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GERMINATION AND INITIAL GROWTH OF EASTERN COTTONWOOD AS INFLUENCED BY MOISTURE STRESS, TEMPERATURE, AND STORAGE

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ABSTRACT

Germination energy of cottonwood seed decreased gradually as moisture stress increased from 0.0 to 10.0 atm; 15.0 atm inhibited germination except at 32 and 38 C. Temperature extremes of 15 and 38 C drastically reduced germination energy, and the reductive effect of 38 C was particularly marked after storage. Only 15-atm moisture stress or 15 C greatly reduced total germination. Germination under optimum conditions (27–32 C) was reduced from 90% to 69% by 12 months' storage.

Little seedling growth took place at stresses above 5 atm and at temperatures of 15 and 38 C. Initial growth was related to seed size, which varied considerably with parent tree.

Introduction

In the Lower Mississippi Valley, eastern cottonwood (*Populus deltoides* Bartr.) becomes established by seed in early and middle summer on open land created by receding water courses. The seed's normally high viability at dispersal decreases rapidly in the absence of a suitable environment for germination. Site conditions during dispersal thus crucially influence establishment. The study described here delineated the effects of several moisture-stress and temperature conditions upon germination and initial growth in the laboratory.

Methods

After preliminary tests, seed from a single tree near Stoneville, Mississippi, was collected in June, 1964, and divided into nine lots of several thousand seeds each. Three replicates (lots) were assigned to each of three storage periods: 0, 6, and 12 months. Storage was at 4 C and 25% relative humidity in desiccators, as suggested by McCOMB and LOVESTEAD (1954).

Following storage, each lot was divided into 50-seed sublots which were randomly assigned to five moisture-stress treatments (0.0, 2.5, 5.0, 10.0, and 15.0 atm) in each of five temperature regimes (15, 21, 27, 32, and 38 C).

Stress treatments were imposed by germinating the seed in covered petri dishes filled with 10 ml of appropriate osmotic solution prepared with *d*-mannitol according to the formula used by WIGGANS and GARDNER (1959): $g = PVm/RT$, where g = grams of solute, P = desired osmotic pressure in atmospheres, V = volume in liters, m = molecular weight of solute, R = 0.0825 atm/degree per mole, and T = absolute temperature.

Dishes were weighed to the nearest 0.1 g at the beginning of tests, and distilled water was added daily to replace moisture lost through evaporation.

Temperatures were maintained within $\pm$ 1 C in laboratory germinators. The only exposure of the seeds to light occurred when dishes were removed for germination counts.

Germination was recorded at 12-hr intervals until completed. A seed was considered germinated when cotyledons were free from the seed coat. Germination speed was evaluated by calculating peak value (CZABATOR, 1962), which in this study is the largest quotient obtained by dividing the percentage of cumulative germination by the number of 12-hr periods elapsed since beginning treatment. The experimental design was a split plot, and an analysis of variance was performed with the arc sin $\sqrt{\text{final germination percentages}}$ and the germination peak values.

Initial growth of seedlings was studied under the same environmental conditions and experimental

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design as in germination tests. Freshly collected seeds from single trees were germinated in distilled water at room temperature. Immediately after germination, 10 seedlings were assigned to each treatment. Total seedling length (radical + hypocotyl) was measured to the nearest millimeter every 12 hr until growth ceased. Progenies were from three trees having seed uniformly weighing 0.3–0.6 g/1,000, a tree-to-tree range common in central Mississippi.

Results

Analyses of variance for both germination and growth data revealed that all test factors and their first-order interactions were significant at the .01 level.

Peak values varied from 0 to 41, the highest being observed with fresh seed at 32 C and 0 atm of moisture stress (fig. 1). As stress increased from 0 to 10 atm, germination energy gradually decreased, and 15 atm inhibited germination except at 32 and 38 C.

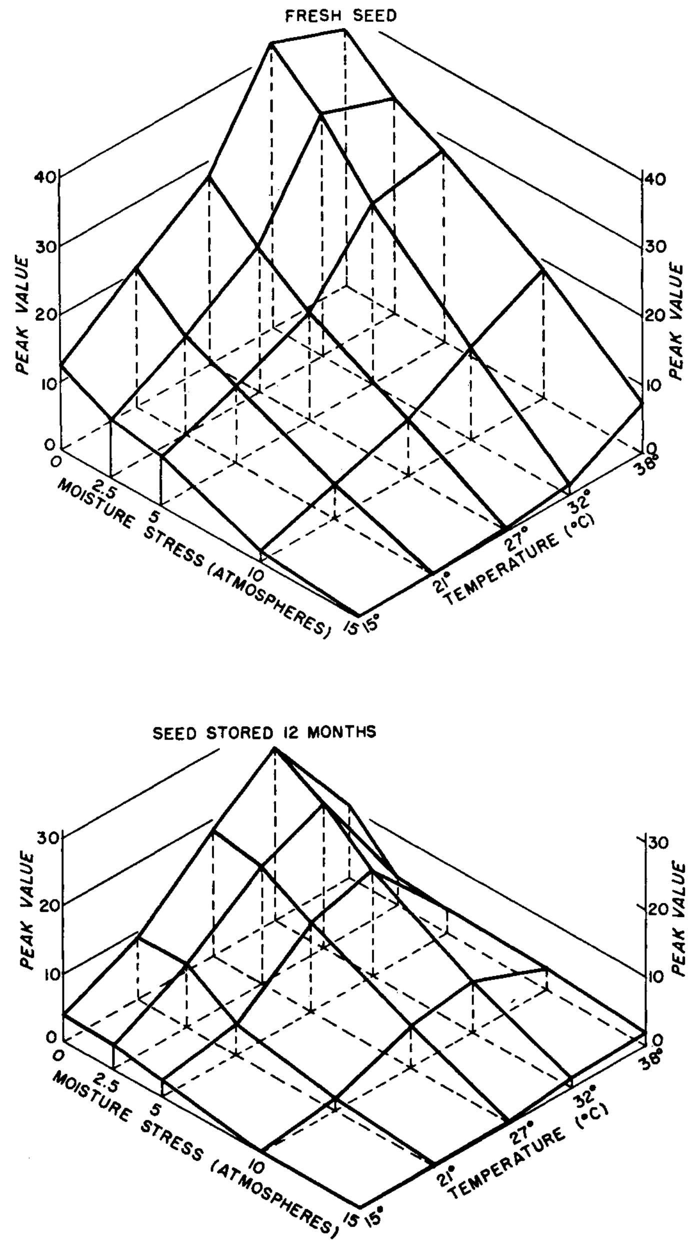

Fig. 1.—Peak values for germination of cottonwood seed as influenced by moisture stress and temperature; each point is an average of three values.

Low temperatures reduced peak values drastically, and after storage 38 C also had a marked reductive effect. Effects of 6 months' storage, which are not illustrated, were intermediate between those of 0 and 12 months' storage.

Although both high and low temperatures and increasing moisture stress reduced germination energy, final germination was less influenced by these conditions, at least when fresh seed was used (fig. 2). Final germination was severely reduced only at 15-atm stress or 15 C. Germination at 27–32 C and 0 stress was 94% for fresh seed and 69% for seed stored 12 months; a similar reduction was reported by McComb and Lovestead (1954) for the same storage conditions and time. Germination of stored seed was markedly reduced at temperatures of 15 and 38 C.

Patterns of seedling growth were similar to those of germination (fig. 3). In a typical experiment with large seed (0.6 g/1,000), seedlings were approximately 12 mm long when growth ceased under 27–32 C and 0 stress. Little growth took place at stresses above 5 atm and at temperatures of 15 and 38 C. Major differences in growth were related to seed size, which varied considerably with parent tree. Hypocotyl growth patterns of progeny from two trees at five temperatures and 0 stress are illustrated in figure 4. Although temperature effects were

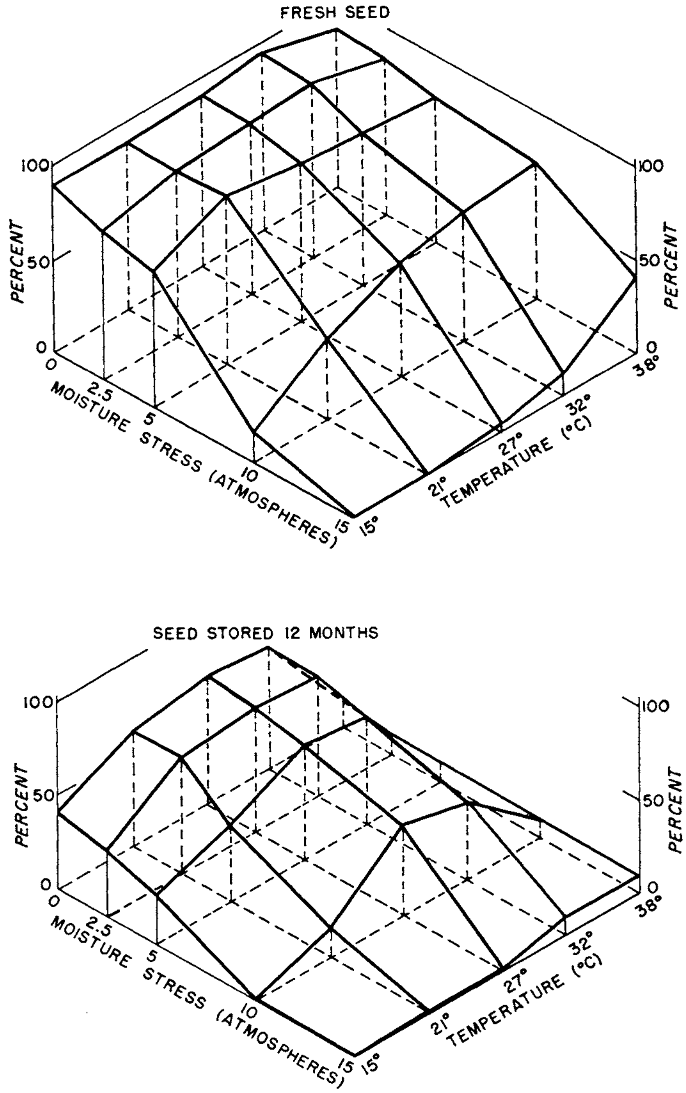

Fig. 2.—Final germination of cottonwood seed as influenced by moisture stress and temperature; each point is an average of three values.

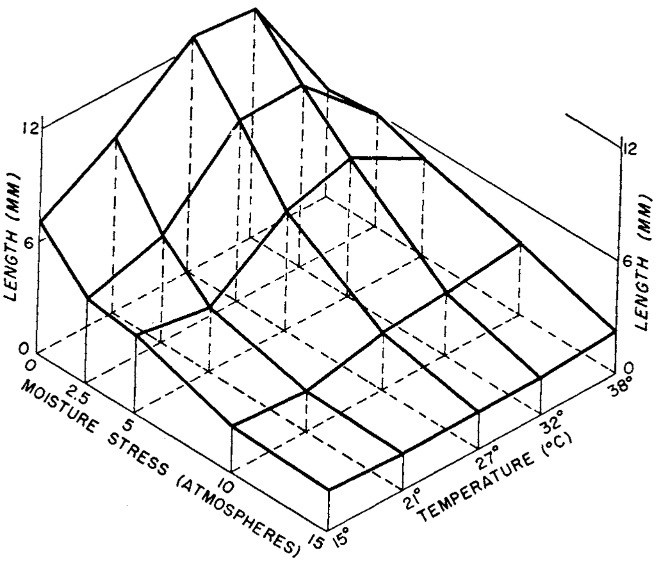

FIG. 3.—Growth of cottonwood seedlings as influenced by moisture stress and temperature; each point represents mean total length of 30 seedlings.

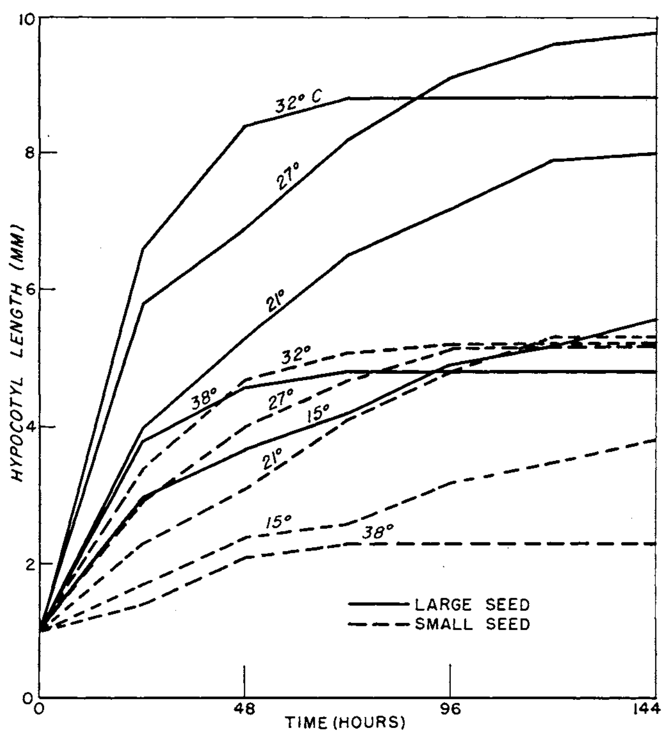

FIG. 4.—Cumulative hypocotyl growth of cottonwood seedlings as influenced by temperature and seed size, O moisture stress.

similar in both progenies, seedlings from large seed (0.6 g/1,000) grew twice as much as those from small seed (0.3 g/1,000).

Discussion and conclusions

The data suggest that chances for successful germination and good early growth of cottonwood are optimum within the temperature range of 27–32 C and at less than 5-atm moisture stress. Under these conditions germination is completed within 24–36 hr. Although total germination is not much less at temperatures below optimum, germination energy is markedly reduced under cooler, drier conditions. This reduction may be ecologically important since speed of germination, rather than total germination, is crucial under the rapidly changing environment typical of sites open to cottonwood. At 38 C, the advantage of quick germination may be partially offset by poor growth, although such high temperatures are modified by lower night temperatures under natural conditions.

Since osmotic stress may have less effect on plants than equivalent soil-moisture stress (Collis-George and Sands, 1962; Manohar and Heydecker, 1964), it is probable that soil-moisture stresses slightly lower than the osmotic stresses in the test would have equivalent effects under field conditions.

Although 12 months of storage resulted in only 20–30% loss in germination under optimum conditions, viability reduction due to storage was more evident under extremes of temperature. A poorer storage environment probably would have accentuated this reduction.

Early seedling growth under natural conditions is dependent upon both current cotyledon photosynthesis and seed-stored substrate. In this test only the effects of stored energy were observed. Optimum utilization of this energy for growth took place at 27–32 C under 0 moisture stress. Low temperature and high moisture stress probably limited growth directly. At 38 C, excessive respiratory loss of energy was most likely an indirect but major limiting factor, although metabolic abnormalities caused by high temperatures may also have been detrimental. Growth variation was affected as much by seed size as by temperature.

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