Temperature Effect on Longleaf Pine Seed Germination at a Container Nursery (2001)

By Jill Barbour, Kathy Holston, Rose Eckhart, Bernard R. Parresol, Ph.D., Dr. James Pharo
Germination specialist, USDA Forest Service National Tree Seed Laboratory
Nursery owner, Nursery co-owner, Statistician USDA Forest Service. retired meteorologist USDA Forest Service

Introduction:

Germination problems with longleaf pine seed can affect the container nursery manager's ability to make a profit and remain in business; therefore, it is crucial that the optimum sowing date be established. It is possible that many of the germination failures with longleaf pine seed could be due to a late sowing date. . The optimum laboratory germination temperature is 68^{O} Fahrenheit (20^{O}Celsius).

This study was designed to investigate the optimum field temperature for sowing longleaf pine seed in a container nursery and indirectly compare it with laboratory temperature.

Materials and Methods:

Longleaf pine seeds were planted weekly over a 8 week period from March 22 to May 10, 2001 in a container nursery in middle Georgia. The irrigation pipes were frozen until the third week of March which precluded sowing earlier. The original laboratory germination was 97%. The seed was soaked for 10 minutes in benlate® solution (19 grams per gallon) before planting. Ten plastic containers containing 45 cells each were planted each week with 1 seed per cell. Colored tags attached to the containers were utilized to distinguish the weeks. Trees were subjected to normal nursery procedures relative to soil media, irrigation and fertilization. Rainfall was not recorded. Germination counts were taken weekly until May 31, 2001.

A portable Hobo temperature monitor was placed on a pole next to the containers to record ambient air temperatures every 30 minutes. Daily ambient air temperature was determined by averaging the maximum temperature and minimum temperature each day. Daily averages were added to calculate a weekly average. Temperatures were not recorded between March 28 to April 12 by the Hobo monitor so Macon airport maximum and minimum temperatures were regressed with nursery maximum and minimum temperatures to fill in the data. The R square was 0.70.

The experiment was laid out as a completely randomized design. Each tray was a replication with 45 holes each. Ten trays per week were sown for a total of 450 seeds. Excel regression and SAS® software was used for statistical analysis (Table 2). Repeated measures analysis was performed on weekly data with the Wilks' Lambda F statistic used to determine significance. The germination curves were best explained by a logarithmic equation which when used in nonlinear regression created 8 sigmoidal curves.

Percent germination = b1 / [1 + b2 x exp(b3 x week)]

Several container longleaf nurseries were queried concerning costs and an approximate cost of $110 per thousand seedlings was determined. All calculations and charts are based on that figure.

Results:

Maximum field germination was 94% and the lowest final germination was 47%. Laboratory germination was 97%. Maximum field germination was achieved in 5 weeks (Table 1). There was a rapid rise in germination the third week after sowing then the germination increased slowly until it leveled off (Figure 1).

When longleaf pine seeds were planted late March and early April the germination was in the 90 percentile and average air temperatures were below 69^{O}F. Early planting created a prechilling effect. There was a spike in temperature between April 5th and April 12th that resulted in an increase in germination from 0% to 91% (Table 1). Planting the latter half of April decreased germination from 90+% to 75% when average temperatures exceeded 69^{O}F for a period of one or more weeks. Delaying seed planting until May resulted in the germination dropping to 47%; average air temperatures were in the 70's F (Figure 3).

An inverse relationship exists between germination and temperature (Figure 1): as temperature increases germination decreases. Warmer temperatures increase rate of germination but reduce total germination (Figure 3). The root mean square error increased as the temperature rose and the R^2 decreased showing that there was more variation around the mean maximum germination (Table 2).

Delayed planting puts your investment at risk. A one week delay could be the difference between profit and loss. As the total germination decreases the costs rise.

A total cost figure of $110 per thousand seedlings was used to figure the costs by planting date (figure 2). The March sowing date costs were $118 per thousand seedlings compared to the last sowing date, May 10th when costs soared to $234 per thousand. If the retail price for seedlings was $150 per thousand, then costs would exceed price when the sowing date was delayed until the 4th week of April. A lower price such as $125 per thousand would require a sowing date no later than the 2nd week of April to breakeven. A lower selling price requires an earlier sowing date to make a profit.

Discussion:

Ambient air temperature can be controlled by planting earlier in the sowing season in containerized nurseries. The best time to plant is when minimum temperatures are above freezing and average temperatures are close to 70^{O} F. The exact sowing dates need to be determined by the owner at each nursery location. The farther south the nursery's location the earlier should be the sowing date to achieve the desired temperature.

By planting longleaf pine seed early, the seedlot has a better chance of reaching the seed's germination potential as measured by a laboratory germination test.
Longleaf pine seed cannot tolerate high temperatures during germination and should be planted earlier than loblolly pine and slash pine seed.

The optimum laboratory germination of 68^{O}F appears to be close to the optimum in the nursery. Longleaf pine seeds have a soft seedlot which makes them very susceptible to fungi. High temperatures promote the growth of fungi on the seed and hinder germination in the laboratory and at the nursery.

Table 1

LONGLEAF PINE TEMPERATURE STUDY 2001
PERCENT GERMINATED
DATE PLANTED AND COLOR OF TAG

	YELLOW	WHITE	PINK	GREEN	RED	ORANGE	BLUE	YEL/WHITE			
COLOR	3/22	3/28	4/5	4/12	4/19	4/26	5/3	5/10	5/17	5/24	5/31
Yellow	P[1]	0	0	91	92	93	94	93	93	93	93
White		P	0	58	76	87	94	93	94	94	93
Pink			P	0	3	44	72	79	81	82	82
Green				P	0	29	77	84	88	89	89
Red					P	0	5	63	72	76	76
Orange						P	0	44	63	72	73
Blue							P	4	52	61	74
Yel/White								P	0	31	47

P[1]= date planted

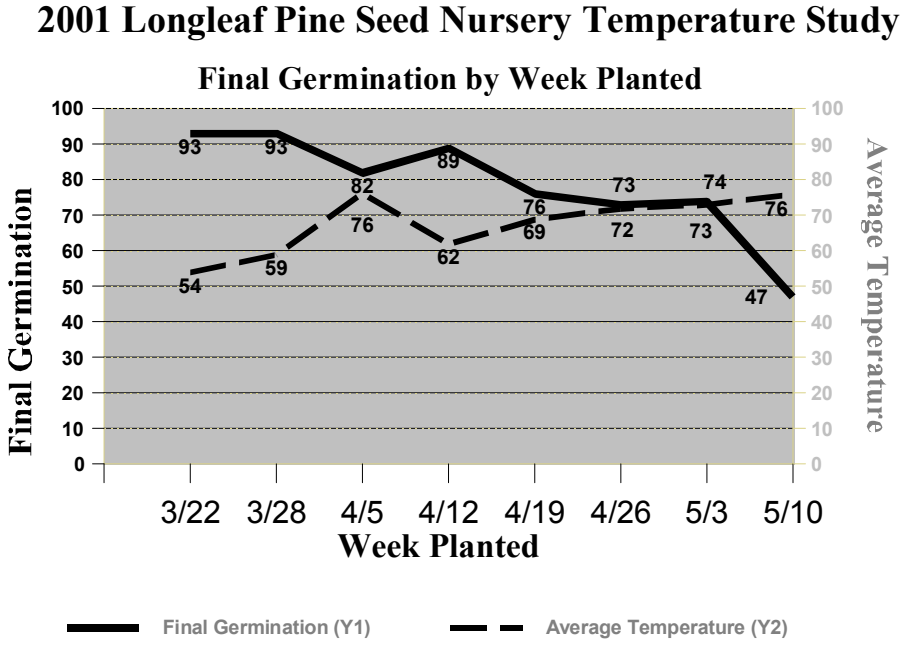
WEEKLY TEMPERATURES

AVERAGE	54	59	76	62	69	72	73	76	76	75
MAXIMUM	68	70	92	90	87	91	90	93	89	89
MINIMUM	41	47	62	49	52	53	57	59	63	62

Table 2. Statistics for Nonlinear Regression

Planting Date	Average Max. Germination	Root mean square error	R^2
March 22, 2001	93	2.95	0.99
March 28, 2001	91	9.00	0.92
April 5, 2001	82	7.34	0.96
April 12, 2001	88	6.52	0.92
April 19, 2001	72	8.58	0.93
April 26, 2001	64	12.90	0.79
May 3, 2001	69	12.38	0.83
May 10, 2001	49	10.02	0.82

Figure 1



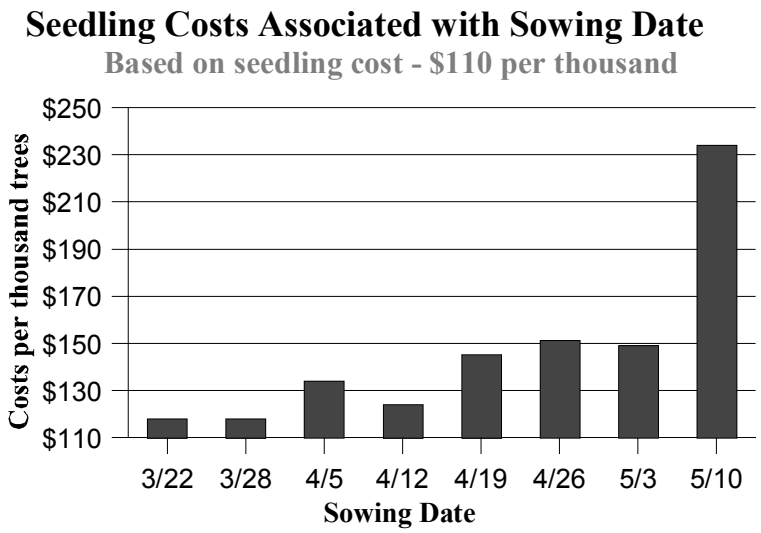


Figure 2.

Figure 3