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Weeping lovegrass and sericea lespedeza control erosion. Woody Plants become established on slopes.

For Highway Rights-of-Way

Direct Plantings

By H. W. EVERETT
 Manager, National Plant Materials Center
 Beltsville, Md.

NEW HIGHWAYS yearly add thousands of acres of vegetation for state highway departments to maintain. Maryland alone seeds and mulches 2,000 acres of disturbed soil on highway projects annually. Such vegetation costs more to maintain than woody cover.

Thus in 1966, the Maryland State Roads Commission and the Soil Conservation Service signed a cooperative agreement, with the approval of the Bureau of Public Roads, to study effective and economic ways to establish woody plant materials on roadside sites. Establishment of low-maintenance plants on part of the normal right-of-way would allow more adequate treatment of sod areas.

Rather than miles of neatly mowed, or somewhat neglected grass, the motorist would have a varied landscape of trees, shrubs, wildflowers, and grass. Idea was to reduce maintenance costs, but not compromise stabilization, erosion control, and natural beauty.

Plant testing and studies are now

being conducted in the three climatic zones of Maryland. Many test sites in the Coastal Plain are problem areas. These consist of sandy, infertile, and droughty soils. The Piedmont soils rate fair to good in fertility, organic matter, and water-holding capacity, though sites with poor fertility and excessive drainage can be found. Shallow, poorly developed, rocky, and droughty shale soils are typical of many Appalachian sites. Both field and laboratory testing has also been done in sandy loam.

Hand-planting seed of many woody species—in the greenhouse, in cold frames, and on roadbank sites—to evaluate emergence results has been tried. Based on favorable emergence results, a corn planter was modified to direct-plant woody species. The machine includes a scalper, sod-seeding shoes, a press wheel, and a drag chain to incorporate seed and fertilizer into the soil. This machine will scalp a 10-inch sod strip, place seed of woody species $\frac{1}{4}$ inch to $\frac{1}{2}$ inch deep, place fertilizer to the side

and below the seed, and cover the seed and fertilizer. In one operation this machine plants two rows of woody seed and places a high phosphorus fertilizer under the soil surface for seedling use.

'Arnot' bristly locust (*Robinia fertilis*), silky dogwood (*Cornus amomum*), smooth sumac (*Rhus glabra*), and indigobush amorpha (*Amorpha fruticosa*) have produced the best stands to date. Using the modified corn planter drawn by a wheel-type tractor, plantings could be made on level areas and on relatively flat slopes in order to control erosion, drifting snow, and noise, or to serve as a natural screen.

One of the test hydroseedings of the cooperative project was the seeding of woody species on 40 acres of the John F. Kennedy Memorial Highway, Interstate 95. Since initial construction in 1963, the original seeding had failed. Slopes were actively eroding. Sedimentation in drainage ditches, roadside unsightliness, and increasing maintenance costs prompted action.

In October 1966, problem areas were checked. Plant materials adaptable to these soils were selected. Soil types included Tuxedo, Glenelg, Aura, and Beltsville. A report recommended that basic erosion repair and slope reconstruction were needed on 40 acres. Several low-maintenance cover-companion and woody plant species were recommended for use in the reseeding attempt. Plans were carried out in the spring of 1968.

Following erosion repair and slope reconstruction, the contractor applied 2 tons of dolomitic limestone and 250 pounds of triple superphosphate (0-46-0) per acre to all areas. Lime and fertilizer were worked into the top 2 inches of soil by dragging the slope with a harrow. The basic seed mixtures, woody species additives, and fertilizer used are shown in the accompanying box.

Basic seed mixtures were required to provide immediate erosion control on the slopes and to allow woody plant establishment between bunchgrass plants. Basic Mixture No. 1 was used on 8.36 acres, and Basic Mixture No. 2, on 31.10 acres. In the actual hydroseeding operation, woody species 1-A was added to a hydroseeder filled with Basic Mixture No. 1 and seeded on a designated site. Woody species 1-B through 1-E were added later, each to a separate tank of Basic Mixture No. 1 and seeded on separate sites. Basic Mixture No. 2 with its woody seed additives was seeded the same way.

Inoculant for leguminous plants was used at four times the recommended rate per unit of seed. All seeded areas were mulched with 2½ tons of wheat straw, and this mulch was cut in with a mulch-anchoring tool drawn by a small bulldozer. Areas inaccessible with the bulldozer were tacked with asphalt. Near the crest of many slopes, oak (*Quercus*) and maple (*Acer*) were hand planted in clumps using seven seeds per group at 1-inch to 2-inch planting depths.

Over the past three growing seasons the seeded areas have progressed from early cover-companion stabilization to present woody plant establishment. By August 1968, all slopes were stabilized with weeping lovegrass and sericea lespedeza. A followup fertilization of 10-20-20 and 38-0-0 at 500 lbs. per acre each was made. No woody seedlings were observed in 1968, and areas seeded to Basic Mixture No. 1 contained a sparse stand of crownvetch in addition to weeping lovegrass and sericea lespedeza.

In 1969 weeping lovegrass and sericea lespedeza were providing most of the plant population, but crownvetch and coralberry were the next most numerous species on their respective seeding sites. Other woody species observed in good distribution but in fewer numbers were as follows:

Scotch broom	<i>Cytisus scoparius</i>
fragrant sumac	<i>Rhus aromatica</i>
flameleaf sumac	<i>Rhus copallina</i>
Siberian crabapple	<i>Malus baccata</i>
cockspur hawthorn	<i>Crataegus crusgalli</i>
lespedeza	<i>Lespedeza daurica</i>
lespedeza	<i>Lespedeza daurica shimadai</i>
lespedeza	<i>Lespedeza japonica intermedia</i>

During 1969 weeping lovegrass set a good crop of seed, and sericea

Modified tool bar planter (F-76) with winged-sweep opener removes 10-inch sod strip, places fertilizer in 1-inch band to side and one inch below seed. Seed is planted ¼" to ½" deep and drag chain aids covering of seed. Large zero



BASIC SEED MIXTURE No. 1

Common Name	Scientific Name	Rate/Acre
weeping lovegrass	<i>Eragrostis curvula</i>	3 lbs.
sericea lespedeza	<i>Lespedeza cuneata</i>	20 lbs.
Scotch broom	<i>Cytisus scoparius</i>	2 lbs.
flameleaf sumac	<i>Rhus copallina</i>	} mixed 2 lbs.
fragrant sumac	<i>Rhus aromatica</i>	
crownvetch	<i>Coronilla varia</i>	20 lbs.

Woody Species Additions to Basic Seed Mixture No. 1:

Code No.	Common Name	Scientific Name	Rate/Acre
1-A	Scotch pine	<i>Pinus sylvestris</i>	2.16 lbs.
1-B	Amur honeysuckle	<i>Lonicera maackii</i>	.79 lbs.
1-C	memorial rose	<i>Rosa wichuraiana</i>	1.5 lbs.
1-D	Siberian crabapple	<i>Malus baccata</i>	1.19 lbs.
1-E	black-eyed-Susan	<i>Rudbeckia hirta</i>	} .33 lbs. 1.44 lbs. (mixed) .33 lbs.
	common lilac	<i>Syringa vulgaris</i>	
	New Jersey tea	<i>Ceanothus americanus</i>	

Fertilizer: Inorganic: 10-20-20 @ 400 lbs./acre
Organic: 38-0-0 @ 440 lbs./acre

BASIC SEED MIXTURE No. 2

Common Name	Scientific Name	Rate/Acre
weeping lovegrass	<i>Eragrostis curvula</i>	3 lbs.
sericea lespedeza	<i>Lespedeza cuneata</i>	20 lbs.
bayberry	<i>Myrica pensylvanica</i>	6 lbs.
coralberry	<i>Symphoricarpos orbiculatus</i>	3 lbs.

Woody Species Additions to Basic Seed Mixture No. 2:

Code No.	Common Name	Scientific Name	Rate/Acre
2-A	American bittersweet	<i>Celastrus scandens</i>	.75 lbs.
2-B	cockspur hawthorn	<i>Crataegus crusgalli</i>	1.0 lbs.
2-C	eastern redcedar	<i>Juniperus virginiana</i>	1.0 lbs.
2-D	lespedeza mixed	<i>Lespedeza daurica shimadai</i>	2.0 lbs.
		<i>Lespedeza daurica</i>	
2-E	lespedeza	<i>Lespedeza japonica intermedia</i>	2.0 lbs.
2-F	Austrian pine	<i>Pinus nigra</i>	1.0 lbs.

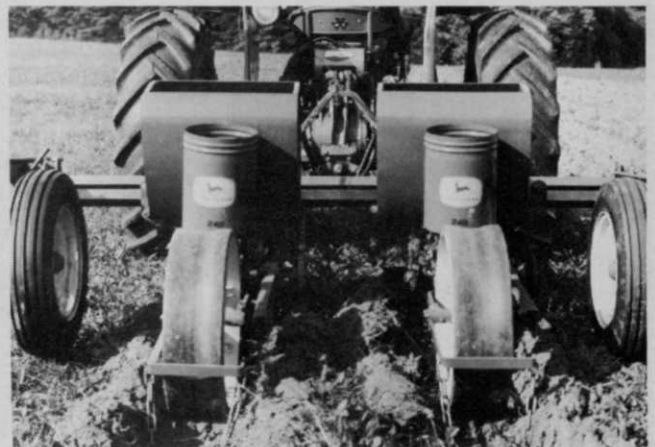
Fertilizer: Inorganic: 10-20-20 @ 500 lbs./acre

lespedeza produced some seed for reseeding sparsely vegetated areas. Spot planted species emerged and were very successful. Woody volunteers, including poplars (*Populus* sp.), black locust (*Robinia pseudoacacia*), staghorn sumac (*Rhus typhina*), smooth sumac, and flameleaf

sumac were noted with several colonies of sumac becoming extensive.

Observations of the seeded sites were made in June and August 1970, the third growing season following seeding. All slopes were stabilized. Areas seeded to the mixture con-

pressure tires and wheels drive seeding and fertilizer units. Outer gauge wheels (3.90 x 15") aid in controlling depth. Note the larger 24-inch drive wheel and drag chain.





Cover-companion species (weeping lovegrass and sericea lespedeza) allow seedling of woody lespedeza to establish (Spring '69).



Mulch anchoring tool for incorporation of seed and mulch with soil requires heavy power unit. Work was done on the John F. Kennedy Memorial Highway in the state of Maryland. Effort was a government research project in cooperation with state.

taining crownvetch are being dominated by this plant. The crownvetch is setting an excellent crop of seed. Areas seeded to the mixture containing coralberry have good plant stands of that species 8 to 36 inches high. Density varies, with the heaviest stands occurring in areas of low-

est competition. All other woody species observed in 1969, with the exception of Scotch broom and Siberian crabapple, are present in 1970. Most are 8 to 10 inches tall, but some of the lespedeza is blooming and should set seed this year.

Weeping lovegrass and sericea lespedeza are acting as a cover-companion crop. They are stabilizing the slopes with a protective canopy of vegetation and an extensive root system, and acting as a living mulch for volunteer and seeded woody species. They will provide an attractive low-maintenance cover until the later stages of succession dominate.

In addition to being tested in direct mechanical seedings and hydroseedings, many species have been tested and compared in line-out stock plantings, row seedings, herbicide trials, mulch trials, and peat pellet seedling trials.

Acceptable species for use on roadsides must be easy to establish, adaptable to subsoil sites, and relatively free from pests. They must have aesthetic value, including desirable form and size. And they must have conservation value. Many species have failed to meet

these criteria in one or more test plantings; some species have been successful.

Test plantings have shown that establishment procedures can differ from species to species. Some species are unadaptable to certain soils and sites. The grass used for initial erosion control when seeding woody plants must be a bunchgrass to reduce competition and allow woody seedlings to establish between grass plants. In several plantings adequate mulch and mulch tacking have proven beneficial for erosion control and stand establishment. Many sites have proven unacceptable as test areas because herbaceous plants grow rapidly after the sites are fertilized.

As a result of fertilizer applications, some sites prepared for test seedings by mowing, spraying, and grubbing out sparse vegetation looked, 2 years after seeding, as though they had never been disturbed.

In plantings where the seed of woody species is incorporated into the soil, germination and establishment have been higher per unit area. Merely broadcasting the seed on the roadside does not, in most

**Coming
In
WTT
For July:
The Big
Aquatic Weed Control
Issue**



Oak seedlings were four feet high by August '70.



Spot planted oak seedlings on John F. Kennedy Memorial Highway emerged in the spring of 1969.

cases, produce a satisfactory stand of woody plants.

Establishment of many shrub and tree species may be possible by direct seeding. Additional tests are needed and will be carried out. A beginning has been made and when the final plantings have been evaluated, direct seeding of woody plant material should be a commonplace.

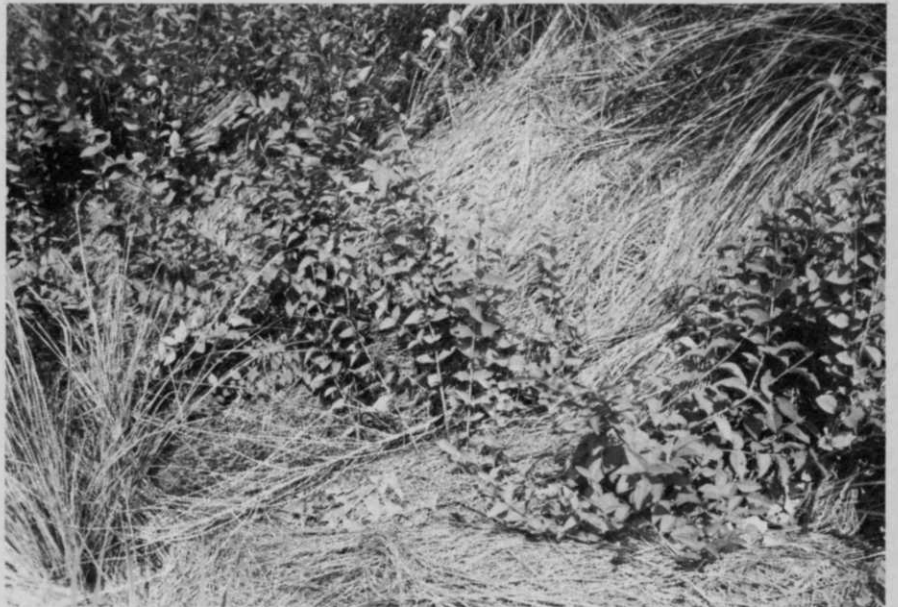
Adapted from a report by H. W. Everett, Charles R. Anderson, Gary V. Schultz, and Richard Dudley, Agricultural Research Center, Beltsville, Md., presented by Mr. Everett at the Twenty-ninth Ohio Roadside Development Short Course at Columbus, Ohio.

Toro Purchases Viking Corporation

Toro Manufacturing Corporation at Minneapolis, Minn., has just purchased Viking Manufacturing Corporation of Manhattan, Kan.

Viking makes a roller blade line of turf-conditioning equipment, a tool which handles various cultural practices from rough grading through seeding and fertilizing. The new addition to Toro's line of mowers and others turfgrass care equipment will be known as the Toro Landscaper. It will be produced in Toro's Minneapolis plant and marketed through Toro's Turf Products Division.

Toro's president, David T. McLaughlin, in announcing the purchase said that key markets sought for the new machine would include golf courses, parks, schools, cemeteries, landscape contractors, and sod growers.



Coralberry seedlings grow through weeping lovegrass cover — companion species. Photo made August 1970.

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Pesticide Legislation — Just Where Are We Headed

HARD NEWS on pesticide legislation is right now in a lull period. Public hearings before both House and Senate committees in Congress have ended—for the Federal Environmental Pesticide Control Act of 1971. Debate on the floor of Congress is not as yet scheduled.

Of the deluge of bills submitted on most every conceivable phase of the current pesticide hassle, only the one major piece of legislation — H.R. 4152 (the House version) and S-745 (Senate) — seems certain of serious congressional consideration this year. No other Federal pesticide bills show promise of being recalled from committee.

But this one major bill, almost sure to be passed (with amendments) this year or in the foreseeable future — the Federal Environmental Pesticide Control Act of 1971 — has the backing of most segments of the pesticide industry, (with suggested changes), including both manufacturers and users. Even many of the ecology and environmentalist groups support major aspects of the bill.

In brief, this Bill (H.R. 4152 and S-745) revises the current Federal Insecticide, Fungicide, and Rodenticide Act and substitutes stronger pesticide controls in a number of areas.

For example, the changes would (1) designate some pesticides for general use, (2) limit some to use by licensed professionals only, and (3)

limit others for use by permit only. Further the Bill places great discretion as to pesticide use in the hands of the Administrator of the new Environmental Protection Agency.

Promising to dwarf in volume the Federal legislation are measures being considered by a number of states. A total of 48 state legislatures are in session this year. All have bills relating to pesticide use, pollution, and the environment in general before them. No judgment as to the effect these state bills will have on local pesticide use is possible at this time.

However, the most heartening aspect of the total picture is the surfacing of considerable pro-pesticide practical research. After a two-year lull, a considerable amount of practical research is coming to light. All segments of the industry seem to be pulling together solid data on which to base decisions — and which both legislators and the industry can use for the common good.

One example concerns contamination of ground water and has been released by North Carolina State University. In this pioneering study on the movement of DDT and toxaphene in surface water, some so-called “surprises” were evident. The N.C. study showed: (1) less environmental contamination (about half) was found when DDT was used in combination with toxaphene than when DDT was used alone; (2) only small amounts of the chemicals were found outside the areas in which they had been applied; and (3) the toxaphene proved to be less persistent than originally thought, though it did pose other problems.

This study was conducted on a cotton crop, to determine movement of insecticides in runoff water. Dr. J. R. Bradley, N.C. Univ., said the crop was treated 12 times at weekly intervals. Only four percent of the DDT and one percent of the toxaphene later appeared in surface runoff water. But practically all that did move off the crop area in surface water was attached to soil particles which moved due to erosion. In short, the chemical left the field while clinging to soil particles being washed away. Dr. Bradley has pointed out that soil conservation is one tool available to prevent contamination of water by DDT and other persistent pesticides.

Another industry plus are manufacturer actions such as one just announced by Dow Chemical — the formation of an Environmental Testing Advisory Board. This board will serve as Dow's technical authority advising all functions and manage-

ment levels on effects of products and new or changed processes. It will also advise on registration requirements and on customer and public environmental safety needs.

Specifically, the Dow board will (1) establish standardized test procedures, (2) assess capabilities of both Dow and non-Dow laboratories and identify those best able to conduct specific environmentally related experiments, (3) serve as a repository for data acquired from studies conducted outside of Dow, (4) help interpret experimental results, and (5) provide advice and recommendations on such environmental testing. Chairman is Dr. Charles W. Hinman, assistant director of Corporate Research and Development. Many groups outside the industry have begun to lend support.

The U.S. Chamber of Commerce for example, has taken a strong stand supporting a sane approach to legislation relating to pollution control and the environment in general. This group presents a powerful voice. President of the U.S. Chamber F. Ritter Shumway, stated that "there is a regrettable tendency in American society to search for a villain behind every problem." The Chamber message by Shumway says

simply that, "It took us years to foul our environment, and it is going to take us years to clean it up. In the process, we must take great care to avoid creating new problems even bigger than the ones we are trying to solve.

"Extremism in any cause, however noble, usually provokes a counterreaction. The environmentalist cause is a good one. I would hate to see it discredited and forgotten by the American people because of immoderate conduct on the part of some overzealous crusaders who are more adept at generating emotions

than in digging out facts."

Meanwhile, the EPA is continuing its "administrative review" of DDT, 2,4,5-T, aldrin and dieldrin, concerning present labels. These evaluations are not connected to legislation. The EPA has authority to issue registrations and lift bans if deemed advisable by the agency itself. Thus, solid data which can be made available by the industry — including users, manufacturers, researchers, etc. — will without doubt have a bearing on Federal regulatory agencies, of which the EPA is now the foremost.

NEW 72" AND 90"

TERRAIN KING FLAIL MOWERS

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The knives in Terrain King's new Flail Mower can be changed without tools — from a selection that tailors the Flail Mower to your exact requirements. And the knives are reversible for extended service life.

Extra heavy duty bearings and rugged frame and roller contribute to long, trouble-free life.

The Flail Mower is especially safe for the operator, pedestrians and property. Guards for both the drive line and the gear box are standard. The rotor enclosure and a heavy flap type deflector positively control flying debris.

The Flail Mower adjusts easily for cutting heights from 1-1/4" to 7". It is available in lift or pull models, in 72" and 90" cutting widths.

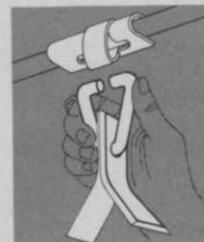
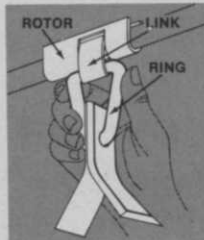
Many of your mowing needs fall easily within the Terrain King Flail Mowers capabilities. The Terrain King One Complete Mowing System, comprising a wide selection of single unit Rotary Mowers, the 15' and 25' Wide-Swath Rotary Mowers, the versatile Slopemower* and the unique RAIL-BIRD®, can handle the rest.

What's The Difference

Part of the trouble that we're having today in understanding the pesticide situation is that we don't understand the language being used. Let's get a couple of terms straight; they are CANCELLATION and SUSPENSION.

CANCELLATION — means that the procedure in section 4C of the Federal Insecticide, Fungicide, and Rodenticide Act is enforced. Section 4C reads that the Secretary of Agriculture (now its Administrator is EPA) may refuse to register a pesticide. He informs the manufacturer of this and the manufacturer has 30 days after receiving the notice to file objections. If he files objections, a committee is appointed to study the pesticide in detail. Eventually a decision is made by the administrator. **In the meantime, the pesticide in question may continue to be used.**

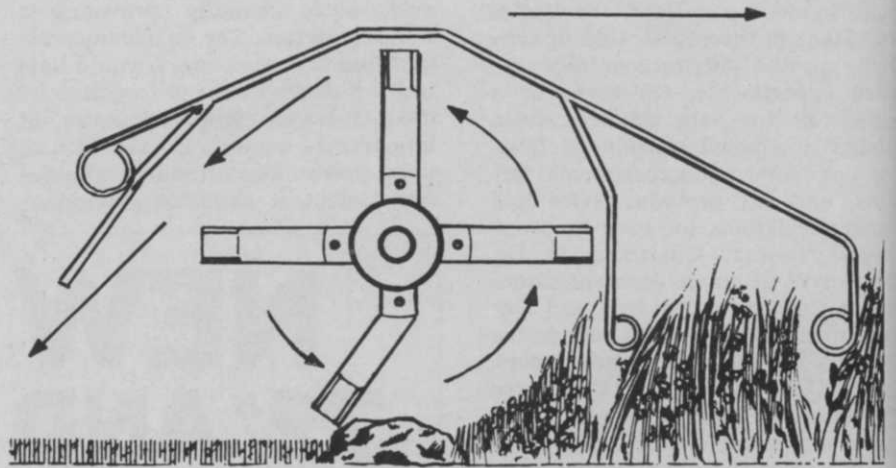
SUSPENSION — means the pesticide in question cannot be used.



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*Slopemower and RAILBIRD are trade marks of Astron Corporation, a subsidiary of Engler Manufacturing Corporation.



'Why I Believe in Flail Mowers'

By **ELMER MOTT**
Mott Corporation, LaGrange, Ill.

COMMERCIAL TURF is big business today. Maintenance is technical and expensive. Professionals in the business may find themselves charged with the greenbelt area of a shopping center, or with the vast sodded areas of an airport. These plus golf courses, factory lawns, city median strips, parks, highway and utility rights-of-way, athletic fields, and a host of other turfgrass areas have led to development of a \$5 billion industry.

Commercial turfgrass areas today range from the very small to the vast, smooth or rough, clean and trashy, level or steeply banked. Vegetation may range from fine lawn type grasses regularly cut and closely cropped to tough field grass growing thick, high and intermittently cut, to weeds and brush, or even revenue producing seed or hay crops.

Moisture conditions may range from dry to "liquid wet!"

A mower must be capable of meeting these conditions. Further, and most important, it must do so with complete safety. Commercial turf areas may involve many people and autos. A misguided object, thrown out by a mower, can result in extremely serious bodily injury or expensive property damage.

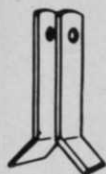
To meet these conditions, the commercial mower must have many qualities. Some, such as width of swath, maneuverability and steep slope stability relate to individual model design and have no bearing as to type. The reel, the rotary and the flail all are available in sizes ranging from small compact highly maneuverable units to wide swath gangs.

Other mowing performance factors such as cutting effectiveness on all types of growths (fine lawn grass, tough field grass, weeds and brush, short or high) on all types of terrain (smooth or rough, clean or trashy, wet or dry); mowing speed; simplicity of operation and safety are directly related to mower type.

The cutter bar, the reel and the rotary have been around so long most are quite familiar with their capabilities and limitations. I am not so sure there is the same degree of understanding about the flail, and in as much as this is "The Case for the Flail," I will direct my comments mostly thereto.

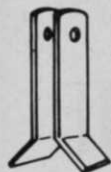
Flail has come to mean a type of mower consisting basically of a horizontal shaft designed to rotate at moderately high speeds and attached thereto a number of free swinging knives, cutters, blades,

Flail Mower Blades Available



GENERAL PURPOSE

C5 (3/4 x 5" pin mounted) Standard. Recommended for general purpose mowing of grass and weeds, and mulching leaves. Used in clean areas relatively free of rocks and trash.



TOUGH CUTTING—SCALPING—OVER SEEDING

H386 (1 1/4 x 5" Hardened-pin mounted) For extremely tough cutting conditions and for renovating (scalping or over seeding). The greater weight of this knife provides more cutting authority and the extra width increases the useful life almost three times over that of the C5 knife listed above.



THATCH THINNING

H387 (1 1/4 x 5" Hardened-pin mounted-straight knife) Used singly with spacer washers rather than in pairs like the other MOTT knives. For Thatch Thinning. Set cutting height to near ground level or slightly below.



ROCKS & TRASH

H293 (1 1/4 x 3" Hardened-Ring mounted) For Heavy Duty mowing operations in rocky, trashy areas. The ring mounting of the knives provides flexibility to allow the knife to move in all directions, sideways as well as fore and aft, thus minimizing the possibility of a knife bending or breaking.

beaters, chains or the like—referred to in themselves as flails. These rotate in a vertical plane about the horizontal shaft, centrifugal force holding them straight out during operation.

Just as there are variations within the families of "reel," "rotary" and "cutter bar" mowers, so there are within the family of "flail" mowers. Dependability or structural integrity is a matter of design detail and will vary depending upon the manufacturer and model offered.

Versatility of performance, cutting ability, and power requirements also will vary depending upon the style or type of the individual cutters or "flails" used. Generally speaking, the sharpened knife type flail, mounted to cut with an edge-wise slicing action, cut more efficiently, take less power, are lighter and therefore operate with a greater degree of safety than other type flails. Even so, all flail type mowers provide far greater operational safety than do rotary type mowers. The reason is a simple matter of physics. Both types cut with an impact action rather than with a shearing action such as the reel and cutter bar types use. Indeed, the flail mower is sometimes referred to as a "vertical rotary."

The impact force imparted by the cutting blade upon contact with an

object, whether it be the vegetation to be cut, or a rock, is dependent upon the mass (weight) of the blade and the square of the impact velocity. Thus a rotary blade weighing 10 pounds, moving with a tip speed of 150 mph has over 400 times the impact force of a flail blade weighing 1 1/2 ounces traveling with a tip speed of 75 mph.

The point is that the light weight 1 1/2 ounce flail blade traveling 75 mph, especially the thin sharpened knife type blade, does impart enough impact force to cut the heaviest of grass and weeds and even light brush up to about one inch in diameter, but does not deliver excessive forces that can hurl a struck object with the speed of a bullet.

Another factor that adds to the

safety aspect of the flail mower is its vertical mode of operation. A horizontally acting rotary tends to move cuttings and struck objects out horizontally in all directions and, to be rendered usable with some degree of safety must be heavily guarded with solid sheet metal or flexible chain shields which extend down to the ground on all sides. However, a discharge chute of some sort is needed to provide means for the ejection of cuttings, so complete guarding is well nigh impossible.

On the other hand, the flail, operating vertically, has no tendency to move cuttings or struck objects sideways, an excellent feature when moving along roadways as nothing is ejected onto the roadway. Most flails

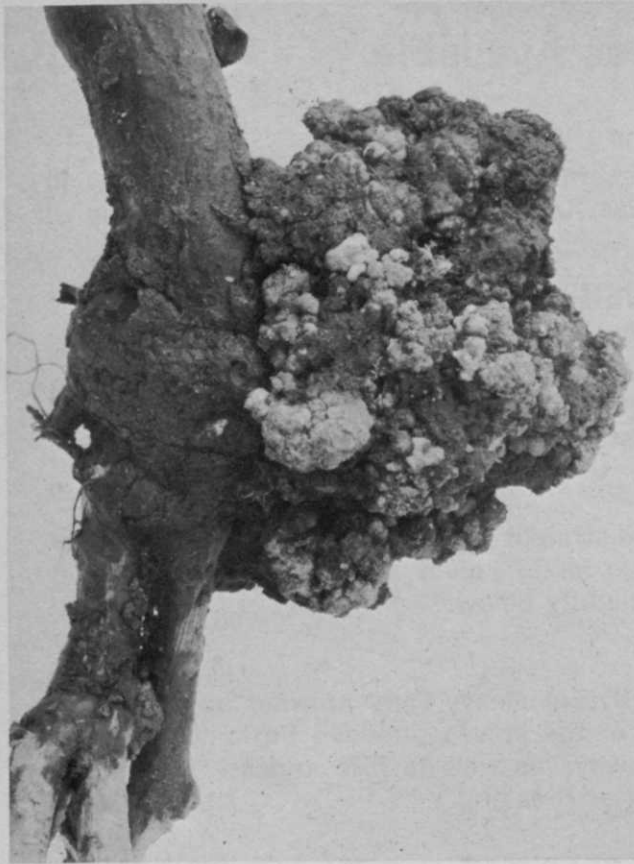
(Continued on page 38)

PLANNING A GOLF COURSE?

If your organization or public works agency is planning a golf course, obtain construction bids and advice from experienced golf course contractors who are members of the Golf Course Builders of America, Inc. Our Builder members will contact you.



GOLF COURSE BUILDERS OF AMERICA
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Washington, D.C. 20006



Crown Gall of Woody Plants

By DR. W. C. HOCK

Plant Pathologist
United States Department of Agriculture
Delaware, Ohio

CROWN GALL is a widely prevalent and destructive disease that occurs on a wide variety of plants including at least 145 genera within 61 widely separated plants families. We here are, of course, more familiar with crown gall on shade, fruit, and nut trees, and on woody and herbaceous ornamentals.

The disease is caused by the bacterium *Agrobacterium tumefaciens*. The organism enters the plants only through wounds. Direct penetration through uninjured plant tissues has not been reported. The most common site of gall development is on the roots of the crown area, but galls may also appear on stems and other above-ground plant parts such as occur on quince, apple, rose, euonymus, willow, and poplar, to name a few.

Severity of crown gall disease depends on several factors:

- 1) species infected,
- 2) location and number of infections,
- 3) size of the galls — incidentally, galls can vary from size of a pea to galls that weigh 50 to 100 pounds.
- 4) and whether or not secondary infections have occurred.

How does the disease affect the

plant and what is the economic impact of the disease to the grower?

Crown gall can reduce the productive life of plants by weakening the stems, disrupting the translocation system, predisposing them to secondary pathogens, and producing a general decline in vigor. Secondary fungus infections from galls in the crown area often result in heartrots which cause trees to die or fall over. For example, hundreds of almond trees in California die or are blown over every year due to heartrot caused by crown gall infections which occurred many years earlier.

Crown gall is a primary cause of condemnation of nursery stock. Substantial losses are sustained by nurserymen discarding trees and shrubs infected with crown gall. A 1963 report estimated that losses in California orchards alone exceeded \$6 million annually. Undoubtedly, this figure today approaches the \$10 million mark. The disease often is initiated right in the nursery when planting liners, propagating, harvesting, or during procedures that may injure the plant; however, it can occur anytime during a plant's life. Since the disease is generally considerably more serious when infection occurs during the first 3

years after planting, extra precautions must be taken to avoid wounding during this period.

How can the grower prevent and control crown gall infections?

1. Avoid wounds during planting, cultivating, and digging.
2. Use disease-free stock — that is, inspected and certified stock.
3. Dip plant stock — since there are many opportunities for apparently disease-free stock to be carrying the bacterium, dip the roots in a bactericide prior to planting.
4. Extreme care should be used in grafting to avoid transmission of the bacterium from one plant to another.
5. Rotate crops and select clean ground. Fumigate, if necessary.
6. Use sanitary practices — avoid mixing diseased and healthy nursery stock at digging time. Destroy diseased stock as soon as possible. Avoid transporting contaminated soil to clean ground.
7. Surgery — remove galled tissues completely.
8. Use resistant plant material whenever possible.