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F. T. Bonner

Southern Forest Experiment Station
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Yellow-poplar fruits are best collected in late October when their color changes from green to yellow-green or yellow. There were no other obvious physical or chemical changes indicating maturity. The seeds are physiologically mature as early as September 1, although high fruit moisture contents make special handling necessary if fruits are collected at this time. Fruits may be picked from logging slash as early as September after natural drying on the limbs.

Additional keywords: *Liriodendron tulipifera* L., physical and chemical changes, germination, artificial ripening, fruit and seed storage.

Yellow-poplar (*Liriodendron tulipifera* L.) is one of the most valuable hardwoods in the United States. It ranges from southern Ontario to the Gulf of Mexico and flowers from April to June (Renshaw and Doolittle 1965). Maturation occurs in September and October (Sargent 1965, Renshaw and Doolittle 1965). The cone-shaped fruit is 2½ to 3 inches long and consists of about 80 winged carpels on a central axis. Each carpel contains one or two seeds, which usually abort because of ineffective pollination (Boyce and Kaeiser 1961); seeds from most trees average only about 10 percent full (Bonner and Russell 1973). The low percentage of filled seeds and the necessity to collect the fruits before they dry and shatter on the trees make collecting and processing yellow-poplar seeds expensive. This paper describes physical and chemical changes occurring during seed maturation, reports results obtained after artificial ripening treatments, and discusses how this knowledge might improve seed collection.

Methods and Materials

Seed-bearing trees were selected in Oktibbeha County, Mississippi, early in 1970. Beginning in July, 10 to 20 fruits were collected from four trees every 2 weeks until early November—just prior to natural

1 Principal Silviculturist, Forest Tree Seed Laboratory, Forest Service—USDA, Southern Forest Exp. Stn., maintained at Starkville, Mississippi, in cooperation with Mississippi State University.

breakup and seed dissemination. The same procedure was followed in 1971 and 1972 for three of the original trees and one substitute, which replaced a cut tree. The fruits were collected in the morning and transported to the laboratory in polyethylene bags.

Diameter, moisture content, fresh weight, and dry weight of 10 fruits from each sample tree were measured in 1970 and 1972; in 1971, these properties were measured for only five fruits per tree. Diameters were measured at the base. Dry weights were obtained after 24 hours at 105°C; moisture contents were expressed as percentages of fresh weights.

In 1971, the specific gravity of fruits from two of the sample trees was measured by water displacement on six dates from July to November. Fruits from one of the trees were split longitudinally, and the green carpels were separated by hand from wings and axes. The dewinged carpels (hereafter called seeds) were dried for 24 hours at 70°C and ground in a Wiley mill to pass a 20-mesh screen. The ground material was then analyzed for crude fat, soluble and insoluble carbohydrates, soluble and protein-nitrogen, phosphorus, calcium, and magnesium, according to procedures explained previously (Bonner 1972, 1974). All analyses were duplicated and repeated for agreement within 10 percent of the mean.

Germination was tested yearly for seeds from all of the sample trees. Immediately after collection, the fruits were air-dried in the laboratory and broken apart by hand. After the seeds were given moist stratification for either 60 or 90 days at 3°C, they were germinated on moist blotters under diurnally alternating temperatures of 20° and 30°C (I.S.T.A. 1966). Observations continued for either 45 or 60 days, according to the speed of germination; seeds with healthy emerging radicles and positive geotropism were considered germinated. At the end of the tests, ungerminated seeds were opened to obtain estimates of total filled seeds.

In 1971, artificial ripening was tested by procedures previously used for sweetgum (Bonner 1970). Five to eight fruits from each of two trees were given one of the following treatments:

(1) extraction immediately after collection

(2) storage in cloth bags at 3°C and 40 to 50 percent relative humidity (dry-cool)

(3) storage at 3°C in damp peat moss placed in polyethylene bags (moist-cool)

(4) storage in cloth bags in a building with temperatures of up to 30°C (dry-warm).

Collections were made on July 28, on September 7 and 21, and on October 5 and 19. Storage treatments began at the time of collection and lasted

until November, when the fruits were air-dried and broken apart by hand. After the carpels were dewinged and cleaned mechanically, germination tests were conducted.

The ripening treatment judged most successful was retested in 1973 by collecting green fruits from logging slash on August 28, September 10, and September 18. Half of the fruits were dried and extracted immediately, and the other half were artificially ripened until early December. The seeds were then extracted, dewinged, and upgraded (Bonner and Switzer 1971) before testing.

Results and Discussion

Physical Characteristics

Yellow-poplar fruits did not change markedly during the measurement period, and little yearly variation occurred (fig. 1). Fresh weight and moisture content decreased slightly; dry weight was almost constant. Specific gravity declined steadily from 0.86 to 0.68 as moisture content fell and was as low as 0.47 for very dry fruits immediately before opening in early November. Mean diameter, which did not change over the 3-year test period, averaged 18 mm at the base from July through October. These results indicate that the fruits are fully grown by July 1, when they contain sufficient food stores for the seeds.

Fruit exteriors remained bright green in July and August but were fading by late September-early October. By late October, the ripest fruits were yellow or light brown although the green color was still visible on many. The completely brown color normally associated with mature yellow-poplar seeds was not prevalent until the dried fruits began to open on the trees in November. Seed collections should therefore be started well before fruit exteriors turn completely brown.

Chemical Characteristics

Seasonal trends in seed chemical components were of little value in assessing maturation. Chemical changes were difficult to measure, partially because of the presence of large amounts of tissue without embryos. This problem occurred previously with sycamore (Bonner 1972), which also has a low percentage of filled seeds. Accurate chemical indices of seed maturity are therefore useful for filled seeds only; however, separation of full from empty seeds in green fruit is not practical.

Crude fat concentration increased somewhat in early fall, but the total amount in the seeds—never above 3 percent of the dry weight—was too low to be significant (fig. 2). Protein-nitrogen was stable at about 0.5 percent, and soluble nitrogen decreased slightly (from 0.3 to 0.1 percent) with maturity.

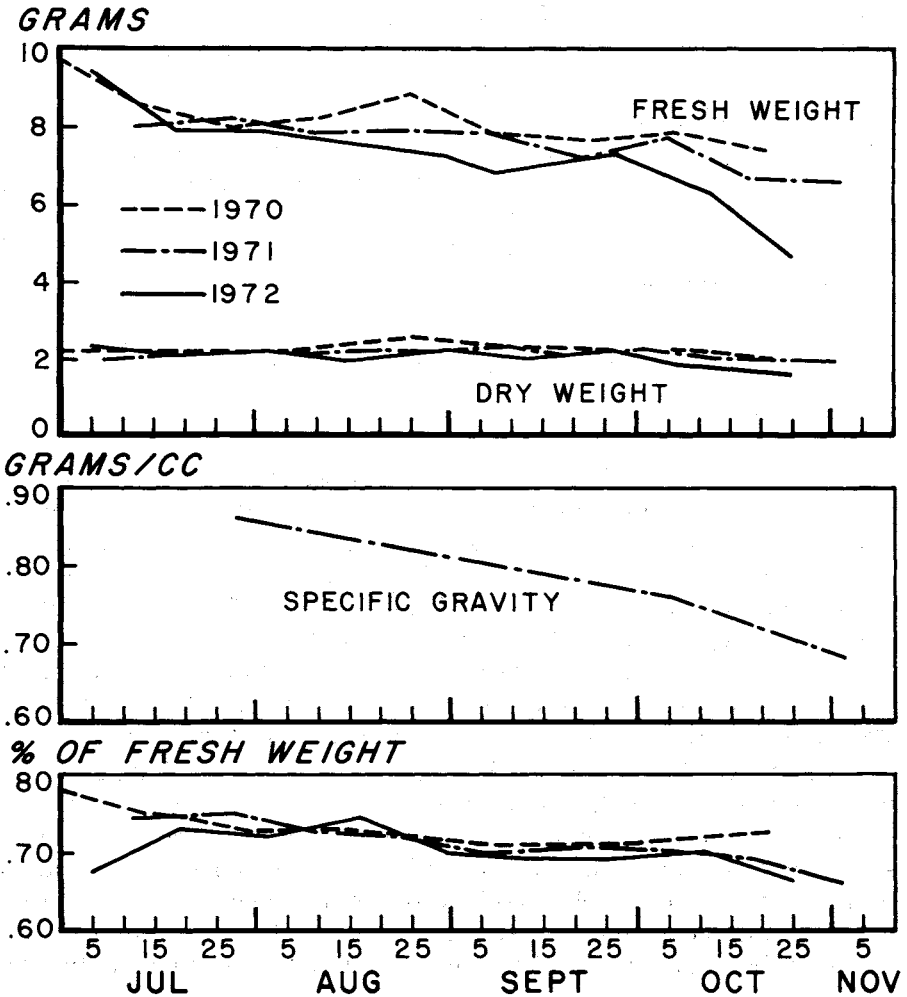

Figure 1.—*Seasonal changes in fresh weight, dry weight, specific gravity, and moisture content of yellow-poplar fruits. Specific gravity data are for two trees only in 1971.*

Although carbohydrates were the most important storage food for these seeds, no perceptible seasonal buildup occurred (fig. 2). Soluble carbohydrate concentration decreased throughout the season (from 11 to about 3 percent), but insoluble carbohydrates fluctuated widely between 15 and 20 percent. At maturity, total carbohydrate content was about 20 percent of the seed dry weight.

Phosphorus content remained relatively steady throughout the season, ranging from 0.12 to 0.18 percent. Magnesium measured 0.18 percent in July and 0.17 percent in November. Calcium content of the seeds more than doubled from 0.14 percent in July to 0.36 percent in November.

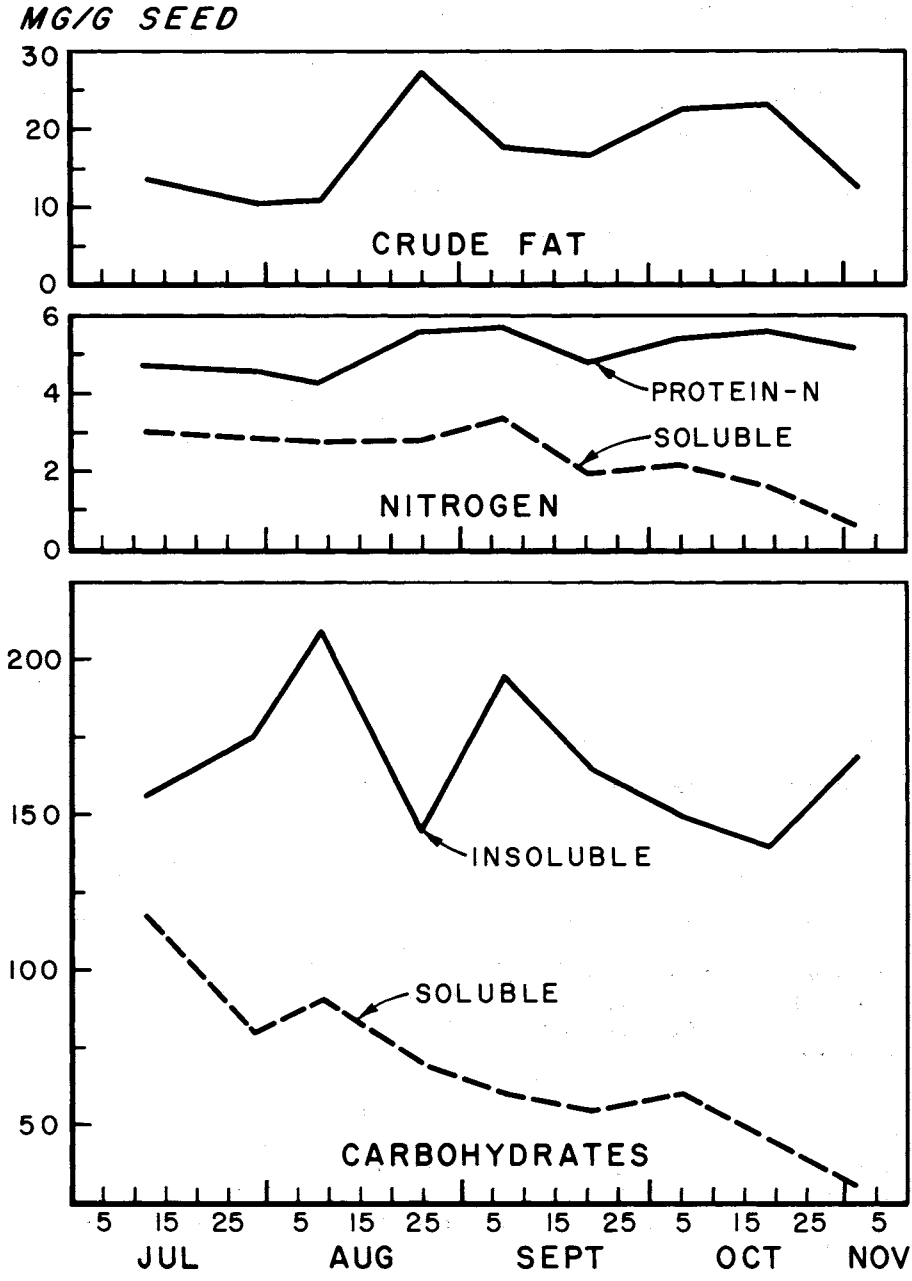

Figure 2.—*Seasonal changes in crude fat, nitrogen, and carbohydrate fractions of yellow-poplar seeds.*

Germination and Artificial Ripening

Germination data indicated that the seeds were physiologically mature by late September or early October (table 1). When judged according to total seeds, germination capacities were quite low, never averaging more than 5.2 percent; however, germination percentages of filled seeds were sometimes as high as 100 percent (table 1). In 1971, all of the artificial ripening treatments produced good, normal germination (table 2). The germinants in the moist-cool treatment

Table 1.—*Germination percentages of yellow-poplar seeds collected at various times*

Collection date	Number of sample trees	Germination capacity	
		Total seeds	Filled seeds
		Percent	
1970			
Sept. 8	1	5.0	100
23	4	4.8	100
Oct. 6	4	5.2	97.0
21	4	2.3	92.8
1971			
Sept. 8	1	1.5	42.1
21	4	2.5	(1)
Oct. 5	5	4.2	79.8
19	5	2.3	94.5
Nov. 2	5	3.9	100

[1] Ungerminated filled seeds were not counted on these samples.

Table 2.—*Germination percentages of seeds from fruits after artificial ripening treatments*

Collection date (1971)	Storage treatment			
	None (extracted immediately after collection)	Moist-cool	Dry-cool	Dry-warm
	Percent			
	Tree A			
July 28	0	4.7 (55.9)[1]	0	0.5 (18.2)
Sept. 7	0.5 (22.2)[1]	7.0 (100)	3.4 (46.9)	0
Sept. 21	.2 (10.0)	3.2 (100)	2.5 (38.5)	1.7 (100)
Oct. 5	.2 (3.6)	5.2 (58.8)	5.3 (100)	0.8 (11.5)
Oct. 19	1.9 (50.0)	7.1 (78.6)	1.3 (100)	2.9 (100)
	Tree B			
July 28	0	0	0	0
Sept. 7	1.5 (42.1)[1]	9.3 (100)	0	5.4 (100)
Sept. 21	6.1 (44.1)	3.7 (39.1)	1.5 (27.3)	3.5 (100)
Oct. 5	1.2 (23.3)	13.2 (88.3)	3.4 (100)	5.4 (100)
Oct. 19	5.2 (72.7)	3.9 (66.7)	3.5 (66.7)	2.3 (100)

[1] Percentages in parentheses are for filled seeds only.

appeared slightly more vigorous than the others. For both sample trees, moist-cool storage after the September and early October collections was usually better than immediate extraction. Seeds from the two sample trees appeared to differ; ripening of fruits picked on July 28 was successful for Tree A but not for Tree B.

In 1973, when the moist-cool ripening treatment was used on half-bushel lots of fruits picked from logging slash, seeds extracted at the time of collection germinated just as well or better than those that were artificially ripened (table 3). The only benefit from artificial ripening was that germination began 4 to 10 days earlier for stored seeds than for those that were extracted immediately.

Table 3.—*Germination capacity of seeds from artificially ripened (moist-cool storage) and upgraded lots*

Collection date (1973)	Extracted immediately after collection	Extracted after moist-cool storage
	Percent	
Aug. 28	39.0 (97.5)[1]	19.0 (82.6)[1]
Sept. 10	14.0 (66.7)	7.0 (50.0)
Sept. 18	17.0 (89.5)	21.0 (95.5)
Mean	23.3 (87.5)	15.7 (79.7)

[1] Percentages in parentheses are for filled seeds only.

Fruits from logging slash may be partially ripened by drying after cutting, thereby lessening the effectiveness of the ripening treatment. Lengthening the collection season might be accomplished by picking fruits from logging tops felled for as long as 4 weeks before natural dispersal (Anonymous 1940). This procedure would be useful to collectors having access to logged trees in August, if they are willing to care for the cones.

Guidelines For Collection

Although the guidelines reported here are based on measurements of trees in central Mississippi, they should be applicable throughout the Midsouth:

(1) Collection of intact fruits from trees should normally not begin until the last half of October.

(2) The best index of maturity is the color change of fruit exteriors from bright green to yellow-green or yellow, a change normally occurring in late October in central Mississippi.

(3) The collection season can be extended by gathering fruits after September 1, when the seeds are apparently physiologically ma-

ture. However, special handling may be required because of the high fruit moisture content (about 70 percent). After collection, fruits should be spread in a thin layer for drying and must never be allowed to overheat.

(4) Fruits may also be picked as early as September from logging slash. Although precautions due to high fruit moisture still apply, natural drying on the limb partially alleviates this problem.

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