

## SHORT ROTATION WOODY CROPS - HYBRID POPLAR

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**ABSTRACT.**—Short Rotation Woody Crops (SRWC) is the application of agroeconomic principles and practices to achieve forestry objectives. The system is similar to mechanized farming. It includes establishing plantations through site preparation, weed control, and fast-growing hybrids. Factors such as proper site preparation and weed control are essential. This paper will describe a procedure for establishing commercial SRWC plantations of hybrid poplar, and summarize field applications in the WesMN Resource Conservation and Development Hybrid Poplar Scale-up Project in Alexandria, MN, including herbicides recently labeled for hybrid poplar, and experience with large-scale plantings.

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### BRIEF HISTORY AND BACKGROUND

Poplar culture has been used in Europe and the Middle East since the late 1600's. Hybrid poplar has been planted across the United States as a landscape and windbreak tree for over 50 years. In fact, records at General Andrews Forest Tree Nursery in Willow River show production of hybrid poplar as early as 1942.

Research specific to Short Rotation Woody Crops (SRWC) with hybrid poplar has been taking place in the Lake States for 25 years. This work was headed by Edward A. Hanson, silviculturist for the USDA Forest Service North Central Research Station (NC); Wendell Johnson, project director of the University of Minnesota's Crookston Biomass Research Programs; William Bergerson, soil scientist for the Natural Resources Research Institute (NRRRI) in Duluth, MN; and David Dawson (NC).

SRWC is seen as a way to grow more fiber on less land, which may reduce potential conflicts between increasing demand for wood fiber, and other forest land uses. Researchers felt that optimum tree growth could be realized by borrowing intensive cultural techniques from agriculture, including the use of hybrids. Most research was done with hardwoods, particularly poplars, because of their rapid growth.

Interest in SRWC intensified in 1977 when the oil embargo provided the impetus for additional funding from the U.S. Department of Energy (DOE) to consider wood as an alternative to fossil fuels. Research in Minnesota on clonal screenings and biomass cash crop development was

funded by the Legislative Commission on Minnesota Resources (LCMR) as early as 1983. The motivation for applied research in Minnesota came in 1987 when Northern States Power (NSP) seriously considered whole-tree burning for power generation.

The Minnesota Department of Natural Resources (MNDNR) became involved in resource assessment to determine if an adequate wood supply was available for NSP wood-fired plants. Little wood was available from forest lands surrounding potential power plant conversion sites, so plans were investigated for implementing large scale hybrid poplar plantings on Conservation Reserve Program (CRP) lands returning to agricultural cropping.

Various agencies, organizations, and individuals were involved in this early research and application.

The National Renewable Energy Laboratory (NREL) was seeking a pilot plant to produce ethanol from SRWC plantations. The Electric Power Research Institute (EPRI) wanted to site a 100 megawatt power plant requiring 50-75,000 acres of SRWC trees. The Agricultural Utilization and Research Institute (AURI) was interested in marketing hybrid poplar as an alternative farm crop. MetaDynamics, Inc., assisted in project development, funding, and technology transfer, as did the Minnesota Public Service Department, Utilities Division. The Natural Resources Conservation Service (NRCS) was involved through soil and site productivity evaluations, as well as through landowner contacts. MNDNR -Wildlife, The Audubon Society, and The Nature Conservancy offered input on plantation locations and designs.

MNDNR - Forestry, through its involvement as the technical agency responsible for CRP tree planting, was the major player in dealing with the CRP enrollees and other private landowners interested in SRWC. Other companies and agencies involved were Energy Performance Systems, Minneapolis, and the U.S. DOE Biomass

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This early planting effort resulted in 500 acres of hybrid poplar being planted on 20 sites in Minnesota, North and South Dakota, and Wisconsin. Discussion then began on implementing this type of planting on a limited, commercial scale. There were cost-share programs in place to help defer establishment costs, and the combination of the factors mentioned previously provided a favorable political climate for implementation. Those involved decided to implement a pilot project where 1,000 acres of SRWC hybrid poplar would be established within an area similar in size to the usual procurement zone (50-mile radius) of a wood-using industry.

### **The Minnesota Agricultural Wood Energy Scale-Up Project, Alexandria**

The Minnesota Agricultural Wood Energy Scale-Up Project planning began in late 1993. The project was to track and monitor economic costs of planting, maintaining, and monitoring large-scale commercial plantings of hybrid poplar. For 15 years, only smaller scale research and experimental plantings of hybrid poplar had been done, primarily to screen for promising high-yield candidate species. Currently, 1,870 acres of hybrid poplar trees have been planted on CRP land within a 50-mile radius of Alexandria, MN.

The project proceeded in five phases. Phase I saw the planting of 1,000 acres in 1994. An additional 870 acres were planted during Phase II in 1995. Phases III through V have consisted of replanting and interplanting work, cottonwood leaf beetle and noxious weed control, aerial photography and GIS, clonal trials, herbicide research, plastic mulch research, yield data collection, and browse control studies. The 19 private landowners initially involved, all enrolled in the CRP program, received a 5-year extension of their CRP contracts by planting hardwood trees. These contracts will begin to expire in 2001 when some of the plantings will be 7 years old.

Public information meetings were held, and landowners enrolled in the CRP program were invited to attend. The establishment process and expected CRP cost-sharing were explained, along with the commitment that would be required to maintain the stands. Many landowners were interested, and candidate plantation fields were chosen from these groups. Appointments were then set up, and sites were picked after these interviews.

Sites were chosen to cover a wide range of soils and conditions. Field tests were conducted to determine soil type and characteristics, including pH, which has been shown to be a limiting factor in hybrid poplar survival. Plantation size and operability were other factors. The

selected sites averaged about 100 acres, ranging in size from 13 to 300 acres.

Additional funding for plantation establishment was provided by the Oak Ridge National Laboratory. To accurately track establishment costs and to remove most of the financial burdens from landowners, DOE paid for most of the establishment costs. The landowners were responsible for preparing the sites for planting.

## **PROCEDURE FOR PLANTATION ESTABLISHMENT**

### **Site Selection**

Site selection is critical for establishing successful SRWC plantings. Although hybrid poplar will grow under a wide range of site conditions, they perform best when grown on more fertile soils, with good moisture-holding capacity. The trees can tolerate wet conditions for a short period of time, but wetter, or poorly drained sites limit appropriate site preparation and proper timing of maintenance activities.

The preferred soil types range from loamy sands to loams with 8 to 10% slopes or less. Organic matter should be in the 3 to 8% range, and a pH over 7.8 should be avoided (preferred range is 5.5 to 7.8). A high moisture holding capacity is desirable, though dry sites with high water tables are also acceptable. Areas that frequently flood in the summer or soils that contain a hardpan in the rooting zone should be avoided. From both cost and landscape management aspects, it also is not recommended that natural forest cover types be converted to SRWC.

### **Site Preparation**

The preparation of land for SRWC is similar to that used for agricultural crops. The types and timing of site preparation depend on the condition of the site. On sites that have sod or heavy grass cover, work should start the season before tree planting. Fields being converted from conventional crop cover will not need the heavy work that a field in grass will. A field that is in sod, pasture, or hay will need a herbicide application. Glyphosate (Roundup®) is commonly used. This application should be done in middle to late July of the year before planting. After the herbicide has taken effect (usually 10 to 15 days), a primary tillage operation should be done. Depending on site conditions, this can be accomplished with a heavy disk, or chisel or moldboard plow. Plowing as deep as possible will facilitate the planting of the poplar cuttings later. This tillage should be followed by a tandem disk or field cultivator in late September or early October. The next spring, the field may be disked or cultivated. Rows should then be marked for planting.

An option for converting sod or grass cover is to allow a farmer to crop the land for 1 or 2 years. Benefits of this approach are that the farmer will perform all of the tillage operations needed for that site, and weed pressures will be reduced. Crops that keep the soil from compacting, such as small grains or soybeans, are best. Corn preceding SRWC can be a problem due to increased crop residue and the need for increased tillage.

Row spacing of the plantation must be carefully controlled. The operator must be able to get tillage and other equipment through the area in at least one direction. The rows in most of the fields in the Alexandria project were marked in two directions to allow for cross-cultivation of the trees. This is ideal, but marking in at least one direction is mandatory. As a general rule, row spacing should be 8 to 10 feet. This can be modified to conform to the operator's equipment. Approximately one foot should be left on either side of the tillage equipment between the rows. For example, if the operator will be tending the planting with an 8-foot wide disk, row spacing should be approximately 10 feet. Row spacings of more than ten feet may add to the time needed to reach crown closure.

Another factor to consider is the knowledge of the landowner or operator. The above prescription is a rule of thumb. If the landowner/operator is aware of specific site conditions that will prohibit certain operations, or knows, from experience, a certain practice is needed, the plan should be altered. Several situations could have been avoided in hybrid poplar plantations if prescriptions had been altered to suit the site. For example, some soil types may require a spring tillage operation to loosen the soil because of a high clay content and to speed the warming of the site. Landowners are usually aware of this type of situation and can prove invaluable to the operation.

## **Planting**

### *Planting Stock*

Hybrid poplar is commonly planted using an unrooted hardwood cutting. The cuttings are typically 10 inches long (thus the need for the "deep tillage" mentioned above). Premium, or Number 1 cuttings are from 3/8 of an inch to 3/4 of an inch in diameter. This should be specified when ordering planting stock.

Several clones of hybrid poplar are commercially available. Cuttings from a clone are from genetically identical parent trees which reproduce the characteristics of productivity, disease resistance, and hardiness of the parent plant. Many clones of hybrid poplar have been developed and tested over a wide range of soil, site and climatic conditions. Clones are commonly referred to by either name, or number (ex. DN-34 or eugenei). The most

common clones are of two main varieties. One group is a cross between eastern cottonwood (*Populus deltoides*) and European black poplar (*Populus nigra*). This results in the DN clone numbers among others. The commercially available clones from this cross are DN-34 (eugenei, Norway poplar, or Imperial Carolina); DN-182 (Raverdeau); DN-17 (Robusta) and DN-5, DN-1, I-4551 and NE-222. Of these, the DN-34 clone is considered to be the "industry standard." Most newer clones are compared to this one for performance. These clones are noted for their ability to perform on a wide range of sites, their resistance to canker, and good pH tolerance.

A newer hybrid group contains crosses between European black poplar (*Populus nigra*) and Japanese poplar (*Populus maximowiczii*). This cross produces the NM numbered clones. Of these, only NM-6 is presently commercially available in the Lake States. This clone is fast growing, with good yield potential, but is sensitive to high pH (pH over 7.5).

The clone should be selected with soil and site conditions in mind. Someone familiar with the clones and their performance should be consulted when selecting appropriate hybrids.

### *Care of Cuttings*

Hybrid poplar cuttings are normally shipped frozen in plastic in bundles of 200 to 500 with all buds pointed in one direction. They should be kept refrigerated, as close to freezing as possible, until 3 to 5 days before planting. At that time, they should be removed from refrigeration and soaked in 4 inches of water for 2 to 5 days. This allows the cutting to begin to break dormancy and rehydrate. Temperature during soaking should be kept below 70°F. Store, soak, and plant cuttings with the buds pointing upward. Leave the cuttings in their bundles and/or plastic bags until planting.

### *Planting*

Hybrid poplar cuttings are planted by placing them 8 to 10 inches deep, buds pointing upward, with not more than 1 inch of the cutting or more than one bud above ground. This deep planting helps prevent multiple stems from forming when the cutting begins to grow. As with bare root trees, the soil should be packed firmly around the cutting to close air pockets. It is generally recommended to plant only after the soil temperature has reached 50°F. This is usually the same time the local farmers begin planting corn.

### *Weed Control*

Weed control normally begins immediately after planting with the application of a pre-emergent herbicide. Several

herbicides are recommended. Historically, the herbicide linuron (Lorox®) was used. The purpose of this application is to control weeds and grasses to give the cutting a chance to root and become established. Linuron controls weeds for 4 to 6 weeks, depending on growing conditions. This will usually get the planting through the normal wet period of June and early July, when the site may be too wet to use tillage equipment. Since the beginning of the Alexandria project, several additional herbicides have been labeled for use in SRWC plantings. These will be discussed later.

### **Maintenance**

To achieve optimum growth rate, hybrid poplar needs good weed control for the first 3 to 4 years. Typically, a combination of herbicide treatments and cultivation is done using common farm equipment. Once the tree canopy has developed to where the crowns close in, the shade will keep most weeds from affecting growth until harvest.

#### *Cultivation and Tending During the First Growing Season*

The most common cultivation equipment used in SRWC plantings are small disks and tractor-powered rototillers. Some landowners have modified large pieces of cultivation equipment (removing disks or teeth), which are then capable of tilling two to three rows at a pass. This can work quite well for the first and second cultivations, but can do more harm than good as the trees get larger. Most successful plantings have used small 5- to 6-foot-wide disks or tillers to operate between each row.

Cultivation should not be deeper than 2 to 3 inches. This is necessary because 80% of the young trees' roots occur in the top 12 inches of soil. Shallow cultivation will avoid pruning these valuable roots. Guide wheels may be needed to keep cultivation equipment from digging too deep.

The number of cultivations needed in a year can vary greatly depending on site conditions, site preparation practices, weather, and herbicide use. As a general rule, a SRWC planting will require three to four cultivations during the first growing season.

After the post-plant pre-emergent herbicide application begins to lose effectiveness (usually around late June to early July), a flush of weed growth will begin. These weeds will be much easier to control if they are cultivated early. Once weeds are no longer being affected by the herbicide, or weeds that the herbicide does not control begin to appear, cultivation should begin. Weather will now become an important factor. The same wet, humid, hot weather that gives excellent tree growth can make

maintenance of hybrid poplar a difficult chore. Equipment access can now become a problem. Sites needing cultivation should be watched carefully so they can be worked when conditions permit. At this time of year, monitoring of plantations becomes extremely important. The plantation manager should arrange to have sites monitored weekly to keep on top of weed pressure and field conditions.

Hybrid poplar is extremely sensitive to grass competition. Due to their extensive root systems, ability to compete for moisture and nutrients, and prolific seeding, annual grasses are the primary cause of concern. Broadleaf weeds do not offer the same competition, but can become a problem if allowed to get ahead of maintenance treatments. Also, most broadleaf weeds are considered noxious weed species. If they are not controlled, township, county, and state weed inspectors will be alerted, and the manager can plan on visiting extensively with them! Specific herbicides used to control some of these weeds will be discussed later.

It should be noted that herbicide use, although effective, is not always necessary. Several plantations have been established with little or no herbicides. This requires very close monitoring and puts the plantation manager at the mercy of the weather. There may be times when, due to weather conditions, equipment access is not possible. During these times, weed pressure may become so high that mowing may be required before cultivation. Playing catch-up with established weeds is not easy. Establishing a SRWC planting without herbicides will typically require five to eight cultivation passes during the first growing season. Weather conditions may not allow this many tillage operations, making this a difficult endeavor.

#### *Plantation Monitoring*

Plantation monitoring must be a planned, systematic activity. Each plantation should be visited weekly during the first three growing seasons. In addition to tree survival and condition, weed pressure and type, and insect and disease outbreaks must be noted. Weeds should be identified by species (ex. foxtail, Canada thistle) and by type (ex. annual grass or broadleaf, perennial grass or broadleaf). This information is needed to properly select and time herbicide applications and cultivation operations. Weekly monitoring also serves as a valuable tool to evaluate the effectiveness of these treatments. Samples of scouting report forms are available from the author.

#### *Second Growing Season Tending*

In the fall after the first growing season, plantings should be checked for the need of a pre-emergent herbicide application to control annual weeds for the first months of

the second growing season. The purpose of this application is much the same as the post-plant treatment mentioned above: to control weeds during the wettest part of the summer when equipment access may be impossible. Some specific herbicides used for this treatment will be discussed later.

Second season tending and monitoring should mirror the first. Weekly monitoring for weeds, insects, and disease should continue. If a pre-emergent herbicide is used in the fall or in the spring before green-up, plantations will usually require between two and four cultivations in the second year. The number and timing will depend on local weather, and duration of the pre-emergent herbicides' control. If no pre-emergent is used, four to five tillage operations will be needed. Again, the manager is at the mercy of the weather if no herbicides are used.

In the fall following the second growing season, the plantation is again checked. If a herbicide treatment is needed, it should be applied in late fall after the leaves have begun to drop and before the ground is frozen.

#### *Third-Year Tending and Monitoring*

If all has gone well, crown closure will be attained this season. If so, the planting may need only one or two cultivations, in addition to the herbicide application. Monitoring should continue weekly until crown closure is realized. Once the planting has reached this stage, monitoring can be reduced. The planting should be checked every 2 weeks for insect and disease problems and for noxious weeds.

### **INSECT AND DISEASE MONITORING**

Although the hybrid poplar clones have been selected for their resistance to insect and disease outbreaks, some pests are a concern. Septoria canker (*Septoria musiva*) can be found in some plantings. It is not a major problem in most commercially available clones, but can be scattered on a few trees in a plantation.

Marssonina leaf spot can also be found in some plantings. Again, it is not a major concern, but it can predispose some trees to secondary organisms and environmental stress (Ostry *et al.* 1989).

The most damaging agent observed, and the only one warranting control, in the Alexandria project has been the cottonwood leaf beetle (*Chrysomela scripta*).

The adults and larvae of this insect defoliate the trees, which can be damaged and deformed as the result of heavy and repeated defoliation. This insect can do a large amount of damage if populations are allowed to build. The young larvae skeletonize leaves. Older larvae

consume the entire leaf except for the midrib and large veins. Large populations of larvae will also feed on growing shoots and buds. The adult beetles feed on leaves as well as the tender bark at the tips of twigs. Adults of the last generation overwinter under leaf debris or in clumps of weeds (Ostry *et al.* 1989). All plantations in the Alexandria project have been sprayed for this pest at least once over the past two growing seasons. Some have been sprayed twice in the same season. The cottonwood leaf beetle is difficult to control because all three life stages tend to overlap. Other than in early spring, all three life stages—eggs, larvae, and adults—are present concurrently. We have been controlling this pest with applications of carbaryl (Sevin®).

### **HERBICIDE RESEARCH AND USE**

Several herbicides have been instrumental in establishing SRWC plantations in the Alexandria project. These herbicides are currently labeled for use on hybrid poplar, SRWC, or CRP sites, or have been in the past. Some have full labeling; others have 24C labeling (special local need registration). Many of these chemicals were originally developed for crop uses, and have been adapted for use in SRWC. All herbicides and rates must be locally tested prior to large-scale application. Hybrid poplar tolerance and the effectiveness of weed control may vary with local site conditions and climate.

#### *Pre-emergent Herbicides Applied Directly After Planting*

Linuron (Lorox®) Du Pont - This herbicide was heavily used in the past as a pre-emergent, applied over the top of newly planted cuttings. It was originally developed for use in soybeans. It is applied to the soil and needs rainfall to activate. Linuron controls a fair spectrum of problem weeds including foxtail, crabgrass, mustard, pigweed, and wild radish. Linuron has some limited post-emergence effect on newly emerged weeds. Weeds are generally controlled from 4 to 6 weeks.

Imazaquin (Septer®) - American Cyanamid - Septer is a relatively new chemical in SRWC hybrid poplar. Its primary use thus far has been as a pre-emergent applied directly after planting. It controls a fairly wide spectrum of grasses and broadleaves. It needs a small amount of rainfall to totally activate. It has some post-emergent activity as well, although the spectrum of weeds controlled is not as wide.

Oryzalin (Surflan® - DowElanco; oyfluorfen (Goal ) - Rohm and Haas; and pendimethalin (Pendulum ) - American Cyanamid provide similar weed control with good hybrid poplar tolerance.

### *Post-emergent Herbicides Applied During the Growing Season*

Fluazifop-P-butyl (Fusilade®, Fusion®) - ICI Americas Inc. - This herbicide was used in the past as an effective grass control. It can be applied over the top of actively growing hybrid poplar. It is used primarily in areas where maintenance equipment cannot access the site due to wet conditions, or where weed crops become established before cultivation begins. It is especially effective on foxtail and wild proso millet. For effective control, weed species can be no taller than 4 to 8 inches.

Clopyralid (Transline®) - DowElanco - Clopyralid has proven to be a very valuable herbicide in hybrid poplar plantations. It is a selective contact herbicide that does an excellent job of controlling many broadleaf weeds including most species of thistle. It can be applied over the top of actively growing hybrid poplar to control these noxious weeds. Some leaf cupping and stem twist have been observed, but there appears to be no reduction in overall growth (Netzer *et al.* 1998).

### *Herbicides Applied in Hybrid Poplar Plantations 1 Year Old and Older*

Glyphosate (Accord®, Roundup®) - Monsanto - Glyphosate is a post-emergent, non-selective, contact herbicide that has been in use in the agricultural and

forestry communities for some time. It has been used extensively for site preparation in SRWC plantations as a burn down herbicide to remove unwanted cover before planting. More recently, it has been used as a directed spray to control a broad spectrum of weeds during the growing season at low rates (1 quart per acre or less).

Sulfometuron methyl (Oust®) - Du Pont - Oust has been successfully used as a pre-emergent, applied late in the fall following tree defoliation but before the ground is frozen or snow covered, to control a wide spectrum of grasses and broadleaf weeds. Directed spray application is safer than overspray even during the dormant season. As with all chemicals listed, label directions should be followed closely for rate and application procedure.

### **LITERATURE CITED**

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