TABLE 1

SEEDS AND AMOUNTS USED

Kind	Pounds per Acre
Red fescue	30
Common ryegrass	5
Weeping lovegrass	2
Alta Fescue	20
Red top	5

TABLE 2

Plot No.	Percent Passing 200 Sieve	
	Sample 1	Sample 2
1	5.5	4.9
2	7.3	6.2
3	4.2	4.1
4	6.9	---

observed which could be attributed to the various treatments, although cover was slightly better in the plot having the soil amendment.

On October 13 cover was fair on all plots and no significant difference was observed which could be attributed to the various treatments.

COMMENTS

Frank H. Brant:

Is a comparison available of growth on the test plots with growth on the soil having neither flyash nor soil amendments?

Turka:

No. However, some years previously the same area was used for a study of the possibility of establishing vegetation using the native soil without amendments other than fertilizer and lime. A poor cover was developed which would have required continued fertilizing to have produced a cover acceptable for highways.

SAWDUST as a SOIL AMENDMENT for TURF GROWTH

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This report has reference to remarks made by the author at the meeting of the Committee on Roadside Development, Highway Research Board, on January 18, 1956, accompanied by color slides showing the results of the use of sawdust as a soil amend-

ment for turf growth. His remarks referred to two different highway locations in Louisiana which will be described below.

Too, this report will include his answers to questions during the discussion which followed his remarks, as well as comments by others who have written since the committee meeting. Also, it may be necessary to add further comments which time did not permit during the meeting. The present status of the two locations will be reported in order to bring the subject up to date, as of March 15, 1956.

LOCATIONS

1. US 90. Hydraulic Sand Fill. Toomey-Sabine River Bridge Highway.

This location is in southwest Louisiana, Calcasieu Parish, west of Lake Charles and near the Louisiana-Texas line (Orange, Texas). The fill is about 3 miles in length, through a marsh area.

On completion of the fill and during the late summer and fall of 1953, both the north and south fill slopes were blanketed with a layer of clay and compacted to a depth of 4 inches. The clay was from subsoil areas. The whole area was fertilized with 8-8-8 at the rate of 800 lb. per acre, then disked and rolled. Bermuda (hulled) and alta fescue were planted and the area again rolled.

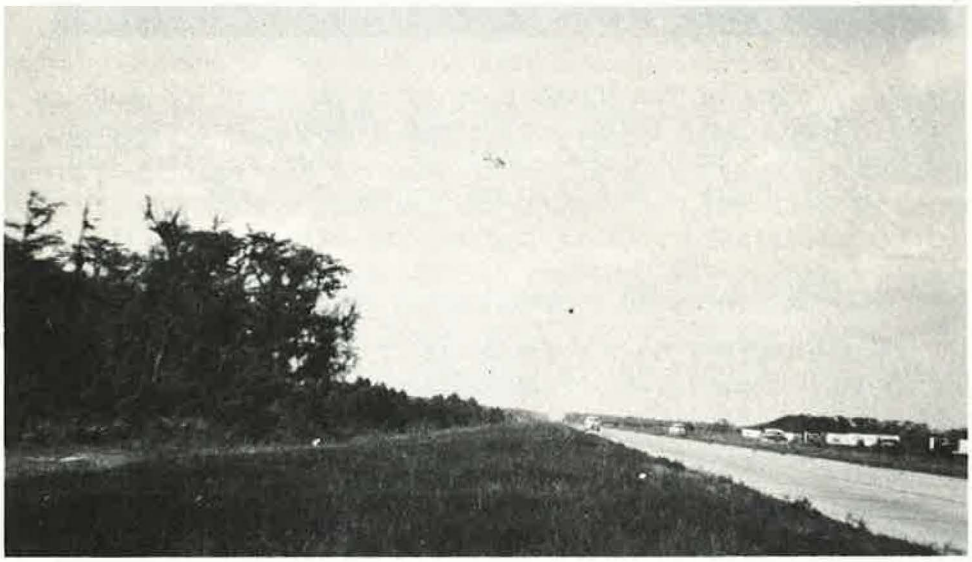

Figure 1. A view of the south roadside on US 90 in Louisiana, showing a section on which pine sawdust was used as a soil amendment, followed by seeding with Kobe lespedeza. Photo taken August 26, 1955.

Because of the dry fall of 1953, it was January 1954, before a fair stand of fescue was obtained. The Bermuda did not have time before cold weather to spread runners sufficiently, and the stand was only fair.

Subsequent winter and spring rains of 1954 created washes, cutting trenches on the slopes, many of which exposed the sand underneath the clay blanket. The summer of 1954 was very dry for several months, and both the fescue and Bermuda suffered.

In the spring of 1955 it was realized that something else must be done, especially to hold the moisture on the slopes, and it was decided to apply sawdust as an amendment to the south slope and part of the north slope, and for comparison to try a top mulch of sawdust on part of the north slope and on the median strip.

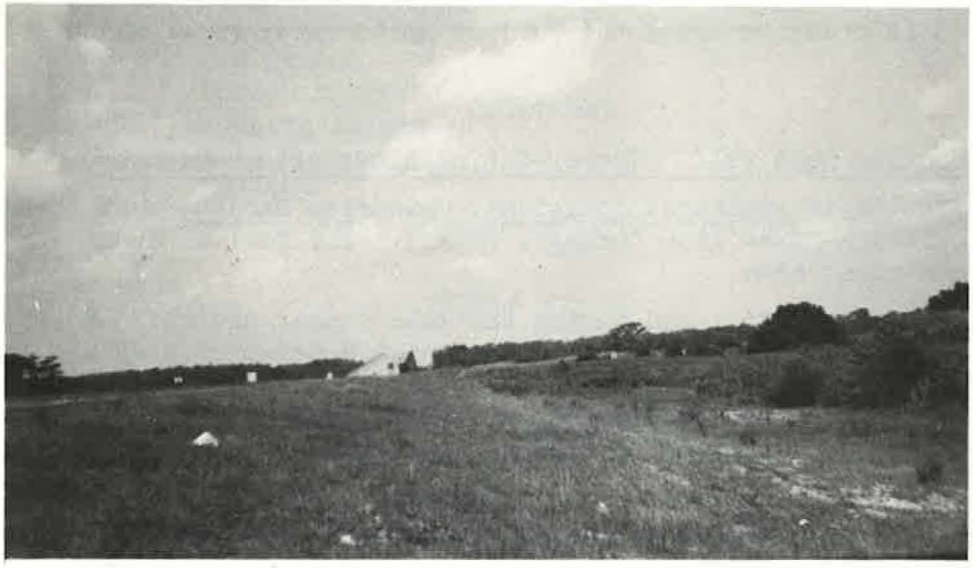

Figure 2. A view of the north side of US 90 where no sawdust was used. Grass here (alta fescue and Bermuda) was planted in October 1954. Many washes occurred in this section, and stand of grass was thin on August 26, 1955.

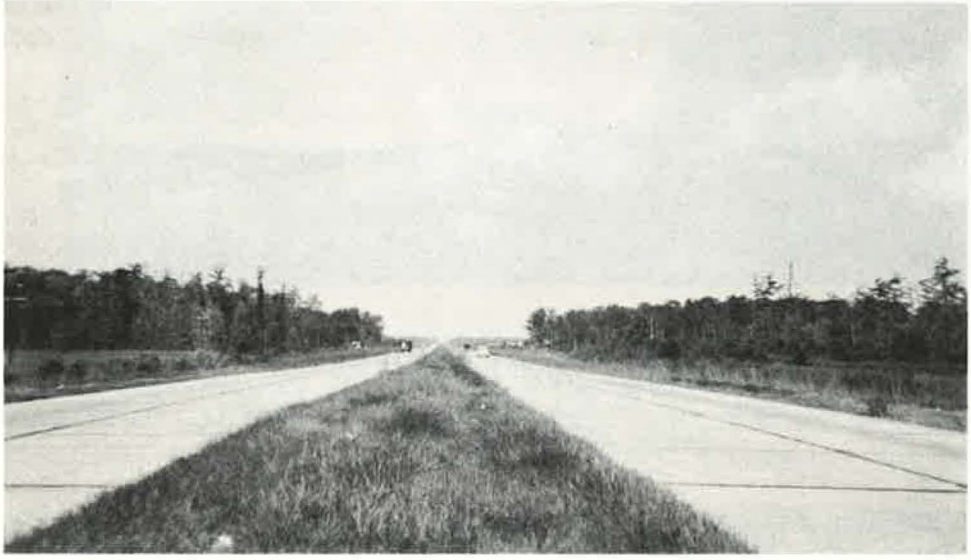

Figure 3. Median on US 90 in Louisiana. This was seeded with alta fescue and Bermuda and mulched with sawdust spread 1 to 2 inches deep. Photo taken August 26, 1955.

The procedure was as follows:

(a) Washes were patched with clay on both south and north slopes.

(b) Eight hundred lb. of 8-8-8 fertilizer was applied and the areas disked.

(c) Sawdust was then spread on the south slope and part of the north slope 2 to 3 inches deep and disked into the soil.

(d) Rolling was done with a cultipacker.

(e) A combination of 10 lb. of Bermuda (hulled) and 20 lb. of Kobe lespedeza (30 lb. per acre) was then seeded and the areas rolled again.

A part of the north slope was handled in the same manner as to the clay patching, fertilizer, and seed, but the sawdust was placed on top of the seeded area as a mulch about 2 inches deep. Also, a part of the north slope was fertilized and seeded but left as a check plot without sawdust.

The median strip was fertilized and seeded and sawdust spread on top as a mulch.

Results and Observations during 1955

(a) Excellent stands of both Bermuda and lespedeza resulted. Throughout the summer and up to October 1955, the lespedeza stood knee high on the area where the sawdust was disked into the soil. This presented a pleasing appearance as well as preventing erosion, even though several hard rains occurred.

(b) On areas where the sawdust was not disked into the soil but was used as a mulch, the sprouting of seed was slower, but finally this method produced a good stand in general, although not as good as the areas on which the sawdust was worked into the soil. It did show a distinct advantage—and has done so in another area—over areas which did not receive any sawdust at all. The median strip of this highway had been seeded for the second time in October 1954. It was seeded again in March 1955, and sawdust was spread as a mulch, 1 to 2 inches deep.

(c) On the check plot (north side) which had no sawdust at all, washing took place again in 1955. (This was also planted for the second time in October 1954.)

Results obtained on this area in 1955 were not nearly as good as on the areas where sawdust was used either by working it into the ground or as a mulch.

(d) The sawdust used on this hydraulic fill was 12 to 15 years old, composed of a mixture of pine-loblolly, longleaf, etc. Examination of the pile in March 1955, showed that native Bermuda had crept up the sides and edges about 3 to 4 feet where no soil whatever was available. Yet there were excellent root systems. No chemical analysis was made.

(e) While an amount of washing takes place in a thin application of mulch sawdust, this washing seems to diminish when the layer is thickened. On the slopes the mulched sawdust washed down a few feet and formed small terraces, leaving a thinner cover between. After the terraces formed and the grass began to sprout, the movement of sawdust practically ceased. The slopes were constructed on a 4:1 ratio.

(f) No mowing was done from planting time in March to October 1955. Crimson clover seed at the rate of 20 to 25 lb. per acre was broadcast over all areas, both south and north sides. The ground was not disturbed. All areas were then mowed in October and the mowings left as a mulch to cover the clover seed.

Observations up to March 15, 1956

The lespedeza stand of 1955 produced more seed than was expected. Lespedeza and crimson clover now cover all areas where sawdust was used. By May 1 to 15, 1956, the crimson clover should be in full bloom.

Bermuda has already begun to put out new, green shoots on the sawdust areas. The check plot is still slower in progress with only a light stand of crimson clover and a smaller quantity of lespedeza and Bermuda.

A valuable point which should not be overlooked is the fact that no mowing, except a final mowing in October 1955, was done. By a planting process, mowings were reduced and an excellent-appearing roadside resulted. Furthermore, by planting a legume, nitrogen was furnished naturally.

2. US 190 Backslopes. East of Opelousas, La.

This location is in the south central portion of Louisiana. The surrounding area consists of fertile, flat farm lands. At this particular point the highway cuts through a ridge about 3/4 to 1 mile wide. The surface soil beyond the tops of the slopes is of fine loamy grade, becoming heavier in clay nearer the bottoms of the slopes. The slopes range from 3:1 to flatter nearer their ends. Several years ago they were "mulch-sodded" during construction. Gradually washes occurred, and the slopes were used as an experimental area for two different soil chemicals.

In March 1955, it was decided to repair the entire area and to use sawdust as an amendment.

The treatment of these slopes was the same as that described for No. 1 project, except that all sawdust was worked into the soil and none was used as a top mulch.

The sawdust used was very old. People in the area stated the sawdust was "piled" long before the 1912 overflow. Exactly how old it was at the time of its

Figure 4. A north slope along US 190 near Opelousas, La., where 50-year-old cypress, oak, and gum sawdust was used as a soil amendment. A thick stand of Kobe lespedeza protects the slope. Photo taken August 21, 1955.

use in March 1955, cannot be determined. It was quite black in color and appeared to be almost entirely rotted. Nothing now remains of the pile except black dirt over which Bermuda and carpet grass have spread since the time of the removal of the pile in March. Judging from other sawdust piles and particularly one which I

Figure 5. South slope directly across from that shown in Figure 4. Bare spots were caused by excessive sawdust which was inadvertently not disked into the soil.

Figure 6. Another northern slope on US 190 where a thinner layer of sawdust was used as a soil amendment. It is believed that, because of less sawdust, the Johnson grass (light-colored stems) was more prevalent here and the stand of lespedeza not as good as on other slopes. Photo taken August 21, 1955.

now to be 30 years old and which does not yet have the black color and rotted ondition that this pile had, I feel that it was at least 50 years old.

It was first thought that the sawdust used on this project No. 2 was pine awdust. Recent investigations showed that this was not likely as there are no ines in the area. Probably it was a mixture of cypress, oak, gum, and other ardwoods.

esults and Observations during 1955

This project, like No. 1, produced excellent results with the lespedeza. The ermuda did not seem to do as well here as on project No. 1. It sprouted but did ot form as good runners as were expected. Some of the spots where the lespedeza as not so rank in growth produced a fair stand.

Crimson clover was planted on project No. 2 in October 1955, and the areas ere mowed for the first time immediately after planting the clover, so that the lippings of lespedeza would serve as a mulch over the clover seed.

Here again (at this writing) project No. 2 has an excellent stand of crimson lover and lespedeza.

ANSWERS TO QUESTIONS AND COMMENTS MADE DURING THE DISCUSSION

It is impossible to recall all questions asked during the discussion and the omments made by others. My answers below and comments quoted are those which I ecall or those sent to me.

. H. Iurka: What about wind blowing the sawdust?

nswer: When the sawdust is disked into the ground, there is little or no loss by ind blowing it away. As a mulch, the dry particles at the top are blown by wind, articularly in exposed places. On project No. 1 it was noticed that the prevail- ng winds from the south blew the mulch sawdust from the median strip across the oncrete to the north shoulder. However, blowing becomes less and less as the rass sprouts and the seedlings increase in growth.

homas J. McMahon: Was there any chemical analysis made of the sawdust?

nswer: No. (Note: Both piles of sawdust used on Projects No. 1 and No. 2 were epleted during operations, and an analysis made now of the sawdust in place on the ites would not show a true analysis of the original piles. The remains of these iles are down to the surface dirt.)

r. McMahon set forth his comments and suggestions in a prepared summary quoted elow.

> The pictures which Mr. Slack presented showed an excellent grass development which was characterized by the absence of weeds. Mr. Slack had stated that the sawdust used as a soil mix was 50 to 75 years old.
>
> The question, "Was any chemical analysis made of this sawdust?" was raised. Neither Mr. Slack nor anyone present knew of any chemical analysis made of the sawdust. Mr McMahon suggested that there must be present in the sawdust some of the chemicals which occur naturally in a plant as growth stimulaters or inhibitors. It has been established that the roots of red fescue ex-

udate a chemical which inhibits the germination of rape seed.

It was the Swedish chemist Osvald who, in 1947, succeeded in isolating this root exudation and, by introducing it into the soil in which the rape seed was planted, succeeded in preventing the germination of the rape seed free from the red fescue itself. These chemicals, which are known as auxins, occur naturally in the plants and, depending upon their location in the plant and the amount of concentration, may either stimulate or inhibit growth.

Mr. Slack confirmed the phenomenon of no weeds in the sawdust-treated soil. Mr. Slack observed that only a few coffee plants appeared, whereas in areas not treated with the sawdust considerable weed growth occurred.

Mr. McMahon suggested that because it is not possible to secure sufficient sawdust to treat all roadsides, it might be worthwhile to have the sawdust analyzed to determine the chemical content, If the chemical which acts as a weed inhibitor can be isolated, there may be an opportunity to introduce the chemical to other soils on a mass basis. He suggested further that this chemical occurring in the sawdust might very well be a herbicide similar to the systemic hormones, such as 2,4-D, etc.

W. H. Simonson and George B. Gordon made observations on the nature of the bacterial action which occurs in sawdust and raised the question of the 2,4-D and its bacterial sensitivity.

Mr. McMahon observed that 2,4-D also is subject to bacterial action, that bacteria will completely break down 2,4-D 14 to 21 days after its introduction into the soil. He observed further that 2,4,5-T methylcholrophenoxyacetic acid and other systemic herbicides are broken down by bacterial action and might be further closely related to the chemical which may be found in sawdust.

Mr. Simonson and Mr. Gordon observed that the age of the sawdust is a factor in use and that any test should contemplate the age of the sawdust. Until the bacterial action is completed, one might not secure the same result which Mr. Slack secured in Louisiana.

Mr. McMahon suggested that an excellent source of information on the subject of the growth stimulaters and inhibitors was the book "Plant Growth Substances" by Dr. L. J. Audus, which contains considerable data on the subject. He referred particularly to Chapter IX.

George B. Gordon commented on the carbon-nitrogen ratios involved in using sawdust, hay, straw, wood chips, peat moss, and other organic materials. His comments are quoted below.

After slides were shown by Mr. Slack illustrating use of 50-year-old sawdusts as a soil-amendment material in Louisiana, the following comments were made:

In using sawdust, hay, straw, wood chips, peat moss, or other organic materials in amending soils, it is important to consider the so-called carbon-nitrogen ratios involved.

Fresh sawdust or grain straw, for example, may contain carbonaceous materials in ratio to total nitrogen of something like 60-70:1. A well-rotted sawdust as shown in Mr. Slack's slides may, after 50 years or so of weathering and bacterial action, be reduced to a carbon-nitrogen ratio on the order of 20:1. This contrasts with what is called humus, an organic material broken down in natural soils until it combines with mineral soil particles. Humus is said to have a carbon-nitrogen ratio on the order of 10:1.

As brought out in a book by Donald P. Hopkins (1945) titled "Chemicals, Humus and Soil," Chemical Publishing Company, New York, N. Y., when we add raw organic materials to soil we are not adding "humus" but a material which after many years of bacterial and weathering action will be reduced to somewhere between its original 50:1 to 75:1 ratio and the 10:1 carbon-nitrogen ratio of humus.

This reduction of the carbon-nitrogen ratio can, it is known, be greatly accelerated by adding high-nitrogen fertilizers to soils treated with organic materials. Humus in Mr. Hopkins' book is defined as "Not the total aggregate of organic matter (in a soil) but only that fraction of it which can combine WITH THE MINERAL PART OF THE SOIL."

We can, no doubt (and Mr. Slack's experiments point in that direction), improve soils for turf growth by adding well-rotted sawdust before seeding. However, if we are to get results, we must add fairly heavy applications of nitrogenous fertilizers at the same time. Without this nitrogen, the addition of heavy amounts of organic materials such as sawdust might, if the rate of sawdust applications were very high, actually prevent active growth of seeded grasses, or very much retard such growth.

'esley Hottenstein: Question about the cost of operations.

nswer: Precise records were not kept of the cost of applying sawdust to these two rojects. There was other work done, such as hauling in and spreading clay to fill ashes on project No. 1. On project 2 complete regrading was done. The haul of awdust on project 1 was a shorter haul than on project 2. Sawdust itself is free or the hauling, and much more of it can be hauled in a load (by building up the ides of the truck body) than in hauling other materials such as dirt, sand, or ravel. It would not be deemed economical to use sawdust if the round-trip haul ould be excessive, say 25 to 30 miles, as one case has recently presented itself. he round-trip hauls on these two projects were about 10 to 12 miles for project 1 nd 15 to 18 miles on project 2.

If I recall correctly, my answer to Mr. Hottenstein was $100 to $150 per acre. owever, this figure could not include the other work done.

uestion: What about the spots of color on the slope?

Answer: This question referred to a specific picture of one of the slopes in project 2 (Opelousas, La.). The color spots were caused by close-knit vines.

However, on another slope there were a few bare spots which at the time of the above question were probably not fully explained.

It was noted that some of the sawdust may have been burned, as burned chips appeared in it. It may be that the bare spots were due to excess potash. A very recent investigation showed also that where the bare spots occurred the sawdust was excessively deep (in some places 4 inches or more) and was not disked into the soil properly. Such spotting was not noticed on project No. 1.

Question: About rain.

Answer: On April 9 and 10, 1955 (about two weeks after finishing project 2) it rained for 24 hours throughout central and south central Louisiana in which project 2 is located. On April 11 there were intermittent rains. Then on April 12 hard driving rains (and tornadoes predicted) fell. Near Alexandria 5 inches fell on another project on April 12 in a few hours, and in the Opelousas area it was reported to me that 9 inches occurred on April 12. This, with the rains of April 9, 10, and 11, added up to at least 12 and probably 14 inches for the total. They were sufficient to wash out the shoulders over a 5-mile stretch of newly constructed highway about 10 to 15 miles north of project 2, where grass had already made a good start. Yet on project 2, where the sawdust was used, the backslopes showed no damage except one minor wash where the water ran from a field and over the backslope.

Additional Remarks about Mr. McMahon's comments:

There is no question about the weed growth being less on the areas where sawdust was used on project 2 and also on project 1. This may be due to a chemical exudation within the sawdust, as pointed out by Mr. McMahon. The question opens up a broad field of chemical investigation which, in my opinion, my Department under present conditions would not be able to handle. Future sawdust piles can be analyzed before using, but from the practical use of sawdust in the past I believe there would be many more points to consider other than analysis when considering the spotted condition. Analysis, however, would be a step and an important one. In subsequent correspondence, Mr. McMahon presented more information to me along this line for which I am grateful.

Additional Remarks about Mr. Gordon's comments:

I agree with Mr. Gordon that nitrogen should be added to sawdust and other organic materials when such are applied to the soil. Mr. Simonson also mentioned this point during the discussion.

Also, I agree that the age of the sawdust should be considered. In the discussion I referred to a bulletin, the number of which I had forgotten. That bulletin is "The Use of Sawdust for Mulches and Soil Improvement," U. S. Department of Agriculture, Circular 891, November 1951. This circular discusses the chemical analysis of sawdust and its practical application. It also stresses the use of nitrogen.

After intermittent experiences with sawdust over a period of time, it is my belief that many factors must be considered besides the chemical analysis of the sawdust to determine a standard amount of nitrogen to add. It seems that chemical analysis of the soil conditions should be considered for the nitrogen content and,

'urthermore, for the crop to be planted. Planting legumes provides an additional mount of nitrogen naturally; this would lessen the amount of nitrogen to be added ;o the sawdust at the outset.

Nitrogen was not added to either project 1 or 2 in the amount called for in ;ircular 891, nor has that amount ever been added to any sawdust I have ever ap-)lied. Yet, results which I consider good and even excellent have been obtained.

In these two projects the soils were entirely different. The same methods .nd procedures were followed in the amendment procedures. One pile of sawdust was ıot nearly as old as the other. The older pile was rotted while the younger pile ;as not. Yet, the general appearances and the results were favorable and much .like, except for details which I have mentioned. I do not predict what will hap-)en to either project during the summer months of 1956. At this writing both pro-ects are similar as to crimson clover stands.

There is plenty of room for investigation in the use of sawdust, and I believe .t is worthwhile for others to try it. By a comparison of efforts and results, awdust may become more useful in our highway work, particularly in the states ;here many piles exist. I am quite certain of one definite point, and that is his: Sawdust is an excellent material for holding moisture in the soil, either ;y a surface mulch or soil amendment.

The work on these projects was done by the maintenance forces of the respec-ive districts in which they are located:

Project No. 1.	District 07.	J. C. Watson, District Engineer
		L. D. McCorquodale, Assistant District Engineer
		Theo. Chenet, Resident Maintenance Engineer
Project No. 2.	District 03.	J. E. Jarman, District Engineer
		E. E. Guillot, Assistant District Engineer
		J. C. Fridge, Resident Maintenance Engineer