RESEARCH AND MANAGEMENT IN A YOUNG NORTHERN RED OAK SEEDLING SEED ORCHARD

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Abstract.--A northern red oak progeny test was thinned at age 15 to produce a seedling seed orchard. Studies were initiated to determine relationships between acorn production and seed source. Acorn production was observed in 1984-1986 and 1989-1992. Family differences were observed in reproductive maturity. Large differences in size of acorns from the same tree were observed. Many acorns appeared to be extensively damaged by insects. A progressive loss of flowers, acornets and acorns was observed on different genotypes from 1989-1991 as the acorns matured. Oak anthracnose disease has been intermittently damaging in the orchard when environmental conditions are favorable for infection. Two different fungi, alone and in combination, have been consistently isolated and confirmed pathogenic. Insect populations were sampled in 1992. Population levels of different species fluctuated throughout the growing season.

Keywords: northern red oak, *Quercus rubra,* seed orchard, acorn, pest management, first-order lateral roots

INTRODUCTION

Many studies have been conducted on cultural practices and pest management in seed orchards of coniferous species (cf. Bramlett 1991). In contrast, management guidelines for orchards containing North American oak *(Quercus)* species are virtually unknown. Past difficulties in vegetative propagation of oak species, either through grafting, rooted cuttings or tissue

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culture, have limited efforts in constructing seed orchards. Additionally, in the few grafted orchards that exist, the growth and acorn production of grafted clones is extremely variable (Schlarbaum et *al.* 1993). Seedling seed orchards are an alternative for production of genetically improved seed, although genetic gains can be lower in comparison to clonal orchards. In 1987, a progeny test of northern red oak *(Quercus rubra L.)* on the Watagua Ranger District, Cherokee National Forest, was converted to a seedling seed orchard (La Farge and Lewis 1987). This seed orchard was constructed to provide acorns for reforestation efforts in the U. S. Forest Service's Southern Region. Since construction, the orchard has been the subject of various studies on acorn production, pest management and harvesting procedures. In this paper, a brief description of completed and ongoing research will be presented. More detailed accounts of the investigations will appear elsewhere in individual publications.

ORCHARD DESCRIPTION

The orchard is located in the southern Appalachian foothills, near Elizabethton, Tennessee (Lat. 36°07"N, Long. 82°00"W, Elev. 610 m) and is 5.9 hectares in size. The site was an old agricultural field that was originally covered by weeds and fescue and was prepared for planting by plowing and discing. The progeny test was established in 1973 by the Tennessee Valley Authority (TVA). It consisted of 220 open-pollinated families from acorns collected primarily throughout the Tennessee River Valley in 1971. Some mother trees were TVA phenotypic selections, although the majority of families came from trees that had acorns and were considered as generally good phenotypes. Initial survival of the seedlings was approximately 60 percent. In 1982, the USDA Forest Service, Southern Region attained control of the plantation as the TVA tree improvement program had been discontinued. By age 13, grass and weed competition had lowered survival to 44.4 percent. Additionally, the plantation was periodically browsed by deer.

The planting was evaluated in 1985 for six traits: height, diameter, straightness, forking, insect defoliation and apical dominance. The study was partially thinned/rogued in 1987. Only a relatively low number of families (12) were designated for roguing, because of the young age. Subsequent maintenance has consisted of mowing and spraying around the base of the trees with an herbicide to control grass competition. A more detailed description of the orchard site and the criteria and analyses used for construction of the seed orchard has been published by La Farge and Lewis (1987).

ACORN PRODUCTION AND QUALITY

Acorn production was assessed in 1984-1986, prior to thinning, and in 1989-1992. No collections were made in 1987 and 1988 due to the activities associated with the conversion. Production was relatively limited in the 1984-1986 period (Table 1). In contrast,

a large number of families bore acorns in 1989.

Table 1. Acorn production in the northern red oak seed orchard, Watagua Ranger District, Cherokee National Forest.

Year	Number of Families	Total Number of Trees
1984	5	unknown
1985	22	26
1986	15	unknown
1989	87	132
1990	11	12
1991	74	98
1992	86	139

Acorn production in 1990 was relatively low, but rose dramatically in 1991. Data in Table 1 suggest that production could be episodic, but environmental factors or insect damage could also be possible reasons for fluctuation. Family differences were present among seed sources for acorn production. Acorn production within a family, however, was not consistent. There was great variation among individual trees in the number of acorns produced.

In 1992, acorn collections from individual trees were made on a daily basis in order to study relationships between quality and date of drop and to determine the length of time required to complete acorn drop. Nets were placed under 66 trees that produced moderate to large crops of acorns. From September 26 until October 9, acorns were collected each day and kept in separate bags. After October 9, it became apparent that predation by squirrels was causing significant losses, so bulk collections were made. The acorns were knocked off the branches using a wooden pole.

Acorn quality was assessed by floating each daily collection in water initially after collection and later, prior to sowing. Floating acorns were discarded from the initial immersion, but reserved from the second immersion for *insect* studies *(see below).* The proportion of floating acorns was higher in the earlier collection dates. Sinking acorns ("sinkers") are generally presumed to be good acorns, i.e., capable of producing a seedling. Destructive and X-ray inspections of sinkers, however, revealed that a high proportion, e.g., up to 90 percent, had significant insect damage.

Viable acorns of ten families were planted at two locations to study first-order lateral root (FOLR) distributions and heritability. Resulting seedlings will be individually graded for FOLR and other growth characteristics (Ruehle and Kormanik 1986). Seedlings will be planted in experimental designs at different locations for performance evaluation over time.

Acorn size variability within an individual tree collection was present. Surprisingly, as much as fourfold size differences

were found. The smaller acorns had the same general shape and cap characteristics as the larger acorns and appeared to be normal. This variation was not observed in all seedlots. For some families, the acorns were sorted and the smaller acorns were kept and grown separately.

DISEASE

The orchard was surveyed for stem canker diseases in 1988, but it was not until 1990 that any potentially serious diseases were recognized. In July, 1990, a foliage disorder was observed that was initially thought to have been caused by the herbicide glyphosate used for weed control around each tree. However, the herbicide hypothesis was discounted after the orchard was thoroughly inspected. Damaged foliage of one tree was often intermixed with healthy foliage of another, with both presumably exposed to th,s same herbicide concentration and environment. Symptoms were concentrated in the lower half of the live crown and were characteristic of an anthracnose-type foliage disease. These symptoms included leaf cupping and curling, marginal necrosis, an irregular leaf blotch, and a discrete pinhole leaf spot. Shoot dieback and epicormic sprouting were occasionaly found on some affected branches. Leaf curling and cupping indicated the initial damage was occurring early in spring during leaf expansion. Despite these indications, oak anthracnose was discounted due to the low susceptibility of red oaks relative to white oak, and the absence of damage on white oaks in the immediate vicinity of the orchard. Laboratory culturing of samples collected in August, 1990 was unsucessful in isolating any known leaf pathogen, apparently due to late sampling.

The disease recurred in 1991, but culturing of late June samples was also unsuccessful. Symptoms were detected in early May, 1992 and this time two fungi were consistently isolated. One bears a close resemblance to dogwood anthracnose fungus in culture and has been tentatively identified as *Discula quercina.* The other fungi has been tentatively identified as *Colletotrichum acutatum.* The pathogenicity of both fungi has been confirmed in laboratory inoculations of northern red oak seedlings.

Disease incidence and severity was greater in 1990 and 1991 than 1992. Heavy infection of some of the smaller trees in consecutive years probably was a siginificant factor in their motality. Repeated defoliation of the lower limbs of larger trees may have resulted in some limb mortality, but the overall effect of the disease on these trees was small.

INSECT STUDIES

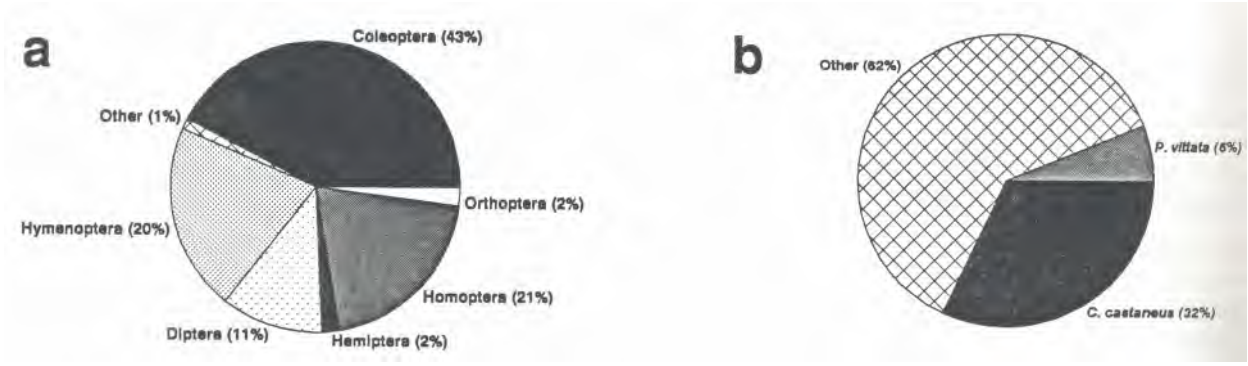
The importance of pest management in conifer seed orchards has been well documented (DeBarr and Barber 1975, Bramlett 1991). Studies have shown that oaks harbor a number of insects that have the potential to damage developing acorns either in the adult or

larval stage (cf. Solomon et *al.* 1987). Correspondingly, studies were initiated to determine if flower/acorn loss was occurring prior to acorn maturity, define the diversity of insect species in the orchard, understand relationships of insects to acorn crop size and quality, and evaluate the effectiveness of spraying for protection.

In 1989, 20 trees from 18 different families were selected for studies on flower, acornet (1st year acorn), and acorn loss prior to maturity. Branches were tagged in each tree and individual flowers/acornets/acorns were counted in early spring, mid-summer and fall. Two complete developmental cycles (flower to mature acorn) were observed, 1989-1990 and 1990-1991. Approximately 4 and 20 percent of the flowers developed into acorns in each respective cycle. These percentages are similar to what can be expected in a coniferous seed orchard without pest control.

A study on insect diversity and population levels was initiated in 1992. Five families were selected for the study based upon previous acorn production information. Four families had some trees that produced acorns in previous years; one family had no history of production. The trees were sprayed with Ansana , and the resulting dead insects were collected on nets. Spraying began in late March immediately prior to budbreak and continued through early October at two-week intervals. A total of 13,052 insects was collected in 1992. Gross sorting revealed that the majority of insects (99 percent) could be classified into six orders (Figure la). Two insect species dominated the collection, in terms of

Figure 1. Insect diversity in 1992 orchard samples. A total of 13,052 insects was collected. (a) Percentages of insects in different taxonomic orders. (b) Percentages of Asiatic oak weevil *(Cyrtepistomus castaneus)* and an oak treehopper *(Platycotis vittata)* in total collection.



numbers. The Asiatic oak weevil, *Cyrtepistomus castaneus,* and an oak treehopper, *Platycotis vittata,* comprised 32 and 6 percent,

respectively, of the total number of insects (Figure lb). Each insect has the potential to cause significant damage to acorn crops. Asiatic oak weevils may damage acornets during the first year of growth. *Platycotis* has sucking mouthparts and could damage flowers and acornets.

Insect damage was evident in mature acorns collected in 1992. Samples of acorns that floated were placed in screened pots containing soil. Weevil larvae emerged from the acorns and migrated to the bottom of the container where they will pupate and emerge in late 1993. Species identification will be made after emergence.

FUTURE STUDIES

The orchard will be surveyed in the early spring, 1993, for acorns. Results will be compared to actual acorn counts to evaluate the reliability of visual survey for predicting production. The orchard will also be surveyed for male catkin production. Sister plantations in west Tennessee and Kentucky will be observed for acorn production to calculate a heritability estimate.

Daily collections of acorns will be made in 1993 by individual trees and kept separately. Daily acorn counts will be used to construct an acorn maturation distribution for each family. Acorn drop will be correlated with weather data to determine any critical environmental factors that influence maturation/drop. Acorn quality will be assessed by floating, destructive sampling and X-ray analyses. After processing, the acorns of selected trees/families will be planted separately according to day of collection. Resulting seedlings will be evaluated for FOLR numbers to determine if there is a relationships between the number of seedlings with high FOLR numbers and seed collection (maturation) date. All data associated with the collection will be used to develop guidelines for harvesting high quality acorns.

The insect diversity study will continue through 1993. Species emergence and population levels for 1992 and 1993 collections will be compared to environmental factors, e.g., growing degree days, to develop predictive emergence models. Additional studies will be made on specific insects suspected of causing flower/acorn damage. Emergence traps for thrips (Thripidae), Asiatic oak weevil and acorn weevils will be placed under trees of five families. Sleeve cages will be placed over feeding populations of Asiatic oak weevils and *Platycotis* to detect damage or mortality to acornets and acorns. A number of trees (30) have been selected for spraying to protect the current acorn crop and the 1994 crop. The quality of acorns from these trees will be assessed after fall collection.

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