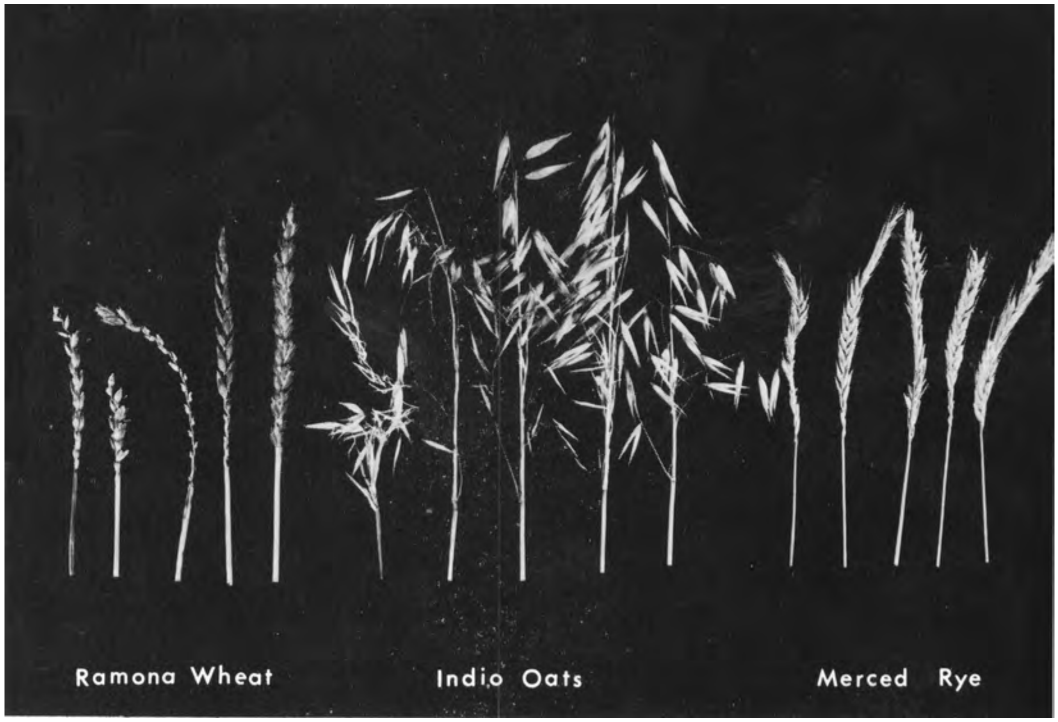


Five heads each of wheat, oats, and rye with variable frost injury, left to right, at Davis, California, 1963.

EFFECTS OF COLD

C. A. SUNESON

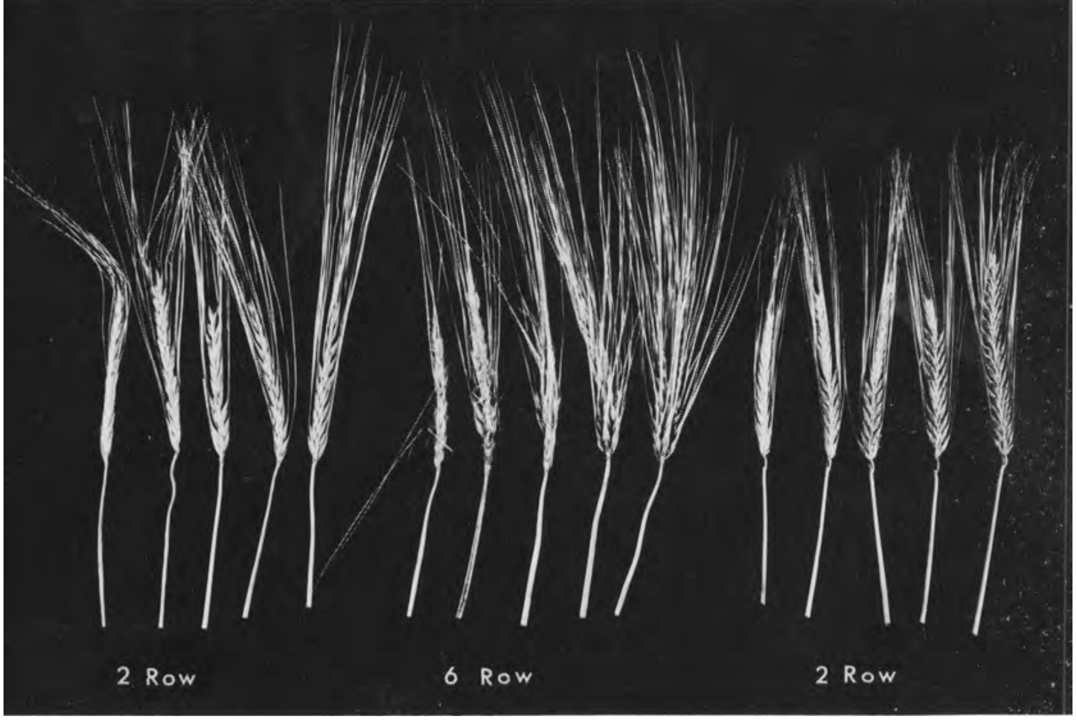
FROST DAMAGE to the floral parts of grain heads (prior to, during and immediately after pollination) is surprisingly common in California, other mountain states, and many cereal-growing areas in the world. Development of early maturing varieties has intensified the problem in all areas, particularly where cereals are fall sown. Many seed and fruit crops also can be damaged by frost. Most plants are extremely sensitive to temperature in stages of rapid growth and reproduction. This is especially true of plant reproductive organs.

Ordinarily, only very early- or very late-flowering cool season cereal crops encounter frost at the heading stage (whether flowering is controlled genetically or by planting date). Very late-flowering varieties may be damaged by frost near the end of the growing season. The damage is most common in low-lying areas, irrespective of general topographical elevation. Injury generally is associated with minimum temperatures in the 29°- to 35°-F range during the most active periods of reproduction. With a climate and topography as diverse as that in California, frost damage occurs as early as February in the Imperial Valley, below sea level, and as late as July in the northern mountain counties, in areas about 5,000 feet above sea level. Thus, frost is a problem somewhere in California every year. Actual observed yield losses have ranged up to 90%, so frost damage can be as disastrous as any disease on barley, wheat, oats and rye.

Portions of heads or even entire heads may be killed by frost, as shown in the photos. The range for the crops and varieties shown may result from microclimate temperature differences, different stages of development when subjected to frost, or a genetic difference. The glumes of rye and oats are generally injured less than those of wheat or barley. The photo of barley damage shows that the glumes and awns of six-row barley are generally more tender than in the two-row varieties. It is important to recognize that often only one frost is involved, and its immediate effects are felt over a period never exceeding a few hours. The degree of uniformity in flowering can vary widely due to topography, nutrition, or plant density differences. For example, if the first four heads, left to right, of any of the barley examples shown in the photo represent the initial pre-frost potential yield for a crop, then the post-frost potential is principally dependent on heads like No. 5 coming from later tillers which usually would be suppressed by competition in a normal unfrosted barley crop. Even though the first head in each group in the photo has been killed, its leaves and stems continue to compete with and limit the light and nutrients supplied to the late tillers.

Flowering in the cereal plant usually takes place shortly after the head is exserted from the "boot" although very early-planted grain may flower and be pollinated while still in the boot. Flowering usually takes place over a 3- to 7-day period on an individual head, while flowering within a field may extend over a 15- to 20-day period.

Pollination in cereals is the transfer of ripe pollen from the dehiscing anthers (male parts) to the pistil (female part). Cereals generally are highly self-pollinated, with the pollen transfer occurring within the individual floret or grain-producing flower. After the pollen is deposited on the stigma, the pollen grains "germinate" and elongate tubes down into the ovary of the style—one ultimately piercing the "egg," thus fertilizing it. During the period when the pollen tube is extending to reach the egg its growth may be slowed or stopped by unfavorable temperature.



Five heads each of 2-row, 6-row barley and a second 2-row variety with variable frost injury, left to right at Davis, California, 1963. The first head in each group of 5 set no seed. The fifth head from the left, in each case, came from a late developing tiller, which escaped with minimum frost injury.

ON CEREAL CROPS

M. D. MILLER

Spike development in barley and wheat, as well as flowering, proceeds from about the center toward both the base and tip. In the case of the oat panicle, development and maturity proceed from the topmost floret downward to the base. This explains seed set only in the middle or at one or both ends of a head.

At temperatures near 32° F there is no killing of glumes, but the greater susceptibility of the male flower parts may become evident through their sterility. This too can be total or banded on a head depending on the rate and stage of growth at the time. Such sterility was common at U.C., Davis in 1963, and could not always be distinguished from genetic or cytoplasmic male sterility. From general observation and controlled experiments, we know that subsequently such flowers, when artificially supplied with pollen, will often set seed. Frost has proven to be one of the causes of cereal hybridization and evolutionary change—and resulting adaptation of the species to local conditions.

To better understand nonfrost, low-temperature-induced sterility, rice, a warm season cereal will serve to illustrate the rather precise requirements of cereal plants in general for successful seed formation. The nonadaptation of rice to certain parts of California results from growing season temperatures that are too low for effective flowering because of prevailing cold sea-breezes or, in some cases, because of excessively cold irrigation water now being received from high storage dams.

Low air temperatures can be very deleterious at three stages of the rice plant's growth and reproduction, according to C. Roy Adair, USDA plant scientist. These are: (1) 20 to 24 days prior to heading, (2) 12 to 14 days before heading and finally (3) during anthesis. During period 1, the panicles are developing. In period 2, the reduction division of the pollen mother cells occurs. Anthesis (3), is the period of pollen maturation and actual pollination. During these periods the critical air temperature was approximately 40° F, with unfavorable temperature effects being most pronounced on the male portion of the flowers. Interference with the reduction division of the pollen mother cells inhibits normal pollen formation, resulting ultimately in high sterility. Note that the critical temperature is well above the freezing temperature of 32° F. Wheat and rye also do not pollinate at 32° F, but wait for higher temperatures.

Pollination

Although studies at the Rice Experiment Station, Biggs, have shown that some pollination in rice can take place at 45° F, higher temperatures are needed for most efficient grain set and formation. For effective lodicule swelling (organs at the base of the florets which open the glumes at anthesis) the temperature must have been approaching 70° F for several hours. By 12:00 noon then, providing the aerial temperature is 70° to 75° F, pollination begins and proceeds very effectively until about 2:00 pm. By 4:00 pm it has practically ceased. A rapid drop in temperature before the pollen tube penetrates the egg can slow fertilization or even stop it.

Management practices growers can use to minimize the possibility of frost injury to barley, wheat, oats, or rye include at least five precautionary steps:

(1) Select an adapted variety in the maturity group which will head and flower within the frost-free part of the growing season.

(2) Plant the variety at a time that will allow it to escape frost at heading and flowering.

(3) Do not seed too heavily. Very high seeding rates frequently result in exces-

sive competition between plants and a more succulent, less frost-resistant plant that is incapable of generating new tillers.

(4) If the crop appears to head too early and becomes subject to a number of frosts, it may be mowed or grazed back—preferably before the stems are strongly jointing or elongating. This procedure can backfire however, if there is not enough residual or added fertility and soil moisture to mature the new or second crop of tillers. If the field is clipped, the crop residue should be promptly removed from the field so that the decomposing or dry residue does not impede recovery of the cereal plants. The use of a green-chop machine which leaves a stubble of 6 to 8 inches has proven an effective method of accomplishing this result.

(5) Where crop irrigation is possible, growers with warmer-than-air irrigation water can actually warm a field by irrigating just before and during a forecasted frost.

Severe frost

When a severe frost strikes a cereal field at the very critical heading and flowering period, in most cases it is best to graze or disc the frost-damaged crop and prepare to plant a spring or summer crop such as grain sorghum, corn or millet. When crop salvage seems to be a possibility, the best bet is to high-mow or roll the field—thus improving the access of light to the crown area to stimulate new tillers. This should then be followed by a top dressing of fertilizer and an irrigation. Regardless of what is done the salvage will only be partial.

Rice growers consistently confronted with the cool water temperature problem also have certain management alternatives: (1) In areas where irrigation water is consistently less than 65° F, growers may use warming basins before turning the water into their seeded fields. For highest yields, rice irrigation water in the paddies during most of the day should average from 76° to 78° F. (2) Select a variety, such as Caloro, that is more resistant to the cool water temperature than other California varieties.

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PLASTIC AND FOR

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V. Q. HALE • J. R. STOCKTON • L. DICKENS

ARTIFICIAL MULCHES have made possible the planting of cold-sensitive crops during seasons of adverse temperature conditions. In many areas of the United States, the use of plastic film in high-return vegetable and fruit crops has become common. These artificial mulches increase soil temperature, permit earlier planting, induce earlier emergence, produce more vigorous seedlings, and hasten maturity.

These trials in the San Joaquin Valley were conducted to determine how the effects of plastic and petroleum-derived mulches differ with soil types, and the effect of these materials on the development and yield of the cotton variety, Acala 4–42.

Three mulch materials—black plastic film, clear plastic film, and petroleum-derived mulch were compared with an unmulched control at the U. S. Cotton Research Station, Shafter, on Hesperia fine sandy loam, and at the University of California West Side Field Station, Five Points, on Panoche clay loam. Tests at Shafter consisted of four replications of four-row plots, 286 ft long, with 40-inch row spacing. At Five Points the rows were 180 ft long with six replications. Rows ran east and west at both locations. All planting and mulching operations were performed between March 11 and 14.

Twenty-inch-wide rolls of plastic film were laid by a machine which rolled the beds, placed the film, and covered about 5 inches on each side with soil to anchor the film. Cotton was machine-planted through the plastic with vermiculite containing fungicide placed over the seeds, and followed with a press wheel. Holes were spaced 8 inches apart with from one to three seeds per hole. The petroleum mulch was sprayed in a 7-inch band at the rate of 100 gallons per acre immediately following planting with a conventional-type planter.

A serious weed problem beneath the film necessitated removal of the clear plastic from plots at Shafter on May 16, and at Five Points on June 5. The seeding rate for the plastic film treatments at both

Planter used with plastic mulches. This planter punches a hole in the plastic and plants the seeds with treated vermiculite.