Cone Maturation and Seed Yield of Ocala Sand Pine

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The serotinous nature of cones of the Ocala sand pine (Pinus clausa (Chapm. ex Englem.) Vasey ex Sarg. var. clausa) allows for their collection at any time of the year. For the development of Ocala sand pine seed orchards, better information was required on optimal collection dates. Data from the tests reported here indicate that to avoid lower seed yields and lower germination rates, collections should not begin before mid-October (depending on the order of clone ripening). Collections should be completed not more than about 3 months after maturation because seed yields per cone decrease with increasing time of exposure on trees.
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Sand pine (*Pinus clausa* (Chapm. ex Engelm.) Vasey ex Sarg.) is a minor species of southern pine with a restricted range in central and northwestern Florida (8). The two recognized varieties differ primarily in their cone characteristics. Variety *immuginata*, commonly known as Choctawhatchee sand pine, is native to northwestern Florida and has cones opening at the normal time, whereas variety *clausa* (11), known as Ocala sand pine, grows in central Florida and has serotinous cones.

The largest concentration of the species occurs on the rolling sandhills of central Florida in a block of some 200,000 acres of Ocala sand pine lying mostly within the Ocala National Forest. Experience has shown that sand pine is the best adapted of the southern pines to these local dry, infertile soils, and it is used to regenerate such sites. Seeds for reforestation have usually been obtained from harvesting operations, but a sand pine seed orchard is now in production and provides increasing proportions of the seed needs.

Collections of the serotinous cones have been made at almost any time of the year when logging operations are under way. However, it seemed worth investigating whether yield and quality of seeds could be improved by making collections during a restricted period after cone and seed maturation had occurred. No reliable data existed about times for either cone and seed maturation or optimal collection. Cone maturity has been related to cone color-ripeness is associated with development of light brown color (5). Specific gravity is the indicator most commonly used for cone maturity in southern pines generally (10), but it is not reliable for sand pines (5).

The present study was undertaken to determine times of maturation in cones and seeds and to identify optimal dates for cone collection from Ocala sand pine.

Methods

Tests were conducted in two successive years (1986 and 1987) in the Ocala sand pine seed orchard of the USDA Forest Service near Silver Springs, FL. First-year cone collections were made at 2-week intervals from late September to early December (6 collection dates). In the seed orchard, six clones that had good cone crops were selected for repeated collections. The clonal collections were from one ramet. Twelve cones were collected from each clone on each collection date. These were placed in Kraft paper bags, marked with clone number and date of collection, and held at ambient temperatures. The collections made from 6 clones on each of 6 dates resulted in 36 bags of 12 cones each.

Cone processing was delayed until all collections were completed. Previous tests had indicated that such cone storage of Ocala sand pine did not affect seed germination (2). The cones were shipped to Pineville, LA, for extraction and seed testing. Extraction began on December 30, 1986, by dipping the 12 cones from each Kraft paper bag individually into boiling water for 15 seconds to break the resinous seal of the cone scales (5). The cones were then dried in a forced-draft oven at 95 °F for 24 hours. Empty seeds were separated by flotation in 95%

ethanol. Full and empty seeds were counted.

All cones from a single clone had about the same number of seeds. The number of seeds extracted per clone was therefore determined for each date of collection to estimate the effect of collection date on seed yield. Studies with other species have shown that this technique works well (3).

A 200-seed sample (2 dishes of 100 seeds each) was tested for each clone and collection date. Germination counts were made 3 times weekly to evaluate the speed of germination. Tests were conducted for 28 days with unstratified seeds on a sand-peat medium.

In the second year, the same methodology was followed, but this time collections were made at 3-week intervals from early August to early January (8 collection dates). The same clones were used as in the earlier study and the cones were handled and processed in the same manner. At the time of three of these collections (August 10, October 13, and January 4), 1-year-old cones also were collected from each clone. Extraction began on February 8, with the full and the empty seeds separated as before. Samples of full and empty seeds of each clone were weighed to determine seed weight per clone for each collection date.

Results

Seed yields. *Year one*. Seed yield varied between clones; for example, clone 25 averaged 28 seeds per cone whereas clone 45 averaged 54 per cone (table 1). Collection dates (between September 22 to December 1) did not have an important effect on seed yield. Seed number per cone varied from 36 (November 17) to 46 (October 20), but variation was so great that the differences were not statistically significant (0.05 level); also they did not follow a logical progression.

The percentage of full seeds per cone averaged 64% and ranged from 53 to 79% (table 1).

Results from other species indicate that these percentages are consistent from year to year within a clone (9).

Year two. In the second year, collection dates were extended from early August to early January and some collections of 1-year-old cones were made from the same trees. The longer collection period revealed trends in yield of both full and empty seeds. Cones collected on August 10 case-hardened, and no seeds were obtained. At the end of August, only 4 of 34 seeds extracted per cone (fig. 1) were full. The yield of full seeds increased on each later collection until November 23 and decreased thereafter.

Table 1—*Seed yields and germination rates of Ocala sand pine cones collected on six dates (year 1), based on 12 cones per clone*

	Clone number						
Collection dates	23	25	28	35	40	45	Avg.
Yield of full seeds (#/cone)							
September 22	39	32	30	22	60	47	38
October 6	28	16	18	47	44	60	35
October 20	44	26	49	44	57	55	46
November 3	30	23	31	44	53	58	40
November 17	40	24	44	42	51	57	36
December 1	32	45	39	19	47	49	38
Average	36	28	35	36	52	54	39
Total yield (#/cone)	62	44	66	58	66	74	61
Percent yield of full seeds	57	63	53	62	79	73	64
Percentage germination							
September 22	81	91	89	92	79	48	80
October 6	88	90	86	94	94	76	88
October 20	93	94	91	95	98	94	94
November 3	97	90	95	95	90	84	92
November 17	93	95	94	99	94	94	95
December 1	96	94	97	96	94	89	94

The trend after maturation toward decreasing numbers of full and increasing numbers of empty seeds was further illustrated by data on cones from the previous cone crop (fig. 1). These data confirmed the trend observed in the first year-the numbers of full seeds decreased with increasing exposure time on the trees. Average numbers of full seeds per cone decreased from about 40 at maturation to 5 fourteen months later. There was, of course, a corresponding increase in empty seeds. Although these data represent two separate years of cone initiation (fig. 1), they are believed to represent the trends realistically because the crops grew in consecutive years on the same trees.

As expected, clones varied considerably in seed yield and in the dates on which optimal yields were obtained.

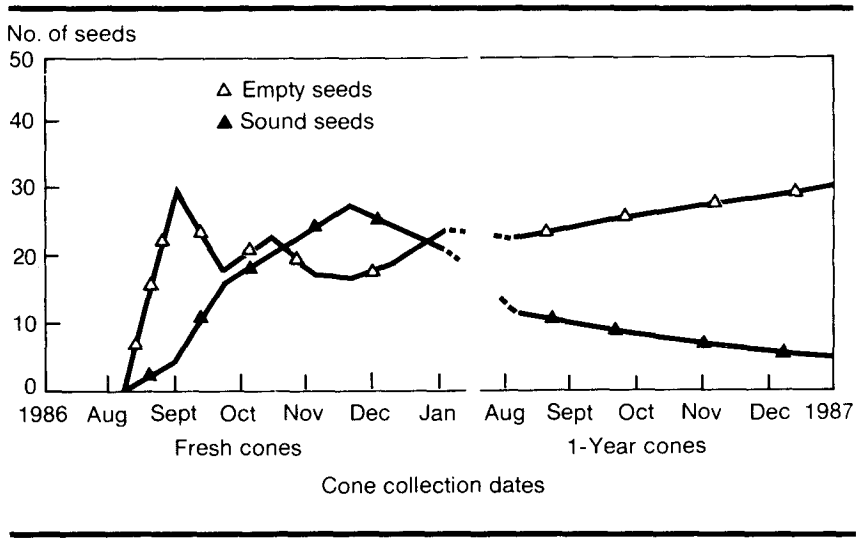

Figure 1—*Seed yield of Ocala sand pine cones on successive collection dates. Each plotted yield is an average from 36 cones (12 cones from each of 6 clones) collected on that date.*

Germination. *Year one*. Germination varied with cone collection date (table 1). Seeds from cones collected on the two earliest dates (September 22 and October 6) averaged 80 and 88% germination, respectively, whereas those for the four later collection dates averaged 94%. Germination also showed a statistically significant interaction with clones, so that some clones were more adversely affected than others by early collection. For example, for clone 45, seeds collected on September 22 yielded only 45% germination whereas, of those collected 4 weeks later (October 20), 94% germinated.

Germination speed expressed as the peak value of the maximum cumulative percentage germination divided by the number of days from sowing (6) followed the pattern for total germination. Seeds from the two earliest collections germinated slower overall, but there was considerable variation among clones. Clone 45, which had the lowest total germination, also had the slowest germination.

Year two. In the second year, trends in germination generally agreed with those in the first. Viability was low for seeds collected on August 31 and September 21 (table 2). Collections made in mid-October or later had relatively constant viability.

Seeds from the August 6 collection of 1-year-old cones had a lower total germination than those collected later. The reason for the low viability at this collection date is not clear.

Discussion

Cone collections did not begin early enough in the first year to decide when cone and seed maturity occurred, but the two earliest collections (September 22 and October 6) resulted in lower germination than later collections, particularly in some clones. Seeds that had lower total germination rates also germinated more slowly. In the

second year, data confirmed that collections in August, September, and early October resulted in seeds with reduced viability. When seed yields also were considered, it became apparent that cones from Ocala sand pine should not be collected until November.

Collections of cones from the same 6 clones over a 2-year period indicated a marked reduction over time in numbers of full or sound seeds. Yields of full seeds from collections in the fall of 1986 averaged about 40 per cone. After a year on the trees, yields were less than 10 per cone. There was a corresponding increase in empty seeds per cone.

Insect damage seems the most logical explanation for the loss of full seeds over time. The damage to seeds in southern pine cones done by the shieldbacked pine seed bug (*Tetyra bipunctata* (Herrich-Schäffer)) is well documented (7), and continuous feeding on cones and seeds by various insect species has been reported to reduce the overall production and cost effectiveness of the Ocala sand pine seed orchard (1).

Earlier research has shown that such decreases in yield do not occur when cones are collected and stored in bags for 1 year at ambient temperatures (4), and that seeds from 1-year cones have lower germination (86%) than new cones collected at the same time (93%) (5). Only 56% of seeds from older cones (2 + years) germinated.

Table 2—*Ocala sand pine germination, based on yields from 12 cones per clone on eight collection dates (year 2) plus yields of some 1-year cones*

	Clone number						
Collection dates	23	25	28	35	40	45	Avg.
Current year's cones (% germination)							
August 10	0	0	0	0	0	0	0
August 31	0	54	0	59	77	0	63
September 21	87	68	79	50	68	60	69
October 13	85	67	82	87	84	84	83
November 2	85	80	62	81	90	88	81
November 11	96	86	86	88	86	88	88
December 14	91	88	76	89	78	86	84
January 4	85	73	66	96	94	88	84
First year's cones (% germination)							
August 10	84	70	78	86	73	60	75
October 13	80	83	78	89	91	69	82
January 4	IS	81	84	93	70	81	82

IS = Insufficient full seed for testing.

Recommendations

The tests indicate that general collections of the current year's cones of Ocala sand pine should not begin until November because both seed yield and viability are lower in earlier collections. For clonal material, it may be more efficient to base collection dates on clonal ripening dates; then, in selected clones, collection may begin in mid-October. The data also indicate that delays in cone collection for 6 months or longer may result in much smaller numbers of full seeds per cone. Thus, the optimal dates for collection of Ocala sand pine cones occur during the 3 months after maturation.

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