Management decisions can reduce blanking in rice

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Early maturing, short-stature varieties; careful water management, and moderate use of nitrogen reduce excessive blanking.

Yield reductions in rice caused by floret sterility (commonly called blanking) can be severe. The amount of blanking varies from field to field and from year to year, creating confusion as to the causes and the steps to avoid losses. Varieties differ in their susceptibility to sterility; however, after the variety has been selected, the most important factors regulating blanking are environmental. Cool night temperature is the primary cause of blanking, and rice-growing areas influenced by nightly cool marine breezes from San Francisco Bay are most susceptible.

Minimum nightly temperatures below 55° F occurring on several successive nights from 7 to 21 days before 50 percent heading are almost certain to cause blanking. At this time young flowers are being formed on the developing panicle, which is still enclosed within the stem. The panicle is usually 6 to 12 inches above ground level. Injury from cool temperatures causes abnormalities in certain dividing cells that ultimately form the pollen grains.

Growers can reduce blanking losses by choice of variety, early planting, water management before heading, and avoiding excessive nitrogen fertilization rates. Cold irrigation water also contributes to sterility; growers have sometimes used warming basins before the water enters the rice field.

Tolerant varieties

Blanking occurs in all rice varieties under unusually cool conditions, but some are more susceptible than others. Those least affected have true genetic tolerance to cool temperatures, mature early, and are of short stature.

True genetic tolerance, fortunately, is present in japonica-type varieties that have been grown in California for many years. These varieties sharply contrast with indica types of tropical origin, which under California conditions are extremely susceptible to cool temperature injury. Within the japonica type, it is possible to select for increased cold tolerance, and this tolerance may be associated with abundant production of pollen grains.

Varieties or selections that mature earlier generally show less blanking than later maturing ones of similar genetic make-up. The three early selections listed in the table averaged 105 days to heading and 16.6 percent blanking; the six late ones averaged 118 days to heading and 24.5 percent blanking.

The basis for the difference in blanking of early- and late-maturing varieties is the climatic pattern in California's rice-growing area. Injurious low night temperatures occur with increasing frequency after mid- to late July. Varieties that head at around 100 days from planting reach the cool-temperature-sensitive stage during the last half of July when night temperatures normally are warmest.

Comparisons between short-statured and tall varieties within similar types were made possible with development of the short-statured mutant from Calrose, grown under the varietal name Calrose 76. This and other short-statured varieties developed from it have shown less blanking than their tall parents. Water is consistently warmer than air at night. The panicle of a short-statured plant is closer to the water as it develops within the stem, and therefore sterility is reduced. The three short-statured lines (36 inches or less) among the late group in the table all showed less sterility than the tall CS-M3 and Calrose. Correlations between plant height and blanking were highly significant in a field trial at Davis.

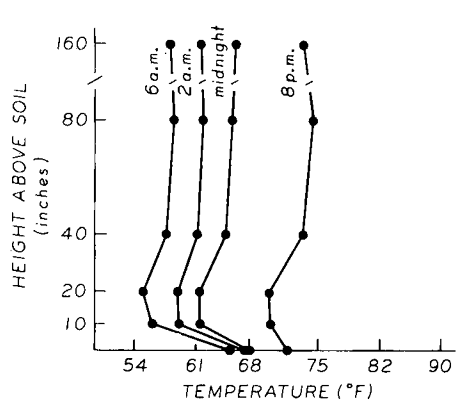

Fig. 1. Temperature profiles, ground level to above Calrose rice canopy during panicle development; water, 6 inches deep.

Early planting

Rice growing in cool areas usually is limited by temperature at both ends of the growing season, and opportunities for altering the planting date are limited. In general, early planting produces less blanking. Certainly, late planting (late May) should be avoided in cool areas. Early-maturing varieties planted early show the least blanking but are likely to produce low head rice yields if ripening occurs while temperatures are still warm.

Water management

In studies to determine effects of water management on rice sterility, temperatures of the surrounding air, the water, and the rice canopy profile were recorded at half-hour intervals night and day during panicle development of the Calrose variety.

A temperature inversion existed between mid-canopy at 20 inches and the top of the canopy at 40 inches (fig. 1). Mid-canopy air temperatures were 2° to 5.5° F lower than those at the top. This inversion was counteracted by the warming effect of water on lower-canopy air temperature.

Ambient air temperature at 80 inches declined much more than water temperature as the night advanced. Mid-canopy air temperature at 8:00 p.m. was 2° F lower than

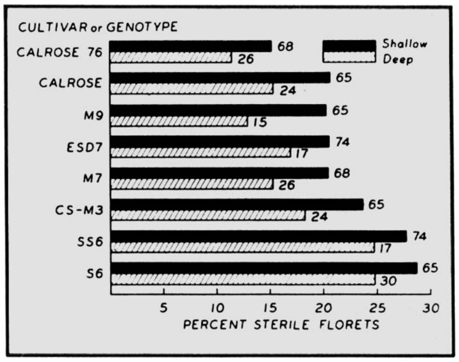

Fig. 2. Percent sterile florets on rice varieties in deep or shallow water. At right of bars are hours of exposure to 60° F during temperature-sensitive period.

water temperature. By early morning (6:00 a.m.) this difference had grown to 9° F. Water acted as a heat source during the night, lessening the decline in lower-canopy air temperature (immediately above water level). Thus, the temperature inversion was arrested at mid-canopy, or about 20 inches height.

Throughout most of the night, lower- and mid-canopy air temperatures were similar. However, during the coldest time (6:00 a.m.) the decline in lower canopy air temperature was less than in the mid-canopy temperature. These differences, although relatively small, are nevertheless significant at threshold temperatures that induce sterility. Temperature probe studies have confirmed that panicle temperature is essentially the same as the air temperature around the panicle.

A temperature inversion occurs on still nights—the usual condition in the California rice-growing area. On occasional windy nights, wind turbulence disrupts the inversion, and temperatures in and immediately above the canopy tend to equalize. The canopy air temperature is warmer on windy nights than on still nights.

These microclimate studies provide the basis for understanding the relation of water depth to sterility. In a field study, eight rice varieties were grown in shallow (3 to 4 inches) and deep (6 to 8 inches) water at the Rice Research Facility at Davis. All varieties had less blanking in deep water (fig. 2). The mean blanking for all eight varieties was 17.8 percent in deep water and 22.2 percent in shallow water. These differences were statistically significant at the 0.05 level. Sterility also tended to decline with decreased plant height. In shallow water, short Calrose 76 had 15 percent blanking, and tall Calrose 20 percent; short M7 had 21 percent, and tall CS-M3 25 percent blanking.

The beneficial effect of deep water on reducing sterility is attributed to the minimum water temperature being nearly 10° F above minimum air temperature at night. In the Davis water depth study, the mean minimum temperatures of water and of air at panicle height during the temperature-sensitive period were 63.1° and 51.8° F, respectively, in shallow water and 66° and 56.5° F in deep water. With the critical temperature for inducing sterility in the 50° to 60° F range, it is reasonably certain that the warmer temperature in deep water lowered blanking. The larger volume of deep water not only maintained higher night temperature but increased air temperature immediately above the water as well.

Panicle location of short (Calrose 76) and tall (Calrose) varieties in deep and shallow water further explains the results (fig. 3). During the most sensitive period 7 to 13 days before heading, the panicles are both elongating and increasing in height above the soil and the water surfaces. Panicle lengths of tall and short varieties are about the same during the development stage, but the short Calrose 76 is closer to the soil surface. In deep water, the panicles of Calrose 76 were almost completely submerged at the start of the sensitive stage and nearly half submerged near its completion.

Blanking percentages for the water depths and the two varieties were:

Shallow water (3 to 4 inches)	
Calrose	21 percent
Calrose 76	15 percent
Deep water (6 to 8 inches)	
Calrose	15 percent
Carose 76	11 percent

The combination of reduced plant height and increased water depth reduced blanking from 21 to 11 percent in this genetically similar pair of varieties.

Nitrogen fertility

Before the era of short-statured varieties, the amount of nitrogen applied to tall rice varieties was limited to the amount that would not cause lodging. The new short-statured varieties in general withstand higher nitrogen fertilization before lodging occurs. However, as nitrogen applications exceed certain levels, the amount of blanking increases. With short-statured varieties, limits on nitrogen fertilizer application probably will be based on identifying the amounts beyond which economic yield increases from nitrogen applications are offset by blanking losses.

Although it is a common field observation that very high rates of nitrogen cause blanking, even in the old tall varieties, few field data have been published establishing this relationship. In 1979, blanking data and yields were obtained on two varieties at various nitrogen fertilizer application rates applied before planting at two locations.

The amount of blanking was affected by nitrogen application rates, rice variety, and geographic location (fig. 4). The location effect in this case can be explained by a planting date (June 1) for the Sacramento County trial that was 10 days later than the San Joaquin County trial.

The long-grain variety L-201 was more susceptible to blanking than M-101 at both locations. The unusually high blanking of L-201 in the Sacramento trial may have been caused in part by molinate (Ordram) toxicity early in the season, which reduced plant stands. Although the plants recovered fully later, it is possible that, because of thinner stands, more nitrogen was available to remaining plants, and this in turn may have increased blanking.

Blanking increased with higher nitrogen fertilizer application rates at both locations and for both varieties. Reasons for this response have not been clearly established. The usual explanation is that high rates of nitrogen delay heading. In these trials, heading was delayed only two to three days at the highest nitrogen rates, which we do not believe was sufficient to account for the increased blanking.

Rice plants also respond to high nitrogen fertility with increased vegetative growth (leaves and stems), tiller number, and flowers per panicle. All three responses increase demands for sugar produced in the leaves. A possible explanation is a deficiency in the sugar needed for the requirements of all the florets produced on each panicle.

Highest yields were obtained with 90 pounds of nitrogen in the Sacramento trial and 120 pounds in the San Joaquin trial. It is clear from these results that maximum yields are achieved with nitrogen rates below those which cause severe sterility.

Summary

Rice growers in areas subject to cool night temperatures can reduce losses from blanking by growing early-maturing, short-statured varieties that carry a reasonable degree of cool-temperature tolerance, increasing water depth during the period 7 to 21 days before heading, and avoiding the use of nitrogen fertilizer rates that cause excessive blanking. As a general rule of thumb, blanking in excess of 12 to 15 percent indicates management improvements are possible.

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Rice panicles show various degrees of blanking induced by low temperatures occurring on successive nights from 7 to 21 days before heading. Panicles, left to right: 100 percent blanked, 50 percent blanked, and fully fertile.

Field laboratory and temperature mast in rice paddy at U. C., Davis, automatically record rice canopy temperatures.

Sterility, Hours Exposure to Low Temperatures, and Plant Characteristics of Nine Closely Related Varieties and Selections

Varieties or selections	Height	Sterility	Time until heading	Time at < 60° F at meiosis
	inches	*%*	*days*	*hours*
Early				
D18	43	16	106	46
ED 7	36	19	108	56
D 31	42	14	100	14
Mean	40.3	16.6	105	38.6
Late				
CS-M3	47	39	118	46
Calrose	44	26	118	46
75/31236-3	37	25	115	54
070	35	21	117	53
SD 7	36	19	119	46
Calrose 76	36	17	119	46
Mean	39.2	24.5	118	48.5

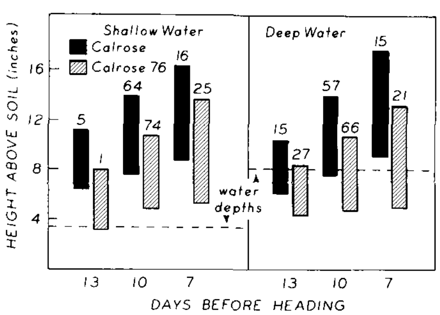

Fig. 3. Tall Calrose and short Calrose 76 panicle locations in shallow and deep water before heading. Numbers above bars: percent total florets at temperature-sensitive stage.

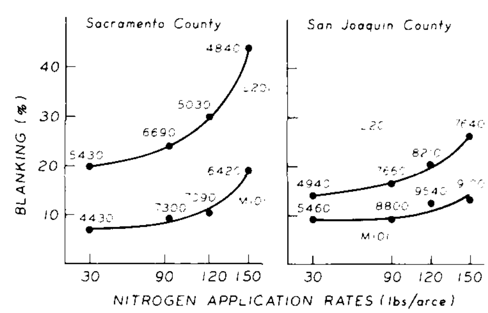

Fig. 4. Percent sterile florets in L-201 and M-101 varieties at different N rates and two field locations. Numerals are grain yields (lb/acre) at 14 percent moisture.