Freeze dam-
age that occurs before heading and flowering usually
does not adversely affect the development of individ-
ual kernels. However, low test weight may result from
stem damage. Freeze injury after the flowering stage
usually leads to shriveled, poorly filled grain. Germi-
nation percentage is also often affected.

Grain that has been frozen after flowering should not
be used for seed unless the seed has normal test weight
and thorough germination tests indicate normal germi-
nation. Numerous tests have indicated that normally ger-
mating seed with low test weight will produce weaker
seedlings and lower yields than seed of good test weight.
Because of a natural seed dormancy in cereal varieties
after harvest, germination tests should be conducted only
by a qualified laboratory, and seed should be pre-chilled.

Most wheat from freeze-injured fields is suitable for
normal milling and baking. Crops that are badly shrit-
eled are usually poor in quality due to their low test
weight; discolored, chalky endosperm; and mixture of
different kernel sizes and maturities. Grain this badly
damaged should not be used for milling and baking.
Malt barley that has been freeze injured after the heading
or flowering stages will probably not pass the require-
ments of brewing companies.

Severely shriveled grain is best used as a livestock
feed. Protein in shriveled grain is usually high. Freeze-
injured grain should be gradually incorporated into feed
rations.

Hay, silage or grazed forage

If the field inspection indicates low grain yields, cut-
ting a freeze-injured cereal for hay or silage may be
the most economical and practical use if feed is need-
ed and harvesting equipment is available. Feed quality
of cereals harvested up to the soft dough stage is gener-
ally excellent.
If the crop is to be used for hay, silage or grazed forage, check its nitrate content to be sure it is not toxic to livestock. Freezing normally does not kill the entire plant, and the roots may continue to absorb nitrates from the soil. With no grain to use the nitrates, they may accumulate in the forage. If the crop contains high nitrate levels, do not use it for hay, silage or grazed forage unless you can adequately dilute it with low-nitrate feeds.

When ensiling a cereal crop, take extra care to ensure tight packing. Proper packing of cereals is difficult because of their round, hollow stems. As the crop develops toward maturity, proper packing becomes increasingly difficult.

Harvesting for hay or silage removes a crop faster than is generally possible by grazing. This earlier harvest may be important if another crop is to be planted in the field in the same crop year. Harvesting for hay or silage also makes it possible to avoid working the vegetation into the soil, which can cause excessive soil moisture loss on dryland fields.

Wheat and barley awns in crops cut after flowering can cause actinomycosis, commonly known as "big jaw" or "lumpy jaw," in cattle. Actinomycosis is much less likely to occur when the crop is harvested before flowering or ensiled than when it is harvested at a later growth stage or fed as hay.

**Alternative crops**

Some areas of the state have much more flexibility with alternative crops than other areas. Parts of the state with irrigation water and a relatively long growing season have available numerous alternative crops if freeze damage occurs before or at heading. In higher elevation areas where the growing season is short, replanting to another shorter-season cereal may be possible. If you decide to replant to another crop, kill the freeze-damaged crop either with chemicals or tillage to prevent it from becoming a weed in the new crop.

Before deciding to plant an alternative crop, be sure that your evaluation includes all costs of removing the freeze-injured crop and reseeding the new crop. Yield potential falls with later-than-optimum seeding dates. For example, at the University of Idaho Research and Extension Center at Aberdeen, yields of spring barley were reduced about 10 bushels for each week planting was delayed between mid-April and early June. Other crops and areas may differ in their response. Always consider yield reductions and reseeding costs before making final decisions.