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Some Responses of Black Locust to Planting Site Treatment

By GEORGE R. COOPER and J. M. AIKMAN

The black locust tree has been of value to man for many decades. It was introduced into Europe from the Appalachian region in the early part of the seventeenth century. Over a wide area on both continents it has had three important uses: the strong, spreading root system is well adapted for holding eroding soil; the durability of its wood in contact with the soil makes it of great value as fence posts which are becoming increasingly difficult to obtain; and it is a legume with that family's useful quality of improving the soil on which it grows by the fixation of atmospheric nitrogen.

Limitations to its adaptability and use have been discovered at intervals throughout the long period since its introduction, in a wide variety of sites. Many locust plantings fail for no apparent reason. Others seem to become established, only to be wiped out by the locust borer in a few seasons. This paper is primarily concerned with the evaluation of some methods of planting-site preparation used in an effort to produce thrifty, vigorous, fast-growing trees on eroded Lindley loam in southern Iowa.

The black locust, *Robinia pseudoacacia* L., is a medium sized tree which may grow to a height of 85 feet. It has deeply furrowed, grey-brown bark and pinnate leaves of 7 to 19 elliptic or ovate leaflets. The short, paired, stipular spines vary in length and persistence. The flowers are white, papilionaceous, very fragrant, and are borne in short, pendulous racemes 4 to 5 inches long. The seeds, 3 to 10 in number, are borne in a smooth, flattened, elongate legume (14, 15).

Black locust is a valuable fence post material. It ranks second only to osage orange in durability in contact with the soil (12). Posts have been, and are difficult to obtain in the central states. A yield of 1,000 posts per acre every 15 years is adequate return from abandoned farm land worth 20 dollars per acre (17). There are three variations in the growth form of black locust. The pinnate form is the most valuable since the central axis is straight and unbranched. The spreading and palmate types are of little value for timber and the latter is quite rare (8).

Black locust is used in controlling erosion chiefly because of its spreading root system (10) and the fact that it will persist for a time even in very poor sites (2). As Auten (2) points out, however, locust may persist for a time but may develop poorly later. In the Ohio Valley, Ligon (11) found that black locust gave much better results on eroding land than any other hardwood tree. Auten (2) and Kittredge (9) have both called attention to the fact that grass grows well under locust and when moderately grazed forms a sod readily. The application of this feature to erosion control is obvious.

The necessity of proper site selection before planting black locust was emphasized by many writers (3, 6, 9, 11). Among soil factors adversely affecting the locust are lack of calcium, poor drainage, poor aeration, excessive drainage of subsoil, poor moisture holding capacity, high water table and an impervious subsoil layer near the surface. In respect to water holding capacity and drainage there is some disagreement, since some authorities frown on sandy soils for locust plantings and others claim good results from plantings made on such soils. This question is still open to further investigation. Adequate soil aeration is required but excessive aeration may cause desiccation of the roots.

Meginnis (13) recommended that the ground be cultivated or plowed. He found that black locust planted on grassy areas, adjacent to gullies, without cultivation or plowing of the area, showed a very heavy mortality. On the same site, splendid growth was obtained by plowing prior to planting the trees. He stated that those trees which had been cultivated bore more than twice as many leaves as the uncultivated check trees and had four times as much actual leaf area.

The final factor which determines the success or failure of a locust planting is often the locust borer. Barger (4), Hall (7) and others have concluded that thrifty tree growth is the cause and not the effect of immunity to the locust borer. There are moderately effective sprays which help to check the borer; an emulsion of orthodichlorobenzene and soft soap is the best, according to Hall (7), but the expense is prohibitive in all but rare instances. Since no practical, inexpensive way of keeping the borers out of the locust has been found, the other approach has been taken, and thrifty trees, able to hold their own in spite of the borer, are the goal of the present work on black locust.

Planting, Establishment and Early Growth

The experiment here reported was initiated in 1941 on the Hillculture Experimental Farm in Davis county, Iowa (4, 17). The planting site was near the lower end of a long south-east facing slope of 9 to 10 per cent. The Lindley loam soil had eroded until only 1 to 4 inches of topsoil remained. Following abandonment in

1933, this field was treated with 3 tons of lime and 200 pounds of phosphate per acre in 1936. Biennial sweet clover was planted in 1937. A sparse, weedy stand of sweet clover from natural reseeding persisted until the trees became well established.

Four methods of planting and subsequent cultural treatment were used. For two of them no site preparations prior to planting were required. In the other two methods a bench terrace (1) was formed for each row of trees by plowing four furrows on the contour. The furrows were all thrown down-slope and were progressively more shallow from the down-hill furrow which was plowed about 8 inches deep. The benches were levelled with a harrow.

The actual planting was done in April, 1941. One year old nursery stock, grown from Idaho seed was used. The stock was carefully graded to assure uniformity. Planting was done in spaded holes of sufficient size to allow the roots of the plants to enter without difficulty. Ten trees were planted in each treatment at intervals of 3.3 feet in the row. The four treatments were randomized in each of the six replications. The distance between the contour rows varied from about 9 to 17 feet. Consequently the rate of planting was approximately 1000 trees per acre.

Fig. 1. View of the southwest corner of the experimental plantation. July 1941. Stakes mark beginning of replications.

The unfurrowed plantings had different cultural methods applied. In one the trees were kept free of competition with other plants by scalping with a hoe. In the second unfurrowed treatment a 4-inch straw mulch was applied early in the spring. The furrowed treatments were kept free of other plants as indicated by the names given the treatments: furrowed, scalped and furrowed, cultivated. A 5-shovel, one-horse plow was used for the cultivation and a hoe for scalping. In Figure 1 is a view of the plantings taken in July, 1941. The stakes mark the beginning of the replications.

The plant cover of sweet clover and weeds between the rows was cut with a scythe as necessary.

The measurements for 1941 were taken in late October of that year and during the winter each year thereafter. The treatments were discontinued after the first two years because the increased size of the trees made them impracticable. Moreover, the object of the experiment was to determine the lasting effect on the trees of establishment under 4 different methods of site preparation. The supply of calcium, an essential element for locusts, was checked in August 1941 and was considered adequate.

Early in the first year the unfurrowed, scalped treatment was observed to lag behind the other three treatments in rate of growth.

Fig. 2. Average tree after one season in the field. Unfurrowed, mulched. 1941.

The root growth was found to correspond to the top growth. The roots of the unfurrowed, mulched trees were found nearer the surface than were those of the trees in the other treatments. In Figure 2 are shown average trees of the unfurrowed, mulched treatment toward the end of the first growing season. This picture shows the average degree of development and size of the trees after one year's growth in all of the treatments except the unfurrowed, scalped treatment.

Determination of Yield and Borer Damage

In September 1947, work was begun to evaluate the four treatments in as quantitative a way as possible. Tree heights were measured, using the highest branch tip as the point of reference. The basal diameter was taken as near the ground as possible, but above any swollen portion of the stem caused by borer injury. Since the primary value of locust timber is as fence posts, the third measurement was made at a height of 7 feet.

Tree height is not always an accurate means of measuring growth, so four trees from each treatment of each replicate were chosen at random and cut in January and February of 1948. These trees were measured at intervals of 2.5 feet and plotted on the standard U. S. Forest Service form 558a and the volumes computed therefrom.

The borer damage was difficult to determine in a quantitative way by examining the trees. What looked like a single borer hole might actually be several holes of exceedingly variable length. To eliminate this error, the trees were cut to 7-foot post lengths and brought to Ames where they were sawed lengthwise into quarters. Correction was made for holes not exposed on any of the 8 faces of the quartered post, by counting each hole in any face. In some

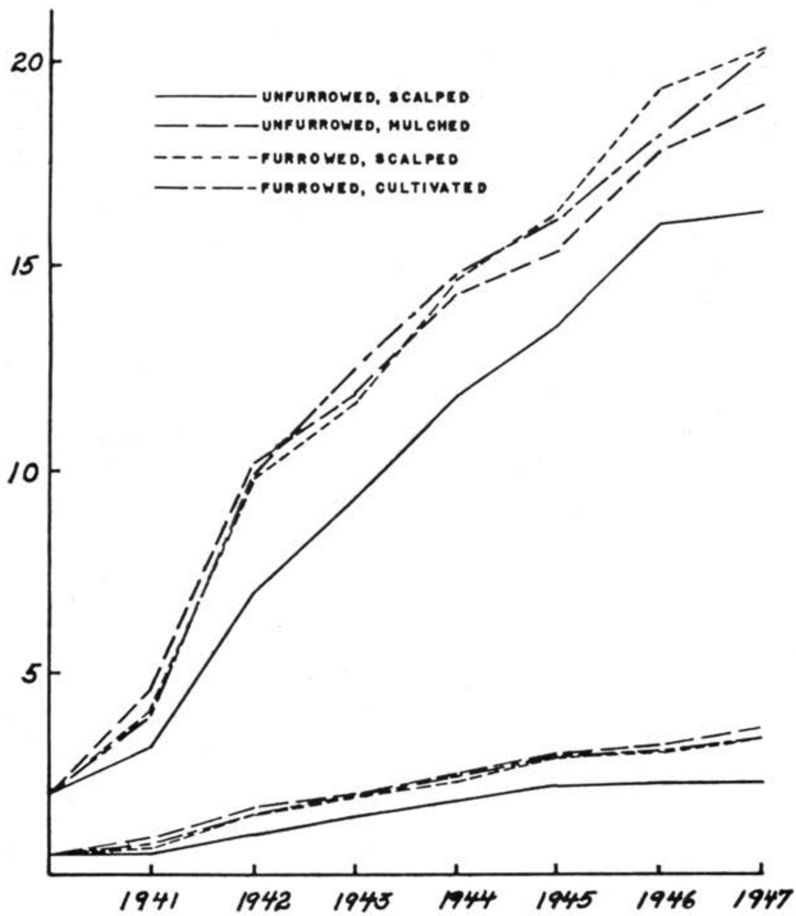

Fig. 3. Average yearly height in feet and diameter in inches of trees in each treatment for the period 1941 to 1947.

cases, 1 burrow which spiraled somewhat would thus be counted as 2 or even 3 separate holes. The cutting was done in a random fashion with no attempt to select the sawing plane.

Inasmuch as many trees contain substances which act in the nature of fungicides, it was considered possible that the black locust might contain varying amounts of a substance inhibitive to borers. Scheffer, Lachmund, and Hopp (16) found a correlation between the proportional amounts of hot water soluble extractives in black locust and their resistance to wood decay fungi. Bray (5) outlined their method. A method similar to theirs was used to sample each of the trees cut. The bark and sapwood were carefully separated, dried

Fig. 4. Black locust 7 years after planting. Unfurrowed, scalped. 1947.
Fig. 5. Black locust 7 years after planting. Unfurrowed, mulched on left. 1947.

and ground to fine sawdust. Five grams of the sawdust was beaten with 75 ml. of distilled water in a Waring blender for 1 minute, then made up to 100 ml. The use of the Waring blender eliminated the foaming which occurred when the beakers were heated without this treatment. The mixing was followed by a period of 30 minutes steaming in an autoclave. Timing was started after 100°C. was reached. This was followed by filtration and evaporation at 90°C. until dry.

Response of Black Locust to Four Methods of Planting-Site Preparation

The yearly growth data compiled seem to indicate a definite increase in rate of growth of the trees in the two furrowed treatments and the mulched treatment as compared to the unfurrowed treatment (Fig. 3). The growth curves in Figure 3 show that the spread in rate of growth between the former three treatments and the unfurrowed treatment occurred in the first two years. However, the difference still persisted after 7 years. The indicated increased spread in 1947 between the curves of the 2 furrowed treatments and the mulched treatments as a group and the unfurrowed treatment is probably not significant. No significance is claimed for the spread among the three more favorable treatments in the final 1947 data reading, but the slight differences in the final tip of

Fig. 6. Black locust 7 years after planting. Furrowed, scalped. 1947.

Fig. 7. Black locust 7 years after planting. Furrowed, cultivated. 1947.
Fig. 8. Black locust trees in spring of 8th year after planting. Furrowed, cultivated at left, unfurrowed, mulched at the right. This year's stump sprout between the tall trees. 1948.

the curves seem consistent with final size and condition of the trees (Figs. 4, 5, 6, 7, and 8).

In Table 1, in addition to the average yearly height and diameter in each treatment, are presented estimates of the borer damage based on the average size of the trees. The degree of variation in final size of the trees within the replicates is given in Table 2 as is also the variation in estimated borer damage. The smallest trees occur in the unfurrowed, scalped; unfurrowed, mulched; and furrowed, scalped treatments. All 3 have trees as small as 6 feet in height. It is interesting to note that estimation of the borer damage by the method used by Hall (7) checked fairly well with the actual

Table 1

Average yearly height, diameter, and borer effect of the 4 treatments for 7 successive years.

Year of Measurement	Treatment							
	Unfurrowed, scalped		Unfurrowed, mulched		Furrowed, scalped		Furrowed. cultivated	
	Ht. ft.	Diam. in.	Ht. ft.	Diam. in.	Ht. ft.	Diam. in.	Ht. ft.	Diam. in.
1941	3.2	.5	4.6	.9	4.1	.7	4.5	.8
Borer effect *	med.		med.		med.		med.	
1942	7.0	1.0	10.2	1.7	9.8	1.5	9.9	1.5
Borer effect	med.		lt.		lt.		lt.	
1943	9.3	1.4	11.9	2.0	11.7	1.9	12.5	2.0
Borer effect	med.		med.		med.		lt.	
1944	11.8	1.8	14.3	2.5	14.7	2.3	14.8	2.4
Borer effect	med.		med.		lt.		lt.	
1945	13.6	2.2	15.4	3.0	16.3	2.9	16.2	2.8
Borer effect	med.		med.		lt.		lt.	
1946	16.1	2.5	17.9	3.2	19.4	3.2	18.3	3.1
Borer effect	med.		lt.		lt.		lt.	
1947	16.3	2.5	19.0	3.6	20.4	3.6	20.3	3.3
Borer effect **	100		66		58		80	

* Method used by Hall (7).
** In per cent based on actual number of borer holes per unit volume.

Table 2

Average growth per replicate for each of 4 treatments. 1947.

Treatment	Replicate	Av. ht.	Borer * injury	Av. butt diam. inches	Av. diam. at 7 ft.	Height max.	Height min.	Butt Diam. max.	Butt Diam. min.	Diam. at 7 ft. max.	Diam. at 7 ft. min.
		feet		inches	inches	ft.	ft.	inches	inches	inches	inches
Unfurrowed, scalped	A	16.9	med.	3.2	1.8	20	15	3.6	2.0	2.6	1.3
	B	13.5	med.	2.2	1.5	20	10	2.4	0.6	1.8	1.3
	C	19.8	lt.	3.7	2.1	23	12	6.0	2.2	3.3	1.2
	D	15.0	med.	2.6	1.6	22	6	3.7	0.7	2.6	0.9
	E	17.7	med.	3.2	2.6	22	14	4.5	1.0	3.6	1.5
	F	18.2	lt.	2.8	1.9	22	8	3.4	1.6	2.8	1.0
Unfurrowed, mulched	A	19.7	lt.	3.4	1.9	23	13	5.6	2.4	2.6	0.9
	B	14.9	med.	2.5	1.8	21	6	4.1	0.8	2.6	0.8
	C	19.7	lt.	4.1	2.9	25	9	6.6	1.8	3.9	1.9
	D	18.8	lt.	3.8	2.4	25	10	6.3	1.7	3.8	1.0
	E	22.0	very lt.	3.9	2.4	25	20	5.0	2.6	3.0	1.7
	F	21.7	lt.	3.9	2.2	24	19	5.2	3.0	3.1	1.8
Furrowed, scalped	A	20.3	lt.	4.4	2.4	23	16	5.7	2.4	3.0	1.3
	B	19.8	lt.	3.4	2.4	25	15	4.5	1.2	3.6	1.5
	C	22.3	lt.	3.8	2.4	25	19	5.6	2.5	3.6	1.5
	D	22.2	lt.	3.9	2.2	24	16	5.4	3.0	2.8	1.5
	E	20.5	lt.	3.5	2.4	27	6	5.7	0.7	2.9	1.1
	F	21.7	lt.	3.5	2.9	24	21	4.6	2.0	2.5	2.1
Furrowed, cultivated	A	18.3	lt.	2.9	2.2	22	10	5.5	1.5	2.5	1.8
	B	16.0	med.	2.7	1.7	21	10	4.4	1.1	2.4	1.5
	C	21.7	lt.	3.9	2.6	26	12	5.4	2.0	4.0	1.3
	D	22.1	lt.	3.8	2.6	25	12	5.6	1.4	3.4	2.0
	E	20.0	lt.	3.5	2.3	27	10	5.7	1.5	3.1	0.9
	F	23.0	lt.	3.8	2.4	26	20	5.4	2.2	1.7	2.8

* Method used by R. C. Hall (7).

count of internal borer holes in Table 1. For this reason, the height method has been used to indicate damage per replicate in Table 2.

Survival of as many trees as possible is requisite to maximum yield from a stand of trees. The average survival of the 4 treatments was 88 per cent. The furrowed, cultivated had a survival of 95 per cent (Table 3).

Table 3

Trees in the replicates of each treatment surviving the 7 year period since planting.

Treatment	Replicate	No. planted	Trees surviving Number	Trees surviving Per Cent
Unfurrowed, scalped	A	10	7	70
	B	10	8	80
	C	10	8	80
	D	10	10	100
	E	10	7	70
	F	10	10	100
Total	6	60	50	83
Unfurrowed, mulched	A	10	10	100
	B	10	8	80
	C	10	9	90
	D	10	8	80
	E	10	9	90
	F	10	9	90
Total	6	60	53	88
Furrowed, scalped	A	10	7	70
	B	10	10	100
	C	10	10	100
	D	10	8	80
	E	10	8	80
	F	10	9	90
Total	6	60	52	86
Furrowed, cultivated	A	10	10	100
	B	10	9	90
	C	10	9	90
	D	10	9	90
	E	10	10	100
	F	10	10	100
Total	6	60	57	95
Grand Total	24	240	212	88

Volume is a more accurate index to the growth of the tree than is height. In Table 4, the average volumes for each replicate are found. Here there is a direct increase in volume with an increase in the intensity of treatment.

As has been previously mentioned, an approximation of the borer damage for the first 6 years is to be found in Tables 1 and 2. The correlation between borer holes and volume is significant in the unfurrowed, scalped treatment only. In the other treatments, although the number of borer holes increases directly with the volume, the correlation coefficient is non-significant (Table 5).

Table 4

Average volume in cubic feet per replicate for each of the 4 treatments. 1947.

	Treatment			
Replicate	Unfurrowed, scalped	Unfurrowed, mulched	Furrowed, scalped	Furrowed, cultivated
A	.206	.232	.397	.359
B	.176	.350	.550	.276
C	.489	.729	.536	.781
D	.270	.475	.412	.592
E	.540	.550	.584	.440
F	.295	.369	.378	.561
Total	.330	.451	.476	.502

Table 5

Average volume and number of borer holes per tree for each treatment after 7 year's growth. 1947.*

Treatment	Volume in cu. ft.	No. of borer holes
Unfurrowed, scalped	.330	21.0
Unfurrowed, mulched	.451	21.0
Furrowed, scalped	.476	23.2
Furrowed, cultivated	.506	26.6
Average for total	.439	22.9

* Volume and borer holes are based on average of four trees chosen at random from each replicate.

The average number of borer holes per tree, determined from the 4 trees cut in each replicate, is exactly the same in the 2 unfurrowed treatments, but higher in the furrowed (Table 6).

Table 6

Average number of borer holes per tree for each replicate of the four treatments. 1947.

	Treatment			
Replicate	Unfurrowed, scalped	Unfurrowed, mulched	Furrowed, scalped	Furrowed, cultivated
A	7	37	28	14
B	9	20	24	22
C	36	11	14	21
D	21	14	21	55
E	45	13	37	18
F	19	31	15	30
—	—	—	—	—
Totals	21	21	23	27

The hot water extractives from the bark and sapwood varied widely within replicates. A consistent element was found in the sapwood extractives. As the intensity of the cultural treatment increased, the amount of extract from the sapwood decreased (Table 7).

Because of the arrangement of the replicates, it was necessary to omit the "B" replicates from the unfurrowed, scalped and unfurrowed, mulched treatments. For the same reason, the furrowed treatments can be compared with the unfurrowed only by logic, not statistically. The most efficient method of analysis was decided to be by paired comparisons of the two unfurrowed treatments, and it was found that only the height measurements gave a significant statistical test (Table 8).

The "B" replicates of 2 unfurrowed treatments were given a 4-inch mulch of sweet clover and weeds instead of straw. They gave the poorest growth of any of the 6 replicates in each of the 2 treatments.

Discussion

It will be necessary throughout the discussion to keep in mind the fact that the only 2 treatments compared statistically were the unfurrowed ones. Since the area of the experiment was relatively homogeneous in nature, the furrowed treatments will be compared with unfurrowed logically. The comparisons will be based on

Table 7

Average weight of hot water extractive found in the bark and sapwood in the 4 harvested trees of each replicate.

Treatment	Replicate	Extractive from 5 gm. of bark	Extractive from 5 gm. of sapwood	Total treatment average in milligrams	
		Milligrams	Milligrams	Bark	Sapwood
Unfurrowed,	A	580	360		
scalped	B	650	520		
	C	597	290		
	D	580	180		
	E	680	302		
	F	702	260	639	324
Unfurrowed,	A	630	270		
mulched	B	515	310		
	C	570	260		
	D	625	280		
	E	645	300		
	F	692	295	610	289
Furrowed,	A	582	242		
scalped	B	450	285		
	C	615	217		
	D	825	287		
	E	702	238		
	F	777	245	658	252
Furrowed,	A	655	278		
cultivated	B	662	258		
	C	605	267		
	D	665	245		
	E	617	232		
	F	742	187	658	245

height, diameter, volume, hot water soluble extractives, and borer damage.

The data presented in Table 1 indicate that the trees of the 2 furrowed and the mulched treatments had greater average yearly height and diameter than those of the unfurrowed, scalped treatment. Using Hall's (7) method of estimating borer damage by height, the furrowed treatments would seem to have been only lightly affected by the locust borer. In terms of borer holes per unit volume, the furrowed, scalped treatment was the best, the damage being 12 per cent lower than the lowest of the other 3 treatments.

The well known variability of black locust growth is shown in

Table 8

Paired comparisons of various data using the averages of each replicate in the scalped and mulched, unfurrowed treatments. 1947.

Data compared	Mean difference	Standard error	"t" value with 4 d. f.
Tree height	2.860	.708	3.660*
Butt diameter	.070	.236	.296
Diameter at 7′	.174	.142	1.789
Bark thickness	.306	.116	2.630
Average no. borer holes	4.080	11.300	.361
Borer holes/unit volume	.018	.010	1.800
Survival of trees	.600	.781	.760
Depth of "c" horizon from surface	.400	2.32	.172
Bark extractives	4.6	18.00	.280
Wood extractives	38.6	31.0	1.24

* Significant at 5% level. $t_{.05} = 2.776$.

Table 2. The maximum-minimum data gave steadily increasing maxima with intensity of treatment. The minima showed more similarity between treatments.

Since it is desirable to have as high a percentage of survival as possible in a stand of trees, the survival value of the treatment is important. In this respect there was very little difference between the unfurrowed, mulched and the furrowed scalped. The furrowed, cultivated was highest with a survival of 95 per cent. The unfurrowed, scalped was the least successful with a survival of only 83 per cent (Table 3).

The treatments were all confined to preparation of the actual planting site and were discontinued after 2 years. The increased growth of the first 2 years gave the unfurrowed, mulched; the furrowed, scalped and the furrowed, cultivated treatments a substantial lead over the unfurrowed, scalped treatment. This lead in height growth was still maintained, even after 7 years of growth on the site. The growth curves (Fig. 3) seem to indicate that the rate of height growth in the unfurrowed, scalped treatment levelled off in 1947. Since 1947 was a very dry year, it will require more observation to determine if this is a permanent condition. Of the other 3 treatments, the unfurrowed, mulched and furrowed scalped also showed a tendency to level off in rate of height growth, but to a less definite degree than the unfurrowed, scalped. The furrowed, cultivated treatment still tended toward a straight line height growth curve with no indication of leveling off.

The diameter measurements (Table 1) supported the conclusion that the rate of growth was leveling off in the unfurrowed, scalped treatment. In fact, the diameter growth for the unfurrowed, scalped became almost static from 1946 through 1947. The unfurrowed, mulched and furrowed, scalped continued to show an increase in diameter for this period.

The average tree volume followed the same pattern as height and diameter. As the intensity of treatment increased, the volume increased, Table 4. The greatest difference in volume was an average of 0.119 cubic feet per tree between the 2 unfurrowed treatments. The volume increased by approximately 0.025 cubic foot per tree from the unfurrowed, mulched to furrowed, scalped and by the same amount from the furrowed, scalped to the furrowed, cultivated.

Had it not been for the tree with 138 borer holes, in replicate "D" of the furrowed, cultivated treatment, the damage per unit volume would have been considerably lower for this treatment. The trees grew larger in spite of the borers. The treatments giving more tree volume had more borer holes. However, the borer holes did not increase in proportion to the volume in all of the treatments. The unfurrowed, scalped showed a positive correlation between borer holes and volume, significant at the 5 per cent level. The unfurrowed, mulched lacked a considerable amount of being significant. The furrowed, scalped gave a negative correlation which would indicate that the larger trees of this treatment suffered less from borers than did the small ones. The furrowed, cultivated treatment, primarily because of the tree with 138 borer holes, showed a positive correlation but not a significant one.

The average number of borer holes per tree was the same in both unfurrowed treatments, yet the average volume of the unfurrowed, mulched was considerably greater. The 2 furrowed treatments had more borer holes, on the average, per tree and still greater average volume, Table 5.

The variation in the number of borer holes was greater within the treatments (unfurrowed, scalped and unfurrowed, mulched) than between treatments, so there was no statistically significant difference between them, Table 6.

The data from the hot water extractives gave evidence which will be used in explaining the differences discussed up to this point. In Table 7 it will be noted that there was but little difference between the average amount of extractives from the bark. The sapwood extractives did show a difference. The amount of extractive decreased as the intensity of treatment increased. This point will be referred to again, later in this discussion.

Statistical analysis, because of the previously mentioned difficulties, was between only the 2 unfurrowed treatments. Only 1 measurement gave a significant test. That was the height of the trees. The bark thickness was measured in all the quartered posts, but it lacked a little of being significantly different in the 2 treatments. The data are shown in Table 8 and are self explanatory.

The fact remains, that despite a lack of statistical significance, the trees of the 3 more intensive treatments showed better growth in height, diameter and volume than the trees of the unfurrowed, scalped treatment. This was true in spite of the borer. The area north of the test plots was plentifully covered with goldenrods, chiefly *Solidago nemoralis* Ait. The blossoms of these plants form a large part of the diet of the adult locust borer, *Cyllene robiniae* Forst. In studying the relation of treatment to degree of borer injury, measurements of the "G" replicate were omitted to equalize as much as possible the distance traveled by the borers from the goldenrod to the different replicates. That the distance traveled by the borer to deposit its eggs was not a critical factor was shown by the fact that the most severely infested replicate, averaging 55 holes per tree, was XXD, a furrowed, cultivated replicate, farthest from the goldenrod community.

The differences in growth obviously could not be attributed to freedom from borers. Other factors must have been responsible. In examining the data, there were several which pointed to a limiting factor or factors as the cause of the differences in growth. In Figure 3 the leveling off of three of the treatments in 1947, a year of exceptional dryness, seems to indicate a sensitivity of the locust tree to conditions of poor water supply. During this same period, the final accumulation of water soluble material in the sapwood was greater in these same 3 treatments. This would seem to indicate that some factor had become limiting in these 3, and that the sugars and related substances were not being used in growth processes as rapidly as in the furrowed, cultivated treatment.

The nature of the treatments was such that they would affect two edaphic factors more than any others (4). These factors are the available soil moisture and degree of soil aeration. Scalping eliminated water loss through transpiration by vegetation other than the locust trees. Mulching eliminated other vegetation and stopped transpiration loss from that source. In addition, mulching conserved soil moisture by reducing the evaporation loss from the soil and increased the overall infiltration from rainfall by preventing compaction and clogging of the soil pores under the beating action of rainfall. Furrowing had 2 effects on the soil. It loosened any hard, compacted initial surface layer and provided a means of catching some of the runoff water. Cultivation had an effect similar to scalping in that it stopped transpiration loss from undesirable plants, and in addition, the mechanical action of cultivation would tend to break up any capillary connections of the water with the surface.

Soil aeration of the unfurrowed, scalped treatment was undoubtedly the poorest of the 4 treatments. The mulched treatment probably improved aeration by prevention of the mechanical effects of rainfall which tend to plug the pore spaces. Furrowing and cultivation both had a tendency to increase aeration because of the more friable condition of the top soil caused by the leaching of silt and clay to a lower depth.

The treatments then had their effect primarily through the extra water made available to the plants. This can be partially attributed to aeration, since it is known to affect absorption by roots.

On the basis of the data to date, the treatments would rank from best to poorest as follows: (1) furrowed, cultivated, which gave the greatest volume and diameter and the second greatest height; (2) furrowed, scalped, which gave the greatest height and the second largest diameter and volume; (3) the unfurrowed, mulched, ranking third in height, diameter and volume; and (4) the unfurrowed, scalped which rated lowest in all measurements of growth and yield. These ratings are for locust grown on eroded Lindley loam in southeastern Iowa.

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