CONE CHARACTERISTICS AND SEED YIELD IN JACK PINE

Richard M. Jeffers[1]

INTRODUCTION

Jack pine (Pinus banksiana Lamb.) is an important pulpwood species throughout much of its natural range, exhibits very rapid juvenile growth on dry sandy soils, and flowers at an early age (Rudolf, 1958; Rudolph, 1966). It has been widely planted within its natural range and currently phenotypic selections are being made in the Lake States for establishment of seedling seed orchards.

Mature cone characteristics are often of prime importance in distinguishing between various pine species, particularly in areas where introgression between species is suspected. Mature cone characteristics have been used in evaluating and distinguishing several pine types in central and northwestern Alberta, an area where the ranges of jack pine and lodgepole pine (Pinus contorta var. latifolia) overlap and there is abundant evidence of introgression between these species (Moss, 1949).

Variation between seed sources in cone characteristics of jack pine has been reported by Schoenike et al. (1959). The study reported here was conducted to determine the kind and magnitude of variation of several cone characteristics, and seed yield in trees from 11 provenances of jack pine planted in a range-wide test in northern Wisconsin. This information would be useful in selection and breeding and for the prediction of cone and seed yields in seed orchards of jack pine.

MATERIALS AND METHODS

A range-wide jack pine provenance test was established in the Hugo Sauer Nursery at Rhinelander, Wisconsin, in the spring of 1962 with the cooperation of Mr. Mark Hoist, Research Scientist, Department of Fisheries and Forestry, Petawawa Forest Experiment Station, Chalk River, Ontario, Canada. Trees from 92 widely distributed provenances in the natural range of jack pine were planted in a 5-year nursery test. In the spring of 1965, 2-1 seedlings from 90 of these provenances were field planted near Lake Tomahawk in Oneida County, Wisconsin. A 4-tree row plot for each provenance was replicated 12 times at a spacing of 6 feet by 8 feet.

Trees from eleven provenances were evaluated for cone characteristics and open-pollinated seed yields in mid-November 1970, when the trees in the field planting were 8 years old from seed. The provenances were selected from as wide a geographical distribution as possible with latitudes ranging from 43.8° to 56.6°N. and longitudes from 65.4° to 111.9°W. (Table 1).

---

[1] Associate Plant Geneticist, USDA Forest Service, North Central Forest Experiment Station, Rhinelander, Wisconsin.

Table 1.--Seed origins.

Petawawa Forest Experiment Station number	Location	Latitude ° N	Longitude ° W
02	Birchtown Brook, N. S.	43.8	65.4
14	Nipisiguit River, N. B.	47.4	66.5
25	Welch Mt., N. H.	43.9	71.6
34	Manouan Lake, P. Q.	47.7	74.1
46	Petawawa Plains, Ont.	45.8	77.4
62	Gowganda Lake, Ont.	47.6	80.7
69	Mosinee, Wisc.	44.8	89.7
74	Marl Lake, Mich.	44.5	84.8
82	Kenora, Ont.	49.8	94.5
91	Kississing Lake, Man.	55.1	101.2
95	Fort McMurray, Alta.	56.6	111.9

Mature cones ripening the current year were tallied and grouped into three classes: (1) No cones; (2) 1 - 9 cones per tree; and (3) 10 or more cones per tree. Based on this information, 8 or 10 trees with a minimum of 4 closed cones per tree were selected, at random, within each provenance. These trees were classified on a cone angle basis--cone angle is the angle between a line from the tip of a cone to its point of attachment and the branch axis--and grouped into three classes:

Class 1. -45° to +15° (a negative cone angle results when a cone actually overlaps the branch to which it is attached).

Class 2. +16° to +75°

Class 3. +76° to +135°

Four closed cones (occasionally three) were collected, at random, from each selected tree and X-ray photographed for determination of cone curvature and longitudinal section area (longi-sect. area). On the basis of the X-ray photographs, the cones from each tree were grouped into four cone curvature classes:

Class 1. Negative curvature (a negative curvature results when a cone curves away (abaxial) from the branch to which it is attached.

Class 2. Straight or slight curvature.

Class 3. Moderate curvature.

Class 4. Strong curvature.

Longi-sect. areas were determined, with the aid of a planimeter, from the outline of the cones on the X-ray photographs. Each cone was measured for maximum length, irrespective of cone curvature, maximum width, apophysis width and height (four apophyses were measured per cone), and number of scales. All seeds were extracted by hand from each cone, counted, and X-ray photographed for counts of full seed. Provenance means, ±1 standard error, were then determined for each character evaluated.

Eight trees were randomly selected in the 10-tree provenances to provide equal numbers of trees per provenance and analyses of variance were computed for cone length, width, longi-sect. area, apophysis width and height, number of scales per cone, total seeds per cone, and full seeds per cone. Percents of variation due to provenances, trees within provenances, and cones within trees for each character were estimated using the following model and computed mean squares:

Provenances	$\theta_e^2 + 4\theta_t^2 + 32\theta_p^2$
Trees within provenances	$\theta_e^2 + 4\theta_t^2$
Cones within trees	θ_e^2

Correlations between cone length, longi-sect. area, and number of scales per cone, and yield of total seeds per cone, and full seeds per cone were calculated using the individual cone data.

RESULTS AND DISCUSSION

Cone production per tree, cone angle, and cone curvature by provenance are included in table 2. There was no clear-cut relationship between cone production per tree and total tree height. However, all trees less than 41 cm tall failed to produce any cones, while all trees producing more than 9 cones per tree exceeded 80 cm in total height. The proportion of trees producing more than 9 cones per tree was greatest for the Nova Scotia (02) provenance (55 percent), while the Wisconsin (69) and Michigan (74) provenances had less than half that number (24 and 23 percent, respectively). Approximately 40 percent of the trees from 5 eastern provenances (02, 14, 25, 34, and 46) produced in excess of 9 cones per tree. Trees from the Manitoba (91) and Alberta (95) provenances have performed very poorly in our test planting, and these provenances had the lowest proportion of trees producing in excess of 9 cones per tree (13 and 9 percent, respectively).

Schoenike[2] reported that fewer cones were produced on trees in natural stands in the eastern region than in other regions, and trees in western stands produced the most cones. Since Schoenike's study was a phenotypic study conducted in natural stands, the differences in cone production in his study and ours may be related to provenance-environmental interactions present in our test planting.

Trees from Wisconsin (69), Michigan (74), and New Hampshire (25) provenances all had cone angles in Classes 2 and 3 (+16° to 135°). The other provenances had at least 25 percent of their trees in cone angle Class 1 (-45° to +15°). The Wisconsin (69) and Michigan (74) provenances had the highest proportion of trees with negatively curved cones (80 and 70 percent, respectively), and all trees in these provenances had negatively curved,

---

[2] Schoenike, Roland E. 1962. Natural variation in jack pine. Unpublished Ph.D. Thesis, Univ. of Minnesota. 211 pp.

Table 2.--Cone production per tree, cone angle, and cone curvature in 11 jack pine provenances.

Provenance	Number of trees	Mean tree height	Trees by cone number classes[1]			Selected trees	Trees by cone angle classes[2]			Trees by cone curvature classes[3]			
			1	2	3		1	2	3	1	2	3	4
		Centimeters	Percent			Numbers	Numbers			Numbers			
02	47	137	6	38	55	10	3	5	2	4	3	3	0
14	46	127	22	39	39	8	2	6	0	1	6	1	0
25	48	118	29	50	21	10	0	5	5	2	6	2	0
34	45	147	7	47	47	10	6	3	1	4	2	4	0
46	46	155	24	28	48	10	3	6	1	4	3	3	0
62	46	153	17	54	28	10	8	2	0	0	2	8	0
69	45	167	18	58	24	10	0	8	2	8	2	0	0
74	44	171	11	66	23	10	0	7	3	7	3	0	0
82	45	153	29	38	33	10	8	2	0	0	2	6	2
91	46	93	33	54	13	8	8	0	0	0	1	5	2
95	45	110	18	73	9	10	5	5	0	0	4	6	0

[1] Class 1 = No cones; Class 2 = 1-9 cones; Class 3 = 10 or more cones.

[2] Each tree classified on a cone angle basis--cone angle is the angle between a line from the tip of a cone to its point of attachment and the branch axis.
Class 1 = -45° to +15° (a negative cone angle results when a cone actually overlaps the branch it is attached to).
Class 2 = +16° to +75°.
Class 3 = +76° to +135°.

[3] Each tree classified as to cone curvature using X-ray photographs for longi-sect. profile.
Class 1 = Negative curvature (negative curve--cone curvature away (abaxial) from branch).
Class 2 = Straight or slight curvature.
Class 3 = Moderate curvature.
Class 4 = Strong curvature.

straight or slightly curved cones. Provenances from eastern Ontario (62), western Ontario (82), Manitoba (91), and Alberta (95) had a considerable number of trees with moderately and strongly curved cones. In general, these data agree with data presented by Schoenike and Schoenike et al. (1959).

Nearly all cone characteristics and seed yields per cone were very similar for seven of the provenances (02, 14, 25, 34, 46, 62, and 82) (Table 3). Trees from these seven provenances had slightly larger cones than trees from the Wisconsin (69) and Michigan (7)4) provenances. Trees from the two western (91 and 95) provenances had the smallest cones and yielded the fewest total and full seeds per cone. Schoenike[4] reported that trees in western stands had larger cones than trees in abher regions. The differences in cone sizes between this study and Schoenike Is are probably associated with the poor performance of the trees from the Manitoba and Alberta provenances in our test planting.

All mean cone lengths of the provenances exceed those reported by Schoenike et al. (1959). This may be related to the age of the trees in this study which is about 10 years younger than the trees Schoenike et al. studied. While no actual data are available, observations in our plantation suggest that cone size and total number of seeds per cone may decrease with increasing age of trees. This will be studied in more detail in the fall of 1971.

The means of total seeds per cone (28.5) and full seeds per cone (23.2) are in close agreement with the 26.4 per cone presented by Rudolph (1967) for 17- and 23-month-old jack pine seedlings, but considerably lower than the 41.4 total seeds and 36.8 viable seeds per cone reported by Roe (1963) for 9-year-old well-stocked jack pine plantations in the Superior National Forest, Minnesota. The exact reason for this rather large discrepancy is not known but may be due to differences in seed years, seed origins, availability of pollen, or age of trees.

Seven of the eight traits analyzed differed significantly at the one-percent level among provenances and among trees within provenances. Scales per cone only differed significantly among trees within provenances at the one-percent level. Variation due to provenance is largely accounted for by the two western provenances, which are markedly different from the remaining nine provenances. An average of 6.8 percent of the variation of all 8 traits was due to differences among provenances, 43.9 percent was due to differences among trees within provenances, and 49.4 percent was due to differences among cones within trees (Table 4).

Correlation coefficients (r) between cone length, longi-sect. area, and number of scales per cone and total number of seeds per cone, and number of full seeds per cone are as follows:

	Total seeds per cone	Full seeds per cone
Cone length	0.66	0.65
Longi-sect. area	0.66	0.65
Scales per cone	0.67	0.67

---

[3] Ibid.

[4] Ibid.

Table 3.--Cone characteristics and seed yield per cone in 11 provenances of jack pine.

Provenance	Cone length	Cone width	Apophysis		Cone longi-sect. area	Scales per cone	Total seeds per cone	Full seeds per cone	Full seeds
			Width	Height					
	Millimeters	Millimeters	Millimeters	Millimeters	cm^2	Number	Number	Number	Percent
02	39.8±1.63	20.3±0.70	7.6±0.29	7.1±0.36	5.6±0.31	83.1±2.93	31.2±3.65	26.5±3.35	83.3
14	41.1±2.20	19.7±0.62	7.0±0.30	6.6±0.30	5.5±0.47	89.8±3.89	31.2±2.68	26.0±2.75	81.3
25	40.2±1.11	21.2±0.62	7.6±0.23	6.9±0.26	6.0±0.33	83.9±2.34	30.1±3.39	25.5±2.88	83.9
34	40.5±1.44	19.4±0.57	7.3±0.20	6.6±0.24	5.6±0.32	88.6±4.53	31.7±3.59	26.3±2.81	84.4
46	41.2±1.38	21.0±0.78	7.8±0.35	7.5±0.29	5.8±0.36	86.3±4.19	33.2±2.87	26.1±2.56	77.7
62	39.8±1.31	20.7±0.50	8.0±0.14	7.6±0.20	5.7±0.29	89.2±3.89	30.4±2.61	26.8±2.36	88.4
69	36.7±1.09	16.6±0.37	6.5±0.15	5.6±0.16	4.5±0.20	83.4±2.66	31.1±2.36	24.9±2.01	79.0
74	37.7±2.19	17.8±0.72	6.7±0.35	6.4±0.38	4.9±0.42	79.0±2.62	27.8±2.23	20.6±1.70	74.2
82	39.7±2.26	21.4±0.57	8.3±0.34	8.3±0.28	5.9±0.38	81.9±2.47	28.2±3.41	22.3±2.96	76.0
91	29.8±0.91	17.5±0.57	7.3±0.22	6.2±0.36	3.8±0.21	79.0±2.35	17.2±1.03	13.8±0.89	78.2
95	32.2±2.02	17.0±0.82	6.8±0.24	6.2±0.24	4.0±0.35	75.7±3.01	21.3±3.42	16.2±2.72	78.1
Mean	38.1±1.60	19.3±0.62	7.4±0.26	6.8±0.28	5.2±0.33	83.6±3.17	28.5±2.84	23.2±2.45	80.4

Table 4.--Percent variation due to provenances, trees within provenances, and cones within trees.

Trait	Variation due to:		
	Provenances	Trees within provenances	Cones within trees
	Percent	Percent	Percent
Cone length	8.5	54.5	37.0
Cone width	10.0	49.5	40.5
Apophysis width	4.9	56.4	38.7
Apophysis height	10.5	61.0	28.5
Longi-sect. area	8.4	48.1	43.5
Scales per cone	1.9	29.6	69.0
Total seeds per cone	4.5	27.4	68.1
Filled seeds per cone	5.4	24.4	70.2
Mean for 8 traits	6.8	43.9	49.4

One can obtain a fairly good estimate of seed yield per cone by measuring cone length. Seed yield is also closely associated with cone curvature. Schantz-Hansen (1941) reported that straight cones yielded 46 seeds per cone, slightly curved cones yielded 41 seeds per cone, and strongly curved cones yielded 21 seeds per cone. A comparison of cone curvature and seed yield in this study resulted in the following:

	(1) Negative curve	(2) Straight or slightly curved	(3) Moderately curved	(4) Strongly curved
Number of trees	30	34	38	4
Total seeds per cone	32.9	30.0	25.2	18.0
Full seeds per cone	26.3	24.1	21.1	14.0

Schoenike[5] studied natural variation in jack pine and concluded "...that clinal relationships are more numerous than ecotypic relationships for most traits," and "...the hypothesis of a single population was preferred since it was simpler than a multipopulation hypothesis, yet sufficient to account for the variation present." Yeatman[6] and Canavera[7] worked essentially on height growth in greenhouse, nursery, and plantation studies of jack pine, and their results also suggest that the variation patterns in characters evaluated are essentially clinal.

---

[5] Ibid.

[6] Yeatman, C. W. 1967. Geographic variation in jack pine (Pinus <u>banksiana</u> Lamb.) seedlings. Ph.D. Thesis, Yale Univ., New Haven, Conn. 283 pp.

[7] Canavera, D. S. In press. Geographic variation in jack pine. (Manuscript based on Ph.D. Thesis, Michigan State Univ., E. Lansing, Mich.)

The data presented here do not contradict these conclusions. The data do emphasize that the variation due to differences among provenances was small compared to the variation due to differences among trees within provenances. This is an important fact, which should be taken into consideration in population studies of jack pine and the related lodgepole pine.

Furthermore, the data suggest that equations for predicting seed yields should be based on cone length and cone curvature. The added precision obtained by adding other factors in the equation would be insignificant. Studies are now in progress to develop an adequate equation.

SUMMARY

Eight-year-old trees from 11 jack pine provenances ranging in latitude from 43.8 to 56.6° N. and in longitude from 65.4° to 111.9° W. were evaluated for cone characteristics and seed yield where they were field planted in Oneida County, Wisconsin.

Data on cone production per tree; cone angle, curvature, length, width; apophysis width and height; cone longitudinal section area; number of scales per cone; and total number of seeds and number of full seeds per cone for the 11 provenances are presented and discussed.

Nearly all cone characteristics and seed yields were very similar for seven of the provenances. Trees from two western provenances had the smallest cones and yielded the least total and full seeds per cone. The mean total and full seed yields per cone for trees from all sources were 28.5 and 23.2, respectively.

There were significant differences among trees from different provenances and trees of the same provenance in cone length and width, apophysis width and height, cone longitudinal section area, and number of total and full seeds per cone. Much of the variation due to seed origin was accounted for by trees from the two western provenances that were markedly different from the remainder. An average of 6.8 percent of the variation of all 8 traits was due to differences among provenances, 43.9 percent was due to differences among trees within provenances, and 49.4 percent was due to differences among cones within trees.

Cone length was found to be correlated with total number of seeds per cone (r = .66) and number of full seeds per cone (r = .65). Seed yield was also closely associated with cone curvature--yields decreased with increased cone curvature.

A new study including more provenances and individual trees is now in progress in an effort to establish more precisely the nature of the variation pattern in cone characteristics and seed yield in jack pine.

ACKNOWLEDGMENT

The author gratefully acknowledges the technical assistance of Mr. Werner Bigalke and Mr. Bernard Williams for their help in various phases of this study.

LITERATURE CITED

Moss, E. H. 1949. Natural pine hybrids in Alberta. Can. J. Res. 27(5): 218-229.

Roe, Eugene I. 1963. Seed stored in cones of some jack pine stands, Northern Minnesota. USDA Forest Serv. Res. Paper LS-1, Lake States Forest Exp. Sta. 14 pp.

Rudolf, Paul O. 1958. Silvical characteristics of jack pine (Pinus banksiana). USDA Forest Serv. Sta. Paper 61, Lake States Forest Exp. Sta. 31 pp.

Rudolph, Thomas D. 1966. Stimulation of earlier flowering and seed production in jack pine seedlings through greenhouse and nursery culture. Joint Proc. Second Genetics Workshop of the SAF and Seventh Lake States Forest Tree Improv. Conf. 1965. USDA. Forest Serv. Res. Paper NC-6: 80-83. North Central Forest Exp. Sta., St. Paul, Minn.

Rudolph, T. D. 1967. Effects of X-irradiation of seed on X_1 and X_2 generations in Pinus banksiana Lambert. Radiat. Bot. 7:303-312.

Schantz-Hansen, T. 1941. A. study of jack pine seed. J. For. 39:980-990.

Schoenike, R. E., T. D. Rudolph, and T. Schantz-Hansen. 1959. Cone characteristics in a jack pine seed source plantation. Minn. Forestry Notes No. 76. 2 pp.

DISCUSSION

HUNT - I have a question for Mr. Jeffers. I believe you stated that the greater the curvature of the cone, the fewer the number of filled seeds present. Is the converse also true? That is, that the more filled or normal seed found in a cone, the straighter will be the cone. Could you say that the influence of empty seed caused a curvature of the cone?

JEFFERS - I don't think we really know yet whether a cone curves because there is less filled seed in one portion of the cone or whether the decreased yield of filled seed resulted from cone curvature. I might just mention that in the curved cones, if we look at the adaxial portion of the cone, we find practically no filled seed. Why should there be more filled seed on the outside of the cone than on the inside?

HUNT - One might suspect that the growth of fertile seed between cone scales could stimulate those scales to greater growth and that little or no stimulation would be present when seeds were empty--even though the seed coats appear normal. I would expect this to he especially true if damage or some physical barrier to pollen prevented seed development. This area of the cone might then grow slowly compared to an area with fertile embryos. The differing growth rates causing cone curvature.

JEFFERS - Right. We also, find that there is less seed, filled or empty, in the adaxial portion of a curved cone. It wasn't simply a case of a seedcoat developing with no embryo and gametophytic tissue developing, there's just practically nothing in here whatsoever. As I mentioned before, I see no reason why we should have more filled seed developing on one side of the cone as opposed to the other.

GERHOLD - When does the curvature first appear? Is it present at the time of pollination?

JEFFERS - We do not know exactly when curvature begins; however, curvature of conelets has been observed the fall prior to fertilization.

SCHREINER - Is the curvature always on the side toward the stem?

JEFFERS - No, not always. The majority of the time it is toward the branch to which it is attached; however, particularly in the two sources from Michigan and Wisconsin, there are trees where the cone is essentially straight but the tip of the cone may actually curve away from the branch. In this case, the yield of total seed and full seed from these cones was greater than the case where we had a rather straight cone. I don't know what the background is for this; it's probably some hormonally controlled thing coming into play here.

VALENTINE - How did you measure your cone length? Did you follow the curvature?

JEFFERS - No. Cone length, as we measured it, was maximum length with no adjustment being made for cone curvature.

VALENTINE - Then, actually, the correlation between seed yield and cone length is a distortion because of the curvature of the cone.

JEFFERS - Right. Because of cone curvature, it is extremely difficult to measure shape of the cone. Probably the best way to estimate shape is to measure volume of the cone. This was considered; but it was not done simply because we were interested in extracting all of the seed in the cone. If we were to determine volume before extracting the seed, one runs into problems of differences in moisture content of the cones. We wanted to take some simple easy measurements to see if we could come up with any prediction equation for yield of seed.

PYEN - Do the seed sources have the same altitude?

JEFFERS - No. The altitude is somewhat variable for these seed sources. I do not have all the elevational data here with me. Probably the latitude and longitude are the two greatest factors involved with some of these variation patterns that we have come up with.

ROLLER - In the early 60's I studied the natural variations of alpine fir occurring in British Columbia. I found then that the location of female zone from the top to the middle part of the crown varied with elevation, i.e. cones were raised in the upper crown at the high elevation and in the middle at the lower elevation. The above observations provided clues for distinguishing attitudinal variations. Have you done any testing on the deviation of cone's size and seed weight in cases such as the above?

POWELL - I think it could be variable across the range of the species. My data refer to one place and one elevation. Casual observations tend to indicate that the size does not vary very much. However, in the Gaspe last year, I noted several trees that had much longer female zones.

GERHOLD - John, do you have any comment on that question?

FRYER - The samples that I collected from higher elevations were so stunted that the cones were occurring all over the crown; there was no dominance and I couldn't really compare the two studies in that way.

MURPHY - I would question Dr. Powell's interpretation of the flower type as relating only to the shoot vigor. It appears that the three conditions he describes, normal apical dominance, full maleness following decapitation, as well as the return of femaleness after grafting, would closely parallel the hormonal theory of control, and that some hormone produced from the apical meristem is involved in regulating which sex appears and where. I wonder if you have done any biochemical or physiological studies of these three types that you have.

POWELL - I have not done any biochemical or physiological studies, although I would like to do some. I think the changes are related to hormonal response, but whether or not this is entirely from the apex I don't know. I think that nutrition and vigor have to be considered as well. There is evidence that what happens on the individual shoot is conditioned by what is happening in the shoots around that individual shoot. The change from female to male is so sudden--and, with it, there is an inversion of bud position on the shoot and a remarkable difference in bud numbers--that I think hormonal and nutritional studies would be fruitful. Studies should include the tree from top to bottom and take account of intrinsic vigor differences on whorl and internode branches. I am hoping to do work on these aspects.

FRANK - It was indicated that the decapitated sample bore more male cones. Is this an indication in regard to balsam wooly aphid and spruce budworm damaged trees, that the incidence of male cones will increase and, therefore, total seed production would be reduced?

POWELL - I don't know that the number of male cones will increase, but the number of female cones will definitely decrease. If the top of the tree breaks off or dies back, this reduces the female zone and, therefore, seed production will definitely diminish. I have seen this in stands at Fredericton. Since the time of my study, my sample trees have been hit by the spruce budworm. The budworm feed in, and kill, the young female flowers as well as attacking some of the male cones. This, and later defoliation, have effects on subsequent shoot development, all on the negative side as far as seed production is concerned.

GABRIEL - You said in observing the lack of dominance, that there are two populations with respect to this dominant/lack of dominance characteristic. Is this obvious enough to say that this might be an inherited trait, or does this qualify under physical damage, birds, or weather?

POWELL - The damage was physical, the response varied. I observed two trees which responded differently. The tree which did not show upward growth appeared to be somewhat less vigorous. It was an older tree, but about equal in size to the other one; they were growing about 20 yards apart. I do not know if the response was inherited, it may have been connected with age, or some other factor.

HUNT - Such observations could be explained as evidence of both topophysis and cyclophysis in *Abies.* Without becoming entangled in any old debates, can we come not gather cones by removing the entire female zone or top of a tree, especially if there is any necessity to return in a few years to gather another crop of cones. We have been able to collect white spruce cones in such a manner. But, based on your paper, unless one had some assurance that a female zone in balsam fir will be reestablished either naturally or mechanically, we must take care not to damage this portion of the tree. Likewise to be certain we are propagating vigorous female portions for our seed orchards, scions should be gathered only from terminals of first order branches in the top whorls. We want to be certain we are increasing the cone production potential not just the sterile or male zones.

POWELL - I think that's a fair conclusion. However, if cones are gathered without shoot injury, it is probable that cones will be borne again in two-years' time.

ELIASON - We often debated about topping trees for the purpose of keeping them down for easier seed collection. Maybe we shouldn't top at all if we're going to cut cone production. But, there may be some recovery, which probably depends on the age of the trees.

POWELL - The tendency towards flat-topped development may not occur on young trees, but it is something to watch for. If we cut the top off a vigorously growing young tree, then our hope will be that we obtain more than one upward-growing stem. If these are of equal vigor, they should bear cones equally.

McCORMACK - I can't help but comment on an old balsam fir tree that I saw a southern Vermont in a Christmas tree planting. The stump diameter, two feet above the ground was maybe 10 or 11 inches, but it had lower branches still living. It had been fertilized quite heavily and the last time I saw it, it had 11 table-top trees from that one stump. And, I've seen this in other Christmas tree plantations where with intensive cultural treatment, particularly with nutrient supplements, new tops and what would be considered multiple leaders came along in pretty good shape. So, I don't know where nutrition fits in here, but there is certainly plenty of evidence in these old Christmas tree plantations that it could very well be a factor.

GERHOLD - How many cones were on these trees?

McCORMACK - Well, these were quite small and he had started to shear them, so I can't say. On some of these small trees, particularly where ammonium nitrate has been used, there is some pretty good cone production on the smaller trees.