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Abstract. Acorns of cherrybark, water, and willow oaks grew slowly but steadily in July and August and reached maximum size in September, when fats and carbohydrates, the major storage foods, accumulated rapidly. At physiological maturity in late October or early November, crude fat levels were 15 to 20 percent of seed dry weight and carbohydrates totaled 25 percent. ***Forest Sci. 20:238–242.***

Additional key words. *Quercus phellos, Quercus nigra, Quercus falcata* var. *pagodaefolia*, germination.

SEED TECHNOLOGY for oaks can be improved with a better understanding of acorn maturation. This paper reports results of 3 years' study of acorns from water (*Quercus nigra* L.), willow (*Q. phellos* L.), and cherrybark oaks (*Q. falcata* var. *pagodaefolia* Ell.), three economically important species of the red oak group.

These three oaks flower from February to May, depending on latitude. In central Mississippi, water and willow oak normally start flowering in the first or second week of March (Toole 1965*a*, 1965*b*). Cherrybark oak probably flowers at the same time. Solitary pistillate flowers are borne on spikes from leaf axils of the current growth. Acorns mature from August to November of the second year (Sargent 1965, Lotti 1965, Toole 1965*a*, 1965*b*). Acorns of all three species are about ½-inch (12.7 mm) long. The number of acorns per pound in central Mississippi ranges from 200 to 400 for water and willow oak (440 to 880 per kg) and from 200 to 700 for cherrybark oak (440 to 1540 per kg) (Bonner 1967).

Acorns of these species exhibit light to moderate dormancy and usually require cold, moist stratification for prompt germination. Water and willow oaks respond well to 60 to 90 days stratification; cherrybark oak usually requires only 30 to 60 days (Bonner 1970).

Procedure

Four seed-bearing trees of each species were selected near Mississippi State University in east-central Mississippi. Ten acorns were collected from each tree every 2 weeks from the end of June until maturation in October or November. All were from the lower one-third of the crown. The original plan was to collect from the same trees each year for 3 years, but crop failures forced some changes. However, good measurements were obtained in 1967, 1968, and 1971 for willow oak; in 1968, 1970, and 1971 for cherrybark oak; and in 1968, 1969, and 1970 for water oak, with data limited to only three trees in 1969. On several occasions late in the season, only five acorns were taken from certain trees because of light seed crops.

All acorns were collected in the morning and transported to the laboratory in polyethylene bags for measurement of fresh weight, diameter, moisture content, and dry weight. Dry weights were obtained after 24 hr of drying at 105°C in a forced-draft oven. Moisture contents were expressed as percentages of fresh weights.

When crop size permitted, extra acorns

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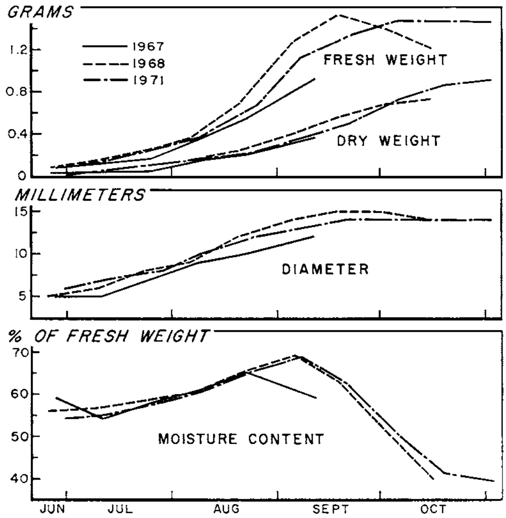

FIGURE 1. *Seasonal changes in fresh weight, dry weight, diameter, and moisture content of willow oak acorns.*

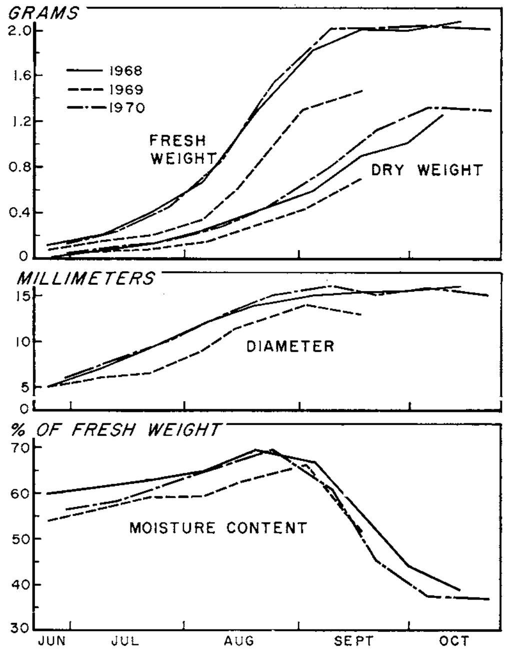

FIGURE 2. *Seasonal changes in fresh weight, dry weight, diameter, and moisture content of water oak acorns.*

were collected in September and October for germination tests. Lots of various sizes were stratified for 30 days at 3°C and germinated on moist Kimpak under diurnally alternating temperatures of 20° and 30°C; light was provided during the 30° period.

During one study year, extra acorns were collected from one sample tree of each species. Acorns and cups were dried for 24 hr at 70°C and ground in a Wiley mill to pass a 40-mesh screen. The ground material was analyzed for crude fat, soluble carbohydrate, insoluble carbohydrate, soluble nitrogen, protein nitrogen, phosphorus, calcium, and magnesium. Methods of analysis were as reported by Bonner (1972). In addition, calcium and magnesium contents were determined by flame photometry during the present study. All concentrations were based on seed dry weight. Analyses were done in duplicate and repeated for agreement to within 10 percent of the mean.

Results

Physical Characteristics. Acorns of all three species increased in size and weight throughout the measurement period and showed very similar patterns of growth (Figs. 1–3). Acorn diameters grew at a steady rate from June through August and reached maximum size in mid- to late September.

Fresh weight increased slowly until early August, then more rapidly as moisture content peaked in late August or early September. Moisture content dropped rapidly in September from 60 or 70 percent to around 40 percent at maturity. Dry weight increased at a more steady rate and continued to rise through late October and early November, long after acorn diameters reached maximum size. In several years, the last collections were apparently made before maximum dry weight was attained.

Variation between years was slight, with several exceptions. Seed crops were poor and acorns were unusually small in 1967 for willow oak and in 1969 for water oak. Extra large acorns were produced in 1971 on cherrybark oak (Fig. 3).

Although some acorns collected in late September and early October germinated, those collected in late October and early November germinated more completely (Table 1). During this same period, acorn

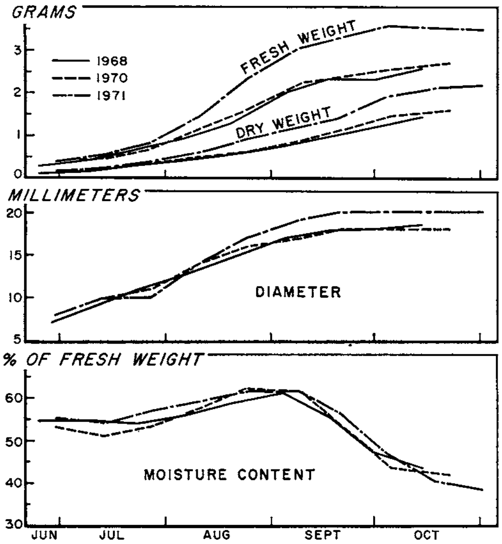

FIGURE 3. *Seasonal changes in fresh weight, dry weight, diameter, and moisture content of cherrybark oak acorns.*

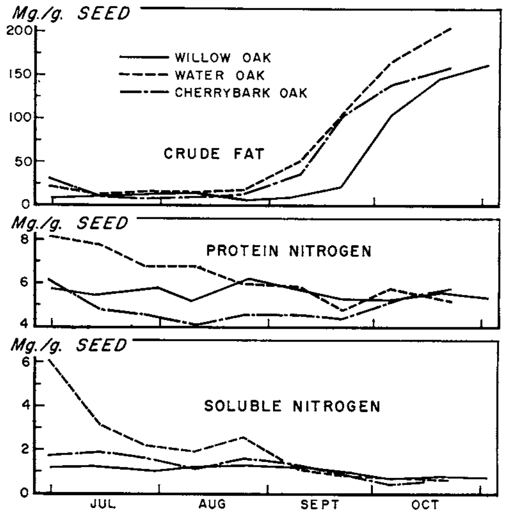

FIGURE 4. *Seasonal changes in crude fat, protein nitrogen, and soluble nitrogen in acorns of willow, water, and cherrybark oaks.*

pericarp color changed from green to dark brown or black, and acorns were easily separated from their cups.

Chemical Characteristics. Fats and carbohydrates are the major seed storage foods in these species. Crude fat levels remained low until September, then climbed sharply to 150–200 mg per gram, or 15 to 20 percent of acorn weight (Fig. 4). Water oak had slightly higher crude fat concentrations at maturity than willow and cherrybark oaks.

The insoluble carbohydrate fraction, like crude fat, was stable until early September, then increased to October peaks of 250 to 300 mg per gram of seed (Fig. 5). In all three species, however, there was a slight drop in concentration at the last collection. Soluble carbohydrates gradually increased from July until early September, then dropped sharply as they were apparently converted to insoluble forms (Fig. 5). Total carbohydrates at maturity accounted for 25 to 30 percent of acorn dry weight for all species. Water oak acorns, which had more crude fat, had slightly less carbohydrates than the other two species. Staining the solid extract residues with IKI (Jensen 1962) indicated

TABLE 1. Germination at 60 days of willow, water, and cherrybark oak acorns collected from September to November.

Collection date	Willow oak–1971		Water oak–1968		Cherrybark oak–1971	
	Tree 1	Tree 3	Tree 1	Tree 3	Tree 1	Tree 3
	Percent[a]					
Sept. 21	14	0	—	—	—	—
Sept. 30	—	—	77	90	—	—
Oct. 6	59	8	—	—	0	9
Oct. 18	86	74	92	78	20	60
Nov. 1	96	94	—	—	72	76

[a] Germination percentages are based on single lots per tree of 15 to 25 acorns each.

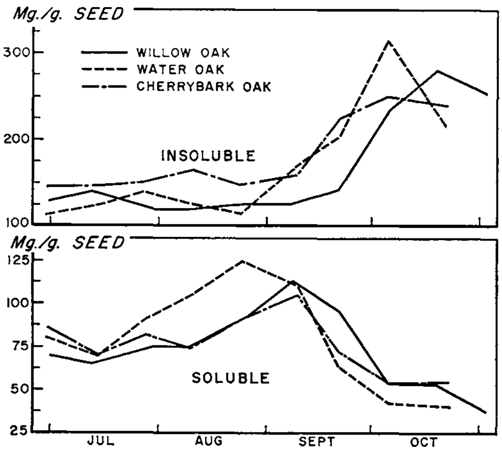

FIGURE 5. *Seasonal changes in soluble and insoluble carbohydrates in acorns of willow, water, and cherrybark oaks.*

that amylose was present in increasing amounts as the season progressed (Table 2).

Both protein nitrogen and soluble nitrogen decreased in concentration during maturation (Fig. 4). In protein nitrogen, the decrease seemed to level off in late September and even reverse itself slightly. There were no significant increases, however. Both nitrogen fractions changed much more in water oak than in the other two species.

Calcium, magnesium, and phosphorus

TABLE 2. Presence of amylose in acorns of willow, water, and cherrybark oak as indicated by IKI staining. (–) absent, (+) light stain, (++) heavy stain.

Collection date		Willow oak	Water oak	Cherry-bark oak
June	29	+	–	–
July	13	+	–	–
July	28	+	–	–
August	10	+	–	–
August	24	+	+	+
September	8	+	+	+
September	21	+	++	++
October	5	++	++	++
October	20	++	++	++
November	2	++		

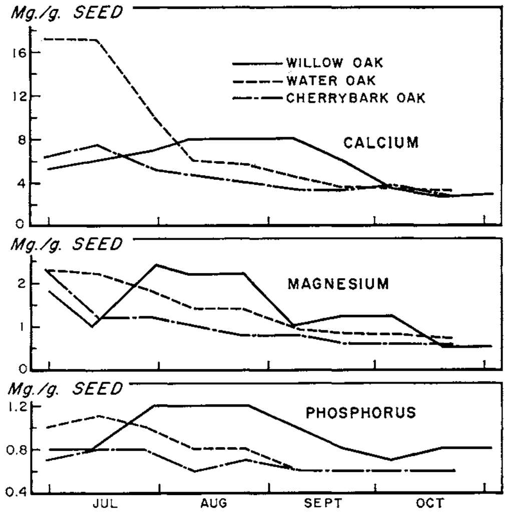

FIGURE 6. *Seasonal changes in calcium, magnesium, and phosphorus in acorns of willow, water, and cherrybark oaks.*

levels in water and cherrybark oak acorns gradually declined during maturation (Fig. 6). Willow oak acorns showed similar trends late in the season, but they also had unexplained increases for all three elements in August (Fig. 6).

Discussion

Acorn maturation was very similar for all three species and in all sampling years. July and August were characterized by slow but steady growth and increasing moisture contents. Acorns reached maximum size in September as the major storage foods, fats and carbohydrates, rapidly accumulated. A drop in moisture content in September and October accompanied this growth. This general pattern fits most fall-maturing dry fruits and seeds that readily dehisce at maturity (Hatano and Asakawa 1964, Pollock and Ross 1972). Acorns differ from the others in this group, however, in their high moisture contents at maturity. Red oak acorns are about 35 to 40 percent moisture at maturity; smaller dry seeds, both crop and tree species, usually are below 20 percent moisture at natural maturity.

Seeds with little moisture can be stored easily, but acorns present a problem because their high moisture contents must be maintained during storage to prevent loss of viability (Bonner 1973). For this reason, Roberts (1973) grouped the oaks among the "recalcitrant" species.

No other published values for chemical contents of these red oak acorns during maturation are known to the author. Analyses of mature acorns of other red oak species are available (Korstian 1927, Wainio and Forbes 1941, Bonner 1971), and those data are similar to concentrations in mature acorns reported in the present work.

The magnitude of change in chemical fractions is dominated by the large amount of storage tissue in the cotyledons of acorns (Vozzo 1973). The embryonic axes of these species comprise less than 1 percent of total acorn dry weight at maturity. Chemical components which are high in nitrogen and phosphorus, such as proteins and nucleic acids, increase considerably in the embryonic axis during maturation; but total concentration changes for the entire acorn are small.

Although germination tests were limited, the data indicate that acorns reached full physiological maturity in late October and early November. Extensive acorn collections for other studies at the Forest Tree Seed Laboratory support this conclusion. Possible chemical indices of maturity are 15 to 20 percent crude fat and 25 percent carbohydrate, but these would have very limited practical use. Generally, the outward appearance of the acorn is the best indication of maturity. Mature acorns are dark brown or nearly black (water oak) and can be easily removed from the cup. If acorns are gathered before they exhibit these characteristics, collections are likely to yield immature acorns which germinate and store poorly.

Literature Cited

BONNER, F. T. 1967. Handling hardwood seed. USDA For Serv Southeast Area Forest Nurserymen Conf Proc 1966:163–170. 215 p. Southeast Area State and Priv Forest, Atlanta, Ga.

———. 1970. Hardwood seed collection and handling. *In* Silviculture and management of southern hardwoods, p 53–63. La State Univ 19th Annu Forest Symp Proc, La State Univ Press. 145 p.

———. 1971. Chemical contents of southern hardwood fruits and seeds. USDA Forest Serv Res Note SO-136, 3 p. South Forest Exp Stn, New Orleans, La.

———. 1972. Maturation of sweetgum and American sycamore seeds. Forest Sci 18:223–231.

———. 1973. Storing red oak acorns. USDA Forest Serv Tree Planters' Notes 24(3):12–13.

HATANO, K., and S. ASAKAWA. 1964. Physiological processes in forest tree seeds during maturation, storage, and germination. *In* International review of forestry research, Vol I, p 279–323. Academic Press, N.Y. 404 p.

JENSEN, W. A. 1962. Botanical histochemistry: principles and practice. W H Freeman and Co, San Francisco. 408 p.

KORSTIAN, C. F. 1927. Factors controlling germination and early survival in oaks. Yale Univ Sch Forest Bull 19, 115 p.

LOTTI, T. 1965. Cherrybark oak (*Quercus falcata* var *pagodaefolia* Ell.). *In* Silvics of forest trees of the United States, p 569–572. USDA Agric Handb 271. 762 p.

POLLOCK, B. M., and E. E. ROOS. 1972. Seed and seedling vigor. *In* Seed biology, Vol I, p 313–387. Academic Press, N.Y. 416 p.

ROBERTS, E. H. 1973. Predicting the storage life of seeds. Seed Sci Technol 1:499–514.

SARGENT, C. S. 1965. Manual of trees of North America (exclusive of Mexico). Ed 2, corrected. 2 vols. Dover Publ Inc, N.Y. 934 p.

TOOLE, E. R. 1965*a*. Water Oak (*Quercus nigra* L.). *In* Silvics of forest trees of the United States, p 628–630. USDA Agric Handb 271. 762 p.

———. 1965*b*. Willow oak (*Quercus phellos* L.). *In* Silvics of forest trees of the United States, p 638–640. USDA Agric Handb 271. 762 p.

VOZZO, J. A. 1973. Germination analyses of excised embryo cylinders and whole acorns of water oak. USDA Forest Serv Res Note SO-153, 3 p. South Forest Exp Stn, New Orleans, La.

WAINIO, W. W., and E. B. FORBES. 1941. The chemical composition of forest fruits and nuts from Pennsylvania. J Agric Res 62:627–635.