Stephanie Johnson and Mark Keeley planting test row at 100 seeds per 25 feet.

Predicting cotton seedling emergence

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Best stand establishment depends on both warm and cool germination rates of seed as well as temperatures during five days following planting.

To ensure a full crop, cotton growers in the past frequently over-seeded, then thinned plants to a desired density after they emerged. Labor costs now make this practice prohibitively expensive. The result is that a given planting rate can produce an excessive density if planting conditions and germination are good, or too low a density if conditions are poor. In either case, yields suffer. The germination percentage of seed and heat units just after planting become important factors in avoiding either situation.

Viability of cotton seed for planting is guaranteed on the basis of warm germination. This is determined by placing seedlings in a moist environment at 86°F for four days; seedlings with combined shoot and root length of more than 1.5 inches are considered to have germinated. This is an ideal temperature for cotton and does not represent field conditions at planting. A more conservative test for cotton germination has been developed in recent years — a cold test, in which seeds are germinated at 64°F for 7 days.

We report here on a three-year study in which field emergence was related to both warm and cool germination percentages as well as to heat units during germination and emergence.

Field studies

Seeds produced under various environmental conditions were collected in the falls of 1983, 1984 and 1985 and planted the following springs in replicated field plots at two planting dates. Over the three-year period, a total of 592 plots were evaluated for field emergence. Warm (86°F) and cool (64°F) germination percentages were established for each seed lot. Heat unit accumulation (base 60°F) was monitored after planting and used along with germination percentage data to interpret field emergence percentages.

Field emergence readings were taken on two dates in each test. The first reading was when most seedlings had emerged, and the second about two weeks later when no new seedlings were emerging. Average heat unit accumulation in the six tests was 73 for the first evaluation date and 178 for the second date.

Seed lots in these tests ranged between 25 and 90 pecent warm germination and between 1 and 88 percent cool germination, and resulted in field emergence percentages between 4 and 98 percent. Heat units for the first 5 days after planting in the six tests ranged between 9 and 28 with an average of 19. For the first 10 days following planting, heat units ranged between 17 and 69 with an average of 53. This range of seed quality and environment covers the variability in conditions normally encountered in the San Joaquin Valley of California.

Rate of emergence

The rate of emergence depends on seed quality and planting conditions. Dur-

TABLE 1. Estimated pounds of SJ-2 seed to plant for a final plant stand of 35,000 plants per acre.

Heat units in 5 days after planting	Warm plus cool germination percentage								
	100	110	120	130	140	150	160	170	180
	lb seed								
8	27	25	23	22	21	20	20	19	19
10	22	21	20	19	18	18	17	17	17
12	20	18	18	17	16	16	15	15	15
14	18	17	16	15	15	14	14	14	14
16	17	15	15	14	14	14	13	13	13
18	15	15	14	14	13	13	13	13	13
20	15	14	14	13	13	13	13	12	12
22	15	14	14	13	13	13	12	12	12
24	15	14	13	13	13	13	12	12	12

TABLE 2. Estimated pounds of SJC-1 or GC-510 seed to plant for a final plant stand of 35,000 plants per acre.

Heat units in 5 days after planting	Warm plus cool germination percentage								
	100	110	120	130	140	150	160	170	180
	lb seed								
8	24	22	21	20	19	18	18	17	17
10	20	19	18	17	16	16	15	15	15
12	17	16	15	15	14	14	14	14	13
14	16	15	14	14	13	13	13	13	12
16	14	14	13	13	12	12	12	12	12
18	14	13	13	12	12	12	12	11	11
20	13	13	12	12	12	11	11	11	11
22	13	13	12	12	11	11	11	11	11
24	13	13	12	12	11	11	11	11	11

ing the first year of the test, we monitored the different seed lots frequently to determine the rate of emergence. Rates for the three highest quality seed lots were compared with those for the three poorest seed lots of 1984.

High-quality seed lots were not sensitive to planting conditions: 88 and 84 percent of the peak plant stand was reached by 50 heat units after planting for the two planting dates (fig. 1). With high seed quality, peak field emergence occurred at 76 heat units in the April 2 planting and 92 heat units in the April 16 planting.

The rate at which poor-quality planting seed emerged depended on conditions at planting. In low-quality seed lots, only 32 percent of the peak plant stand emerged during the first 50 heat units for the early planting date compared with 79 percent for the more favorable late planting date, when conditions had improved. Under cool planting conditions, poor-quality seed lots required 132 heat units to reach their peak final plant stand, which was only 33 percent of the seeds planted (fig. 1).

This finding emphasizes the need for high-quality seed. Differences in speed of emergence may be small when planting conditions are ideal, but when conditions are less favorable, poor-quality seed emerges more slowly, subjecting the plant to seedling disease for a longer time.

Germination tests

The ability to predict field emergence (plant stand) by seed quality and temperature measurements was better at the first evaluation date (average 73 heat units after planting) than at the second. The second date was not as accurate, because some seedlings were lost because of seedling diseases and other, unexplained factors. The remainder of this report will deal only with the effects of environment and seed quality on field emergence percentages at the first evaluation date.

The warm germination percentage accounted for 24 percent of the variability in field emergence. Cool germination readings more closely approximated normal field conditions, accounting for 32 percent of the variability in field emergence. Combining the warm and cool germination percentages resulted in a slightly superior estimate of field emergence, accounting for 35 percent of the variability (fig. 2).

Alone, these germination tests have deficiencies. The warm germination percentage overestimates field emergence under cool or adverse conditions. Cool germination has just the opposite problem: it underestimates field emergence when conditions are favorable. Using both warm and cool germination percentages together provides a more realistic estimate of field emergence across a wider range of planting conditions than either alone.

Even though relationships between germination percentages and field emergence given in figure 2 explain 24 to 35 percent of variability, there was significant scatter in the data points. This was caused by variation in field emergence due to temperature during planting as well as other unexplained factors. Germination tests provide useful information, but used alone cannot accurately predict plant stand.

Heat units after planting

We monitored heat units for 5, 10, or 15 days after planting in each of the six trials. Averaged across germination percentages for all seed lots, cumulative heat units for 5 and 10 days after planting accounted for 35 and 37 percent, respectively, of the variability in field emergence. When 10, 20, and 30 heat units were received the first 5 days after planting, field emergence averaged 50, 72, and 77 percent, respectively. Heat units for 15 days after planting were not as predictive and accounted for only 9 percent of the variation in field emergence.

These field observations indicate that the temperature during the first 5 days following planting has the biggest impact on seed germination, emergence, and survival. This finding is consistent with published literature (Christensen, 1964, *Crop Science* 4: 584-6) demonstrating that temperatures during the first hours after planting (when seeds are soaking up water) and again about two to four days after planting are most important to seedling survival. Including temperatures from days 6 through 10 after planting only increased the predictive ability 2 percent over the first 5 days alone. When temperatures during days 11 through 15 were included, the relationship dropped drastically. This is evidence that warm or cool temperatures 10 days after planting have little effect on the ability of a seed to germinate or emerge.

Germination plus heat units

Warm and cool germination added together accounted for 35 percent of the variability in field emergence. Heat units for the 5 days after planting also accounted for 35 percent of the variability in field emergence. When both variables were added together, 61 percent of the observed variation in field emergence was explained.

Figure 3 illustrates the combined influence of both heat units and seed quality on predicted field emergence. When only 8 heat units were available during the first 5 days of planting, only 5 percent of the planted seeds emerged from the worst quality seed compared with 54 percent emergence from the best seed lot evaluated. Peak field emergence occurred when 22 heat units were received in the first 5 days after planting. Under these optimum conditions, 38 percent of the worst quality seed lot emerged and 88 percent of the best seed lot.

Field emergence improved steadily between 8 and 22 heat units. The warmest conditions evaluated in these trials had 28 heat units within the 5 days after planting.

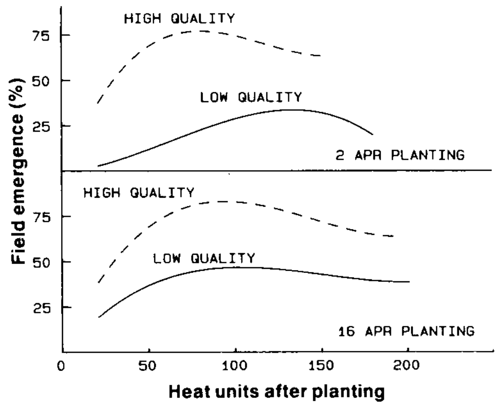

Fig. 1. Cool weather increases heat units required for emergence of poor-quality seed but has little effect on good-quality seed.

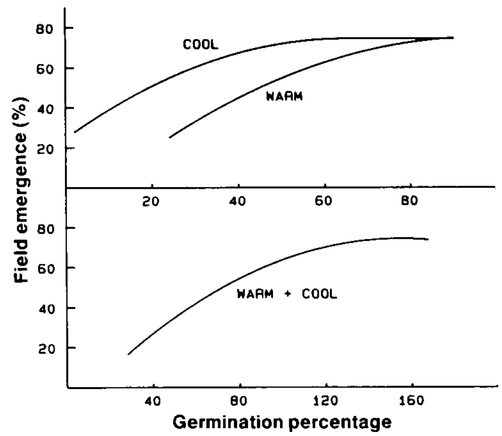

Fig. 2. Comparison of warm (86°F), cool (64°F), or warm plus cool germination in predicting field emergence.

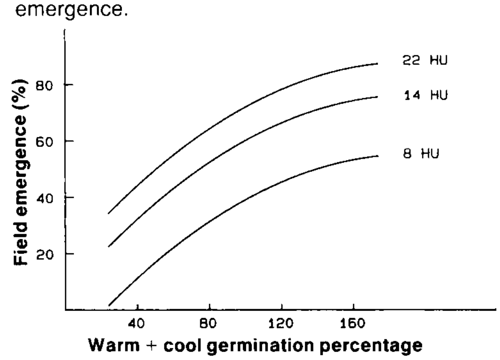

Fig. 3. Emergence is most accurately predicted using both germination tests and heat units forecast for five days after planting.

These results suggest that there is a slight adverse effect when seedlings have more than 25 heat units during the first 5 days after planting. Since the optimum temperature for germination in controlled environments is not obtained with 25 heat units, some other factor is probably responsible for the slight decrease in emergence at heat units above 25.

The National Oceanic and Atmospheric Administration (NOAA) provides a weather forecast service. The Bakersfield office has participated the last two years by providing the 5-day heat unit forecast. It is anticipated that other NOAA offices in the San Joaquin Valley will provide the same service in the future. Cotton growers will be able to make sound planting decisions by obtaining warm and cool germination percentage data on seed lots for planting, then refining planting decisions based upon quantifiable weather data.

Conclusions

If less than 10 heat units are predicted for 5 days, planting would not be recommended. If heat units are predicted to be between 11 and 15, planting should proceed only if germination testing verifies that the seed is of superior quality. If large numbers of acres are to be planted and a grower feels planting must proceed with 11 to 15 heat units, planting rates could be adjusted upward to obtain the desired plant stand. When heat units are predicted to be greater than 16, conditions are favorable for stand establishment with all but poor-quality seed lots.

Planting rates should be adjusted for the planting conditions and to a lesser extent for the quality of seed (tables 1 and 2). Seeding rate changes very little when 16 or more heat units are predicted for 5 days across all ranges of seed quality. When warm plus cool germination percentage is 140 or more, there is also very little adjustment in seeding rate for higher quality planting seed. With 14 or fewer heat units predicted during the 5 days following planting, large adjustments must be made in seeding rates, especially if the seed quality is poor.

Unless growers have no choice, it is recommended that planting seed have at least a warm plus cool germination percentage of 140. With seeds of lesser quality, plants will take longer to emerge (fig. 1), and these seedlings will be exposed to seedling diseases for a longer time. Best yields will be obtained with good-quality seed that can emerge rapidly in an environment promoting fast early growth.

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The two cherries at right show typical symptoms of buckskin disease of sweet cherries, named for the pebbly, pale color of diseased fruit. Symptoms may vary, depending on the rootstock and the strain of the disease.

Buckskin disease of cherry

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Serious sweet cherry tree losses occur in California as a result of "cherry decline," a collection of diseases caused by fungi, mycoplasma-like organisms, viruses, and other unidentified agents. A major cause of cherry decline is cherry buckskin disease, also called X-disease of cherry. Buckskin disease was first reported in 1931 on sweet cherry in California and within 20 years eliminated the sweet cherry industry in Napa and Sonoma counties. The disease now threatens cherry production in San Joaquin County.

Symptoms

The name buckskin disease derives from the pebbly, leathery-skinned, pale fruit of diseased trees. In California, two strains of buckskin, "Napa Valley" and "Green Valley," have been described in sweet cherry. Each strain produces distinct symptoms, depending on the rootstock on which the tree is grafted.

Trees grown on sweet cherry (*Prunus avium*) 'Mazzard' rootstock and having the Green Valley strain produce small-sized, conical-shaped fruit with short, thick stems. The skin of dark-colored cherry varieties may remain light in color. In addition, leaves on severely diseased trees are smaller, sparser, more yellow, and more erect than normal leaves, giving the tree a "see-through" look. New terminal growth on twigs is usually reduced or absent, and the ends of twigs or branches may die back each year. In contrast, the Napa Valley strain on sweet cherry rootstock induces small, but normal-shaped fruit with normal stem length.

Trees grown on 'Mahaleb' rootstock (*P. mahaleb*) and having either the Green Valley or the Napa Valley strain may not develop fruit symptoms but instead suddenly wilt and collapse above the graft union. This reaction is thought to be caused by very rapid killing of the rootstock cambium tissues at the graft union when they are contacted by the buckskin disease agent. The rapid death of the cambium tissue prevents the disease agent from spreading into the rootstock. When sweet cherry is grafted high on Mahaleb rootstock on several separate limbs, a single limb may become infected and die without affecting the remainder of the tree. This limb then can be removed and the remainder of the tree reworked.

Cause and spread

Buckskin appears to be caused by mycoplasma-like organisms found in the nu-