SOME FACTORS AFFECTING GERMINATION OF SWAMP TUPELO SEEDS[1]

DEAN S. DEBELL

Southeastern Forest Experiment Station, Forest Service
U.S. Department of Agriculture, Charleston, South Carolina

AND

AUBREY W. NAYLOR

Botany Department, Duke University, Durham, North Carolina

Abstract. The effects of three temperature levels (15°, 21°, and 33° C) in combination with four soil-water regimes (moist-drained, surface-saturated, flooded-stagnant, and flooded-aerated) on the germination of seeds of swamp tupelo (*Nyssa sylvatica* var. *biflora* (Walt.) Sarg.) were investigated. Germination was rapid in the moist-drained regime at temperatures of 21° and above. No germination occurred in potted soil where water levels were at or above the soil surface, regardless of temperature or whether the water was aerated. However, seeds germinated under water in the absence of soil, and aeration and partial removal of the seed-coat enhanced germination and early growth of the radicle. Seeds that had been submerged in flooded soil for up to 5 weeks germinated when placed in moist sand, but the germination response of such seeds was substantially reduced at 33° C.

INTRODUCTION

Swamp tupelo (*Nyssa sylvatica* var. *biflora* (Walt.) Sarg.) is a major species in hardwood swamps of the southeastern United States. Forest ecologists would like to prescribe a method for regenerating this species when mature stands are logged, but essential information concerning effects of environmental factors on germination of swamp tupelo seeds is lacking. Because water levels in hardwood swamps often are above the soil surface, data regarding the effects of flooding on germination are especially important.

Some work has been done with wetland species. Demaree (1932) and Shunk (1939) reported that seeds of baldcypress (*Taxodium distichum* (L.) Rich.) and water tupelo (*Nyssa aquatica* L.) will not germinate under water. DuBarry (1963), working with several hardwood species, compared the germination of seeds when submerged in water but in the absence of soil and when placed on sponges in open containers. He also found that baldcypress and water tupelo will not germinate under water, but he reported 37% germination for submerged seeds of swamp tupelo. Morinaga (1926) has shown that a number of herbaceous species will germinate under water provided that temperature and oxygen content of the water are adequate. Recent work by Heydecker and his co-workers (1968, 1969) indicates that the failure of some species to germinate under water results from inadequate supply of oxygen to sites where it is required. This delay has been traced to mechanical barriers which restrict transport of oxygen by convection currents to certain seeds when they are over-supplied with moisture.

[1] Received October 5, 1970; accepted September 23, 1971.

The purpose of the present study was to determine the effects of temperature, water level, and aeration on germination of swamp tupelo seeds.

GERMINATION TESTS

Effects of temperature, water level, and aeration on germination in soil

A sample of swamp tupelo seeds was collected from Bluebird Swamp in Berkeley County, South Carolina, depulped, wetted, and stored in polyethylene bags at 4° C. Ten months later the seeds were planted in 24 half-gallon (2.2-liter) plastic pots filled with a mixture of loam, peat, and sand to within 10 cm of the top. Twenty-five seeds were planted 1 cm deep in each pot. Four soil-water regimes were randomly assigned to the pots: (1) moist-drained (soil kept well watered); (2) surface-saturated (water table held at the soil surface); (3) flooded-stagnant (water table maintained 5 cm above the soil surface); and (4) flooded-aerated (water table maintained 5 cm above the soil surface and air bubbled continuously through the water). Two pots from each regime were placed in each of three growth chambers to test the effects of constant temperatures of 15°, 21°, and 33° C with a photoperiod of 16 hr. A weekly tally was made of the number of seeds that germinated. No seeds germinated during the fourth and fifth week after planting, and the experiment was discontinued after 5 weeks.

Germination did not occur when the water table was at or above the soil surface (regimes 2, 3, and 4) at any temperature tested. Germination did occur in the moist-drained pots. The relationship of germination to time and temperature for the moist-drained

TABLE 1. Percentage germination of swamp tupelo seed in moist-drained pots at three temperatures 1–5 weeks after planting

Temperature (°C)	Weeks after planting				
	1	2	3	4	5
15	0	30	76	84	84
21	22	92	92	92	92
33	78	88	88	90	90

TABLE 2. Percentage germination at 21° C of swamp tupelo seeds previously submerged in aerated or stagnant water and exposed at various temperatures

Soil-water regime	Previous exposure			Average
	15°	21°	33°	
Flooded-stagnant	88	98	62	83
Flooded-aerated	80	88	68	79
Average	84	93	65	

regime is presented in Table 1. Rate of germination was correlated positively with temperature.

Residual effects of flooding on germination response

When the previous experiment was terminated, 40 seeds (two replications of 20 seeds each) from each pair of pots subjected to the flooded-stagnant and flooded-aerated regimes at the various temperatures tested were planted in flats filled with sand. All flats were placed in a growth chamber at 21° C for 4 weeks to determine whether the various environments to which these seeds had been exposed had affected their ability to germinate under presumably more favorable conditions.

Germination response after 4 weeks was significantly lower for seeds previously exposed at 33° C than for those previously exposed at 15° or 21° C (Table 2). The reduction in germination of seeds that had been aerated in comparison with those in stagnant water was not statistically significant.

Effects of aeration and partial removal of the seedcoat on germination in the absence of soil

Because our data failed to confirm DuBarry's (1963) findings that swamp tupelo seeds germinate under water, we conducted further tests in which we duplicated his study conditions by submerging the seeds in water without soil. In conjunction, we also tested the effects of aeration and of removing the hinged portion of the seedcoat through which swamp tupelo radicles emerge after germination. Seeds collected from Bluebird Swamp were depulped, wetted, and stored in polyethylene bags at 4° C. After 18 months, 20 seeds were placed on moist filter paper and 20 were submerged in 100-ml beakers with or without aeration. The hinged portions of the seedcoats were removed from half of the seeds tested under each condition, and the remaining seeds were tested intact. Air temperature during the germination test was not controlled and varied from 20° to 30° C.

TABLE 3. Effect of aeration and partial removal of the seedcoat on percentage germination of swamp tupelo seeds and early growth of the radicle

Testing conditions	Seedcoat	Percentage germination	Percentage germination with radicles > 5 mm
Moist filter paper	Intact	80	50
	Partially removed	100	80
Submerged without aeration	Intact	40	0
	Partially removed	50	0
Submerged with aeration	Intact	50	10
	Partially removed	80	70

Data collected after 1 week indicated that germination did occur under water in the absence of soil and that germination and early growth of the radicle were enhanced by aeration and partial removal of the seedcoat (Table 3). Additional tests indicated that seeds of this collection did not germinate in flooded soils when water levels were above the soil surface.

DISCUSSION

Natural ecological conditions and germination of swamp tupelo seeds

Swamp tupelo reproduces itself under conditions hazardous to germination and early growth. A single rainstorm during the growing season (April to November) will often raise the water table in a headwater swamp from several centimeters below to several centimeters above the soil surface. Although seedlings can be submerged for long periods during the dormant season without suffering damage, more than a few days of complete submergence while seedlings are in the cotyledon stage is likely to kill them. Therefore, survival of swamp tupelo seedlings depends upon rapid germination and growth when conditions are favorable. In moist-drained soil, we found that temperatures above 21° C favor rapid germination and early growth. At 15° C germination was extremely slow and early height growth lagged.

Apparently swamp tupelo seeds will not germinate when submerged in flooded soil. This delay in germination is advantageous to the seed's survival. In some years, water remains above the soil surface in swamps for several months during the growing season. If germination were to occur under water, the entire

seed crop could be lost. In our tests seeds that had been submerged in flooded soil for periods up to 5 weeks germinated, but germination was reduced substantially in the case of seeds tested at the highest temperature. Possibly reduction in germination was due to toxic accumulation of by-products of fermentation.

Aeration requirements of swamp tupelo seeds

Our finding that germination did not occur in potted soils if the water table was at or above the soil surface appeared to be at variance with work by DuBarry (1963). However, subsequent tests made in the absence of soil resulted in 40% germination under water with no supplementary aeration. Aeration and partial removal of the seedcoat enhanced germination and early growth of the radicle.

The equal germination of submerged, aerated seeds with partially removed seedcoats and intact seeds placed on moist filter paper indicated that oxygen supply to the embryo could be limiting when the seeds were submerged. Similarly, Heydecker and his co-workers (1968, 1969) found that removal of the ovary cup or partial removal of the seedcoat enabled certain herbaceous seeds to germinate under water and that increased oxygen pressure also improved germination. Submersion of swamp tupelo seed had a greater effect upon early growth of the radicle than upon germination. Only when air was bubbled through the water did submerged seeds have radicles longer than 5 mm after 1 week. The available oxygen supply was probably much lower for seeds planted in flooded soil than for those placed under water in beakers, especially if convective transport of oxygen in water is important for germination, as has been hypothesized by Heydecker and Orphanos (1968). Moreover, Chetram (1968) has shown that bacteria can aggravate, if not cause, the sensitivity of some seeds to water. Thus, decreased oxygen supply and microbial complications could account for the fact that germination did not occur in soil-water regimes when the water level was at or above the soil surface, but did occur under water in the absence of soil.

LITERATURE CITED

Chetram, R. S. 1968. Effects of excess water, inhibitors, and microorganisms on the germination of *Beta vulgaris* L. Ph.D. Thesis. Univ. Nottingham, Nottinghamshire.

Demaree, D. 1932. Submerging experiments with *Taxodium*. Ecology **13**:258–262.

DuBarry, A. P. 1963. Germination of bottomland tree seed while immersed in water. J. Forest. **61**:225–226.

Heydecker, W., and P. I. Orphanos. 1968. The effect of excess moisture on the germination of *Spinacia oleracea* L. Planta **83**:237–247.

Heydecker, W., P. I. Orphanos, and R. S. Chetram. 1969. The importance of air supply during seed germination. Proc. Int. Seed Test Ass. **34**:297–304.

Morinaga, T. 1926. Germination of seeds under water. Amer. J. Bot. **13**:126–140.

Shunk, I. V. 1939. Oxygen requirements for germination of *Nyssa aquatica*–tupelo gum. Science **90**:565–566.