

T H E S I S

on

Weed,Disease and Insect Control

in

Lawns and Turfs

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WEED DISEASE AND INSECT CONTROL IN LAWNS AND TURFS

INTRODUCTION

The use of grass for golf courses, aviation fields, football gridirons and polo fields, together with the home beautiful campaigns, has increased interest in lawn and turf management. The following excerpt from the "United States Golf Association Bulletin of the Green Section" is timely: "The quack always has something to sell. It may be seed, or fertilizer, or what-not, or perhaps himself; and when the sucker buys he always gets less than he pays for, and usually, what is worse, he loses time that can never be replaced."

Commercial fertilizers, chemical weed killers and treatments for disease and insect control have been exploited by manufacturers and individuals until the public has lost confidence in modern methods and are resorting to the old methods of control.

Modern science, however, has been enlisted by the United States Golf Association, Greens Section, and other agencies, to study and test new species of grasses, new diseases, new pests, new weeds and to perfect methods of combating the old and new alike.

The United States Department of Agriculture and the Agricultural Colleges are cooperating with these private agencies in the study of weeds, disease and insect control in lawns and turfs.


Weeds, disease and insects often are allowed to increase until an epidemic stage has been reached; then the public is aroused to action. Prevention in the incipient stage is much less costly and is entirely feasible. The means of prevention lies in the early recognition of the causal agent. This problem undertakes to point out the chief pests of lawns and turfs and to recommend methods of control. Much of the literature is not readily available and so it is reviewed herein.


WEED CONTROL

Dickenson(11) suggests that weeds should be prevented from entering the lawn. In his text he sets forth the primary means of prevention, as follows: use clean certified seed; have the seed-bed free of weeds, and use only weed-free fertilizers.

Westover and Enlow(54) give detailed instructions on building the lawn to favor grass and discourage weeds. They emphasize the need of good drainage, fertile soil of good structure, and the proper methods of grading to dispose of the soil from excavations. Such soils have poor structure and seldom have much organic matter. This must be supplied in some form if one expects success in maintaining a good lawn. Organic matter not only improves the texture of the soil, especially clay soils, but it also increases the water-holding capacity and improves the drainage. Fine, thoroughly decomposed stable manure or mushroom soil can be used to supply organic matter. This should be thoroughly mixed with the soil, one-half ton to 1000 square feet usually being sufficient. Where neither of these is available some of the granulated peats may be helpful. One should be careful, however, in the use of peats, as some of them are toxic to most plant life.

CERTIFICATION TAGS

 9547	Inspector	OREGON CERTIFIED SEASIDE CREEPING BENT GRASS <i>Agrostis palustris</i> (Formerly <i>Agrostis stolonifera maritima</i> , <i>A. Stolonifera palustris</i> , <i>A. Maritima</i> .)
	Crop	<p>This special tag is issued by the Oregon State Agricultural College, Corvallis, Oregon, for exclusive use on certified seed grown by or for the undersigned, and is valid only when the guarantee is signed by them. This tag was sealed on the bag by a representative of the Oregon State Agricultural College, and indicates that this seed passed its inspection.</p> <p>I guarantee that at the time of sealing the seed in this sealed container was inspected by a representative of the Oregon State Agricultural College, and that it consisted only of seed from areas passing the field inspection, or from hand-picked heads of Seaside Bent.</p> <hr/> <hr/>
Sealed		

	<p>Oregon certified Creeping Bent grass seed has a weight per bushel of not less than 32 pounds and is estimated to contain not more than a slight trace of Red Top, $\frac{1}{2}\%$ other Bent, and 1% foreign seed, and to be at least 97% pure when sealed.</p> <p>This grass, formerly certified as <i>Agrostis stolonifera maritima</i>, was discovered growing in native stands of remarkable purity in Coos County, Oregon, and is being principally produced in the southwest coast counties of the state.</p> <p>This grass is a very vigorous creeper, and produces a fine dense turf by means of stolons or above ground runners. It has a wide range of uses and has given excellent results over much of the United States for lawn and turf purposes. The exceptional natural purity of this grass tends to the production of a much more uniform and velvety turf than is true of many of the lots of imported Bent grass seed.</p>
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Certified seed assures the buyer of good seed.

Longley (25), Enlow and Stokes (12), Welton and Salter (53), Westover and Enlow (54) state that many lawns are doomed to fail because of infertile soil from basements being graded over the surface soil. Weedy manure, early planting and poor quality of grass seed contribute to the failure. The following seed analysis of a sample submitted to the Oregon State Agricultural College, Seed Laboratory, is given as an illustration of seed that may be sold within the state of its origin.

KENTUCKY BLUE GRASS

	<u>Per cent pure seed</u>	<u>Per cent crop seed</u>	<u>Per cent inert</u>	<u>Per cent weed</u>
Test No.39879				
Poa Pratensis	00.74	69.11	29.41	0.74

<u>Weed Seeds</u>	<u>Seeds per lb.</u>	<u>Crop seed</u>	<u>Number per lb.</u>	<u>Per cent by weight</u>
Yarrow	1800	Red top		43.32
Tansy hedge mustard	9450	Alsike clover		25.60
Aster sp.	2250	White clover	1800	
Monolepsis	1800	Canada blue	900	
Dandelion	1350	Timothy	450	
Potentilla	900			
Biennis				
Plantain	450			
Fleabane	450			
Sweet clover	450			
Tumbling mustard	450			
Artemesia sp.	450			
Polygonaceae	450			
	<u>21.150</u>			

Time of planting often means success or failure to lawn maintenance. The old adage "haste makes waste" was evidently coined by a lawn gardener. The person who takes time to prepare the lawn base, free soil of weeds and weed seeds, will thereafter enjoy a good lawn with minimum care.

The selection of the grass seed is the most important step after preparing the base. Piper(45) suggests the sowing of only one variety of seed in the proper place. The selection of the variety or strain is based upon individual tastes and the locality. Of the two chief genera used for lawns and turfs, the *Agrostis* species (Bent grasses) are considered the best of fine grasses and the *Poa* species (Blue grasses) somewhat coarser.

Bent is the common name for the *Agrostis* genus, of which there are, according to Monteith(31), four species, as follows:

1. *Agrostis tenuis* (Colonial Bent)
2. *Agrostis alba* (Red Top)
3. *Agrostis canina* (Velvet Bent)
4. *Agrostis pulustris* (Creeping Bent)

Several of the strains of Agrostis tenuis, which have been developed, are as follows:

Rhode Island	New Zealand
Waipu	Oregon
English	Astoria
Prince Edward Island	

Agrostis pulustris has the following strains:

Carpet	Virginia
Seaside	Columbia
Washington	Iverness
Metropolitan	Ekwanok

Agrostis canina has the following strains:

Capitol	Acme
Highland	Kernwood

Kernwood is reproduced by stolons as seed is not available.

Poa pratensis (Kentucky blue grass) is one of the best-known turf grasses. It has lost much of its former favor, however, to the finer textured bent grasses. It is susceptible to a leaf spot disease caused by the fungus Helminthosporium vagans, and is not well adapted to acid soil conditions.

Poa trivialis (rough-stalked meadow grass) and Poa nemoralis (wood meadow-grass) are considered superior to all other lawn grasses for shady conditions.

Festuca tenuifolia (fine-leaved fescue) and Festuca rubra (red fescue) have found some favor as lawn grasses on poor soil. Festuca rubra fallox (Chewing's fescue) is not as stoloniferous as red fescue but otherwise it is similar. While leaves are fine in texture the turf is coarse and bunchy and does not withstand close clipping.

Lolium perenne (perennial or English rye grass) and Lolium multiflorum (Italian or Western rye grass) are used in mixtures to produce a quick green lawn. They are especially good in supplementing Bermuda grass in the Southern States. English rye grass is frequently quite durable in many turfs not subjected to severe conditions.

Cynodon dactylon (Bermuda grass) is the most widely used lawn grass in the South. Atlanta Bermuda grass is a strain which produces exceptionally good turf.

Axonopus Compressus var. (carpet grass) is a perennial creeping grass and forms a dense close turf. It is adapted to the hot humid climate of the South.

Poa compressa (Canada blue grass) seed is often sold as a substitute for Kentucky blue grass. Its sparse top growth and persistent root system is not so well adapted for lawns and turfs.

Trifolium repens (Dutch or white clover) is not recommended for lawn mixtures.

Table I

FINE GRASS RATINGS FROM 14 DEMONSTRATION GARDENS

as reported by Monteith(32) in order of favorable ratings

Colonial bent

Western grown.....	1
Rhode Island grown.....	2
New Zealand grown.....	3

Creeping bent

Metropolitan (stolons).....	4
Seaside (seed).....	5
Washington (stolons).....	6
Columbia (stolons).....	7
Virginia (stolons).....	8

Velvet bent

No. 14276 (stolons).....	9
Seeded (Prince Edward Is.)..	10
Highland (stolons).....	11

Mixed bent (German).....12

Fescue

Chewings.....	13
Red.....	14

Annual bluegrass.....15

ESTABLISHING THE LAWN

The base is drained, graded, fertilized and made ready for the seed, but before seeding, an application of 35 pounds of arsenate of lead mixed with 2 pounds of cyanamid are evenly distributed over 1000 square feet. The mixture is watered into the soil. A light sprinkling every other day will serve to sprout any weed seeds and

settle the soil. This sterilizing and pest-proofing of the lawn is the last step in construction of the lawn. Three weeks after sterilizing the soil the seed may be sown and covered lightly.

Seeding may be accomplished with either seed or stolons. In the case of stoloniferous grasses, a desirable turf may be established in less time by the vegetative method of planting than with seed. The "runners" are chopped into pieces an inch or so in length and broadcast over the lawn. They are rolled and covered with a thin layer of compost or soil and kept well sprinkled. The surface must not be allowed to dry until the stolons have taken root. A second method of vegetative planting is to set out stolons in rows 8 inches apart with pieces 4 to 6 inches apart in the row. Long stolons are used in this method. 10 pounds of stolons are required per 1000 square feet of surface with either method.

Sprague and Enval(47) state that Spring is the time of year when most lawn owners contemplate seeding a lawn, or scattering seed to thicken up thin places in turf already established. Unfortunately, experimental work shows that this is not the most satisfactory time for seeding grasses, for two reasons: first, the temperature and rainfall are not so favorable for starting grass in spring as in late summer or early fall; and

second, spring seedings invariably suffer from competition with weeds.

Recommendations for lawn seeding are presented in Table II. It also incorporates the optimum PH requirements for grasses.

TABLE II
SEEDING RATE AND SOIL REACTION FOR VARIOUS
LAWN AND TURF GRASSES AND CLOVER

Data compiled from reports by Powers(42) and Wherry(56) on soil requirements. Seeding rate by Welton(52).

Name	Rate of Seeding per 1000 sq.ft.		Reaction Range		
	Turf	Lawns	Limit	PH Opt.	Limit
All bents	3-5	3-5	3.5	5-6	8
Redtop	3-5	3-5	4.5	5-6	7.5
Kentucky blue	12-15	10	4.5	6-8	9
Red Fescue	10-15	8		6-8	
Rough stalked meadow	12-15	10	4	5-6	8
Wood meadow	12-15	10	4	5-6	8
Chewings Fescue	10-15	8	5	6-8	8.5
Dutch or white clover		2-3	4.5	5-6	7.5
Bermuda	5-7	4-5	3.5	4-5	9
Carpet grass		4-5	3.5	5-6	7.5

Welton(52) recommends close clipping as soon as grass is up about 2 inches. Regular, close clipping causes the grasses to form fine textured, dense turfs. The bent grass stolons of some species will come to the surface if the lawn is not regularly top-dressed with compost which has two functions, as follows: it is the source of organic plant food and it serves as a top dressing to keep the lawns smooth and of fine texture.

Compost is made by decomposing organic matter such as leaves, grass clippings, lawn rakings and vegetable parings.

ILLUSTRATION NO.I



CONCRETE COMPOSTING PIT

Illustration No.I gives a good idea of an elaborate composting pit built and maintained by two neighbors. For ordinary use a box about 3 feet square is

sufficient to provide for the average lawn. The organic matter is dumped into the box and a handful of ammonium sulfate is added to about every 10 pounds of organic matter. The ammonium sulfate hastens decomposition. Keep the composting materials fairly wet and it will be ready for use quickly.

The compost should be screened to break up all particles. If it is permitted to dry a few days it simplifies the screening and mixing. Compost is used to carry or dilute chemicals for disease and pest control, as well as concentrated commercial fertilizers.

Monteith(32) in reports of fertilizer trials, conducted by fourteen member clubs of the United States Golf Association, found that certain fertilizers not only improved the quality of the turf but discouraged the growth of weeds.

Westover and Enlow(54) recommend a fertilizing program that provides for a liberal supply of available nitrogen. Grasses do not demand so much phosphorus and potash, and since these elements are less soluble than nitrogen they are often present in the soil in sufficient quantities, though to avoid the possibility of a deficiency a fertilizer containing

some phosphorus and potash should be applied occasionally. Experience indicates that the most liberal application of such fertilizers should be made early in the spring, as soon as the danger of hard freezes is over, as such application encourages a vigorous growth of grass that tends to hold the weeds in check. An early fall application of 10 pounds of 6 - 8 - 4 fertilizer to 1000 square feet is desirable. Late in the fall a heavy application of compost is beneficial.

TABLE III

RATINGS FOR BENT GRASS FERTILIZERS
Data from Monteith (32)

<u>Fertilizer</u>	<u>Rating</u>	<u>Number of applications</u>
6 - 12 - 4	1	6
12 - 6 - 4	2	6
Sulfate of Ammonium	3	6
Ammonium Phosphate	4	6
Sulphate of Ammonium and compost	5	6

RATINGS FOR BLUE GRASS FERTILIZERS

Activated sludge	1	6
6 - 12 - 4	2	6
Bone Meal	3	6
12 - 6 - 4	4	6
Sulphate of Ammonium	5	6

Ratings were based upon the color,
texture and growth of grass.

In Table III the rate of application was based upon the nitrogen content and applied in quantities to provide 1 pound of nitrogen per 1000 square feet, monthly, through the growing season. The results are based upon three years of the experiment. The experiment will continue and it will be of interest to watch the annual reports as ammonium sulfate and compost were rated eighth the first year.

Monteith(33) found that there is a close correlation to excessive acidity and the disease known as brownpatch. Lawns or turfs that are acid suffer from scald in the hot weather. Lime applied to turfs fertilized with compost and ammonium sulfate was found to help the lawn resist both brownpatch and scald. Sufficient data are not available to draw conclusions regarding the relationship of fertilizers and turf diseases.

Oakley(36) reported upon the results of experiments conducted at Arlington Turf Garden on weed control by means of fertilizers. The following fertilizers were used:

Ammonium sulfate	Calcium cyanamid
Ammonium phosphate	Bone meal
Nitrate of soda	Soy bean meal
Acid phosphate	Cottonseed meal
Muriate of potash	Carbonate of lime

The first noticeable results were that the nitrogenous fertilizers thickened the stand of grass in a short time. All plots showed an improvement in stand except those fertilized with cyanamid and lime.

The results after three years are summarized as follows: ammonium sulfate and ammonium phosphate were practically weed-free. The alkaline reacting fertilizers were weedy, the important weeds being goose grass, crab grass and white clover. Turf fertilized with lime alone has always been poor and weedy with much moss. Soybean meal and cottonseed meal produced excellent turf but weedy. Muriate of potash and acid phosphate, when added to ammonium sulfate or nitrate of soda, did not improve the turf, but when used with ammonium sulfate increased the weed growth. The outstanding fertilizer was ammonium phosphate. It produced better turf and was practically weed-free. The phosphate residue is better for the grass than is the sulphur. In conclusion he cites the correlation between quickly available nitrogen and the acid reaction as the weed-controlling factors.

TABLE IV

EFFECTS OF FERTILIZERS ON SOIL REACTION, BENT GRASS AND WEEDS
Data from Westover (55)

Fertilizer	pH value	Bent grass stand	Per cent of weeds in turf	Kind of weeds
Ammonium sulfate	3.7	good	12	crab grass
Ammonium phosphate	4.6	good	15	crab grass
Ammonium sulfate, bone meal & muriate of potash mixed	4.1	fair	20	crab grass
Ammonium sulfate and acid phosphate	3.7	good	20	crab grass
Ammonium sulfate and bone meal mixed	3.8	fair	25	crab grass with trace of silver crab grass
Cottonseed meal	4.8	fair	30	crab grass, silver crab grass and yarrow
Check plot	4.6	poor	45	31 % crab grass 9 % spurry 3 % yarrow 2 % plantain

Bone meal	4.9	poor	55	22 $\frac{1}{2}$ % crab grass 22 $\frac{1}{2}$ % yarrow 2 $\frac{1}{2}$ % clover 2 $\frac{1}{2}$ % plantain
Soybean meal	4.6	poor	60	52 % crab grass 6 % yarrow 2 % chickweed
Sodium nitrate	6.3	poor	80	72 % crab grass 4 % silver crab grass 4 % yarrow
Acid phosphate, sodium nitrate and muriate of potash mixed	5.8	poor	80	56 % crab grass 4 % silver crab grass 4 % yarrow 16 % miscellaneous
Manure	5.1	poor	85	51 % crab grass 9 % yarrow 4 % plantain 21 % dandelion, etc.
Ground limestone	6.8	very poor	85	68 % crab grass 4 % yarrow 9 % dandelion, etc. 4 % clover

Many of our common weeds cannot be controlled by means of fertilizers. They must be subjected to more drastic treatment.

Professor Bolley is credited by Aslander(2) with being the Dean of chemical weed control investigators in the United States. His early experiments were with copper sulfate and iron sulfate.

Chemical weed control has been exploited by chemical companies and individuals until the public has lost much of its faith in all weed killers. The advertisement of one chemical company will serve to illustrate the extravagant claims made for their product. They state: "-----will kill false flax, worm seed, wild mustard, tumbling mustard, ball mustard, shepherds purse, pepper grass, corn cockle, chickweed, dandelion, Canada thistle, bind weed, plantain, pigweed, Kings head, red-river weed, cocklebur and rag weed. One application will be sufficient for complete eradication."

Iron sulfate, sodium chlorate, carbon bisulfide and sodium arsenite are often sold under trade names at exorbitant prices.

Chemical control of weeds has been limited to field conditions until recently. The development of selective sprays and chemicals has made it possible to use them on lawns and turfs. The United States Golf Association,

Greens Section, has carried on many investigations for developing proper technique in applying the existing chemicals. Aslander(2) has said that sprays must have three qualities, as follows: 1. They must be selective. 2. They must not leave undesirable residues in the soil. 3. They must be simple and safe of application.

Residual deposits under field conditions are dispersed by cultivation. In the lawn the residue remains in the soil and accumulates until a toxic condition often develops. Some of the selective sprays are not satisfactory for lawn use because of the fire or poison hazard. The chlorates are combustible and the arsenics poisonous.

Study of weed characteristics are essential to determine the proper methods of control and the plant factors influencing the selection of chemicals are:

1. Methods of reproduction
2. Length of life
3. Habits of growth (upright or recumbant)
4. Soil requirements
5. Character of leaf (broad, grass-like,
waxy, pubescent)

Weeds are endowed by nature with various means of propagation, as follows: spores, seeds, root-stocks, roots and stolons. Spores and seeds are the primary

sources of infestation. Wind, water, animals, birds and man are disseminators of spores and seeds. When certain weeds are established they may spread by means of roots, root-stocks (underground stems) and stolons (above-ground stems).

Annual plants are those that complete their life cycle in one season. Heavy turf and close clipping will control or kill most of the annual plants. Biennial plants are those plants that require two seasons to complete their life cycle. The first year they develop storage roots that are capable of feeding the plant while maturing seed the second year. Perennial plants are those that live more than two seasons. Perennial plants often produce seed their second season. They also develop more or less deep rooting systems with food reserves. The perennial weeds are the most difficult to control or eradicate.

Plants that grow upright are often rendered harmless and are controlled by close clipping. The recumbent or rosette type of growth is difficult to control by mowing as the growth is close to the soil surface.

Broad-leaved plants offer a large surface for chemical action and are not difficult of control. Leaves that are waxy resist chemical sprays unless applied at

a strength that will also kill the grass. Pubescent leaves may be dusted as the fine hair will retain the chemical dust and cause death or injury.

There is no easy "royal-road" to the eradication or even control of weeds in lawns and turfs. Weeds may be controlled by observing rigorously three important principles, as follows:

1. The prevention of weed seeds being planted in seed mixtures.
2. The prevention of weed seeds maturing.
3. The prevention of any vegetative growth above ground.

Annual and biennial weeds produce but one crop and die. Since their only method of reproduction is by seed, they may be controlled by prevention of seed-maturing or infestation.

Annual blue grass (*Poa annua*) is one of the few annuals that blooms every month in the year and is constantly maturing seed. Most of the annuals and biennials have definite seeding periods, but vigilance is required to prevent their seeding.

Perennials are reproduced vegetatively and by seed. The perennials that reproduce solely by seed are controlled by the use of chemicals or rogueing. The veg-

etative reproduction is accomplished by underground runners or root-stocks and stolons or above-ground runners. Prevention of infestation and roguing are the most practical methods of controlling these types of perennials.

Experiments have been carried on to determine the proper time for roguing perennials that are established. The conclusions are that the plants should be rogued before they are established or established plants should be rogued in the bud stage.

It is often impossible to rogue the perennials without spoiling the lawn. In such a case it is necessary to resort to chemical means of control. Two to six sprays in one year will usually kill the most persistent of the perennials with but little damage to the lawn. The sprays are applied at intervals to prevent the building-up of reserve food in the roots.

Common salt was used for centuries to prevent the growth of weeds in restricted areas. There was but little interest shown in the development of chemicals for weed control until golf became the sport of the people. Putting greens that were weed-free were the desire of every golf club. Hand weeding was resorted to in the early days of the game to provide the desired type of green, but few clubs could afford it.

List of the most common lawn weeds, as compiled from the Journals of the Greens Section, U. S. Golf Association.

BROAD-LEAVED WEEDS

Perennial	<u>Agoseris hirsuta</u> - False dandelion
	<u>Hypochaeris radicata</u> - Cats ear
	<u>Taraxcum officinale</u> - Dandelion
	<u>Trifolium repens</u> - White clover
	<u>Ornithogalum umbellatum</u> - Star of Bethlehem
	<u>Rumex spp.</u> - Sorrels
Biennial or perennial	<u>Plantago lanceolata</u> - Buckhorn
	<u>Plantago major</u> - Plantain

GRASS-LIKE WEEDS

Biennial or perennial	<u>Agropyron repens</u> - Quack grass
Annual	<u>Digitaria humifosa</u> - Smooth crab grass
	<u>Digitaria sanguinalis</u> - Finger crab grass
	<u>Ellusine indica</u> - Crowfoot grass
	<u>Poa annus</u> - Annual blue grass
Annual or perennial	<u>Polygonum aviculare</u> - Wire grass or knot weed
	<u>Setaria glauca</u> - Yellow foxtail

SMALL-LEAVED WEEDS

Perennial	<u>Achilla milleforium</u> - Yarrow
	<u>Anthemis cotula</u> - Dog fennel - May weed
Annual	<u>Euphorbia maculata</u> - Carpet weed - Spurge
	<u>Hydrocotyle umbellata</u> - Pennywort
	<u>Stellaria media</u> - Mouse ear chickweed
Annual or Perennial	<u>Bryophytes sp</u> - Moss

A survey made by Grau of Maryland on the worst turf weeds in the United States found that Dandelion, Crabgrass, Plantains, Chickweeds and Rumex Spp. were reported from every state.

The Rhode Island Agricultural Experiment Station conducted experiments over a number of years on fertilizers suitable for golf course grasses. They found that certain fertilizers discouraged weed growth. The North Dakota Station(5) has conducted experiments on weed control in grain fields by use of chemical sprays and the New York Station(35) adapted the sprays of the North Dakota grain fields to the control of dandelions in lawns.

Chemical weed sprays have been developed from by-products of industry and are not the result of research. Many of the present chemicals used are crude and of varying strength and composition, so results are often unsatisfactory. Standardization is essential in the chemicals to obtain desired results under favorable conditions.



Type of pressure spray suitable for lawn use.

The following chemical sprays and dusts have been used in weed eradication:

Acid sludge	Sodium chloride
Ammonium phosphate	sodium nitrate
Ammonium sulfate	Sulfuric acid
Ammonium thiocyanate	Zinc sulfate
Arsenic acid	Formaldehyde
Arsenic of lead	Gasolene
Arsenic trichloride	Iron sulfate
Bordeaux mixture	Kerosene
Carbolic acid	Lime, slaked
Carbon bisulfide	Potassium chlorate
Copper sulfate	Sodium arsenate
Corrosive sublimate	Sodium arsenite
Crude oil	Sodium chlorate
Cyanamid	Diesel oil

There are but few of the above chemicals that are suitable for weed control in lawns and turfs.

Bolley(5) and Munn(35) recommended iron sulfate for the control of dandelion and other broad-leaved weeds. They have found that it is most effective when applied at the rate of four and one-half pounds per 1000 square feet of turf.

Dissolve the iron sulfate in 3 gallons of water and spray it on the grass. Five applications are recommended the first year, starting at bud time, followed at four and eight week intervals for the first three sprayings. The fourth and fifth sprays are applied after hot weather.

Aslander(3) recommended potassium chlorate for the control of broad-leaved weeds. It is a selective spray with a beneficial residual effect. He used a six and one-half per cent solution, or, one and one-fourth pounds per 15 gallons of water applied on 1000 square feet. He stated that his best results were obtained from sprays applied in November.

Pammel(40) used copper sulfate for controlling broad-leaved annuals. It is selective and does no injury to grass when applied at the rate of 12 pounds in 52 gallons of water per 1000 square feet. He recommended that it be used in dry weather to be most effective.

Collins(8) used sulfuric acid to kill broad-leaved weeds. He found that it was selective and effective when used in a 5% solution at the rate of 2 gallons per 1000 square feet. This spray was recommended for use in clearing up bracken fern; two sprayings will generally kill the fern. Sulfuric acid is potent and extreme care must be exercised while using it.

Cyanamid dusting for broad-leaved weeds was recommended by Pranke(43). He found it to be most effective when applied early in the morning while the dew was still on the grass. One and one-half pounds per 1000 square feet did little damage to the grass and killed the broad-leaved annuals. A duster is the best means of applying.

According to Kephart(23) a 2% solution of sodium arsenite will kill chickweed. This spray is not selective and should not be used on bent grasses. It will not injure Kentucky blue grass permanently although it burns it. Sodium arsenite should be applied early in April. Use enough of the solution to wet the grass. It is poisonous to animals or man and should be handled with care. Arsenite will sterilize the soil, so it is not to be recommended for lawns and turfs. The best results are obtained from the use of arsenite as a soil sterilizer. Used on walks, driveways, tennis courts and places where it is desired to prevent plant growth, it will be found satisfactory.

Harvey(17) reported on ammonium thiocyanate experiments conducted at the Minnesota Agricultural Station and found it has great possibilities as a weed killer.

He stated that 2 to 4 pounds dissolved in 1 gallon of water can be used to kill dandelions in lawns. He does not state whether it is a selective spray or is used on individual plants.

In unpublished experimental data at Oregon State Agricultural College a solution of 1 gallon sodium arsenite in 25 gallons of water was safe to use on lawns. It killed dandelion, false dandelion and broad-leaved weeds.

Hyslop(20) found that ammonium sulfate dissolved in water at the rate of twenty-two ounces per gallon of water was effective for killing moss, if applied on sunny days and did not injure normal grass-leaves. Grass-leaves mutilated by tramping were injured to some extent. A pressure spray was recommended for applying the solution.

Applications of chemicals should always be based upon the recommended amounts. Damaged turf results from the heavy application or uneven distribution of chemical sprays or commercial fertilizers.

Dry chemicals should always be diluted with additions of sand, soil, compost or pulverized coal ashes. Application of the concentrated chemical in dry form is impossible without injuring the grass.

Application of solutions is best if made with a pressure spray. A fine spray nozzle gives the best results. Always strain the solution before pouring it into the spray tank as small particles will clog the nozzle and cause an uneven distribution. Always rinse out the spray tank after use as most of the chemicals are corrosive and will destroy the metal parts.

DISEASE CONTROL

Van Slyke(51) found that a deficiency of potash lowers the resistance of plants to disease and that an excess of nitrogen increases the susceptibility.

Monteith and Dahl(34) published a comprehensive report on turf diseases and control. They classified the diseases as parasitic and non-parasitic. Their methods of control are based upon resistant varieties of grasses, cultural methods and fungicides.

Environment is an important factor in the occurrence and severity of diseases. The parasites and the host plants respond directly to environmental conditions. Fungi have a definite optimum of temperature, water, soil reaction and light. If their optimum requirement factors are disturbed, the fungi remains inactive. It is only when all factors are favorable that fungi cause damage. Cultural methods are recommended to prevent the ideal conditions for their growth.

The first step in disease-prevention is the proper construction of the lawn or turf base. Attention in construction to the following details are essential to the healthy lawn: drainage of the subsoil water, surface-soil water and air. Soil that is saturated for long periods make conditions ideal for fungi. Turf plants located

in air pockets formed by trees and shrubbery are often attacked by disease.

Over-fertilization reduces the resistance of the grass by producing a tender, succulent growth. When tender and succulent grass is attacked, fungicides applied to control the disease, may do more damage than the disease. Top dressings of organic materials must be judiciously used. The grass should always be raked and cut before the top dressing is applied. The dressing should then be worked down to the soil level with a brush or by dragging a steel doormat over the turf.

Soil sterilization before planting is essential to kill "damping-off" fungi and other soil-borne diseases.

The height of cutting grass has some relation to diseases. "Zonate eyespot" has been found to be more severe where turf is clipped close. Long grass and matted grass suffer much from other diseases.

Cultural practices influence, to a great degree, the frequency and severity of diseases. Most of the non-parasitic diseases can be corrected only by proper cultural practices. When cultural practices fail to control fungi, the use of fungicides are relied upon for control.

Fungicides, like herbicides, have been exploited by chemical companies and individuals. Trade names

have been used to sell calomel and corrosive sublimate at higher prices. Monteith and Dahl(34) cite the following trade names and products: Calogreen (calomel) Caloclor and Pfizer are calomel and corrosive sublimate mixtures. Other mercury compounds and some inert material which has no fungicidal value include Semesan, Nugreen, Turfcalomel, Barbak 211, Barbak XX and Fungo.

Corrosive sublimate called bichloride of mercury or mercuric chloride, is an effective mercury compound for control of turf diseases. Calomel, mercurous chloride has been found to be superior to corrosive sublimate in the treatment of some diseases.

There are some fertilizer - fungicide combinations on the market. They are made up of organic fertilizer combined with organic and inorganic mercury compounds. The disadvantage of such combinations is the high price.

Bordeaux mixture is effective for controlling brown-patch only when the leaves and stolons are covered with the fungicide. Its continued use causes development of toxins. Formaldehyde, sulfur, zinc sulfate, silver nitrate and potassium permanganate have been tested for controlling turf diseases, none having proven to be valuable. Silver nitrate was effective but the cost was prohibitive.

TABLE V

TREATMENTS FOR DISEASES

	<u>Rate per 1000 feet</u>	
	<u>Summer</u>	<u>Spring and Fall</u>
Corrosive sublimate	1 - $1\frac{1}{2}$ oz.	3 oz.
Mercuric oxide	1 - $1\frac{1}{2}$ oz.	3 oz.
Calomel	1 - 2 oz.	3 oz.
Bordeaux mixture	1 pound	1 pound

Mercury compounds are more active in warm humid weather so the rate of application is decreased to prevent burning.

Methods of applying fungicides vary with the equipment at hand. If a spray pump is accessible, the fungicide may be dissolved or suspended in water. Dry applications give as good results as the spray method but care must be exercised in mixing and spreading. The dry fungicide should be thoroughly mixed with dry sand, soil or fertilizer and spread evenly over the turf or lawn.

Uneven distribution in the dry state or solution will cause chemical burns to the grass. It is essential to sprinkle the grass after application, taking care not to flood it as this may concentrate the chemicals and cause burns.

The common turf diseases may be classified as parasitic and non-parasitic.

PARASITIC

<u>Disease</u>	<u>Causal Agent</u>
Brownpatch.....	<u>Rhizoctonia solani</u>
Dollarspot.....	<u>Rhizoctonia sp.</u>
Spotblight.....	<u>Pythium butleri</u>
Snowmold.....	<u>Fusarium nivale</u>
Damping-off.....	<u>Rhizoctonia sp.</u> , <u>Pythium sp.</u> <u>Fusarium sp.</u>
Leafspot on bluegrass....	<u>Helminthosporium vagans</u>
Zonate eyespot.....	<u>Helminthosporium giganteum</u>
Smut.....	<u>Ustilago striaeformis</u>
Fairy Ring.....	<u>Agaricus compestris</u> <u>Calvatia Cyanthiformis</u> <u>Marasmius oreades</u>
Rust.....	<u>Puccinia graminis</u>
Mildew.....	<u>Erysiphe graminis</u>
Slime mold.....	<u>Fuligo septica</u>

NON-PARASITIC

Black or green scum.....Algae

Symptoms of turf and lawn diseases are often similar and render correct diagnosing difficult. Without a correct diagnosis, no disease can be treated intelligently. Treatment for one disease may be of no avail with other diseases.

There are many factors involved in diagnosing turf diseases, such as:

- (1) Time of and amount of watering.
- (2) Kind, time and rate of application of fertilizer.
- (3) Chemical treatment of turfs for weeds, diseases or pests.

The disease should be studied in its incipient stage as many symptoms that may disappear later, are present then.

Brownpatch occurs in irregularly-shaped browned areas, usually more or less circular, varying from one inch to three feet or more in diameter. The affected area turns dark and then gradually becomes a light brown. In the early morning the mycellia of the causal agent are intertwined with the leaves and gives the appearance of a smoke ring. The smoke ring is the most important symptom. Prevention measures are good drainage and proper fertilization. Control measures are use of suitable fungicides. Mercury products have proven most effective and economical in control of this disease.

Dollarspot occurs in spots ordinarily not larger than a silver dollar. The spots are regular in size and shape. In the early morning the mycellia of the causal fungus appear as a white spot; later in the day, the affected grass has a water-soaked appearance and then shrivels, turning light brown. The light colored my-

cellia is the symptom that distinguishes dollarspots from other diseases. Treatment consists of judicious use of fertilizer and control by use of calomel when infection occurs.

Spotblight appears much as dollarspot in its early stage. The injured turf turns reddish brown which distinguishes this disease from others. Treatment of this disease is not satisfactory but it is somewhat checked by use of corrosive sublimate. Water control is essential in connection with this disease.

Snowmold is a disease of fall, winter or spring. The disease may be confused with winterkill unless the cottony-like mycellia are noticed. Treatment of this disease depends more on preventative measures than in the use of fungicides. Late fertilization with nitrates causes the grass to go into the winter in a soft condition and is very susceptible to the snowmold fungi. Drainage lessens the severity of the attacks of snowmold.

Damping-off of seedlings is caused by several species of fungi. The young seedlings are attacked and killed. Treatment depends upon soil sterilization before planting the seeds. According to Franke(43) cyanamid will destroy the causal fungus if applied several days before planting.

Leafspot on bluegrass is often called footrot of bluegrass. The two common names do much to describe the disease. The leaves or roots may be attacked individually or simultaneously. The spots on the leaves turn brown and is the best symptom. Control of leafspot depends upon cultural practices. Fertilizing to produce stronger growth and raising the mower to leave the turf longer, are the best methods of combating this disease.

Zonate eyespot is similar to leafspot in its attacks upon the leaves. The control measures are selection and planting of resistant varieties of grasses. Virginia bent is susceptible and the other varieties of bent are fairly resistant.

Smut occurs on leaves, stems or seed-heads of grasses, usually, as elongated, discolored streaks. When grass is kept clipped for turf the disease is apparent as long black stripes or pustules on the leaves. The pustules break, exposing masses of black soot-like spores. No satisfactory treatment is known for smut on turf grasses.

Fairy rings are produced by fungi that attack the roots of the grass. The symptoms are stimulation of the affected grass with a slow spreading-out in the form of a large ring. The outer edge of the ring is characterized by the stimulated grass with a dead area on the inside. At certain seasons the fungi produces fruiting

bodies. Shantz and Piemeisel(46) state the type of fruiting body varies with the species of fungi; some produce mushrooms; others produce puffballs.

ILLUSTRATION III.



Mushroom fruiting structure
of a fairy ring fungus.

Bressman(7) (unpublished work at Corvallis) has obtained satisfactory results from the use of Semesan. Monteith and Dahl(34) reported that the use of mercury compounds aid in control.

Powdery mildew appears on the surface of grass blades as a thin white powdery growth. It does but little damage but often mars the beauty of the lawn by discoloration. Dusting dry sulfur on the turf will check the mildew.

Slime mold. Different species produce different types and forms of spore-forming masses. Some species commonly appear as small, elongated, capsulelike spore masses growing upright from the surface of the leaves. They are so numerous as to give the grass a dusty appearance. Other species produce spores in a large mass, having the appearance of foam. The slime molds cause but little damage to turfs and are not given treatment.

Black scum is an algae growth that develops in wet low places. It often covers the grass and forms a tough parchment-like surface that may kill the grass. A very light application of copper sulfate to standing water or wet places will prevent the algae growing.

NUTRITIONAL DISORDERS

Injury from poor drainage, thin soil or nutritional deficiencies have similar symptoms and knowledge of the fertilizer and watering program, as well as construction, is essential to diagnose the cause of such troubles. The symptoms are similar in that the grass grows slowly, often turning yellow, then drying up and turning brown.

Scald is a term used to cover any browning of turf not caused by disease, while Winterkill is used for winter injury the same as scald for summer injury. Scald and winterkill may be caused by concentration of salts or toxins, too little or too much moisture, unbal-

anced nutrient ratio and numerous other soil or climatic conditions.

INSECT PESTS

Insects do much damage to turfs and lawns by attacking the leaf blades or the roots. Above ground feeders are more difficult to control as they must be poisoned by prepared bait. The underground feeders are controlled by saturating the soil with acid arsenate of lead.

Ants do not damage the grass and are pests only in so far as they destroy the enjoyment of the lawn by their presence. Carbon bisulfide injected in their nests will destroy them.

The injurious insects are:

Japanese beetles.....	<u>Popillia japonica</u>
Southern June beetle	
White grub May beetle.....	<u>Lachnosterna fusca</u>
Grasshoppers.....	<u>Acrididae sp.</u>
Cutworms.....	<u>Noctuidae sp.</u>
Earthworms.....	<u>Lumbricidae</u>
Earwigs.....	<u>Dermaptera sp.</u>
Army worm.....	<u>Leucania unipuncta</u>

The Japanese beetle has become a serious pest in lawns and turfs. The adult beetle lays her eggs in the turf during June. The eggs hatch in July and the grubs start feeding on the grass roots. The grub lives in the soil until the next June when it emerges as an adult. Leach and Johnson(27) estimate that one hundred grubs per square yard will do but little damage; any increase

over this number will result in extensive damage. They recommend the use of carbon disulfide emulsion for treatment. Leach and Lipp(28) recommend the use of arsenate of lead.

The Southern June beetle, May beetle and White grub are the same insect, the white grub being the larvae stage.

The presence of white grubs is usually indicated by individual plants dying. If the infestation is heavy, the observer may be misled by the symptoms of large patches of grass dying. Removal of an injured plant with the roots and soil attached will disclose the white grub which is about an inch to an inch and a half long. Arsenate of lead or carbon disulfide emulsion is the recommended treatment.

Grass hoppers, Army worms, Cutworms and Earwigs damage lawns and turfs by feeding on the tender leaves. The earwig nymphs do some damage to roots but the great damage is to the leaves. Stearns(48) has found that a bait prepared from 1 pound sodium fluride, 2 quarts molasses, 2 gallons water, and 16 pounds of wheat bran, will control the earwig, if spread over the lawns in May or June when the nymphal earwigs emerge from the soil and start feeding. Spraying with a solution of corrosive sublimate for disease control has been found to kill or drive out the earwigs.

G Grasshoppers, army worms and cutworms are poisoned by the same type of bait. The common practice is to substitute arsenic for the sodium fluride.

Earthworms do but little direct damage to lawns but are undesirable because of the casts deposited on the turf. It is the opinion of the author that a close relationship exists between the spread of certain fungus diseases and the migrations of earthworms. Arsenate of lead or corrosive sublimate will rid the lawn of earthworms.

SUMMARY AND CONCLUSIONS

Lawn management is an art and not an exact science and no definite rules apply to every lawn. Conditions of soil, climate, available water and individual needs vary with every locality. General rules may be laid down but these rules must be adapted by the individual to meet their needs.

The lawn may be mowed every day without injury if it is given proper care. The average home-owner will mow his lawn once a week. Regular mowing is essential to the well-kept lawn; lawns that are permitted to grow more than a week will become coarse textured.

The following program is based upon weekly mowing and average care of a lawn or turf in the Willamette Valley:

- March 1. Rake the lawn and clip it lengthwise; rake it and clip it crosswise. Rake out all of the matted areas. Clip them close. Fertilize with 1 yard of compost and 4 pounds of ammonium sulfate. Use a brush or steel door-mat to work them down into the turf.
- March 15. Spray the lawn with iron sulfate. Use $4\frac{1}{2}$ pounds of iron sulfate dissolved in 3 gallons of water. Apply the solution with a pressure spray using a fine spray nozzle.

- April 1. Apply a second spray of iron sulfate if the lawn is weedy.
- May 1. The third iron sulfate spray should be applied to the weedy lawn.
- May 15. Seed the bare spots and apply compost and ammonium sulfate as of March 1.
- June 1. Watch for the invasion of pests, and diseases. At the first sign of pests treat the lawn as recommended. Diseases will appear with warm weather and should be treated promptly.
- June 15. Mow the lawn and leave the clippings. Sprinkle the lawn with ammonium sulfate. Dissolve 4 pounds of ammonium sulfate in 5 gallons of water and apply it with a pressure spray.
- July 15. Mow the lawn and leave the clippings. Sprinkle the lawn with a solution made up of 2 pounds of ammonium sulfate dissolved in 5 gallons of water.
- Sept. 15. Spray with a solution of iron sulfate if weeds are still present.
- Oct. 1. If the weeds have persisted spray again with iron sulfate.
- Oct. 15. Fertilize with compost and 6 pounds of 6-12-4 fertilizer. Mix the 6 pounds of fertilizer with 1 yard of compost.

All recommendations are based upon 1000 square feet of lawn surface and care must be exercised in not exceeding the recommended amounts of chemicals.

Much of the weed, disease and insect control lies in the proper construction of the lawn or turf base. Soil structure and drainage are the two most important factors to be considered in constructing the base. Excessive drainage is as bad as poor drainage. Clay mixed with a light soil will prevent excessive drainage and give good texture. Poor drainage is encountered in heavy clay soils, sand mixed with the top soil will give a better texture to the soil and improve the drainage. The sub-soil should be drained with tile.

Sterilization of the seed bed may be accomplished by the use of heat or an application of cyanamid. Many golf clubs have steam devices arranged to sterilize the top soil and kill the fungi and weed seeds. Cyanamid applied three weeks before planting will kill the fungi and weeds. The lawn should be watered regularly to sprout the weed seeds as the cyanamid will not kill viable seeds.

Pest proofing the lawn consists of mixing 35 pounds of arsenate of lead with the top soil on every 1000 square feet of lawn. This treatment will last for at least two years. The arsenate of lead may be added to the compost

and spread on the lawn or it may be suspended in water and sprinkled over the lawn.

The established lawn will stand more drastic treatment than the new lawn. The weedy old lawn should be sprayed with iron sulfate early in the spring as the new growth of weeds are beginning to grow. Two weeks later a second spray will kill most of the weeds especially the annuals and biennials. One week later an application of ammonium sulfate will kill weeds and stimulate the growth of the grass. Bare spots should be seeded after the ammonium sulfate application.

The results of experiments conducted over a long period of years has demonstrated the value of acid reacting fertilizers. Ammonium sulfate has proved its worth as a fertilizer and weed killer. Plats fertilized with ammonium sulfate contained no moss and fewer weeds than any other plat trial at Rhode Island Experiment Station.

Experiments have shown that lime does not stimulate the growth of grass; it is, however, essential to the best plant growth. One application of ammonium phosphate each year will furnish sufficient lime for the best plant growth without materially affecting the acid reaction of the soil.

The practice of leaving one or two clippings a year on the lawn is quite general. It is recommended that clippings be left on the lawn preceding the application of ammonium sulfate. The clipping will not develop an odor if they are wet down with the ammonium sulfate.

Products advertised to control disease, pests and fertilize, all in one operation, are expensive and should not be used. The patented fertilizers are expensive and often carry lime in large quantities, and, they are not desirable for lawn purposes.

Moss and weeds will not encroach upon the well cared and properly fertilized lawn. The grass should be kept growing in a hard luxuriant condition. Soft succulent growth is susceptible to disease and scald.

Seaside and Astoria strains of bent grass are adapted to the soils of Western Oregon, many of which are somewhat wet and acid. These strains are stoloniferous and should be clipped close to form a dense fine textured turf.

Rough-stalked meadow grass or Wood meadow-grass are adapted to moist shady conditions and form a dense fine textured turf if kept closely clipped. Red fescue and chewings fescue are recommended for terraces.

Kentucky blue grass is the leading turf grass for the drier and semi-arid soil of Eastern Oregon where water for irrigation is available. Chewings fescue is probably the best lawn grass for strictly dry-land conditions. Short alkali grass Puccinellia lemmonii is especially adapted for lawns that are extremely alkaline. Seaside bent does well on moderately alkaline soils.

Seed of A. pulustris maritima(Seaside bent), A. tenuis astoriana(Astoria bent), A. tenuis oregansis (Oregon bent), P. trivialis(Rough-stalked meadow grass), P. nemoralis(Wood meadow-grass), and P. pratensis(Kentucky blue grass) are all produced commercially in Oregon. The Oregon State Agricultural College provides for certification of seeds produced within the State. A purchaser of seeds should buy only certified seed, as it is the only guarantee of varietal strains and purity.

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