BLACK LOCUST

by

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A Thesis

Presented to the Faculty

of

School of Forestry

Oregon State College

In Partial Fulfillment

of the Requirements for the Degree

Bachelor of Science

June 1938

Approved:

[redacted]

Professor of Forestry

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INTRODUCTION

In the past few years black locust (Robinia pseudoacacia L.) has received extensive attention as a tree for planting in erosion control and in windbreaks and shelterbelts. The use of black locust for these and many other specialized uses is not a recent development. The tree and its wood have been used since the days of the early Dutch settlers in the vicinity of New York in the late 1600's. Prior to that time it was known in the shipping trade as a superior wood for shipbuilding purposes. Since that early day black locust has spread through planting of single trees and plantations until now it is found in almost every state in the union.

The increasing importance and emphasis on farm forestry and woodlots has brought a demand for species suitable for such planting with uses adapted to farm purposes. Black locust, because of its suitability for fence posts, general planting utility, rapid growth, and inexacting soil requirements, has a definite place in fulfilling this demand. Since the advent of the CCC and recent emphasis on soil conservation, black locust has been used in large scale plantings for erosion control, a use to which it is particularly adapted. In the shelterbelt region black locust has been found suitable for planting and has been widely used in the southern states of the area.

In addition to these important and growing uses of the tree, there are certain uses of the wood in the manufacture of specialized articles for which there are no satisfactory substitute woods. These uses include such articles as wagon hubs, insulator pins and cobs, and tree nails. Besides these special uses, black locust is utilized in large

quantities for fence posts and, to a lesser extent, for mine timbers, ties, and minor manufactured products. In the aggregate these products constitute a large volume of material; in some instances the supply of raw material is not equal to the demand.

In view of the importance of black locust, the purpose of this thesis is to present, as nearly as possible, a complete, condensed discussion of the facts relating to black locust, its history and characteristics, and the planting, growth, utilization, and value of the tree.

The studies that have been made on black locust and related problems are too numerous and voluminous to be reviewed even sketchily here. The government publications have been printed relative to plantations, use in erosion control, shelterbelt planting, protection from insects and diseases, and utilization. Various states such as Pennsylvania, Ohio, Kentucky, Tennessee, Alabama, Idaho, and others have published pamphlets on black locust. The periodical magazines such as the Journal of Forestry, Journal of Agricultural Research, and American Forests, as well as non-professional magazines have had a large number of articles pertaining to black locust. Some of these articles treat specific problems; others are of a general nature. While this large mass of material, in total, covers the field well, there is considerable duplication and repetition, there is no specific source of information on black locust that covers the field.

A large part of the material for this thesis was obtained by library research. In addition, some material was drawn from work in pruning a small plantation on the Peavy Arboretum in the winter of

1936 - 37. Measurements were also made of experiments in inoculation, pruning of seedlings, and fertilization of black locust carried on near Corvallis.

DISCUSSION

BOTANICAL CHARACTERISTICS

Black locust, also called yellow, white, green, and common locust, false acacia, and acacia is specifically Robinia pseudoacacia L. It is a member of the genus Robinia, named for Jean and Vespasian Robin, French botanists. The genus contains seven species native only to North America; of these seven, three attain tree size; and of these, only black locust is of any great importance.

Black locust is characteristically a tree 40 to 70 feet in height and occasionally 80 to 90 feet, with a trunk 3 to 4 feet in diameter. In the open the trunk is short, branching a little distance from the ground to form a long oblong crown. In dense stands such as plantations or in the forest, black locust is straight and long boled with a short narrow crown.

The leaves are 8 to 14 inches long with slender petioles, pinnately compound, 7 to 21 leaflets; leaflets oval, apiculate, entire, dull, dark blue-green at maturity, turning clear yellow in the autumn; $1\frac{1}{2}$ to 2 inches long and $\frac{1}{2}$ to $\frac{3}{4}$ inches wide; stipules forming straight or curved spines $\frac{1}{2}$ inch or exceptionally 1 inch long (14). A coppice sprout from the plantation on the Arboretum had spines 1 inch long. These spines persist on the trunk and branches for several years.

The flowers, opening late in May or early in June, are white, dark red, or red tinged with green; fragrant; borne on a slender stem in loose racemes 4 to 5 inches long, the individual flower resembling the flower of a pea.

The fruit is a pod that matures in the autumn and contains 4 to 8

black or gray mottled seeds. The pods do not open until fall or early winter; some of the pods retain their seed until the following spring.

The bark of the trunk is 1 to 1½ inches thick, dark brown, deeply furrowed, and prominently ridged.

The root system is extensive, fibrous, and dense - one of the factors that make the tree particularly valuable for erosion control planting.

RANGE

The natural distribution of black locust is on the slopes of the Appalachian Mountains from Pennsylvania through West Virginia, Virginia, North and South Carolina, and northern Albama and Georgia, westward through Kentucky, Tennessee, southern Ohio and Indiana to southern Illinois. A shrubby form is indigenous to the hills of west central Arkansas and east central Oklahoma (4). The natural stands of greatest commercial importance are found in a comparatively narrow strip along the Appalachians from southern Pennsylvania to northern Georgia, an area 500 miles long and 150 miles wide at the widest point (4).

The range of black locust has been extended by planting to almost every state in the United States and has been planted extensively in Europe. Alfred Gaskill (9) speaking of black locust in Hungary says, "Locust is, perhaps, our most valuable tree species when rapidity of growth, adaptability to soil and climate, and qualities of wood are considered collectively." The larger part of the planting has been done east of the Great Plains, but recently it has gained considerable favor in the shelterbelt area and in the western states Some of the best plantations are found in Idaho, Utah, Oregon, and Wash.

ECOLOGICAL RELATIONSHIPS

Within the natural range of black locust, the climate is characterized by well distributed, abundant precipitation averaging between 45 and 55 inches per year, a moderately long growing season of seven months, and relatively moderate temperatures. Except at the higher elevations, the climate is mild with a mean annual temperature of 50° to 55° F or slightly more. The snowfall varies from less than a foot to 31 or 55 inches at elevations above 2000 feet (29).

In its range as extended by planting, black locust will survive in much severer climates and under more adverse conditions than are found within its natural range. In Idaho it grows on sites where the annual precipitation is as low as 15 inches and in eastern Oregon and Washington under similar conditions (24). In Utah it grows under extremely adverse conditions of low soil moisture, extremes of temperature, and short growing season. In plantings of black locust in the shelterbelt region, many of the sites were characterized by low soil moisture and extreme temperatures. Much of this extended range has low humiditys in summer, little precipitation during the growing season, and frequent extremes in temperatures.

While black locust does survive under these conditions and in many instances makes moderately good growth, for best development the climate should be similar to that found within its natural range. Of particular importance is the factor of adequate soil moisture during the growing season. In southern Idaho, black locust grown on irrigated land made exceptionally good growth (24). Good growth is made by the tree under less favorable soil moisture conditions, but it is not comparable to that on the better sites.

Black locust is not exacting in its soil requirements. It grows best on moist fertile brown loams along streams or on limestone soils (18). Poorly drained, acid, or sandy soils are not recommended for planting of locust (17). It does well on a variety of soils from the loams to thin rocky infertile soils. In a number of places black locust has produced a valuable crop on soils submarginal for agricultural crops, the value of the trees often being more than that of adjacent farm crops on better soils. On some of the worst eroded lands in the south where black locust has been used, it reaches post size in from ten to twelve years (22).

One of the important characteristics of this tree in relation to the soil is the presence of nitrifying Bacteria on the roots. It has been found that the fertility of the soil is increased by black locust to the extent that crops grown in mixture with or adjacent to black locust plantations show better growth (18). Measurements made on catalpa trees adjacent to and in mixture with black locust showed that the growth rate of the catalpa decreases as the distance from the black locust increases; this accelerated growth is apparent for 40 feet from the locust. The catalpa in mixture was almost equal in size to the black locust (19). It has also been noted that the growth of grass and herbaceous plants is much more luxurient under black locust (2, 19, 21). This property also accounts, in part, for the success of black locust on infertile soils.

TOLERANCE

Black locust is classed as very intolerant. Because of its intolerance, the lower branches die and drop off readily when the trees are in dense stands. In spite of its intolerance, black locust main-

tains itself well in competition with other species, due largely to its rapid growth and favorable reproduction characteristics. Intolerance is an advantage where locust is grown for posts and similar material; with a dense stand little pruning is necessary except in the first two or three years, after which, natural pruning takes place readily.

ASSOCIATES

In the Appalachians black locust is commonly associated with red maple, beech, basswood, black walnut, ash, black cherry, red and white oak, Virginia pine, yellow poplar, sweet birch, cucumber magnolia, pitch pine, and shortleaf pine. It is also occasionally associated with the other species of the southern Appalachian region, but all of these are too numerous to name here (29).

In Ohio it is found with sugar maple and beech. In the central hardwood region black locust is a minor component of the stand in the scarlet oak-black oak type of the uplands and is associated with chestnut oak, white oak, hickories, pitch pine, black gum, chestnut, and dogwood (29).

WOOD CHARACTERISTICS

Black locust is a ring porous wood, the pores in the late wood variable in size, occuring in cluster, the wood parenchyma paratracheal and confluent, tyloses abundant, and the rays distinct on the cross section. In color the heartwood varies from yellow brown to cherry red or reddish brown to almost black, often with a greenish color; the sapwood may be yellow, white, or greenish. The heartwood forms early; the sapwood in older trees being from $\frac{1}{4}$ to 1 inch wide and 2 to 4 years old. In young trees, because of the rapid growth, the sap is often much wider, however, the age of the sap is the same as in older trees. This ability

to form heartwood at an early age is a characteristic of importance when growing trees for posts.

The wood is very hard, tough, heavy, durable, and flexible. Generally speaking, wood shrinks and swells with changes in moisture content in direct proportion to the density. Black locust is one of the exceptions on the dense end of the scale, having a very low factor of shrinkage and swelling for its high density. This property is one that makes black locust very desirable for such specialty products as insulator pins, tree nails, and wagon hubs.

Table 1. Physical and Mechanical Properties of Black Locust (4)

Weight per cubic foot green	Pounds 58
" " " " air dry (12%)	" 49
" " " " kiln dry	" 48
Specific gravity, oven dry, based on green volume	.66
Shrinkage from green to oven dry in volume	9.8%
" " " " " " " radial	4.4%
" " " " " " " tangential	6.9%
Strength in bending at 12% moisture content	
Modulus of rupture	19,400 lbs. per
Compared to white oak at 100	128 sq. inch
Strength in compression parallel to grain	
Maximum crushing strength	10,250 lbs. per sq. in.
Compared to white oak at 100	138
Composite values	
Strength as beam or post	16,180 lbs per sq. in.
Compared to white oak at 100	163

Hardness - lbs. to imbed .44 in. diam. ball ½ its depth.	1,610
Compared to white oak at 100	149
Shock resistance	17.0
Compared to white oak at 100	134
Stiffness	2,200
Compared to white oak at 100	145
Weight per 1000 bd ft. air dry (12%)	4,000 lbs.

DURABILITY

No other property has had as great an influence in the wide and growing popularity of black locust than its high durability. This characteristic, combined with its strength, hardness, and resistance to shock, has placed black locust in a special class for certain products manufactured from the wood. It is likewise the durability of the wood that has been responsible for its wide use for fence post material. The largest use of black locust in the United States is for fence posts, a use where durability is of prime importance. Records of this remarkable durability have come from all parts of the country and have been made under a variety of conditions. In New York black locust posts have served 75 years and are still in use (2). One and one-half inch surveyors stakes on Long Island made of black locust last from 15 to 25 years (25). In Pennsylvania black locust posts are in use after 55 years of service; in one fence of black locust posts with chestnut rails, the posts were pulled after 40 years and reset for another fence (18). In Ohio posts 42 years old are in use with 77 to 90% of the original posts sound (10). Black locust poles have lasted 20 years untreated. As compared to other woods on a basis of durability, black locust

ranks at the top. Of the woods extensively used for posts in the U. S., black locust is exceeded in durability only by osage orange (17). The heartwood of black locust is rated as very durable when exposed to warm, humid conditions favoring decay (7). In this same category come such woods as Alaska cedar, Port Orford cedar, western red cedar, chestnut, southern cypress, osage orange, and Pacific yew, of which black locust exceeds all but osage orange in durability.

Table 2. Comparison of black locust to other woods on a basis of composite strength as necessary for ties (7).

Species	Composite value	Specific gravity
Black locust	161	.66
Douglas fir	78	.45
White oak	103	.59
Longleaf pine	90	.54
True hickories	141	.65

Disregarding durability and availability of the various species for tie purposes, it is seen that the suitability is directly correlated with the density. When durability is considered, black locust again ranks high, but when availability is taken into account, black locust is not a leading tie wood. Black locust, on the basis of composite strength and durability, has the highest rating of any of 61 tie species listed for ties by the Forest Products Laboratory (7).

Management of Black Locust Within Its Natural Range.

In the natural distribution of black locust (see range under Botanical characteristics) it occurs as a pure or mixed type in the cove

hardwoods of the Appalachians, as a minor species in the scarlet oak-black oak type in the central hardwoods, and scatteringly associated in the other upland types within its range in the central hardwood region (29).

STAND REGENERATION AND DEVELOPMENT

Black locust has very little trouble maintaining itself in either of these regions because of its rapid growth and its ability to regenerate by means of stump sprouts, root sprouts, and seed. It is not exacting in its seed bed requirements, but a moist, loose, mineral soil is best for seed regeneration. It comes in readily on burns, in old fields, and in openings in the stand (24).

Very little advance reproduction of black locust occurs in the pure stands, but the more tolerant of the associates usually seed in underneath the locust. When cut, black locust has little difficulty in competing with these species because of the rapid growth of the sprouts. If a very dense stand of brush is present, the locust may be overtopped (29).

Because of the damage inflicted by the locust borer in this region, it is imperative that the stand be maintained in a dense condition when the trees are 1 to 6 inches in diameter. It has been found that the damage from the borer is much greater in open than in dense stands because the borer will not deposit its eggs on well shaded trunks (8). This condition is maintained much better by a mixed stand than a pure stand because of the intolerance of the locust (29). If black locust is grown in mixture with such more tolerant trees as basswood, birch, red maple, and red oak, sufficient protection will be obtained.

UTILIZATION AND MARKETING

Black locust is a valuable commercial tree of this region and there is a considerable demand for it in cordwood sizes, for fence posts, manufactured products, and fuelwood.

Stumpage values vary from $1.00 per cord to as high as $7.00 per cord (4). The value depends on the density of the stand, the proportion of black locust, the size, and the quality of the material. The average stumpage price is $3.00 per cord. The three main methods of purchase of the material are: (1) Delivered at the manufacturing plant; (2) Buyers arrange with owners to have wood cut and delivered at the plant; (3) Stumpage purchased outright and cutters hired to cut and haul it to the transportation point. The trees are cut with a ground line stump height and then cut into bolts of the desired size. Two men can fell and buck from 2 to 3½ cords a day; an average of 1 to 1½ cords per man-day is good for experienced choppers. In 1926 in Virginia, choppers were receiving $2 to $2.75 per day (4).

The average price per cord delivered at the manufacturing plant was $15 in 1926. This price was made up of the items given below.

Table 3. Log price at the Mill

Items Involved (4).

Item	Cost		
	High	Low	Average
Stumpage	7.00	1.00	4.00
Cutting and bucking	2.50	2.50	2.50
Bunching, piling, and hauling	6.50	2.50	4.50
Loading on cars	.50	.50	.50

Railroad freight	5.50	1.50	3.50
	22.00	8.00	15.00

For certain uses, black locust can be utilized down to small diameters. A high quality of timber is necessary for manufactured products and definite diameter limits must be applied. Generally a diameter limit of 8 inches is satisfactory (4). On the cutting operation much of the material not suitable for manufactured products can be satisfactorily cut into fence posts. This would apply to the smaller trees in the stand and to the tops of the larger trees cut.

The growth of black locust within its natural range is rapid for the first 25 to 30 years, after which it fall off rapidly (29). For the production of most material on good sites, a rotation of 25 years is recommended; on the poorer sites it may require 40 or 45 years to attain a size large enough for profitable utilization.

SILVICULTURAL MEASURES

Little money need be expended for protection in this type. Protection from the locust borer is easily obtained by proper management, i.e., maintainance of rapid growth and dense shade, and can be secured at no extra cost. Likewise, the cost of regeneration of black locust is low in most instances because of its ability to coppice and regenerate readily from seed. In mixed stands where black locust has been taken out, it may be necessary to do some improvement work to give black locust more room and maintain it in the stand. On areas of dense brush it may be desirable to remove the brush that is likely to overtop the locust. Cleanings are at times needed in the sapling stands to give locust room for best development. Generally the cost of measures to maintain black locust in the stand are low. Where

black locust has come in on old fields in a very dense stand, thinning is essential (29).

The type of cutting recommended for the other cove hardwood types also applies to black locust - namely a group selection that leaves a comparatively open site.

Management of Black Locust Plantations

ESTABLISHMENT OF PLANTATIONS

Planting stock for the establishment of black locust plantations may be obtained from a state or private nursery, by growing it from seed, or by shoot or root cuttings. Of the cuttings, root cuttings are more readily obtained and easier to get than shoot cuttings. Root cuttings are secured by digging up root suckers in a black locust plantation or adjacent to single trees. These are a very satisfactory source of planting stock for small areas but, because they are more expensive, are not suitable for large operations.

For a large scale planting, the better method is to grow your own planting stock from seed or buy it from a nursery. In growing the seedlings, a well drained, loamy soil that has been thoroughly cultivated is best. The seeds are sown one inch apart in rows $\frac{3}{4}$ to 1 inch deep, the rows 18 to 24 inches apart to facilitate cultivation (18). April to May sown seed will produce seedlings the following fall (17). Because of the nitrifying properties of black locust and the necessity for the proper type of bacteria being present, it is essential that the seed bed be inoculated. This inoculation can be done by obtaining soil from a black locust plantation and scattering it over the seed rows.

INOCULATION

An experiment in inoculation of black locust was instituted at Corvallis in the fall of 1934 using 1 - 0 stock. These trees were inoculated by mixing a pure culture of the bacteria with dirt and placing a small amount of the dirt in each hole and by pouring the culture directly in the hole. The trees were planted in a straight line on cultivated Amity silty clay loam, part of the row was adjacent to previously planted locust and part in the open.

Table 4. Inoculation Measurements

Treatment	1935 leader length	1938 total height
1. Inoculated by mixing soil and culture	28.44 in.	6.9 ft.
2. Check	21.92 "	5.8 ft.
3. Inoculated by pouring culture in hole	6.08 "	14.8 ft.
4. Check	7.74 "	13.9 ft.

Any conclusion made on the basis of these data would be subject to considerable variation because of the variation in growing conditions between the sets of trees. Group one is in the open while group two, the check, is adjacent to older locust trees and competing for soil moisture. The trees of group three are likewise adjacent to older trees, but because a ditch carrying water in the summer runs along this part of the planting at a distance of 40 feet, these trees have not suffered from soil moisture competition. Some of these trees had leaders 11 feet long. The group four trees likewise receive water from the ditch but are not shaded by the older trees. The experiment is further confused by the fact that there were black locust trees already on part of the area and therefore nitrifying bacteria were

already present.

PRUNING SEEDLINGS

Cutting black locust seedlings back before planting has been recommended by some workers and has been considered detrimental by others (23, 26).

An experiment in pruning black locust seedlings was undertaken near Corvallis in 1933 with 1 - 0 stock. In this work the seedlings were cut to a 4 inch top, ½ the top cut, and the check untreated. Two rows of each type were set out adjacent to another row of older black locust trees. The results are variable because some of the seedlings had to compete with the older trees for soil moisture and were partially shaded by them while others were in the open. This made it difficult to get comparable results because of the variable conditions. This experiment was also confused by the drainage ditch supplying moisture to part of the experiment. However, in that part of the experiment where conditions were nearly similar, the ½ pruned seedlings had an average height of 7.6 feet as compared to 13.9 feet for the checks, measurements made in 1938. In that part of the planting where conditions were not similar, the checks had an average height of 5.8 feet as compared to 6.9 feet and 7.3 feet for the 4 inch tops and 4.1 feet for the ½ cut seedlings. On the whole the pruned seedlings did not grow as well as the unpruned seedlings.

Table 5. 1938 Measurements of pruned Seedlings.

Treatment	Average Total Height	Standard Deviation
½ pruned	7.6 feet	1.88 feet
Check	13.9 "	2.81 "

¼ pruned	6.9 feet	1.28 feet
¼ pruned	7.3 "	3.21 "
½ pruned	4.1 "	.83 "
Check	5.8 "	1.88 "

SCARIFICATION OF SEED

Although the seed of black locust is very viable, often as high as 90%, treatment of seed to hasten germination is a common practice. The impermeability of the seed coats causes the germination to extend over several weeks and sometimes to lie over until the following year. Numerous methods have been tried by various investigators, and much variation in results has occurred between different investigators using the same method. The more commonly recommended treatments are soaking in hot water, short immersion in boiling water, sulphuric acid, and mechanical scarification. Recently the use of wax solvents has been tried with success (20).

Soaking the seeds in hot water at 160 to 180 degrees F. and allowing the seed to stay in the water 16 to 24 hours at room temperature has been widely used. This method has several advantages but is accompanied by disadvantages as well. It is a simple method to use and increases both the rate of germination and the total per cent of seed germinated. The disadvantages are the variability of results with different lots of seed, the likelihood of injury to the seeds when handled in a softened condition, and the danger of germination of some of the seeds in the water (20). Because of the large amount of water necessary in proportion to the seed in order to be effective, the hot water treatment is not practicable. As much as 350 times the volume of seed is necessary to secure consistently favorable germination by this method (30).

Boiling water treatment has been found to be a much better method than soaking of the seeds. With this method the seeds are immersed in boiling water for a short period. The best length of time for immersion was found to be less than 2 minutes for both black seeds and mottled seeds (30).

The sulphuric acid treatment consists of soaking the seeds in concentrated acid for from 6 to 10 hours depending on whether the seeds are mottled gray and permeable or black and relatively impermeable. With the acid treatment, as high as 90% germination can be obtained. Some of the disadvantages of this method are difficulty in handling, irregular results, damage to the seeds because of varying permeability of the seed coats, and acid treated seeds are more susceptible to fungi and harder to establish (1). Damage to the seeds can be overcome by treatment according to permeability and by neutralization of the acid in the seed coats after the seeds are taken from the acid. This can be done with chloride of lime (30).

Mechanical scarification has been used with success by some experimenters (1). In this method the seeds were put through modified Ames scarifier orginally designed for treatment of agricultural seeds. The seeds are fed through a narrow opening and blown by a fan against coarse emery paper on a semi-circular tunnel. As the seeds scrape along the sandpaper, the seed coats are punctured deep enough for later penetration of water but not so deep as to injure the embryo or cotyledon. This treatment produced seeds that had a high total per cent of germination and a high rate of germination. This method gave better results than acid treatment (1). The disadvantages are the necessity of special equipment and the possibility of injuring the seeds.

Another recent method is the treatment of the seed with wax solvents in the belief that the seeds are covered with a thin wax coat that causes slow germination and its removal will aid germination. It was found that this wax could be removed by soaking for two hours in wax solvents such xylene, ether, acetone, choloroform, benzene, and ethyl acetate, with the first three named being the most effective. Results comparable to those of mechanical scarification were obtained (20).

Of these treatments, the short immersion in boiling water is best, it is fast, effective, the seed is not injured, and no special equipment is necessary.

PREPARATION OF THE SITE

For best results on most areas, preparation of the planting site is desirable. Varying degrees of preparation, from a spot for each seedling to complete plowing and harrowing have been used, depending on the nature of the soil and the competing vegetation. On sod covered lands, plowing single furrows and planting the trees in the bottom of the furrows has given results in Pennsylvania (18). In Idaho complete preparation is recommended (24). In the south, on gulled land planted with black locust, considerable preparation is practiced. edges of the gullies are plowed in, dams built, and the trees are planted in the soil caught by the dams and along the plowed edges (21, 23). On severely eroded lands in Albama, spot preparation accompanied by a complete fertilizer and subsequent cultivation was found necessary to obtain satisfactory survival and growth (20).

FERTILIZER

Table 6. Comparison of Different Treatments
Of Black Locust on Eroded Sites and Old Fields (28)

Age	Land Character	Land preparation	Cultivation	Fertilizer	H. ft.	D. ft.	Basal area	Relative B. A.
13 mo.	old field	prepared	none	none	3.4	.39	.12	1.00
"	"	"	cult	"	5.0	.59	.27	2.27
"	"	"	"	P	5.6	.69	.37	3.09
"	"	"	"	P/N	6.9	.92	.67	5.54
"	"	"	"	NPK	8.1	1.04	.85	7.07
"	"	"	"	½NPK	7.3	.95	.70	5.86
"	"	"	"	NPK	5.9	.78	.48	3.96
"	"	"	"	NPK	8.0	1.01	.80	6.67
9 yrs.	gully	none	none	none	3.7	.55	.24	1.98
3 yrs.	old field	"	hoed	"	2.7	.37	.11	.88
3 yrs.	" "	"	"	"	.8	.19	.03	.23

P = .32 lbs. per plant of superphosphate.

N = .22 lbs. per plant of nitrate of soda.

K = .06 lbs. per plant of muriate of potash.

In this experiment the gully soil was eroded sandy clay. The old fields were slightly eroded, of low fertility, and a clay soil. All of the 13 months plants were on a loamy soil of low fertility.

This experiment indicates that where black locust is planted as a crop, it should receive the same attention as any other crop during the first 2 to 3 years. On infertile, severely eroded sites, and in old fields slightly eroded, preparation and fertilization with later cultivation is necessary to establish black locust (28). Partial prepara-

tion can be recommended where the competing cover is not large and where the soil conditions are favorable. Partial preparation is a cheaper method initially than complete preparation.

In 1929 a number of fertilization treatments were applied to black locust seedlings in an experiment near Corvallis. These treatments included manure, sheep guano, nitrate of soda, ammonium sulphate, a commercial complete fertilizer, and agricultural gypsum. The fertilizers were applied on the surface and as an underground treatment. Subsequent measurements of these trees gave no evidence that fertilization aided growth on this site; the best treatment was manure, but the difference in growth was not significant.

In 1933 another fertilization experiment was started on the same area. In this experiment manure, manure and lime, ammonium sulphate, calcium cyanimid, maple leaves, ammonium phosphate, murate of potash, and a complete fertilizer were used in varying amounts and combinations. As in the previous experiment, no definite, positive results were evident. In all of these treatments the checks show as good, and in most instances, better growth than the fertilized trees. The ammonium sulphate plus muriate of potash treatment has a slightly better growth, but the difference is slight. The maple leaf treatment gave equal growth to the check; all the other treatments gave poor results as compared to checks. The lesser growth of the treated trees is probably due to the application of too much fertilizer.

From these experiments the following conclusions can be drawn: that on good land cultivation is more important than fertilization

and that the application of too much fertilizer is detrimental to growth. On poorer soils the results of fertilizer treatment would be more significant.

SPACING

A variety of spacings have been tried with black locust from a regular 4 x 4 or 10 x 10 to irregular spacings such as 2 x 8 and 4 x 10 with all gradations between these (17, 18, 24). For best results a regular spacing of 5 x 5 or 6 x 6 is recommended (17, 18, 22, 24). With a regular and fairly close spacing, the trees are equally shaded on all sides, forming a well pruned, straight trunk and a regular, narrow crown. In areas where losses from the locust borer are expected, a closer spacing than 5 x 5 or 6 x 6 may be necessary to give the proper shading in the early life of the stand (3). As the stand grows older, thinnings should take place to maintain the sustained, fast growth but should not be so severe as to open up the stand to borer attacks. On erosion control projects several methods of spacing have been used with success. Since black locust has a high rate of spread by means of root suckers, it is unnecessary to plant the whole area in certain types of work. The planting can be concentrated where the erosion is the worst and natural spreading relied upon to fill up the blanks (16). It has been found that black locust will spread at a rate of from 3.3 to 10 feet per year by means of root sprouts; the spreading will take place up and down slopes, across eroding gullies, through loose soil and heavy subsoil, and across deep ravines caused by erosion (16). Such a spacing would materially reduce the cost of planting, but where erosion

control is combined with growing fence posts, better results would probably be obtained by a regular, close spacing.

PLANTING TOOLS

A number of the ordinary tools used in planting other trees are satisfactory for planting black locust. In the south in erosion control work, spades, post hole diggers, and planting bars have been used (22).

PLANTING

In setting out the young plants care should be taken to have a large enough hole so that the roots are not crowded. The value of fertilizer has already been discussed. In Alabama a ½ pound application of 2 - 8 - 4 complete fertilizer with one-tenth pound nitrate of soda one month later is recommended for fairly fertile land when the planting is for fence posts. In erosion control ½ pound of 6 - 8 - 4 complete fertilizer is recommended (28).

The cost of planting per acre is extremely variable depending on spacing, planting stock, preparation, fertilizer, labor costs, etc. In the south, with complete preparation and addition of fertilizer, costs vary from $9 to $14 per acre (28). On loose, favorable soil in Indiana and Ohio, without preparation, a 7 x 7 spacing, and 1 - 0 stock, an average cost of $7.45 per acre was found (5). Meginnis concluded that the cost of planting black locust was about the same as for other tree species (21).

CULTIVATION

Cultivation of black locust during the first 2 or 3 years increases materially the rate of growth and the per cent of survival.

In Idaho cultivation is recommended until the stand closes; with a 6 x 6 spacing, this is a period of 2 to 4 years (24). 1 - 0 stock planted in rows and hand and plow cultivated showed a 17 per cent increase in height at the end of the season with a greater leaf area and root development than the uncultivated plants (23). It was also found in the latter experiment that there is a definite relation between cultivation as affecting growth rate and the damage inflicted by the digitate leaf miner. As previously mentioned, cultivation was found necessary in Alabama plantations; on old fields, three cultivations gave good results (28). The conclusion reached in this experiment was that it is useless to plant black locust unless cultivation and attention were given to the plantation.

PRUNING

Black locust trees showed a marked tendency to fork; often 80% of the trees will fork six feet or less from the ground (18). Because of this forking tendency, pruning is a decided aid in growing profitable trees. The need for pruning can be considerably reduced by a closely spaced stand, but even in closely spaced stands, some pruning will be necessary to produce the best formed trees. In special instances, such as in erosion control work, it may be undesirable to prune the young trees because a complete cover is wanted as soon as possible. Pruning is likewise undesirable where borer damage is likely to occur as it opens the stand to sunlight (17). However, here again close spacing will eliminate the need for extensive pruning.

The trees should be pruned regularly, sometimes twice a year, from the second year until the stand closes. It is advisable to prune frequently in order that the branches will not get too large and provide an entry for rot when the limbs are finally cut. A plantation on property of T. J. Starker near Corvallis had a large number of swollen and partially decayed trunks at the points where the branches were cut off. Most of these branches were large or grouped so that rot entered before the scar could heal over.

With young trees that are very crooked or much branched, it may be better to cut the tree back to the ground and rely on the subsequent sprout growth to produce a straight stem rather than attempt to prune.

The tools used in pruning are the regular pruning shears, preferably with a 2 inch capacity, and the pruning saw. The pruning shears are much faster, give as clean a cut, and cut as close to the trunk as the saw. There is a limit to the size of branch the shears will cut, and on the largest branches the saw must be used.

THINNING

Thinning of black locust plantations is necessary to sustain the height growth of the stand. If the thinning can be delayed for 8 years, it will ordinarily pay for itself since some Class 3 posts will be cut with a possibility of a few higher grade posts (18). The thinning should be made at the season most unfavorable to sprout growth - in the late spring or summer - so that sprouts will not come up and compete with the remaining trees. The trees removed should be the crooked, small, much branched, or defective trees.

In stagnated stands of young trees, the thinning may take the form of a complete cutting so that the slow growing trees will be replaced by fast growing sprouts. Care must be taken in thinning young stands where the locust borer is prevalent, as the opening of the stand may invite attack (3). After the stand has been cut and the sprouts come up, it is necessary to thin out all but the best sprout from each stump. In order to keep the stand from becoming a jungle, the root suckers will have to be thinned out.

CUTTING

Black locust produces vigorous and numerous sprouts from the root collar, stump, and roots. If the stand is not too old or scattered, sprouts from the stump can be relied upon in regenerating the stand. Coppicing is not vigorous in trees over 60 years old; a scattered stand of stumps will not produce as good a coppice stand as when the previous stand was closely spaced (18) Numerous sprouts arising from the roots supplement the stump shoots and, with the few seedlings, produce a good stand.

The stump height is the groundline. Sprouts from a high stump break off easily; sprouts from a low stump and from the root collar are best. The groundline stump height is also desirable because of the value of the wood.

The best time of cutting for coppice reproduction is in the late fall and winter.

Because of the intolerance of the tree, clearcutting of the whole plantation or clearcutting in blocks or strips is the

recommended procedure (17, 18, 24). Sprouts from stumps cut in the summer do not become sufficiently hardened to withstand frost (17).

GROWTH, YIELD, AND ROTATION

Black locust is a very rapid grower during the first 25 or 30 years of its life. After 25 years the growth rate falls off appreciably; however, for the production of some types of material, a longer rotation is necessary. In Pennsylvania a rotation of 18 years has been found best for fence post production (18). Approximately the same rotation will hold for most sites with a shorter one on the best sites. For production of material for tree nails, insulator pins, and wagon hubs, 30 to 40 years is probably better because of the better quality wood and larger size of the trees. In the south, on erosion plantings, fence posts can be harvested in 10 to 12 years (21).

Numerous records of the rapid juvenile growth of individual black locust trees and plantations have been published as have records of plantations. In Ohio on plantings to reclaim stripped coal lands, 3 year old seedlings had an average height of 16.5 feet, an average diameter 3 feet from the ground of 2.2 inches; these measurements were averages for several acres (5). On an adjacent similar area two year old trees had an average height of 9.5 feet; average diameter 1.24 inches; maximum height 13 feet and diameter 2 inches. A black locust seedling one year of age in an Illinois nursery had a height of 11.5 feet and a DBH of .7 inches (13). The growth of coppice sprouts and root suckers is much more rapid than the growth of seedlings. Three year old sprouts in Pennsylvania attain a height of 20 feet and a DBH of 3 inches. The fact that the rota-

tion for coppice stands is 5 years less than for seedling stands is indicative of the rapid growth of the coppice.

For yield tables see Appendix.

PROFITABILITY OF GROWING BLACK LOCUST

As a tree for profitable planting from a dollar and cents point of view, black locust has much to recommend it. The short rotation that can be practiced makes possible early returns and rapid realization on the investment. Because of its rapid growth, durability when used for posts, and moderate soil requirements, it is an excellent tree to plant for posts on the farm woodlot and on soils unsuitable for agricultural crops. There is a considerable demand for durable fence posts, a demand that is not likely to diminish in the future. There is also a demand for high quality black locust wood for manufactured products.

An 18 year old plantation in Pennsylvania clearcut for posts gave a net annual income of $11.94 per acre (18). In Maryland stumpage values run as high as $200 per acre. Idaho plantations yield up to $44 per year and compete successfully with agricultural crops in the same locality (24).

A table of yields in Idaho is given in the Appendix.

MIXED PLANTATIONS

Mixed plantations have the advantage of less locust borer damage because of the better shading of the trunks by a more tolerant species. Better natural pruning is also secured by mixing with a tolerant species. Various trees are recommended as fillers in different regions: sugar maple, red oak, yellow poplar, ash, basswood,

and Norway spruce (17, 18). Black locust should not be planted with a species having a more rapid height growth than black locust. The species may be mixed in alternate rows with the black locust or alternate in the rows. Other species planted with black locust show an accelerated growth due to the increase in nitrogen compounds in the soil by the black locust. Black walnut, white ash, white pine, red pine, Scotch pine, red spruce, and catalpa have shown this acceleration when planted with locust (19).

Insect Enemies of Black Locust

THE LOCUST BORER

The most important insect enemy of black locust is the locust borer (*Cyllene robiniae* Forst.) It has caused extensive damage to plantations and single trees in all parts of the east where black locust is found. The borer is now found as far west as Colorado.

The locust borer, a member of the family Cerambycidae is an active, slender beetle about .6 inches long, black with cross bands of yellow, the bands in the middle of the back W shaped (8).

The injury to the trees is caused by the larva of the beetle boring in the wood of the trunk and branches to a diameter of $1\frac{1}{2}$ inches (8). Trees from 2 inches to 6 inches are most susceptible to attack (3). The working of the insect larva ruins the wood for posts and other material where durability is needed as the tunnels provide a ready entry for rot and moisture. The wood is useless for manufactured products. The beetle often devastates whole plantations; few trees are killed outright, but they become

stunted, knotty, rotten, and are easily broken off by the wind. Old trees badly riddled are lopsided and rough with a small crown and branches reduced to stubs. Once a tree has been attaked, unless the trunk is shaded, the riddling will continue until the tree dies. These trees, called brood trees, are older trees up to 18 or 20 inches in diameter. The trees, in attempting to close over the wound caused by the borer entry, put on an accelerated growth of the cambium which forms a bulge, giving the tree eventually a knotty, gnarled appearance.

The eggs are deposited in crevices of the bark by the adult beetle from mid-September to mid-October. These hatch in about 6 days, the young borer bores through the bark to the wood and overwinters in a small cavity between the wood and the bark. Active feeding begins in the spring; the larva bores up and into the heartwood one inch from the surface and then bores down parallel to the grain. A dark fluid is secreted that makes the wood easily eaten. When full grown, the larva is $\frac{1}{2}$ to $\frac{3}{4}$ inches long, white, with a brown head. Before pupation the borer makes a passage to the surface, plugs the opening, and pupates in a small chamber; pupation usually occurs in August. The adult beetle emerges in September or October and deposits the eggs (8). An important fact relative to the deposition of the eggs is that the female will not deposit eggs on a densely shaded trunk but will on a sunlit trunk (8).

The alternate host of the borer is the goldenrod. The adult beetle feed on the pollen of species of the genus Solidago found extensively in the eastern states along roads, in fields, and waste places. Important in this connection is the lessening or absence

of damage where goldenrod is not in or adjacent to the plantation (8). No accurate estimate of the loss due to this insect has been made. Plantations set out by eastern railroads have suffered extensive damage due to improper management, thining, and pruning practices (7). In many places the growing of black locust has been discouraged because of the damage resulting from this beetle.

In plantations and stands the method of control is to maintain a dense shade on the trunks of the trees until they have reached a diameter of more than 6 inches. This can be accomplished by close spacing, careful thinning, and pruning. Often a dense growth of underbrush, weeds, and vines will protect the trees and where these occur will aid materially in preventing damage (7). Mixed plantings are also beneficial. In short, anything that will maintain a shaded condition during the early life of the stand will prevent injury.

On single shade trees, numerous sprays have been used with varying success. A spray of soluble arsenate in an oil emulsion applied in the spring when buds are beginning to open will reach the young larva and effect control (3). The shade principle can also be applied by growing climbing vines on the trunks.

There is also one important parasitic enemy of the locust borer, and that is the wheel bug, Prionidus cristatus.

OTHER INSECT ENEMIES

The twig miner (Ecdytolopha insiticiania), does minor damage to young trees by mining lengthwise in the twigs. It can be controlled by cutting and burning the infected twigs (8).

The carpenter moth (Drionoxystus robiniae) sometimes damages small trees (8).

Of the leaf miners, the black and yellow hispa (Chalepus darsalis) causes defoliation of trees. The damage may be extensive enough to cause a general brown appearance of the entire foliage (8).

A number of other leaf miners and puncturing insects are found on black locust but none of these occur extensively.

FUNGUS DISEASES

Generally black locust is not seriously attacked by fungus diseases either saprophyticly or parasiticly.

In nurseries black locust seedlings are damaged by the damping off fungi: Pythium, Corticum, Phytophythora, and Fusarium.

Trees in the south have been damaged considerably by Fomes rimosus (15). In Michigan Trametes robiniophila has caused some damage (15).

Of the following rots to which black locust heartwood was artificially exposed, Poria incrassata caused the most damage.

Table 7. Damage to Black Locust Heartwood by Various Woodrots (12).

Fungus	% of Decay
Trametes robiniophila	3.99 %
Fomes igniarius	2.24
Poria incrassata	33.32
Fomes rimosus	8.63

Utilization of Black Locust Wood

ANNUAL CUT AND PRESENT SUPPLY

Table 8. Annual Cut in U. S. 1926 (4)

Material	Quantity - Cords
Fence posts	20,000
Insulator pins and cobs	18,000
Mine timbers	2,725
Wagon hubs	1,000
Poles	350

Table 9. Estimated Stand of Commercially Important Black Locust Timber in U. S. 1926 (4)

State	Quantity-cords	Per cent of total
Tennessee	280,000	22
Kentucky	250,000	20
West Virginia	200,000	16
Virginia	175,000	14
North Carolina	100,000	8
Pennsylvania	60,000	5
Georgia	20,000	1.5
Ohio	20,000	1.5
All others	150,000	12
	1,255,000	100

Within its natural distribution, one acre will occasionally have a stand of 20 cords; 10 acres with an average of 10 cords per acre is a good yield; 100 acres with 5 cords per acre is an exceptional yield; 100 acres with 1 cord per acre would be unusual.

USES OF THE WOOD OF BLACK LOCUST

Black locust wood is used for fence posts, poles, ties, insulator pins and cobs, tree nails, wagon hubs, tool handles, and fuel wood.

INDUSTRIAL USES OF BLACK LOCUST WOOD

1. Insulator pins and cobs

The largest industrial use in the United States is for insulator pins and cobs. In 1926, as shown in Table 8, 18,000 cords were used from which $25,000,000 worth of pins were cut. The product is used extensively in the U. S. and exported to many parts of the world such as Europe, South America, Africa, Australia, and the Hawaiian Islands (4).

Insulator pins are a turned product, tapered and threaded at one end, the other end slightly tapered and turned smooth. The pins are inserted in the crossarm, held by a nail, and the insulator screwed on. The most common size is a pin 8 inches long and one and five-eighths in diameter at the widest place. Fourteen to fifteen million of these are manufactured from black locust for use by telephone companies. Seven to nine million pins nine inches by one and three-quarters inches are used by power and light companies each year. Three million pins somewhat larger than the latter are used by power and light companies.

Cobs or tops are a threaded product fitted on steel or metal bolts.

Black locust is an excellent wood for pins and cobs because of its durability, strength, and freedom from excessive shrinkage and swelling. The pins do not have to be replaced often, and the insulators stay tight on the pins.

Small quantities of elm, osage orange, and eucalyptus are also used for this purpose.

The pins are manufactured from either flitches or bolts. 1500 to 1800 eight inch pins are cut from each cord of wood and 1200 - 1500 nine inch pins from each cord. 80% of the raw material is wasted in sawdust, trimmings, turnings, defective heartwood, and sapwood, leaving 20% for the final product. Some of this waste is used at the mill for fuel, some burned, and some sold for fuel. Much of this "waste" is suitable for small tool handles such as for chisels, awls, and screwdrivers. With 5 to 7 inch bolts, manufacturers just break even; 8 inch bolts begin to show a profit (4).

2. Wagon hubs

1000 cords of best quality black locust bolts 9 inches and over in diameter were used for this production in 1926. The supply of wood of the high quality necessary is not equal to the demand and as a result many cords of less suitable woods are used.

Strength and durability, and small shrinkage and swelling make black locust an excellent wood for wagon hubs.

The small shrinkage and swelling makes it particularly suitable for use in bottomlands and moist situations. It is also very servicable in Mexico and the southeast.

The hubs are turned from bolts 9 inches and larger in diameter and four to eight feet in length cut into sections the width of the hub. These sections are bored through the center, rough turned, morticed for spokes, and allowed to season six to twelve months before being finished to correct dimensions.

Black locust is also used for spokes which are manufactured from material unsuitable for hubs and from waste. Black locust spokes in a black locust hub are not as good as oak or hickory spokes in a locust hub but work well in hubs of other species (4).

3. Treenails

As early as the 17th century black locust was in demand for shipbuilding. In these early times it was used for planking, stanchins, martingales, braces, posts, ribs, knees, tillers, and trunnels. Today only the trunnels or treenails are in demand. Prior to the World War 300,000 treenails were produced yearly. A 10 million production was planned for war purposes in building wooden ships, but this figure was never reached. In 1926, 200,000 nails of black locust were produced. Black locust pieces $1\frac{1}{2}$ inches square and from 22 to 58 inches in length are turned on lathes to a diameter of eleven thirty-seconds inches while in the green condition (4).

Low shrinkage and swelling, durability, strength, toughness, and ability to stand driving are the characteristics that make black locust particularly suited to this purpose.

A loss of 69% of the raw material occurs in the manufacture of treenails; 5 to 10 per cent of this is in sizes suitable for manufacture of insulator pins. This points to better utilization where several different turned products are manufactured in each plant.

NON-INDUSTRIAL USES OF BLACK LOCUST WOOD

1. Fence posts

Almost as much black locust wood is used for fence posts as for all other purposes combined. Because of the wide distribution of the tree and its universal use for fence posts, only a rough estimate of the number used is possible. Approximately one million posts of black locust are used each year or a total of 20,000 cords (4).

Osage orange is the only post wood superior to black locust from the standpoint of durability. Black locust makes a good post wood because of its durability, strength, and nail and staple holding capacity.

Prices obtained for black locust posts vary between localities and with the quality of the posts. In Baltimore as high as $1.25 per post and $75 a hundred was paid for number 1 posts in 1926 (4). In Idaho prices range from 15¢ for Class C posts to 40¢ or 75¢ for Class A posts (24). Pennsylvania prices range from 10¢ for Class C to 35¢ for Class A posts (18).

2. Minor uses

There are a number of uses of black locust wood that are important locally. Approximately 1,925 cord were used in 1926 for mine timbers, largely in bituminus mines. The satisfactory qualities of the tree for mine timbers points to the fact that it may be profitable for mining companies to grow black locust on old tailings (4). One planting of several hundred acres was made on an area of stripped coal lands in Ohio, and the tree showed excellent growth on the exposed limestone mineral soil (5).

A few black locust poles are used in areas where the tree grows, but none are shipped out for use elsewhere. Locust makes a very durable pole but, because of the weight and the difficulty in sinking spurs in the wood, it does not make a good pole. Generally the pole sized timber brings a better price when sold for insulator pins or wagon hub material (4).

In the early 1900's numerous plantations of black locust were set out by eastern railroads for tie production purposes. Many of these plantations have suffered considerable damage from the locust borer. For tie purposes black locust is rated first among 61 species listed for ties by the Forest Products Laboratory (7). The chief drawback to its use for ties is the high cost.

Black locust is also used for grape stakes, vehicles, farm implements, and for small tool handles (4).

Locust was first introduced into Europe in 1635 from North America; the uses of the wood in Europe include spokes, shafts, plow handles, fence pickets, rake and harrow teeth, table legs, gear teeth, stanchions, and pulleys (4).

Use of The Tree

EROSION CONTROL

Black locust has been extensively planted in erosion control work, particularly in the south. The extensive, fibrous root system, rapid growth, and low soil and moisture requirements make the tree particularly adapted to this use. The general practice in reclaiming gullied lands is to build check dams, plow in the sides and edges of the gullies, and plant black locust (21). Washes 30 feet deep and several acres in extent have been reclaimed by black locust and fence posts cut in 10 to 12 years. The same principle of treatment applying to ordinary plantations are applicable to the care of erosion control plantings. The most extensive planting of black locust in erosion control covers an area of several thousand acres in Tennessee (18).

The cost of planting gullied lands is only slightly higher than for planting other lands (22).

SHADE TREE AND WINDBREAK PLANTING

Because of its attractive appearance and rapid growth, black locust has been used in all parts of the country as a shade tree. In places where soil moisture limits the growth of other species, black locust will make a good showing. In eastern Oregon and

Washington, Idaho, Utah, and California, there are many black locust trees that have grown where other species, less drought resistant, have failed. In cities all over the country black locust has been planted as a shade and ornamental tree.

In windbreak planting its advantages are rapid growth and drought resistance. It has been widely used in southern Idaho for protection around houses and other buildings (24). The southern portion of the shelterbelt region from Nebraska to Texas is an area where black locust is an excellent tree and has been used extensively (27).

Strains or Races - Shipmast Locust

HISTORY

Black locust exhibits considerable variation in characteristics over its range; most of these variations are probably produced by differences in climate, age and site. One of these strains, or races, has characteristics which are distinct and transmutable and has been given a varietal name. This variety has the technical name of Robinia pseudoacacia var. rectissima Raber (25).

The original plantings of shipmast locust were made by John Sands, a sea captain, who reputedly brought them from Virginia in 1683 and set them out at Roslyn and Glen Cove, Long Island. These early plantings were supposedly made for the production of shipmasts and hence the common name (6). The counterparts of these trees have never been found in Virginia or any of the neighboring states (25).

DISTRIBUTION

The quakers early recognized the superior qualities of the tree as compared to the common locust and propagated it extensively on the northern and western portions of Long Island (25). At present, shipmast locust is distributed on the north and west portions of Long Island, on the mainland at Rawling, New York, at one place in New Jersey, and two places in Massachusetts. Because of the difficulty in propagation, it is generally associated with plantations.

COMPARISON WITH COMMON LOCUST

1. Shape of the tree and branching habit.

The trunk of shipmast locust ascends nearly as straight as that of a lombardy poplar, a characteristic that occurs in the open as well as in stands; the trunk is not buttressed but columnar. The lateral branches of the crown are few, leaving the trunk at an angle of 60 to 90 degrees and ending abruptly, forming a narrow, more or less columnar appearance.

The common or black locust has a more branching habit, a buttressed base, the branches make an angle of 30 to 60 degrees with the trunk, and gradually taper to the ends. Shipmast locust commonly attains a height of 75 to 100 feet, which is uncommon with ordinary locust (25)

2. Bark

The bark of shipmast locust is dark, ashy gray, extremely thick with a fine grain or fibrous structure and lines running lengthwise, crosschecks few. The bark of common locust is

lighter in color, not as deeply grooved, not conspicuously longitudinal in grain, and with numerous cross checks. Common locust 2 feet in diameter will have a bark similar to shipmast locust half that size (25).

3. Wood.

Old seasoned heartwood is a dark, deep, rich, reddish brown while common locust from the same locality is a much lighter color.

Physically the wood structure is no different from that of black or common locust.

The durability of shipmast locust and the long straight bole make it especially desirable for posts. The greater durability is backed by several records of posts and by inoculation tests of heartwood samples. Near Westbury, Long Island, posts set in 1807 and pulled in 1932 were in fair condition after 125 years of service (25). Posts 50 to 75 years old are still in service and in good condition (25). Shipmast locust posts 110 years old were pulled and resold for 50¢ each (6). Common locust on Long Island lasts only 30 years, shipmast locust lasting from 50 to 100 per cent longer.

Following are results of an inoculation test of black locust and shipmast locust heartwood from the same locality.

Table 10. Comparison of Durability of Black Locust and Shipmast Locust (12)

Fungus	Per cent of decay based on oven dry weight	
	Black locust	Shipmast locust
Polyporus robiniophila	3.99	.01
Fomes igniarius	2.24	.07
Poria incrassata	33.32	2.31
Fomes rimosus	8.63	.09

4. Growth rate

Shipmast locust has a longer life span and a greater total height growth than ordinary locust. Comparison of yields from the Central States and Long Island shows that black locust grows faster for the first 40 years and after 40 years shipmast locust takes the lead (11). Trees 14 inches in diameter are 80 years old; trees 9 inches in diameter 40 years old; and trees 21 inches in diameter 50 years old; these figures illustrate the variation in shipmast locust and the low rate of growth. The oldest trees are 250 years old, 4 feet in diameter, and 90 to 100 feet in height (25).

Shipmast locust yielded 40,000 bd. ft. per acre at 65 years on 2 plots; 36,000 bd. ft. per acre at 80 years on 2 other plots.

5. Resistance to insects

There is no difference between the two in resistance to attacks of the locust leaf miner (25). However, the damage to shipmast locust by the locust borer is much less than the

damage to black locust in the same locality (11).

6. Flowers and fruits

The flowers, and hence the fruits, of shipmast locust are much less abundant than on black locust; the calyx is less pubescent and almost always green or yellow green with an occasion red bloth; the flowers of black locust are usually reddish or brown. The seed pods of shipmast locust are seldom found, and the pollen grains are less viable than those of black locust.

PROPAGATION

Because of the scarcity and often complete absence of seed, the propagation is ordinarily by vegetative means. The early propagations were probably by root cuttings; root cuttings have also been found best today. Root cuttings should be from roots $\frac{1}{4}$ to 1 inch in diameter, cut in 3 to 5 inch lengths, and planted perpendicular in a light soil (26). A nursery in North Carolina, established by the Soil Conservation Service, has undertaken large scale propagation. Softwood cuttings have given uniformly poor results on a large scale yielding 25%. Hardwood cuttings, budding, and grafting have also been tried but are not recommended for large scale operations. Mulching and top pruning are supposed to be advantageous to shipmast locust rootcuttings (11). In view of the results of top pruning on black locust, it is probably not a good practice on shipmast locust.

POTENTIALITIES OF THE TREE

Shipmast locust is apparently superior in many ways to ordinary black locust. The greater durability ofthe wood, the

straighter, taller habit of growth, and the larger size make it a tree that may be more profitable to grow than black locust for certain products such as wagon hubs, tree nails, and insulator pins. This points to the desirability of planting shipmast locust in erosion control because of the higher quality of wood produced. Little is known about the characteristics of shipmast locust in regard to soil and moisture requirements, or its suitability for planting under varying conditions. The necessity for propagating the tree vegetatively is a decided drawback and may limit its use. However, the apparent favorable characteristics indicate that shipmast locust deserves considerable attention, adequate study, and experimentation.

Summary

Black locust is a valuable tree for planting in erosion control, for fence posts and manufactured articles, windbreaks, and shade.

It is not exacting in its site requirements, showing good growth under conditions of low fertility, extreme temperatures, and deficient soil moisture. Best growth of black locust is on fertile, moist soils such as a loam or limestone. It should not be planted on poorly drained, acid, or sandy soils.

Black locust is very intolerant and requires full light for best development.

The wood of black locust is heavy, hard, strong, tough, and durable with a small factor of shrinkage and swelling. As a post wood, it is one of the best; it ranks first in quality as a tie wood.

The tree may be grown in either pure or mixed stands in its natural range and has little difficulty maintaining itself in the stand because of its rapid growth and ease of regeneration.

For establishment of black locust plantations, 1 - 0 seedlings, root, or shoot cuttings are planted. Seedlings are best for large scale operations, but cuttings can easily be obtained from older black locust trees.

The seed of black locust, because of the impervious seed coat requires scarification. This may be done satisfactorily by soaking in a large volume of hot water, careful treatment with sulphuric acid, by use of wax solvents, mechanical scarification, and short immersion in boiling water. Boiling water is the best of these methods; it is convenient, fast, gives good results, and requires no special equipment.

In all but the best sites, preparation of the soil is necessary for the best growth. This preparation may consist of plowing and harrowing of the area or spot preparation with hand tools. Coupled with preparation and equal in importance during the first few years, is cultivation of the trees.

Fertilization is a valuable aid in establishing black locust on poor sites. The addition of ½ pound of a complete (6 - 8 - 4 NPK) fertilizer is recommended on infertile soils. Fertilization is not appreciably affective on good soils; cultivation is a more beneficial practice on good sites than is fertilization.

In plantations black locust should be spaced 6 x 6. Irregular spacings produce crooked stems; wide spacings of 10 x 10 produce a

much branched tree requiring considerable pruning.

Cost of planting varies from $7 to $14 per acre depending on amount of preparation, site conditions, spacing, fertilizer needed, cost of planting stock, and labor costs.

Inoculation is desirable on sites where black locust has not been grown previously or where the soil is deficient in nitrogen fixing bacteria of the proper group. This inoculation can be done by placing soil from a black locust plantation in each planting hole or by addition of a bacteria culture. On large scale plantings inoculation is not practical, but, if the seedlings have been grown in nursery soil where the nitrogen fixing bacteria are present, inoculation is not necessary.

Pruning seedlings before planting is not a beneficial practice and materially reduces the growth of the seedlings.

Pruning of the trees is essential to the production of a straight stem because of the marked tendency to fork. In a stand with a close spacing such as 6 x 6, pruning will be necessary for the first 4 or 5 years. Pruning is inadvisable in erosion control where immediate protection is desired; in regions where the locust borer is prevalent, it is likewise bad practice.

Thinning of black locust stands and plantations is necessary for sustained rapid growth, but if delayed until a few low class posts are produced, it will pay for itself.

Black locust should be clear cut with stumps at or near the ground line so that good coppice will be produced. Cutting in the late fall or winter gives the best subsequent coppice stand.

The most important enemy of black locust is the locust borer. It attacks trees from 1 to 6 inches in diameter. Complete protection can be obtained by maintining a densely shaded condition on the trunks until the trees are more than 6 inches in diameter.

The important uses of the wood of black locust include insulator pins and cobs, wagon wheel hubs, tree nails, and fence posts. Minor uses include ties, mine timbers, poles, handles, grape stakes, vehicle, and farm implements.

Important uses of the tree include erosion control, shelterbelt, windbreak, and shade tree planting.

Shipmast locust, a variety of black locust, has a more upright habit of growth then the common locust, and the wood is more durable. Because of these characteristics, it may be a valuable tree in subsequent plantations established for erosion control and fence posts.

BIBLIOGRAPHY

1. Chapman, A. G. 1936
Scarification of Black Locust to Increase and Hasten Germination.
Jour. of For., Jan., 1936 p 66 - 74

2. Cope, J. A. 1929
Concerning Black Locust in New York.
Jour. of For., Nov., 1929 p 825 - 831

3. Craighead, F. C. 1919
Protection from the Locust Borer.
U. S. D. A. Bul. 787, p 1 - 12 plates 1 - 3

4. Cuns, John B. 1930
Utilization of Black Locust.
U. S. D. A. Cir. 31, pp 1 - 31 figs. 1 - 2 plates 1 - 5

5. Dean, W. F. 1925
The Reclamation of Stripped Coal Lands.
Jour. of For., October, 1933 p 659 - 656

6. Detwiler, S. B. 1937
The History of Shipmast Locust.
Jour. of For., Aug., 1937 p 709 - 712

7. Forest Products Laboratory 1935
Wood Handbook
U. S. D. A. For. Service pp 1 - 325 figs. 1 - 64

8. Garman, H. 1916
The Locust Borer and Other Insect Enemies of Black Locust.
Ken. Ag. Exp. Sta. Bul. 200, pp 1 - 35 figs. 1 - 23

9. Gaskill, Alfred 1906
Growing Locust in Hungary.
For. Quart. 4:106 - 111

10. Green, W. J. and Waid, C. W. 1905
Some Trees Suitable to Plant for Posts, Poles, and Ties, With Cultural Suggestions and Financial Possibilities.
Ohio Ag. Exp. Sta. Bul. 158, pp 1 - 28 figs. 1 - 10

11. Hall, R. C. 1937
Growth and Yield of Shipmast Locust on Long Island and its Relative Resistance to Locust Borer Injury.
Jour. of For., Aug., 1937 p 721 - 727

12. Hirt, Ray R. 1938
A Progress Report on Laboratory Tests of the Relative Durability of Different Varieties of Black Locust Subjected to Certain Wood Decay Fungi.
Jou. of For., Jan., 1938 p 53 - 55

13. Horton, Gerald S. 1932
Notes on Black Locust.
Jour. of For., April, 1932 p 501 - 502

14. Illick, Joseph S. 1925
Pennsylvania Trees.
Pennsylvania Department of Forests and Waters.
pp 1 - 237 plates 1-29, figs. 1 - 28

15. Kauffman, C. H. and Kerber, H. M. 1922
A Study of the White Heart Rot of Locust Caused by Trametes robiniophila
Am. Jour. of Bot. Nov., 1922

16. Larsen, J. A. 1935
Natural Spreading of Black Locust in Southeastern Ohio.
Jour. of For. June, 1935 pp 616 - 619

17. Mattoon, W. R. 1930
Growing Black Locust Trees.
U. S. D. A. Far. Bul. 1628 pp 1 - 13 figs. 1 - 10

18. Mc Intyre, Arthur G. 1929
Black Locust in Pennsylvania.
Penn. State Ag. Exp. Sta. Bul. 236 pp 1 - 20 figs. 1 - 11

19. Mc Intyre, A. C. Jeffries, C. D. 1932
The Effect of Black Locust on Soil Nitrogen and Growth of Catalpa.
Jour. of For. Jan., 1932 pp 22 - 27

20. McKeever, D. G. 1937
A New Black Locust Seed Treatment.
Jour. of For. May, 1937 p 500 - 501

21. Meginnis, H. G. 1933
Using Soil Binding Plants to Reclaim Gullied Sands in the South.
U. S. D. A. For. Bul. 1697 pp 1 - 18 figs. 1 - 14

22. Meginnis, H. G. 1933
Tree Planting to Reclaim Gullied Land in the South.
Jour. of For. October, 1933 p 656 - 659

23. Meginnis, H. G. 1934
The Effect of Cultivating Young Black Locust.
Jour. of For., May, 1934 p 569 - 571

24. Miller, F. G. 1928
Black Locust and How to Grow It.
U. of Idaho, School of For. Bul. 2, pp 1 - 17 figs 1 - 5

25. Raber, Oran 1936
Shipmast Locust, a Valuable Undescribed Variety of Robinia pseudoacacia.
U. S. D. A. Cir. 379 pp 1 - 8 plates 1 - 6

26. Swingle, Charles F. 1937
Experiments in Propagating Shipmast Locust.
Jour. of For., Aug., 1937 p 713 - 720

27. Tinker, E. W. 1938
What Has Happened to the Shelterbelt.
Am. For., Jan., 1938 p 7 - 10

28. Ware, J. M. 1935
Black Locust in Albama.
Albama Ag. Exp. Sta. Cir. 73 pp 1 - 15 figs. 1 - 6

29. Westweld, B. H. 1936
Applied Silviculture in the United States.
Edward Brothers Inc. Ann Arbor, Mich.
pp 1 - 415 figs. 1 - 87

30. Wilson, J. K 1937
Scarification and Germination of Black Locust Seeds.
Jour. of For., March, 1937 p 241 - 46

APPENDIX

Table 1

Growth and Yield of Black Locust Plantations.
Average figures of 21 plantations in Pennsylvania.

Age	DBH	Total Height
5	1.2	7.5
10	2.4	15.5
15	3.6	23.5
20	4.8	31.5
25	6.0	39.0
30	7.2	46.5
35	8.4	53.0
40	9.6	59.0
45	10.8	65.0
50	12.0	71.0
55	13.2	76.5
60	14.3	81.5
65	15.6	86.0
70	16.7	90.5

Table 2

Yield of 8 foot posts 3 inches top diameter, per acre.

Age	Spacing	No. planted	No./acre now	%	posts	posts/acre per yr.
5	6x6	1,210	1,192	98	0	0
7	5x4	2,178	1,236	57	0	0
8	6x6	1,210	680	56	58	7
18	6x6	1,210	384	32	1,064	59
26	10x10	435	284	66	1,252	48
26	10x10	435	284	57	1,311	50
40	6x6	1,210	324	27	1,834	46
40	6x6	1,210	368	30	1,901	47

Table 3

Yield of posts from different sizes of trees. By post classes.

DBH	Class 1 $4\frac{1}{2}$-6 in.	Class 2 $3\frac{1}{2}$-$4\frac{1}{2}$ in.	Class 3 $2\frac{1}{2}$-$3\frac{1}{2}$ in.	Total number
3	-	-	1.0	1.0
3.5			1.3	1.3
4		1.0	1.0	2.0
4.5		1.0	1.1	2.1
5	1.0	1.5	1.1	3.6
5.5	1.5	1.2	1.1	3.8
6	1.9	1.4	1.2	4.5
6.5	2.4	1.7	1.3	5.4
7	2.8	1.7	1.4	5.9
7.5	3.3	1.8	1.0	6.1
8	3.8	2.0	1.0	6.8
8.5	4.2	2.2	1.0	7.4
9	4.7	2.2	1.1	8.0
9.5	5.2	2.5	1.2	8.9
10	5.6	2.1	1.0	8.7
10.5	6.1	2.2	1.5	9.8
11	6.5	2.4	1.3	10.2
11.5	7.0	2.3	1.3	10.6
12	7.5	2.2	1.0	10.7
12.5	7.9	2.0	1.0	10.9
13	8.4	2.6	1.0	12.0

Table 4

Yeild Table for Black Locust in Idaho (24)

Wood-lot Number	Age.	Spacing Original	Trees per Acre Now	Size of Dominant Trees DBH	Size of Dominant Trees Height	Yeild of Posts per Acre 1	Yeild of Posts per Acre 2	Yeild of Posts per Acre 3	Yeild of Posts per Acre Total	Value per Acre Net	Yeild of Posts per acre per year 1	Yeild of Posts per acre per year 2	Yeild of Posts per acre per year 3	Yeild of Posts per acre per year Total	Annual income per acre per year	Woodlot Number
1	7	8x7	405	3.9	43	173	500	510	1183	219.87	25	71	73	169	$27.00	1
2	*9	8x8	438	4.8	45	450	504	634	1588	341.47	50	56	98	176	30.97	2
3	*9	6x5	726	4.7	44	560	714	879	2153	462.48	62	79	101	239	41.94	3
4	*9	6x5	943	4.2	45	591	653	908	2152	462.53	66	74	84	241	41.95	4
5	9	4x4	838	3.8	34	327	584	755	1666	324.38	36	65	99	185	29.42	5
6	11	8x2	944	3.4	43	268	728	1092	2088	367.61	24	66	92	189	35.88	6
7	13	6x5	764	5.6	53	1359	632	1200	3191	788.66	104	49	76	245	44.41	7
8	13	6x4	976	4.3	44	608	792	984	2384	504.66	47	61	47	184	28.49	8
9	14	7x4	697	5.8	58	1179	785	654	2618	697.61	84	56	71	187	35.59	9
10	14	6x4	925	5.3	49	1132	809	994	2935	718.81	81	58	22	210	36.68	10
11	14	4x6	477	6.6	59	1337	636	947	2920	619.36	91	32	68	145	31.60	11
12	14	—	1004	5.2	—	829	752	1047	2628	752.86	95	45	81	208	38.41	12
13	14	3½x4	954	4.8	38	358	835	1506	2699	588.70	64	58	108	203	30.09	13
14	14	5x2	1419	3.6	37	517	494	505	1516	466.91	26	60	34	194	23.82	14
15	15	10x5	519	4.8	53	1782	754	754	3290	343.38	34	33	47	101	15.92	15
16	18	5x4	745	6.2	72	1276	454	311	2041	933.43	111	47	31	205	33.18	16
17	20	8x7	518	7.5	50	1815	582	612	3009	844.94	91	29	33	151	26.76	17
Average	12.9	—	782	4.96	48	856	659	841	2357	557.39	64	55	71	190	31.88	Average

* Sprouts
No. 1 post: 7 ft. long, 4-6 inches at small end. Value 40¢
No 2 Post: " " " 2.9-3.9 " " " " " " 25¢
No 3 Post: " " " 1.9-2.9 " " " " " " 10¢