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An Evaluation of Longleaf Pine Cone Specific Gravity by Family

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Introduction

A significant part of longleaf restoration initiative is the establishment of new longleaf forests and the subsequent need for seedlings. To meet the demand for seedlings a reliable supply of high-quality seed is required. Longleaf has several unique characteristics that will hinder seed supply efforts. One of the most important is longleaf pine's infrequent cone crop production. Typically, good cone crops occur every 5-7 years with large bumper crops even less frequent [11]. Cone crops at the Bladen Lakes State Forest cone production research site recorded fair or better crops (greater than 25 cones per tree) in only 9 out of 38 years[6]. In addition, longleaf seed quality tends to decline the smaller the cone crop. And infrequent larger cone crops are often followed by smaller ones[10].

Figure 1. Longleaf pine cones have unique characteristics that must be addressed during harvest, handling, and processing.

Proper cone collection, handling, and processing is important to ensure top-quality seed. A key first step is to not start cone collection until after the cones are fully mature[1,3]. Longleaf seed viability (number of seeds that will germinate) is lower if cones are collected before they are fully mature[4]. Unlike loblolly or slash pine, longleaf seed does not continue to ripen in storage and immature cone seed viability will further decline during the storage period before extraction [2,5].

Cone specific gravity provides an index of cone maturity for southern yellow pines. Wakeley reported that southern yellow pine cones are ready for harvest when they reach a specific gravity of less than 0.89 [8]. Barnett suggested that longleaf cone specific gravity should be less than 0.86 before collecting[2]. Cone maturity in southern yellow pine is genetically influenced; that is, some family's cones ripen and begin to open earlier than others[9]. Cone maturity is especially important for longleaf pine and only cones that are fully mature should be harvested.

By using specific gravity the orchard manager can identify longleaf families whose cones tend to mature earliest, and schedule the harvest to collect those families first. Allowing the cones to remain on the tree until fully mature will improve seed viability and increase seed yield. Our study seeks to identify and rank the families in the NC Forest Service longleaf orchard which mature earliest.

Methods

The study was conducted at the NC Forest Service longleaf seed orchard at Bladen Lakes State Forest. The orchard was established in 1985 and initially contained 76 families originating from counties across the longleaf range in North Carolina. We calculated cone specific gravity by family for three cone crop years - September 27-28, 1999, September 25-26, 2000, and October 1-2, 2003. The cone crop for those years could be categorized as good (1999), fair (2000) and fair (2003)[6]. Cones were collected from 53 families, 42 families, and 38 families in 1999, 2000, and 2003 respectively.

When possible we collected a total of 10 cones from each family, two cones per tree from five different trees. One cone was collected from the southern aspect and one

Figure 2. We used a 20-foot pole to collect cones. This limited collection to the tree's lower half.

from the northern aspect. Trees were selected from different quadrants in the orchard. A 20-foot pole was used to knock the cones from the tree. This limited cone removal to the lower third of the tree.

We determined cone specific gravity immediately after removal using the water displacement method described by Karrfalt [7]. *"A simple field method of measuring specific gravity is to use a cylinder slightly larger in diameter than the cone. Three or four-inch PVC pipe works well. A toilet flange with a knock-out plug makes a good base and plug for one end of the pipe. A ¼ to ½ inch drainpipe is installed on the side near the top of the cylinder. Water is put into the cylinder until it flows out of the drainpipe. The cone is then slowly lowered into the water and the overflow caught in a 100 ml graduated cylinder. The volume of water displaced from the cylinder by the floating cone is the weight of the cone. Record this volume. Next, the cone is pushed below the surface of the water displacing more water. This second amount of water equals the volume of the cone (or the weight of "an equal volume of water") that is needed for specific gravity measurement. Dividing the first volume by the second volume gives the specific gravity."*

Figure 3. The water displacement method was used to determine cone specific gravity. Specific gravity was determined within five minutes of collection.

We ranked family specific gravity from lowest to highest for each year of the study. If one family's specific gravity was the identical to another, they would receive the same rank. A family's overall rank was determined by averaging the ranking it received in each of the three years.

Results

Overall family specific gravity (SG) was consistent for the three collection years averaging 87%, 87%, and 86% in 1999, 2000, and 2003 respectively. Total average SG was 87%. Thirty-seven families (67%) had an average cone SG less than 0.89 and only 20 families (36%) had cones with SG less than 86%. See Table 1. However, these numbers varied from year to year, perhaps due to weather conditions prior to and during collection. The SG we measured would not meet Wakeley's maturity criteria of 19 of 20 cones (95%) having a SG of <0.89 before collecting in any of the collection years.

	Cone Specific Gravity		
Collection Year	Avg.	Below 0.89	Below 0.86
	--- percent ---		
3-Year Avg.	87%	67%	36%
1999	87%	62%	30%
2000	87%	60%	43%
2003	86%	74%	50%

Table 1. Three-year average of Longleaf pine cones that met the required specific gravity (<0.89) for cone maturity/ ripeness. Collected during the last week of September.

Cones of certain families consistently matured earlier, indicating a family genetic influence on specific gravity. By-family specific gravity ranged from a low of 0.72 to a high of 0.96.

Ranking by family was also consistent each year. Those families with lower specific gravity rankings at the end of September remained the same each year. Table 2. shows average specific gravity ranking for families with a specific gravity below 0.89 on date of collection, and the number of years cones were produced during the 3 crop years.

Discussion

Historically cone collection was completed by starting at one end of the orchard and collecting from trees down one row and up the next. In good years this may take three weeks. The orchard manager would by necessity need to start collection during the end of September or the beginning of October in order to complete before natural seed fall occurred. Inevitably seed from some trees was lost before the cones were harvested.

Longleaf seed quality improves the longer the cone remains on the tree to ripen. Seed viability decreases during cone storage if immature cones are collected[5]. It is important to know which families mature earliest to ensure high seed quality during harvest.

In our study we identified the top families whose cones consistently matured the earliest. The orchard manager can use this ranking to schedule a by-family collection of the early openers. The cones will be more mature and higher seed quality will result.

Our study found that cone maturity within the family

varied year to year, but the general ranking remained consistent. See Table 3. Rain and high humidity can increase cone specific gravity. Year-to-year variation is likely due, in part, to weather conditions prior to collection.

Although not a part of our study we found that cone crop frequency differed among the families. Some families produced cones all 3 years while others produced cones in only one of the years studied. This may have skewed the overall average. Cone production frequency and reliability may be a desirable family trait to use in selecting which families are retained in the orchard and thus warrant further research.

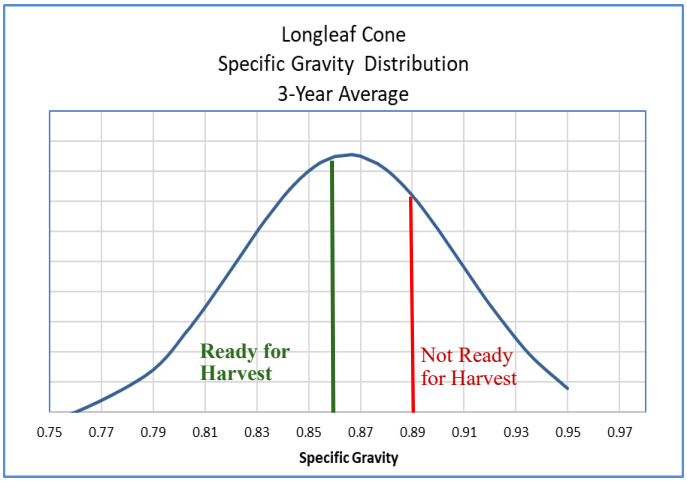

Figure 4. The normal distribution of longleaf pine cone specific gravity in our study is a classic bell-shaped curve. The families with cone specific gravity to the left of the green line are mature and ready for harvest. Cone specific gravity to right of the red line are not ready to harvest and need to stay on the tree longer. Seed quality of the cones in the zone between the lines would likely increase if allowed to remain on the tree to ripen further.

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Table 2. Average specific gravity ranking for families whose specific gravity fell below 0.89 on the date of collection. The number years cones were produced during the 3 years of collection is seen in the last column

FAMILY	3-Year AVG. SG	Rank	# years Cones Produced
16-201	0.72	1.0	1
16-140	0.75	1.5	2
16-206	0.79	2.7	3
16-224	0.80	3.7	3
16-131	0.81	4.5	2
16-146	0.81	4.3	3
16-290	0.82	6.0	1
9-48x	0.83	6.0	3
16-142	0.83	6.3	3
16-218	0.83	6.7	3
16-139	0.84	7.5	2
16-151	0.84	7.0	1
16-158	0.84	7.0	1
16-221	0.84	7.0	3
9-57x	0.84	7.0	3
16-161	0.84	7.3	3
16-134	0.85	7.7	3
16-216	0.85	7.7	3
16-163	0.85	8.0	3
16-149	0.85	8.3	3
8-192	0.86	8.5	2
16-116	0.86	9.0	3
16-135	0.86	9.0	3
16-154	0.86	9.0	3
8-54x	0.86	10.0	1
16-132	0.87	9.7	3
16-160	0.87	9.7	3
8-151	0.87	10.0	3
9-59x	0.87	10.0	3
16-157	0.88	10.7	3
16-202	0.88	10.7	3
9-54x	0.88	10.7	3
16-133	0.88	12.0	1
16-145	0.88	12.0	1
16-211	0.88	11.0	3
16-219	0.88	11.0	3
9-50x	0.88	11.3	3

Table 3. NCFS longleaf pine family specific gravities sorted from lowest to highest by their 3-year average. Specific gravities for each year measured is included. Blank cells indicate that no cones were collected from that family for that year.

	Specific Gravity			
FAMILY	1999	2000	2003	3 -Year AVG
16-201	0.72			0.72
16-140	0.76	0.74		0.75
16-206	0.81	0.77	0.78	0.79
16-224	0.81	0.80	0.80	0.80
16-131	0.82	0.79		0.81
16-146	0.78	0.84	0.81	0.81
16-290	0.82			0.82
9-48x	0.81	0.82	0.86	0.83
16-142	0.80	0.88	0.82	0.83
16-218	0.89	0.80	0.81	0.83
16-139	0.83	0.85		0.84
16-151			0.84	0.84
16-158		0.84		0.84
16-221	0.85	0.84	0.83	0.84
9-57x	0.81	0.88	0.83	0.84
16-161	0.85	0.84	0.84	0.84
16-134	0.85	0.83	0.86	0.85
16-216	0.86	0.84	0.84	0.85
16-163	0.87	0.84	0.84	0.85
16-149	0.88	0.85	0.83	0.85
8-192	0.86		0.85	0.86
16-116	0.90	0.83	0.85	0.86
16-135	0.86	0.88	0.84	0.86
16-154	0.88	0.86	0.84	0.86
8-54x	0.86			0.86
16-132	0.90	0.86	0.84	0.87
16-160	0.87	0.84	0.89	0.87
8-151	0.87	0.89	0.85	0.87
9-59x	0.83	0.91	0.87	0.87
16-157	0.87	0.90	0.86	0.88
16-202	0.90	0.91	0.82	0.88
9-54x	0.88	0.86	0.89	0.88
16-133	0.88			0.88
16-145	0.88			0.88
16-211	0.87	0.85	0.92	0.88
16-219	0.89	0.87	0.88	0.88
9-50x	0.86	0.89	0.90	0.88
16-118	0.87	0.91	0.88	0.89
16-112	0.89			0.89
16-119	0.88	0.91	0.88	0.89
16-238	0.89			0.89
16-208	0.84	0.94	0.90	0.89
16-143	0.90			0.90
16-148	0.92	0.91	0.87	0.90
16-159	0.92	0.88		0.90
8-156	0.89	0.89	0.92	0.90
9-58x	0.91	0.91	0.91	0.91
8-150	0.93	0.9	0.92	0.92
8-158	0.89	0.96	0.90	0.92
16-222	0.94	0.94	0.88	0.92
8-154	0.90	0.94		0.92
16-115	0.92			0.92
16-153	0.91		0.93	0.92
8-193	0.91	0.96		0.94
16-136	0.95			0.95
1st day collected	29-Sep	25-Sep	1-Oct	
Count	53	42	38	55