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GENETIC IMPROVEMENT OF BLACK CHERRY FOR TIMBER: A LITERATURE REVIEW[1]

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Improved silvicultural systems are being developed in order to meet the ever-increasing demands for high quality black cherry timber. The increased use of clear-cutting and the perfection of artificial regeneration techniques for this species will make it possible to utilize genetically improved varieties that are currently being developed. It is pertinent, then, to examine some of the related literature and to review the scope of black cherry improvement and research projects.

TAXONOMY

Prunus serotina Ehrh., in the family Rosaceae and subfamily Prunoideae, is a member of a broadly conceived genus consisting of a fairly heterogeneous group of some 200 species having a world-wide distribution. The opinions of botanical authorities concerning the delimitation of this genus have differed considerably, moreover, some of them have changed their opinions during their careers. McVaugh (1951) recognizes five sections in the genus, and regards black cherry as the central species in the all-American section Iteocerasus. He considers Iteocerasus to be phylogenetically coordinate with section Neocalycinia, the gap between them being bridged by the more primitive Asiatic species in section Calycinia. Iteocerasus is also thought to be closely related to the more advanced section Eupadus.

The range of black cherry nearly covers the eastern half of the United States and adjacent parts of Canada into Nova Scotia; geographically disjunct populations occur in Arizona, New Mexico, and Texas, becoming more continuous in the mountains and high plateaus of Mexico; and there are separate populations in southern Mexico and Guatemala. The inclusive species Prunus serotina contains several subspecies and species proposed by various authorities. Extensive herbarium and field studies by McVaugh (1951) have confirmed that several real entities are involved, and indicate that five of these are of major importance. Little (1953) has given varietal names to the subspecies of McVaugh. The typical variety (subsp.) serotina is found in mesophytic areas of eastern U. S., Canada, Mexico, and Guatemala; most Central American specimens cannot be distinguished from the others. Variety alabamensis (subsp. hirsuta) in parts of Alabama, Georgia, and Florida is hardly in contact with var. serotina, and is more pubescent on branchlets and the undersurface of leaves. McVaugh feels that a higher intensity and frequency of pubescence indicates a closer relationship to the ancestral type, while the more glabrous condition is more advanced. The xerophytic variety rufula (subsp. virens), extending from the southwestern states into central Mexico, also contains more pubescent populations, especially in the Sierra Madre Occidental, a region of relatively undisturbed geological antiquity. Variety (subsp.) exemia on the Edwards Plateau of central Texas

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also grows under dry conditions, but its branchlets and foliage are often entirely glabrous. Variety salicifolia (subsp. capuli), the "capulin" cherry with its larger and sweeter fruit, has been cultivated and moved by man from Mexico to parts of South America and California. Observations at several locations suggest that hybridization with var. serotina has occurred. McVaugh (1951, 1952) has recorded some interesting speculations about the evolution of these races.

In view of the large amount of phenotypic variability and the diverse habitats of the species, it is evident that provenance experiments can be expected to uncover a diverse pattern of genetic variation.

REPRODUCTIVE CHARACTERISTICS

Flowering of black cherry occurs when leaves are nearly full grown, extending from late March in Texas through mid-May in Pennsylvania and New York to early June in Quebec (Hough 1960). The flowers are perfect, and pollinated chiefly by several species of insects. It is likely that the species contains genetically controlled self-incompatibility systems (Berger 1963, Pandey 1959). The fruits ripen from mid-August to early September on the Allegheny Plateau of Pennsylvania (Hough 1960). Seed production may begin by age 10, and is said to be fairly regular with good crops every 3 or 4 years. In collecting seed for a provenance experiment, however, we found a large variability in abundance within one county, ranging from moderate crops in some stands to complete failures in others. It has been estimated that trees in seed orchards will produce an average of 20 pounds of clean seed per tree in a heavy crop year (Schreiner et al 1965).

Procedures for seed collection and treatment have been described by Baldwin (1942), Cummings et al (1933), Belcher and Hitt (1965), Hough (1960), and Huntzinger (1964). Seeds should be collected when they are fully ripe, and their pulp removed before drying by maceration rather than fermentation. A potato ricer has been used for this purpose with running water. The cleaned seed should be air dried before storage. To improve germination, a 8-hour soak in a 0.1 percent citric acid solution followed by stratification for 120 days has been recommended. A 17 percent table salt solution has been used to separate inviable seeds.

Several techniques are available for vegetative propagation. Hatmaker and Taft (1966) prefer bench grafting, and have also been successful with field grafting, using a whip graft or side graft; both chip and patch budding may be used in late July or early August to increase the number of ramets. A 35 percent success was achieved with inferior scionwood, and it was believed that 75 percent was attainable. Differences in rootstock effects have been reported by several authors for various cherry species (Anthony et al 1937, Chandler 1942, Tukey and Brase 1935). Cummings et al (1933) propagated black cherry by layering, and Hough (1960) suggested that cuttings could probably be rooted through the use of auxins.

GENETIC INFORMATION

The basic chromosome number in Prunus is 8 (Darlington and Wylie 1955). In the five sections of the genus polyploid series are not uncommon, with somatic numbers of 16, 32, 40,48, 64, and others. Most cherry species are diploid with 16 chromosomes. Prunus serotina is listed as having 32 chromosomes, as are the other bird cherries P. grayana, P. padus, P. ssiori, and P. virginiana, and therefore a tetraploid origin may be assumed A paper by Kobel (1927) is the basis for the listed chromosome number in black cherry. Somatic tissues of vegetative buds that were leafing out in the botanical garden at Bern, Switzerland, were studied, as no flower buds were available. Kobel did not state if more than one tree was examined, nor did he indicate the geographic origin.

In the horticultural breeding of cherries several compatibility groups are recognized (Bailey 1949, Berger 1963, Crane and Lawrence 1952, Darlington 1928, 1930, 1933, Gardner 1946, Grubb and Taylor 1949). The diploid sweet cherry varieties derived from P. avium are self- and sometimes cross-incompatible. Sour cherry varieties are derived from P. cerasus, which is believed to be an autotetraploid derivative of P. avium . P. avium and P.cerasuscrosses. Tetraploid sour and duke cherries are usually self- and.cross-compatible, while triploid sour x sweet crosses are sterile.

No information could be found concerning crossability patterns within P. serotina, or in crosses attempted with other species.

Knowledge about inheritance in Prunus is rather meager, and limited to characteristics primarily related to fruit quality and productivity (for example, Fogle 1958, 1961, Hansche 1965, Lamb 1953, Wellington and Lamb 1950). Flesh color of the fruit is controlled by a single gene, with red dominant to light color. A few major genes are believed to affect vigor. Dwarfness was believed to be controlled by two or more recessive genes. Fasciation was found to be the single factor inheritance of a weakness which prevents separation of lateral buds from the main stem under certain environmental conditions. Genotype x environment interactions in orchards tend to be fairly small.

CURRENT TREE IMPROVEMENT AND RESEARCH PROJECTS

The SEED ORCHARD PROGRAM FOR BLACK CHERRY ON THE ALLEGHENY NATIONAL FOREST is a cooperative project that includes U.S.F.S. Region 7, the Northeastern Forest Experiment Station, and the Pennsylvania Department of Forests and Waters (Schreiner et al 1965). Starting in 1965, 90 trees are being selected on the Allegheny Plateau as the basis for three seedling seed orchards and three smaller and comparable clonal seed orchards. Each seedling orchard is to contain the open-pollinated progenies of at least 20 plus trees, which are to be rogued on the basis of progeny tests in the nursery and in the orchards. Selection intensities will be approximately 1/10 to 1/20 in the nursery, and 1/8 in the orchards by age 20. Selection criteria for the 90 plus trees include rapid growth rate, excellent timber form, absence of gummosis and black knot, freedom or recovery from ice damage, and high veneer quality; candidate trees are compared to at least the five best trees of the same species within 110 feet. The 21 acres of seedling orchards and 3 acres of clonal orchards are expected to yield more than 18,000 pounds of cleaned seed per year by age 20.

Black cherry is one of six species in the TENNESSEE VALLEY AUTHORITY'S HARDWOOD TREE IMPROVEMENT PROGRAM, which started in 1963 (Taft 1967 and personal communication). About 30 superior trees have been selected and grafted into 2.8 acres of seed orchard. Plans call for orchards in eastern, western, and southern Tennessee to insure seed crops every year. Seed production is estimated at 2 pounds per ramet at 20 years. A seven parent open-pollinated progeny test and a seed source study have been established recently. Mr. Donovan Forbes is conducting doctorate research on cross- and self-incompatibilities, and developing control pollination techniques. He also plans to study phenology, flower structure, pollen collection and storage techniques, and chromosome numbers.

The FOREST TREE IMPROVEMENT PROGRAM AT THE STATE UNIVERSITY COLLEGE OF FORESTRY AT SYRACUSE UNIVERSITY includes several studies on the genetics and breeding of black cherry under the direction of Gerald R. Stairs (personal communication). A recently completed investigation of selfing, microsporogenesis, and embryogenesis is the subject of a paper at this meeting. The next cytological study is to evaluate chromosome numbers across the range of the species. Intra- and inter-specific hybridization is planned for the near future. Preliminary studies have shown that black cherry can be grafted easily into seed orchards, and flowering has been early and prolific.

A black cherry provenance trial has been started at the DIVISION OF FORESTRY, WEST VIRGINIA UNIVERSITY, by Franklin C. Cech. There are plans for comprehensive sampling of the distribution, and plantings in several northeastern states. Further details and initial results are provided by another paper at this meeting.

CONCLUSION

The information needed for black cherry improvement projects is deficient in several respects. Variation patterns can be described only roughly and in phenotypic terms. The potential genetic contributions that might be obtained from non-local populations and related species are entirely unknown. There is much to be learned about incompatibilities, species-crossabilities, chromosome numbers, and possibilities of haploidy and artificial polyploidy. No quantitative information exists about pollen dissemination, population structure, or inheritance of timber characteristics. Therefore, it is not surprising that improvement projects which have existed for just a few years generally incorporate conservative features that minimize risks of failure, while providing for modest genetic gains. The related research projects that are now underway already have started to fill these voids. The knowledge that they generate probably will lead to the design of much more sophisticated breeding programs for this economically valuable and genetically fascinating species.

LITERATURE CITED

Anthony, R. D., R. H. Sudds, and G. E. Yerkes. 1937. Orchard tests of mazzard and mahaleb cherry understocks. Proc. Amer. Soc. Hort. Sci. 35: 415-418.

Bailey, L. H. 1949. manual of cultivated plants. MacMillan Co., New York. 1116 pp.

Baldwin, H. I. 19¹+2. Forest tree seed of the north temperate regions with special reference to North America. Chronica Botanica Co., Waltham, Mass. 240 pp.

Belcher, E. W., Jr. and R. G. Hitt. 1965. Eastern tree seed laboratory 12th annual report. P. 0. Box 1077, Macon, Ga. page 46.

Berger, K. 1963. Fertilitatsuntersuchungen an der Wildkirsche *Prunus* avium L. var. *avium*. Kulturpflanze 11: 358-375.

Chandler, W. H. 19+2. Deciduous orchards. Lea & Febiger, Philadelphia. 438 pp.

Crane, M. B. and W. J. C. Lawrence. 1952. The genetics of garden plants. MacMillan Co., London. 301 pp.

Cummings, M. B., F. W. Jenkins, and R. G. Dunning. 1933. Rootstock effects with cherries. Seed and propagation. Vt. Agr. Expt. Sta. Bull 352. 36 pp.

Darlington, C. D. 1928. Studies in *Prunus*, I and II. J. Genet. 19: 213-256.

_____ 1930. Studies in *Prunus*, III. J. Genet. 22: 65-93.

_____ 1933. Studies in *Prunus*, IV. J. Genet. 28: 327-328.

_____ and A. P. Wylie. 1955. Chromosomes atlas of flowering plants. Allen and Urwin, London. 519 pp.

Fogle, H. W. 1961. Inheritance of some fruit and tree characteristics in sweet, cherry crosses. Proc. Amer. Soc. Hort. Sci. 78: 76-85.

_____ 1958. Inheritance of fruit color in sweet cherries (*Prunus avium*). J. Hered. 49: 294-298.

Gardner, V. R. 1946. The cherry and its culture. Orange Judd. Pub. Co., Inc., New York. 146 pp.

Grubb, N. H. and H. V. Taylor. 19+9. Cherries. Crosby Lockwood & Son, Ltd., London. 186 pp.

Hansche, P. E. 1965. Temporal and spatial repeatabilities of a series of quantitative characters in sweet cherry. Proc. Am. Soc. Hort. Sci. 86: 120-128.

Hartman, H. T. and D. E. Nester. 1959. Plant propagation. Prentice-Hall, Englewood Cliffs, N. J. 559 pp.

Hatmaker, J. F. and K. A. Taft, Jr. 1966. Successful hardwood grafting. Tree Planters' Notes No.79: 14-17.

Hough, A. F. 1960. Silvical characteristics of black cherry. Northeastern For. Exp. Sta. Paper 139. 26 pp.

Huntzinger, H. J. 1964. Germination, survival, and first-year growth of black cherry under various seedbed and supplemental treatments. Northeastern For. Exp. Sta. Res. Note NE-26. 6 pp.

Kobel, F. 1927. Zytologische Untersuchungen an Prunoideen and Pomoideen. Archie. A. J. Klaus-Stiftung 3: 1-84.

Little, E. L., Jr. 1953. Check list of native and naturalized trees of the United States (including Alaska). U.S.D.A. Handbook 41. 472 pp.

Pk Vaugh, R. 1951. A revision of the North American black cherries (Prunus serotina Ehrh., and relatives). Brittonia 7 (4): 279-315.

1952. Suggested phylogeny of Prunus serotina and other wide-ranging phylads in North America. Brittonia 7 (5): 317-346.

Lamb, R. C. 1953. Notes on the inheritance of some characters in the sweet cherry Prunus avium. Proc. Amer. Soc. Hort. Sci. 61: 239-298.

Pandey, K. K. 1959. Mutations of the self-incompatibility gene (S) and pseudo-compatibility in angiosperms. Lloydia 22: 222-234.

Schreiner, E. J., G. E. Smith, W. T. Doolittle, and S. Dolgaard. 1965. Seed orchard program for black cherry on the Allegheny National Forest. Northeastern For. Exp. Sta. 31 page mimeo.

Taft, K. A., Jr. 1967. TVA's hardwood tree improvement program. Proceedings of the Southeastern Area Forest Nurserymen Conference, Columbia, South Carolina, August 23-24, 1966. pp. 24-31.

Tukey, H. B. and K. D. Brase. 1935. Random notes on fruit tree rootstocks and plant propagation, II, N. Y. Agr. Exp. Sta. Bull. 657. 26 pp.

Wellington, R. and R. C. Lamb. 1950. Sweet cherry breeding. Proc. Amer. Soc. Hort. Sci. 55: 263-264.