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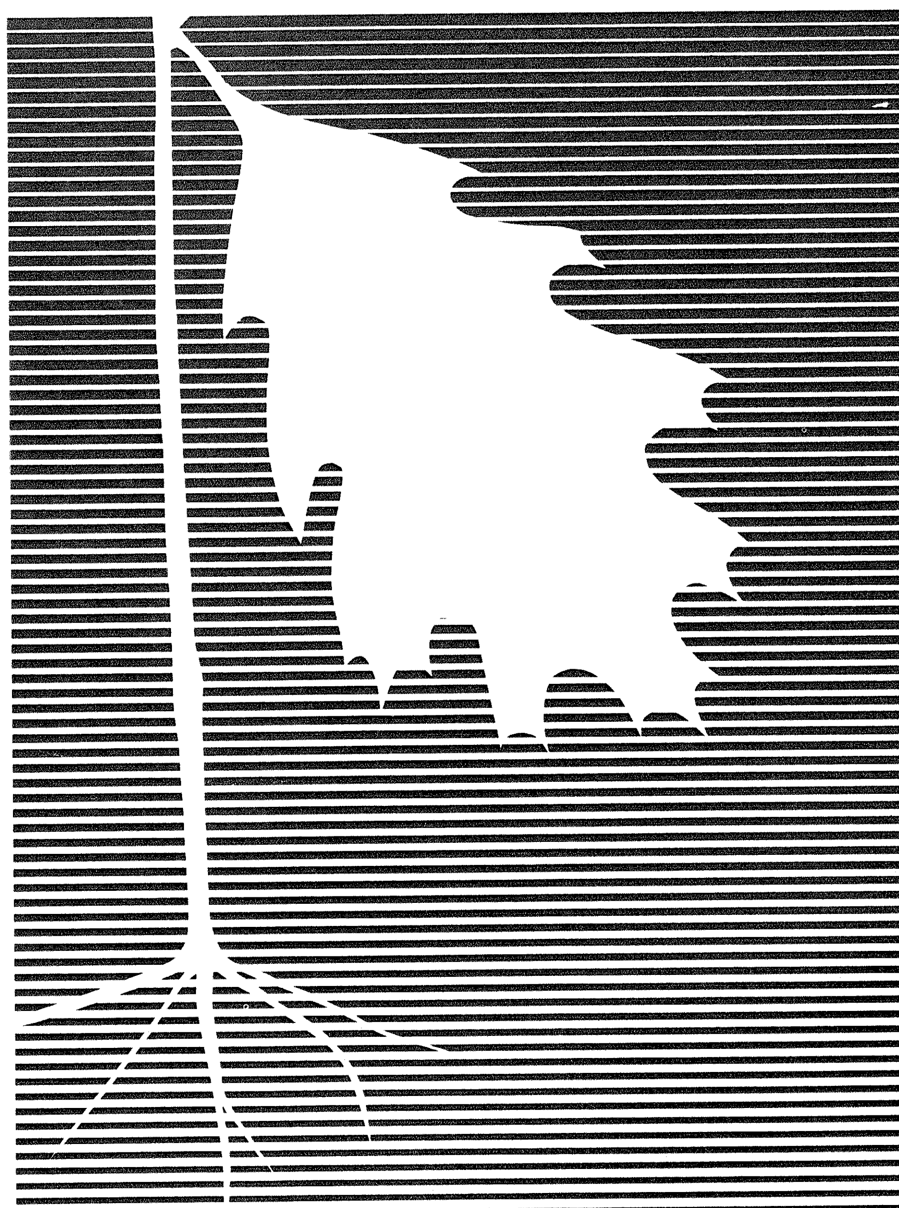
Third Workshop on Seedling Physiology and Growth Problems in Oak Plantings

(Abstracts)



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THIRD WORKSHOP ON
SEEDLING PHYSIOLOGY AND GROWTH PROBLEMS IN OAK PLANTINGS, CARBONDALE, ILLINOIS, FEBRUARY 12-13, 1986 (ABSTRACTS)

Edited by
J. W. Van Sambeek, George Rink, and Paul S. Johnson

Sponsored by

Department of Forestry
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PREFACE

On February 12-13, 1986, a group of foresters, forest scientists, tree physiologists, horticulturists, and entomologists met at Southern Illinois University-Carbondale for the Third Workshop on Seedling Physiology and Growth Problems in Oak Plantings. The first workshop, held in 1979, was prompted by an increase in interest among North American foresters in planting oak. This continuing interest has resulted in an initative to develop integrated management guidelines for the central hardwoods, especially the oak-hickory forest type. The third workshop provided a forum for exchange of ideas and research results in three subject areas: (1) oak physiology and genetics, (2) oak seedling propagation and production methods, and (3) field performance of planted oaks. Abstracts of papers given at the workshop are presented here, as well as, those of our southern colleagues who could not attend because of a major ice storm that occurred the preceding weekend.

Jerry Van Sambeek, workshop coordinator, gratefully acknowledges the assistance of the following session moderators: Paul S. Johnson, George Rink, Carl A. Budelsky, and Phil Pope. In addition, the workshop coordinators are grateful to Mel Larson and Ohio State University for accepting the responsibility of hosting our fourth workshop in 1989.

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George Rink, Research Geneticist
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A white oak (*Quercus alba* L.) progeny test was initiated in April 1983, using 2-0 seedlings from 12 sources. Progeny of six individual trees in southern Illinois or Indiana (families), of four stand collections, and of two check seedlots were tested. In fall 1985, after three growing seasons, survival averaged 78 percent. Mortality appeared to be randomly distributed, and survival differences among families were not significant. There was no correlation between survival and basal stem diameter at outplanting.

Height differences among open-pollinated families were not statistically significant primarily because of the low number of families represented in this test. Expressed on a plantation mean basis, however, there was a 35-percent difference in height growth between the fastest and slowest growing families in the third growing season. Height growth averaged 55.4 cm after three growing seasons. By contrast, there were significant differences in basal stem diameter among families at outplanting. The differences persisted through the third growing season with a 45-percent difference in average diameter growth between the fastest and slowest growing families. After the third growing season, the correlation between height and basal stem diameter was 0.73, indicating that the tallest trees had the greatest diameter growth. There was no correlation, however, between basal stem diameter at outplanting and third-year height growth, indicating that outplanting basal stem diameter is not a good indicator of future growth potential. The pattern of variation among provenances was similar to that among families.

AN OVERVIEW OF OAK TREE IMPROVEMENT PROGRAMS IN INDIANA

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The Indiana Department of Natural Resources, Division of Forestry, has initiated tree improvement programs for four oak species. In 1983, a provenance/progeny test plantation of cherrybark oak (*Quercus falcata* var. *pagodaefolia* Ell.) was established using thirty half-sib families from five southern states and Indiana. Plans are to convert this plantation into a seedling seed orchard.

A limited range white oak (*Q. alba* L.) provenance/progeny test was established at six locations in 1984. Up to seventy half-sib families (five trees per stand) from Indiana, southern Illinois, and Missouri were included in three Indiana plantings. The purpose of these plantations was (1) to quantify the levels and patterns of genetic variation within the Indiana white oak population and (2) to serve as populations for future tree improvement activities such as seedling seed orchard conversion and/or plus-tree selection work. Using these same families, additional plantings were established by the USDA Forest Service in southern Illinois and by Michigan State University at the Kellogg and Rust Experimental Forests.

A clonal program for northern red oak (*Q. rubra* L.) was begun in 1984 using scionwood from eighty nine plus-trees from throughout Indiana. Greenhouse grafting success was 92 percent in the spring of 1985. Grafts were used to establish a closely-spaced, seed orchard/clone bank in the spring of 1986. Seed for progeny testing will be collected from the orchard and progeny test results will be used to rogue the orchard.

In 1985, eighty half-sib families of English oak (*Q. robur* L.) from West Germany, France, and Yugoslavia were established in six provenance/progeny test plantations. Also included were seedlings from six Michigan State University seedlots and a single commercial check seedlot. The Indiana plantation will provide information on the potential value of this exotic in Indiana. The five other provenance/progeny tests were established by Michigan State University at two locations, the Ohio Department of Natural Resources, Iowa State University, and the University of Maine.

A MORPHOLOGICAL INDEX FOR STUDIES ON OAK SEEDLINGS

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Several morphological indices have been developed to relate morphological measurements to biochemical, physiological, and anatomical events or processes in plants. The leaf plastochron index (LPI) has been widely used in developmental studies of trees. However, morphological indices used for trees with indeterminate shoot growth cannot be effectively applied to trees with determinate or semi-determinate shoot growth such as oak (*Quercus* spp.). The need for a suitable morphological index for use in oak studies is probably greater than for most other species because of their extreme variability.

A *Quercus* morphological index (QMI) based on simple leaf and stem growth measurements has been useful in our studies on northern red oak (*Q. rubra* L.) seedlings. Three distinct stages have been defined for each flushing episode--linear stem elongation (Slin), linear leaf elongation (Llin), and flush lag (Lag). The QMI is currently used at our laboratories in several ways: (1) to ensure uniformity of morphological stages of development in parallel studies of the same seed source at different locations, (2) to compare seed sources from year to year, (3) to compare growth of different species within a defined environment, (4) to determine shifts in plant development due to different treatments or environments, and (5) to relate the morphological stages of oak seedling development to biochemical, physiological, and anatomical events and processes.

We hope that other research groups studying oak will also use the QMI and/or a similar morphological index to standarize research techniques and facilitate the transfer of research information between various research groups and geographical regions. Currently, we are applying the QMI to our oak studies on (1) apical bud development, (2) anatomical and physiological changes in developing leaves, (3) photosynthesis and respiration of developing leaves, (4) photosynthate distribution and quantification of photosynthetic products, (5) herbicide tolerance, and (6) vegetative propagation and physiology of rooting oak cuttings.

PHOTOSYNTHESIS AND RESPIRATION OF NORTHERN RED OAK SEEDLINGS

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Slow growth and shoot dieback of northern red oak (*Quercus rubra* L.) seedlings may be the result of an unfavorable balance between photosynthesis and respiration. We grew red oak seedlings in a controlled environmental chamber to better understand carbon dioxide exchange and growth of recurrent flushing seedlings at various stages of growth. Carbon dioxide exchange measurements at several light intensities were made on an attached median leaf within each flush at each of nine growth stages that were identified using the *Quercus* morphological index (QMI). An optimized sampling strategy was used to choose light levels to minimize variance of photosynthetic and respiration rate estimates. Light saturated photosynthesis and dark respiration were determined by nonlinear regression.

Our experiments showed that photosynthesis and respiration of oak seedlings changed dramatically throughout leaf expansion of the first flush and did not peak until after full leaf expansion. Moreover, the onset of a third flush of growth restimulated photosynthesis of first flush leaves. The pattern of photosynthesis in second and third flush leaves was similar to first flush leaves in relation to shoot ontogeny. For all flushes, leaf respiration rates were high during leaf expansion and declined to a constant level after full expansion. The observed photosynthetic and respiratory patterns provide a basis for building growth models for northern red oak seedlings; however, additional experimentation will be required to understand the physiological events behind the observed patterns.

CAN OAK SEEDLING QUALITY BE QUANTIFIED BY LATERAL ROOT NUMBER?

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Recent research suggested that it might be possible to quantify seedling quality by lateral root characteristics. Initially, we found that approximately 35 percent of all sweetgum (*Liquidambar styraciflua* L.) seedlings produced in the nursery had fewer than four permanent lateral roots. Sweetgum seedlings with fewer than four lateral roots had significantly poorer survival and growth after 3 years than those with six or more lateral roots. The aboveground seedling biomass could be readily altered by various treatments; however, the frequency distribution of lateral root numbers remained relatively constant.

Using ten half-sib seedlots of northern red oak (*Quercus rubra* L.), essentially the same frequency distribution of lateral root numbers was found as in sweetgum. Northern red oak seedlings with 12 or more lateral roots were rated the best. Depending on the seedlot, these seedlings represented from 5 to 26 percent of the total seedling population. Seedlings with fewer than seven lateral roots were judged the poorest and represented from 26 to 68 percent of the seedling population.

ROOT REGENERATION IN NORTHERN RED OAK SEEDLINGS

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Two experiments were conducted investigating budbreak, shoot elongation, and root regeneration of 3-0 northern red oak (*Quercus rubra* L.) seedlings in root observation boxes under greenhouse conditions. The first experiment compared three treatments-- (1) 5 second root dips in 1,000 ppm potassium salt of indolebutyric acid (K-IBA), (2) inserting auxin impregnated toothpicks (soaked for 24 hours in 1,000 ppm K-IBA) into taproot, and (3) untreated seedlings. Auxin treatment did not effect budbreak, rate of shoot extension, or leaf area of first flush relative to untreated seedlings. The auxin-toothpick treatment increased leaf area in the second flush relative to the untreated seedlings. First root regeneration in auxin treated seedlings occurred 4 to 8 days after first root regeneration in untreated seedlings. Root elongation rates of auxin treated seedlings were also slower. Root regeneration occurred first from cut surfaces of small diameter pruned lateral roots and 28 days later from the cut surface of the primary root. Budbreak occurred 14 days before first root regeneration; however, the second flush occurred after the second pulse of root regeneration.

In the second experiment, dormant 3-0 northern red oak seedlings were given a 3 second root dip in 20 millimolar solutions of either K-IBA, indole-3-butyric acid (IBA), N-phenyl indole-3-butyramide (NP-IBA), phenyl indole-3-thiobutyrate (P-ITB), or phenyl indole-3-butyrate (P-IBA). Seedlings dipped in water or 95 percent ethanol served as controls. Fifty-six days after treatment, seedlings treated with NP-IBA and P-ITB regenerated up to 3 times more roots than did ethanol treated control seedlings (48.7, 40.0, and 14.3 roots per seedling, respectively). Seedlings treated with NP-IBA and P-ITB had smaller leaves than K-IBA and IBA treated seedlings. Seedlings treated with NP-IBA had more leaves than K-IBA and IBA treated seedlings (155.3, 59.0, and 53.3 leaves per seedlings, respectively); however, leaf surface areas were similar. Seedlings treated with P-ITB had a similar number of leaves as seedlings treated with K-IBA and IBA; however, P-ITB treatment reduced total leaf area.

IN VITRO MICROPROPAGATION OF WHITE OAK

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Dormant buds and newly emergent shoot tips of mature white oak (*Quercus alba* L.) could not be surface-sterilized without killing the explants; however, 68 percent of shoot tips taken from greenhouse-grown seedlings could be surface-sterilized and acclimatized on woody plant medium. After 4 to 8 weeks in culture, 70 percent of apparently sterile cultures showed contamination by a slow-growing, white bacterium believed to be an internal contaminant. Axillary shoot proliferation and elongation were better on woody plant medium than on either Murashige and Skoog's or Driver and Kuniyuki's medium. No differences in axillary shoot proliferation were observed with 6-benzylaminopurine (BAP) concentrations ranging from 0.1 to 20 ppm. The addition of indole-3-butyric acid (IBA) at 0.002 and 0.1 ppm had no effect on axillary shoot proliferation or elongation.

Axillary shoot proliferation and elongation differed among half-sib progeny in several experiments; however, no interaction with medium, BAP, or IBA levels was found. After 8 weeks in culture, the number of elongating axillary shoots ranged from 0.2 to 1.9 and the length of the longest axillary shoot ranged from 2 to 11 mm among 10 half-sib progenies. Of the 67 uncontaminated cultures that initiated new growth and were tranferred to new medium biweekly, more than 60 percent died within 10 months.

We failed to root newly emergent, surface-sterilized shoots from greenhouse-grown seedlings with various combinations of sterile media, IBA, and the fungus *Pisolithus tinctorius*. Subsequent rooting trials with 70 microshoots taken from 10-month-old cultures (ramets of five ortets) and treated with IBA quick dips resulted in 11 rooted plantlets. Rooting occurred at five IBA concentrations ranging from 0.2 to 20.0 ppm.

PRODUCTION OF NURSERY GROWN NORTHERN RED OAK WITH PISOLITHUS TINCTORIUS

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The influence of the ectomycorrhizal fungus *Pisolithus tinctorius* (Pers.) Cohen and Couch (*Pt*) on the production of 1-0 northern red oak (*Quercus rubra* L.) seedlings was studied for 3 years. Inoculation of nursery beds after seedling emergence with vermiculite medium containing vegetative mycelium of *Pt* at 2.25 liter per square meter increased seedling height and diameter all three years and increased the number of salable seedlings in two of the three years. The number of seedlings in the larger size classes (height > 40 cm, stem diameter > 9 mm) and seedling root dry weight (principally the lateral roots) were increased by *Pt* inoculation all three years.

Nursery bed inoculation influenced the mycorrhizal species found on the seedling roots in mid-November, but not the percent of infected lateral roots. The high percent of *Pt* on the primary lateral roots in the inoculated plots (65 to 80 percent) suggests that *Pt* can successfully complete with indigenous fungi. In the inoculated plots the percent of primary lateral roots infected with *Pt* was significantly correlated in all three years with stem diameter (r = 0.55 to 0.71) and lateral root dry weight (r = 0.65 to 0.73) and in one of three years with methanol extractable carbohydrates (year 1, r = 0.65), stem height (year 2, r = 0.69), and total seedling dry weight (year 2, r = 0.71).

ESTIMATING ACORN PRODUCTION OF INDIVIDUAL OAK TREES

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Reliable information is needed on the variation in seed production among individual trees in oak regeneration and mast production research. In the past, visual estimates (counts) before acorn fall or acorn traps have been used, but it is not known how reliable such estimates are. In 1962, total acorn counts and the location of each acorn beneath three mature cherrybark (*Quercus falcata* var. *pagodaefolia* Ell.) oaks were determined. Crown perimeter and location of each acorn were analyzed by plotting them on paper and then sampled by using overlays of different sized and shaped sampling units. It was concluded in an unpublished file report that 61 to 767 samples per tree were needed to estimate the actual population within 10 percent and that 8 to 93 percent of the area needed to be sampled.

We propose to reanalyze this data, which consists of more than 12,000 acorn locations, to determine the spatial distribution of the acorns and to test if it differs from a random distribution. If so, we will attempt to characterize the type of distribution that exists. We will also retest the sampling variables including sampling unit size and shape, distribution of sampling units, and sampling intensity. Results will be compared to the known population means, and sampling variance will be examined to determine at what intensity it becomes stable so that sampling effectiveness and efficiency can be calculated.

ASIATIC OAK WEEVIL IN MISSOURI'S OAK-HICKORY FORESTS

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The lack of natural oak regeneration in the central and eastern hardwood forests is a serious problem. Currently research is underway to study the impact of the Asiatic oak weevil (*Cyrtepistomus castaneus* (Roelofs)) on oak reproduction in Missouri's oak-hickory forests. Study objectives included assessing the temporal and spatial distribution of emerging adult Asiatic oak weevils and investigating host acceptability of feeding adult weevils. Between June and September of 1985, we monitored adult weevil emergence from the soil using 160 emergence traps in eight trapping areas. Peak emergence occurred during the month of July. Aggregation within trapping areas was also observed.

Newly emerged adult weevils collected from emergence traps were introduced into feeding arenas using paired comparisons of feeding on leaves of seven hardwood species. After 24 hours, the leaf area lost to feeding was measured with a portable leaf area meter. White oak (*Quercus alba* L.), northern red oak (*Q. rubra* L.), and black oak (*Q. velutina* Lam.) were the preferred hosts. Sugar maple (*Acer saccharum* Marsh.) was an acceptable host when oaks were not present. Hickory (*Carya* spp.), dogwood (*Cornus florida* L.), and sassafras (*Sassafras albidum* (Nutt.) Ness) were not acceptable hosts because no feeding occurred on them. The results indicate that Asiatic oak weevil perfers the foliage of oaks over that of other hardwoods.

INSECTS AFFECTING OAK SEEDLING ESTABLISHMENT

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Research on insects affecting acorns has revealed that 60 to 98 percent of germinating acorns in plots in southern Ohio were destroyed by insects considered to be minor pests. In addition, several "new" species were linked to oak seedling mortality in nursery and forest sites. Future research will concentrate on determining the life histories and impact of these insects.

REGENERATION OF BOTTOMLAND HARDWOODS

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The effects of residual stems on the natural regeneration of bottomland hardwood stands were evaluated on Coastal Plain branch bottoms, wet flats, and muck swamps. Residual control treatments included (1) mechanical (shear or saw), (2) chemical (injection), and (3) control or no treatment. Stocking, origin, and growth of reproduction were evaluated 1 and 5 years after treatment. Although results differed among sites, the mechanical and chemical treatments usually caused a delay in regeneration stocking. After 1 year, both the mechanical and chemical treatments tended to have fewer stems than the control. After 5 years, however, mechanical and chemical treatments had equal or greater stocking than the control. The mechanical treatment resulted in the greatest height growth of all hardwoods in year 1 and year 5.

The oak regeneration showed a pattern similar to the overall response. Oak establishment after 1 year was lower for both the mechanical and chemical treatments than the control. Oak establishment between years 1 and 5 for both the mechanical and chemical treatments exceeded the control. After 5 years, the chemical treatment results in the most oak regeneration, especially on the muck swamp and branch bottom sites. The mechanical treatment resulted in the greatest height growth for the oaks after year 1 only.

EFFECTS OF A NITRIFICATION INHIBITOR AND NITROGEN FERTILIZERS ON WHITE OAK ESTABLISHMENT

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White oak (*Quercus alba* L.) seedlings germinated from seed collected under a single tree were planted on an old field site in southern Illinois that previously had a tall fescue (*Festuca arundinaceae* Schreb.) cover. Urea, potassium nitrate, ammonium nitrate, or calcium nitrate was broadcasted alone or with the nitrification inhibitor N-Serve (2-chloro-6-[trichloromethyl]pyrimidine) and raked into the upper soil surface after preplant cultivation. Fertilizers were applied at 211 kg/ha elemental nitrogen, and N-Serve was applied at 1.5 kg/ha. Treatments also included unfertilized controls with and without N-Serve. Fertilizer and N-Serve were reapplied in the spring of the second year. Weeds were controlled by applying herbicides and by hoeing for 3 years.

Survival after 3 years was 62 and 52 percent with and without N-Serve, respectively, across all fertilizer treatments. Plots fertilized with potassium nitrate had the highest survival (81 percent); in plots fertilized with urea, ammonia nitrate, and calcium nitrate had lower survival rates than the unfertilized controls (67 percent). Trees in the unfertilized controls with N-Serve were 49 percent taller and 29 percent larger in basal stem diameter than trees without N-Serve. Seedling growth in response to fertilizers was as follows: potassium nitrate > calcium nitrate > urea > control > ammonium nitrate.

Percent foliar nitrogen, phosphorus, and potassium during the first growing season were higher in trees receiving N-Serve than those without N-Serve; however, only foliar phosphorus was significantly higher. Percent foliar calcium and magnesium were only slightly affected by the N-Serve. Only percent foliar nitrogen was still higher in the trees receiving N-Serve than in those without N-Serve during the third growing season (3.3 and 2.4 percent, respectively). Significant interactions between the fertilizers and the N-Serve were observed only during the first growing season.

ESTABLISHMENT AND GROWTH OF OAKS ON MINED LANDS

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Oak seed or seedlings were planted each autumn and spring over a five-year period on either unmined old fields, ungraded minesoil, graded only minespoil, or graded minespoil with topsoil replaced. Oak species tested included white oak (Quercus alba L.), bur oak (Q. macrocarpa Michx.), chestnut oak (Q. prinus L.), northern red oak (Q. rubra L.), black oak (Q. velutina Lam.), pin oak (Q. palustris Muenchh.), Shumard oak (Q. shumardii Buckl.), and shingle oak (Q. imbricaria Michx.). The oaks were seeded or planted each autumn or spring depending on availability of acorns or nursery stock; however, as the study progressed we increasingly used seed in the autumn and dormant seedlings in the spring. Replicated plots on the four neighboring sites consisted of 50-tree rows of each species on a 2.5 x 2.5 m spacing. During the last three years of the study, we sprayed a Roundup and Princep mixture around each seed spot or seedling to control the herbaceous competition and reduce rodent damage.

Federal and state regulations now require the replacement of topsoil and establishment of an herbaceous cover to control erosion. These practices result in compacted graded lands unsuitable for establishing most hardwoods. Oaks are among the best species to establish on compacted, graded minespoil. In general, white, bur, chestnut, northern red, and shumard oak performed better than black, pin, and shingle oak. The latter three oak species frequently naturally invade pine or other tree covers on stripmines. Pin oak was among the tallest of the three-year-old trees. Future plans are to continue comparing establishment and growth of hardwoods, including oaks, on several types of sites and in different rooting media to identify the physical limitations to root development.

A PRESCRIPTION FOR PLANTING NORTHERN RED OAK

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A four-step prescription has been developed for planting northern red oak (*Quercus rubra* L.) on forest sites in Missouri. The prescription calls for: (1) controlling undesirable woody understory vegetation with a herbicide before planting, (2) creating a shelterwood overstory at 60 percent stocking, (3) underplanting 2+0 undercut seedlings or 1+1 transplants with clipped tops and basal stem diameters that average about 1/2 inch, and (4) removing the shelterwood three growing seasons after planting. If this prescription is applied, about half of the planted trees should be competitive 2 years after shelterwood removal. Preliminary cost estimates for planting and site preparation range from 200 to 400 dollars per acre depending on numbers of seedlings planted per acre.

ROOT REGENERATION AND GROWTH OF NORTHERN RED OAK SEEDLINGS TREATED WITH HORMONES

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Previous research has shown that endogenous auxins and cytokinins increase in root tissues during root regeneration of northern red oak (*Quercus rubra* L.) seedlings. Furthermore, preplant application of indoleacetic acid (IAA) and kinetin to roots of 1-0 seedlings greatly increases root regeneration in greenhouse studies. In subsequent experiments the following three methods of applying IAA-kinetin hormone mixtures to roots of 1-0 northern red oak seedlings were tested: (1) soak roots in aqueous hormone solution for 24 hours, (2) apply a vacuum for 4 hours during root soak to increase penetration of hormone solution into roots, (3) dip roots into a hormone-starch polyacrylonitrile gel (Super slurper) solution. Part of the seedlings from each hormone treatment were planted in a greenhouse to determine their root regeneration potential. Half of the remaining seedlings were outplanted on a weedy site (only mowed infrequently) and the other half on a site about 200 yards away that was clean cultivated on a regular basis (weed-free). Seedling height and stem dry weight were determined after two growing seasons.

Root regeneration and leaf weight of seedlings in all hormone treatments except starch gel were significantly greater than for untreated seedlings in the greenhouse study. Similarly, all hormone treatments except starch gel significantly increased seedling height and stem weight on the weed-free site. Maximum stem growth resulted from a 4 hour vacuum infiltration with 200 ppm IAA and 0.1 ppm kinetin solution. Seedlings for this treatment on the weed-free site averaged 33.4 g stem dry weight compared to only 13.9 g for untreated seedlings. Stem dry weight of seedlings on the weedy site averaged only 10 percent of dry weight of seedlings on the weed-free site and preplant hormone treatments were without benefits.

Future research will include determining variability in root regeneration potential among families and/or seed sources to applied hormones. Several "new" root promoting compounds such as phenyl-modified auxins and a non-hormone willow extract will also be tested.

SPRAY APPLICATION OF INDOLEBUTYRIC ACID ENHANCES OAK ROOT REGENERATION

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Spray treatments of indolebutyric acid (IBA) on roots of 2-0 seedlings of white oak (*Quercus alba* L.) and northern red oak (*Q. rubra* L.) were investigated to test for differences in seedling growth and root regeneration. Concentrations of 0, 1,000, 3,000, 5,000, and 7,000 ppm IBA in 20 percent ethanol solutions were tested. Lateral root number, tap root length, and root dry weight were evaluated after one growing season and total length of shoot growth was measured after two growing seasons.

White oak seedlings treated with 5,000 ppm IBA averaged 43 secondary roots and 48 cm of new shoot growth per plant compared to only 35 secondary roots and 35 cm of shoot growth for seedlings without IBA. Seedlings treated with 7,000 ppm IBA averaged 49 roots secondary roots and 45 cm of shoot growth; however, root dry weight was decreased. For white oak seedlings, tap root length and root dry weight were unaffected by all other treatments.

Northern red oak seedlings treated with 3,000, 5,000, and 7,000 ppm IBA had increased numbers of secondary roots, but no corresponding increase in shoot growth. Seedlings which received 7,000 ppm IBA averaged 43 regenerated roots compared to only 24 for the seedlings without IBA. Shoot growth was significanty increased by 1,000 ppm IBA without an increase in root numbers or dry weight.

EARLY GROWTH OF UNDERPLANTED BOTTOMLAND HARDWOODS

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Two studies were designed to evaluate the potential of underplanting hardwood seedlings for enhancing regeneration of desirable bottomland tree species. The first study involved partial overstory removal and subsequent underplanting of five bottomland tree species on three sites in southeastern Louisiana. Survival after the second growing season was 45, 59, 77, 82, 88, and 98 percent for sweetgum (*Liquidambar styraciflua* L.), cow oak (*Quercus michauxii* Nutt.), Nuttall oak (*Q. nuttalli* Palmer), green ash (*Fraxinus pennsylvanica* Marsh.), rooted green ash cuttings, and baldcypress (*Taxodium distichum* (L.) Rich), repectively. Mean height growth for the second growing season ranged from 9.3 to 21.5 cm. Initial seedling quality affected early growth and survival of all species; however, local site conditions also influenced the survival of cow oak and sweetgum.

In the second study, green ash, baldcypress, Nuttall oak, pecan (*Carya illinoensis* (Wangenh.) K. Koch), and water oak (*Q. nigra* L.) were underplanted in an over-mature cottonwood-willow stand located in the Atchafalaya basin in South Central Louisiana. First-year survival ranged from 88 to 99 percent. Mean height growth from seedlings not clipped off by animals was 8.5, 9.3, 11.0, 17.1, and 23.4 cm for baldcypress, water oak, pecan, Nuttall oak, and green ash, respectively.

GROWTH OF FOUR BOTTOMLAND OAK SPECIES PLANTED AT FIVE SPACINGS IN AN ARKANSAS STREAM BOTTOM

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Seedlings of water oak (*Quercus nigra* L.), Nuttall oak (*Q. nuttallii* Palmer), cherrybark oak (*Q. falcata* var. *pagodifolia* Ell.) swamp chestnut oak (*Q. michauxii* Nutt.) and four bottomland hardwood species were planted at five different spacings in a minor stream bottom in southeastern Arkansas. Each plot consisted of 169 trees planted in rectangular grids of 13 by 13 rows on 2 x 8, 3 x 8, 4 x 8, 8 x 8, and 12 x 12 foot spacings. The plantation was cultivated only during the first growing season.

After 8 years, survival averaged 70 to 80 percent for all the oaks. Water oak had the best growth and swamp chestnut had the poorest. Nuttall oak and cherrybark oak grew only slightly slower than water oak. Average heights ranged from 10 feet for swamp chestnut to over 21 feet for water oak. The oaks were 2 to 4 feet taller at the wider spacings than at the more narrow spacings. Diameter growth averaged 1/10- to 1/3-inch per year and, except for swamp chestnut oak, generally increased as spacing increased.

Bolewood, branches, and bark comprised 40 to 50, 30 to 40, and 15 to 20 percent, respectively, of the total tree dry weight. Bolewood weight tended to decrease as a proportion of total weight as the spacing increased, while the percentage in branches increased. Percentage bark was not related to spacing. Initially, leaves made up a high proportion of the total weight; however, the proportion of total weight had stabilized to around 10 to 15 percent after 8 years. Greatest biomass production was in water oak, followed by Nuttall, cherrybark, and swamp chestnut oak. Biomass production per acre was about three times higher at the 2 x 8-foot spacing than at the 12 x 12-foot spacing. Highest green weight production (130,000 pounds per acre through age 8) was in the 3 x 8-foot spacing of water oak.

U.S. Department of Agriculture, Forest Service.

1988. Van Sambeek, J. W.; Rink, George; Johnson, Paul S., eds. Third workshop on seedling physiology and growth problems in oak plantings, proceedings abstracts; 1986 February 12-13; Carbondale, IL. Gen. Tech. Rep. NC-121. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 19 p.

Research results and ongoing research activities in oak plantings and related physiology and genetic studies are described in 19 abstracts.

KEY WORDS: Plantations, propagation, regeneration.

FINDING OUT AND TELLING

Our job at the North Central Forest Experiment Station is discovering and creating new knowledge and technology in the field of natural resources and conveying this information to the people who can use it--in short, "finding out and telling." As a new generation of forests emerges in our region, managers are confronted with two unique challenges: (1) Dealing with the great diversity in composition, quality, and ownership of the forests, and (2) Reconciling the conflicting demands of the people who use them. Helping the forest manager to meet these challenges while protecting the environment is what research at North Central is all about.

NORTH CENTRAL FOREST EXPERIMENT STATION