# FIRST YEAR COPPICE PRODUCTION FROM A 5-YEAR-OLD BLACK LOCUST STAND ON SURFACE MINE SPOIL

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Abstract.--The utility of the fuel plantation concept, i.e. the production of biomass for fuel purposes, on marginal lands hinges on the ability to regenerate after harvest at minimal cost. Black locust coppices readily; the wood has a high heat equivalent; it fixes nitrogen; and it can be established by direct seeding on surface mines in the Appalachian Region. In 1979 a project was established to study the nature of black locust coppice, and to test several cultural treatments on north and west aspects after harvesting a 5-year-old stand of saplings on surface mine spoil in eastern Kentucky. The treatments included fertilization, application of foliar insecticide (Orthene®), and a combination of fertilizer and insecticide. After one year the greatest coppice production (6.3 MT/ha) occurred on the west aspect in plots treated with insecticide and fertilizer. This treatment resulted in a 50 percent increase in biomass over the control plots, but it was not significantly different from the insecticide treatment, which ranked second. This may suggest that elimination of the locust leaf miner, which greatly reduces photosynthetic area, may significantly increase black locust biomass production in the southern Appalachians.

Additional keywords: Coppice, sprouting, black locust, *Robinia pseudoacacia* L., hardwood, fuel plantation.

Plantations of highly productive woody species harvested on short rotations of 5 to 20 years have been proposed as a source of biomass for combustion in steam-powered electric generators or conversion to other forms of fuel, thus easing our reliance on fossil fuels (Szego and Kemp 1973). Species which possess high juvenile productivity, high caloric values, and coppice after harvest would be likely candidates for fuel plantations (Inman 1977). Species which meet these criteria and can be grown on marginal sites may be of greater importance. Since fuel plantations would compete with agricultural crops for the use of land, areas marginally suited for agriculture would be more readily available for fuel plantations.

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Such areas are currently available throughout the eastern United States as a result of surface mining for coal. Crop production on these areas after reclamation is generally low and forest use would be more appropriate. Black locust (Robinia pseudoacacia L.) has shown good survival and growth on surface mines in the eastern United States.

Black locust is also a promising species for fuel plantations (Carpenter, Graves and Eigel 1979). It can be established readily by direct seeding and dominates many spoil areas within two years (Ruffner 1978). After harvest, it produces vigorous sprouts (Lust and Mohammady 1974). The heat content of black locust wood is higher than most species, even at a young age. Black locust is also a nitrogen-fixing species which minimizes, if not eliminates, the need for sustained nitrogen fertilization.

In 1978 we initiated a project to study the production of black locust biomass on surface-mined sites in the Southern Appalachian Region. As a part of this project we harvested a 5-year-old stand of black locust to study the ability of this species to coppice and its biomass production on a surface mine in eastern Kentucky. This paper reports on the nature of black locust coppice and biomass production after one year.

## METHODS

In March 1979 plots were established to measure coppice regrowth after harvesting a 5-year-old black locust stand on lands of the Falcon Coal Company located in Breathitt County, Kentucky. The study site has an average slope of 30 percent and plots were established in 3 slope positions on both north and west aspects. The original black locust stand averaged about 12,000 stems/ha and was established by direct seeding in 1974. At the time of harvest the locust saplings averaged 3.1 cm in diameter and 2.6 m high.

The parent stand was harvested in 12 x 48 m strips. Three strips were harvested on each aspect separated by 9 m unharvested strips. Within the harvested strips 12 x 12 m plots were established to study the effect of aspect and several cultural treatments on coppice production. Half of the plots which constituted a block were located on the north aspect and the other half, the second block, were located on the west aspect. Within each aspect, 12 plots were equally divided into 3 slope positions separated by the 9 m buffer strips. Within each slope position 4 treatments were assigned at random: 1) annual broadcast NPK fertilization (16-32-8) at the rate of 338 kg/ha; 2) monthly foliar application of Orthene® insecticide to control leaf miners, at a rate of 20 kg/ha; 3) combination insecticide/fertilizer application at the above rates; and 4) a control where no treatments were applied.

Each 12 x 12 m overall treatment plot was subdivided into four 6 x 6 m plots to study biomass production. In October 1979, a randomly-selected subplot was harvested to determine above-ground biomass production. The remaining subplots will be harvested in similar fashion at the end of the next 3 growing seasons. Harvested plant material was separated into woody and foliar components and biomass was computed after ovendrying at 60°C for a period of one week. Subsamples of the harvested material were chosen to determine heat contents with an adiabatic calorimeter at a moisture content of approximately 20 percent.

In order to study the nature and vigor of black locust coppice, 108 stumps were selected for continuous observation. The stumps which were chosen represented a cross section of small, medium, and large stumps throughout the study area. The vigor and growth of sprouts originating from these stumps were followed during the 1979 growing season.

## RESULTS AND DISCUSSION

The appearance of sprouts in our study plots lagged 3 weeks behind normal bud break for undisturbed 5-year-old trees, which occurred on approximately April 2. Sprouts on the west aspect were observed one week earlier than sprouts on the adjacent north aspect. The onset of sprouting appeared to be related to stump size of the original parent tree with larger stumps sprouting a few days ahead of smaller stumps. As the growing season progressed, the average number of sprouts per stump decreased as average sprout height increased (Table 1). Large stumps produced larger numbers of sprouts and they were more vigorous in growth than sprouts on smaller stumps. This situation led to the overtopping of sprouts from small stumps and their numbers declined markedly during the growing season.

First year biomass production is presented in Table 2. Yields are based on the production of 3 plots located on the same aspect. Highest average yield (6.32 MT/ha) resulted from the combined application of Orthene® insecticide and NPK fertilizer on the west aspect. This was approximately a 50 percent increase in biomass production over the control plots (4.31 MT/ha). The insecticide/fertilizer treatment means were significantly higher than both the fertilizer only and control treatment means, but not the insecticide means. This may suggest that elimination of the locust leaf miner, which greatly reduces photosynthetic area, may be a more important treatment than fertilization for this nitrogen-fixing species. However, further study is required before this can be concluded. Biomass production was approximately 1 MT/ha greater on the west slope. Most of the biomass produced after one year was woody. Leaf biomass averaged only 0.52 MT/ha.

Average heat content of the one-year-old coppice was 4,661 cal/gm (8397 BTU/lb) at 20 percent moisture content. This value compares favorably to other determinations for black locust wood and emphasizes the higher energy values for this species. Total biomass for our best treatment was 6.32 MT/ha which could produce $29.5 \times 10^6$ kcal/ha.

## SUMMARY AND CONCLUSIONS

The first year coppice production of control plots represented a 100 percent increase over the annual production of the original stand which averaged 2 MT/ha/yr. The insecticide/fertilizer treatment improved yield by 50 percent over the control plots. The cost effectiveness of the cultural treatments was not evaluated during the initial part of this study. Adequate sprout regeneration was accomplished with an early spring harvest. Numbers of sprouts declined over the year due to competition. Large stumps produced more sprouts which had faster growth rates than small stumps. Heat contents of coppice appear to be as high as that reported for black locust wood.

Table 1.--Average sprouts per stump and average sprout height from small, medium and large stumps after harvesting a 5-year-old stand of black locust.

| Stump Classification | Average Stump Diameter (cm) | Average Number of Sprouts/Stump (time after harvest) | | | | Average Sprout Height (cm) (time after harvest) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2 months | 3 months | 4 months | 5 months | 2 months | 3 months | 4 months | 5 months |
| Small | 1.6 | 4.0 | 3.1 | 2.1 | 1.3 | 34.6 | 72.3 | 109.2 | 147.8 |
| Medium | 3.0 | 6.7 | 5.3 | 3.6 | 2.6 | 45.9 | 96.1 | 151.0 | 194.4 |
| Large | 4.8 | 9.4 | 7.4 | 5.1 | 3.8 | 50.1 | 111.2 | 177.8 | 227.8 |

Table 2.--Oven dry woody biomass, sprout characteristics and caloric content for 1-year-old black locust coppice.

| Aspect-Treatment | Woody Biomass Mean* MT/ha | Woody Biomass Range MT/ha | Number of Sprouts/Hectare Mean | Number of Sprouts/Hectare Range | Average Grams/Sprout | Heat Content kcal/ha. x $10^6$ † |
|---|---|---|---|---|---|---|
| West - Control | 4.31a | 3.14-5.16 | 42,837 | 35,697-53,821 | 101 | 20.1 |
| - Fertilization | 5.13a | 4.31-6.09 | 31,304 | 29,656-32,402 | 164 | 23.9 |
| - Insecticide | 5.28ab | 4.64-5.84 | 51,441 | 29,656-65,354 | 103 | 24.6 |
| - Fertilization/Insecticide | 6.32b | 3.48-9.74 | 31,670 | 23,615-37,345 | 200 | 29.5 |
| North - Control | 3.77a | 2.76-5.51 | 35,698 | 29,656-43,386 | 106 | 17.6 |
| - Fertilization | 3.49a | 2.67-4.49 | 29,107 | 16,476-45,583 | 120 | 16.3 |
| - Insecticide | 4.63ab | 3.61-5.31 | 37,345 | 25,263-44,484 | 124 | 21.6 |
| - Fertilization/Insecticide | 5.00b | 3.62-6.82 | 18,490 | 15,927-22,517 | 270 | 23.3 |

*Means followed by the same letter do not differ significantly, Duncan's multiple range test (0.05 level).

†Calculated using average caloric value of 4.661 kcal/gram (8397 BTU/lb).

Black locust coppice stands after harvest appear to be adequate to regenerate production. Cultural treatments increased production as high as 50 percent. The production will be measured for three more years to establish trends. The results of this study suggest that black locust is a promising species for the fuel plantation concept.

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