


1979

## Summer 1979

Joseph Troll

K. A. Hurto

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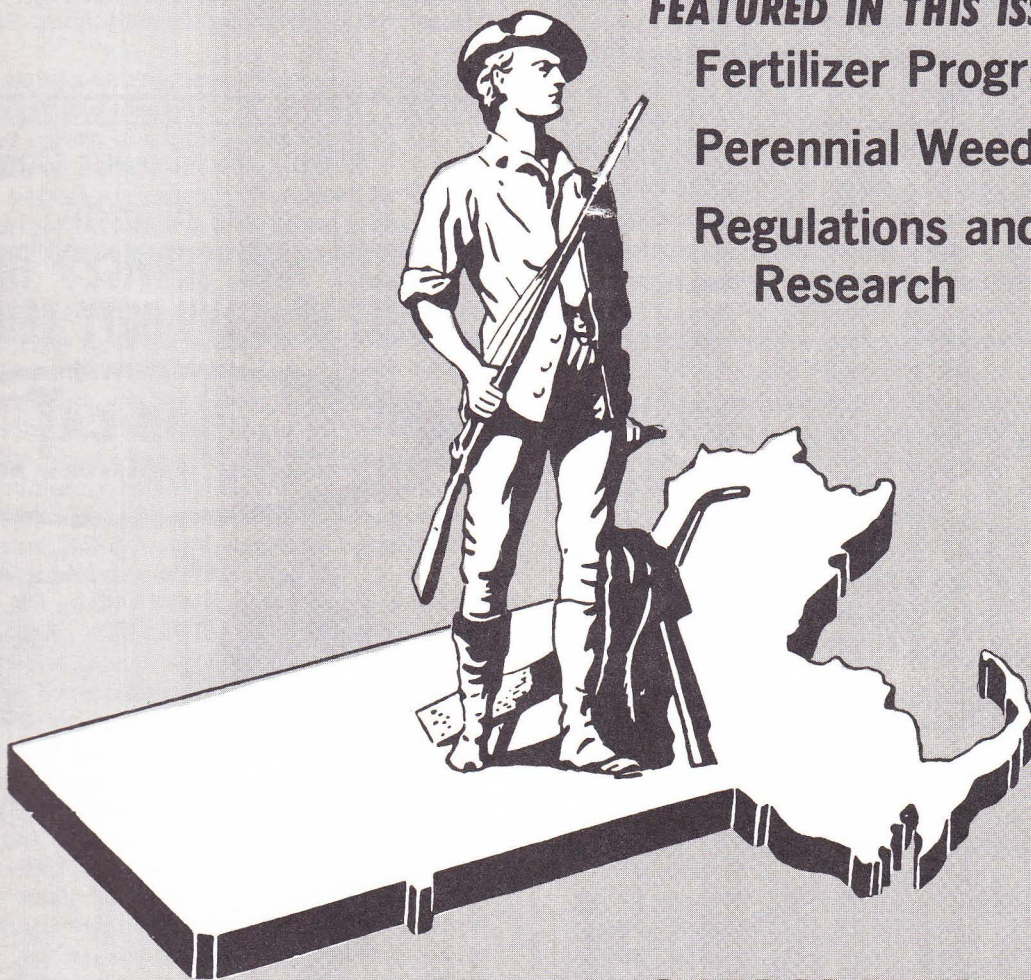
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**FEATURED IN THIS ISSUE:**

**Fertilizer Programs**

**Perennial Weed Control**

**Regulations and Pesticide  
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**SUMMER 1979**

**BETTER TURF THROUGH RESEARCH AND EDUCATION**



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Summer 1979

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Dear Reader,

Seasons have changed since the Turf Conference, all for the better. The ice has melted and mowers are back in action. At the University Turf Plots everything came out of winter in fine condition except for the ryegrasses. A ryegrass trial planted in September alongside a fine fescue trial was nowhere to be found this May except for the plotmarkers and a few weeds. A real disappointment, cultural practices were identical and now the fescues are vigorous and healthy, the ryes are by the wayside. Any explanation?

This summer issue starts with an article by Dr. Joseph Troll which may help you plan feeding your bluegrass and ryegrass more efficiently. Without leaving Stockbridge Hall we go to Dr. Kirk Hurto for a continuation of his views on weed control. Also, a new twist on Japanese Beetle control. And the reason why more new pesticides are not to be found.

And now the most important inch of print in this bulletin: University of Massachusetts Turfgrass Field Day, Wednesday, July 25, 1979, South Deerfield Turf Plots. Many new trials were initiated this spring and progress of the research program will be well noted. So, if you plan ahead and leave July 25 for education I'm sure you'll leave South Deerfield happy.

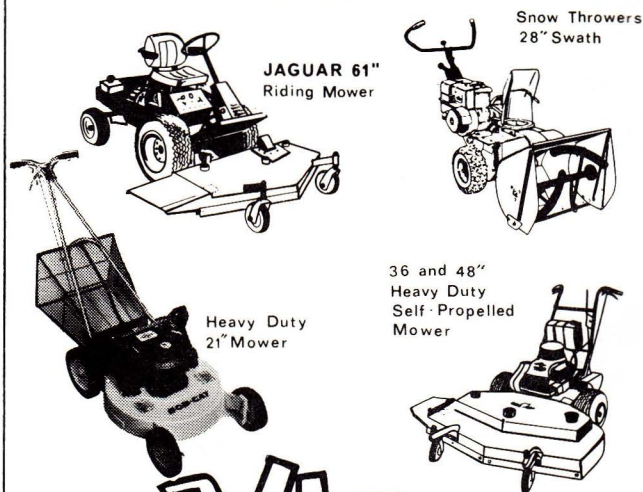
See you soon,  
Pat Kristy

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## Fertilizer Programs for Bluegrasses and Ryegrasses

By Dr. Joseph Troll  
Dept. Plant and Soil Sciences  
University of Massachusetts, Amherst, MA 01003

Fertilizer is an important tool of turf management. It affects turfgrass color, density (hence weediness), root depth and extent, build-up of thatch and the degree of injury to turf by fungal diseases, insects, high and low temperatures.<sup>3</sup>

Many factors must be taken into account when programming fertilizers for bluegrass and ryegrasses. These factors are:

- (1) the species and/or cultivar of the grass being maintained;
- (2) the texture, drainage, aeration, and reaction of soil, and the inherent fertility of the soil in which the turf is being grown;
- (3) the form or properties of fertilizer material being used;
- (4) climatic conditions at any time during the growing season and/or at the time of application of fertilizer to turf;
- (5) the management practices the grass is subjected to, including height and frequency of mowing, frequency of irrigation and return of clippings; and finally,
- (6) maintenance budget allotted.

Time does not permit an in-depth discussion of each of the above important factors but does allow presentation of a brief consideration of their specific roles in a fertilization program.

Bluegrass and ryegrasses, in fact all turfgrass species, require sixteen nutrient elements for growth and each element is needed by the plant in a range of concentration. If amounts are too low, grass growth is reduced; conversely, excessive amounts of mineral elements, especially minor elements, can be phytotoxic. All required plant minerals, other than carbon, oxygen, and hydrogen, are taken up by the roots of grass from the soil solution. However, soil type and structure contribute to nutrient exchange and availability.

Generally the mineral fraction of a soil constitutes its major component. Minerals are placed into various inorganic particle size groups, sand, silt and clay. The proportion of each of these particles, collectively termed separates, in a soil determines the textural class of the soil; the arrangement of soil particles into larger aggregates is referred to as soil structure. The clay and organic colloids in a soil attract, hold and exchange into the soil solution the nutrient elements, cations, needed for plant growth. Sandy soils have low cation exchange capacity and need much water for plant growth. Soils having high organic content are well buffered and hold applied minerals efficiently. Not especially desirable for intensively used turfgrass areas are soils containing high amounts of clay because they are prone to poor drainage and compaction. Soils categorized as sandy loam are preferred for turf. Knowledge of soil texture gives us an indication of the aeration, drainage, water retention capacity, and inherent fertility of the soil in question.

Soil reaction, acidity/alkalinity of a soil, is yet another important factor that governs a turfgrass fertilization program. Most grasses, including bluegrass and ryegrasses, grow within a relatively wide pH range but respond favorably to a slightly acid soil. In our region, the Northeast, most soils are naturally acid. The region receives high amounts of precipitation. This excessive water causes leaching of the basic nutrients from our soil thereby enhancing the soil acidity. Improper irrigation practices and the use of acid reacting fertilizers also lower soil pH. Of great importance to a fertilizer program is liming to correct soil pH. Liming enhances base saturation of clay and organic colloids, improves nitrification, and increases the availability of phosphorous and most of the needed sixteen elements. In addition liming decreases the availability of iron, zinc, copper and manganese, necessary minor elements which may reach levels toxic to plants in an acid soil.

There are a number of diagnostic aids that can be employed to determine the nutrient status of soil and turfgrass requirements. One is to recognize each deficiency symptom as expressed by the plant for each of the missing elements. A nitrogen deficient grass plant becomes chlorotic, its topgrowth turns to a yellow green, and its shoot growth is reduced. Unfortunately, deficiency symptom diagnosis is not always a simple matter, for even though turf plants show a specific symptom for each of the missing elements, the plant exhibits similar symptoms for any one of several essential nutrient deficiencies. Also, some cases, on site tissue tests for determining nitrogen, phosphorus, and potassium are useful. They provide a rapid, fair approximation of the amount of free nutrients present in leaf tissue but they do not measure nutrients converted into complex compounds within the plant itself. Soil tests to determine available plant nutrients can be run. There are a number of different soil testing methods but essentially they all measure available phosphorus, potassium, calcium and magnesium. A test might also measure nitrate nitrogen in the soil but available soil nitrogen is subject to rapid change. Soil tests do not measure total nutrients in a soil but a complete soil test is an extremely important tool in establishing a turfgrass fertilization program. In addition, soil pH should be determined for correction soil reaction. Soil tests are probably best made in the spring or fall prior to fertilizing.

Research and observations of growth made by both bluegrasses and ryegrasses have provided information valuable in determining their fertility requirements. Both species are cool season turfgrasses. Bluegrass is best adapted to a medium-textured, loam type soil. Ryegrass will do well in a wide range of soil types. Both grasses make good growth in a moist, slightly-acid fertile soil. Top growth of bluegrass may slow down during periods of water and temperature stress but will respond to



irrigation. Both grasses require the 16 elements for growth as mentioned. Bluegrass responds to high phosphorus levels. Both species require a balanced fertilizer program and react favorably to approximately four pounds of actual nitrogen per 1000 sq. ft. per season. However, there are many new improved cultivars of both blue and ryegrass and most of improved bluegrass cultivars are high nitrogen feeders. That is to say, they require more than 4 pounds of nitrogen per season. Usage to which these grasses are subjected must also be a consideration when fertility needs are being assessed.

We will assume that bluegrass and ryegrass in a mix is used in fairways and tees. Several of the new turf-type perennial ryegrass cultivars seeded into Kentucky bluegrass were shown to be quite competitive with the bluegrass during establishment. Their persistence and high shoot density also were shown to result in high quality turf over time<sup>2</sup>. Ryegrasses, however, are not tolerant to low temperatures and are prone to injury by ice cover. Turf subjected to divot removal and excessive wear will require more nitrogen to hasten its recovery.

The return of turf clippings to the area of growth influences a fertilization program also. Clippings should be removed when they interfere with the purpose of the turf because excessive amounts smother turf and enhance disease development. Clippings are not removed from bluegrass fairways, however; therefore, less fertilizer will be required in these areas to supplement soil nutrients. Beard pointed out that the removal of 'Merion' Kentucky bluegrass clippings from a turf area required two pounds of nitrogen per 1000 sq. ft. to obtain the same color and shoot density of a turf area to which clippings had been returned<sup>1</sup>.

Next, thought should be given to the form or properties of the fertilizer to be applied to turf. It will supplement the usually inadequate inherent soil fertility to bring about the desired turfgrass quality.

Once again, we know that 16 elements are necessary for plant growth but greater amounts of nitrogen, phos-

phorus, and potassium are needed by the plant than of the other minerals. Application to turf of these three elements will result in greater yield response. They are known as the major elements and the three applied together are often referred to as a complete fertilizer. In Massachusetts, the 3 elements are posted on a fertilizer bag as numbers, for example 10-5-5. The numbers mean in order 10% N - 5% P<sub>2</sub>O<sub>5</sub> - and 5% K<sub>2</sub>O. You also are aware that the 10-5-5 analysis is in a ratio of 2-1-1, two parts N, 1 part P<sub>2</sub>O<sub>5</sub>, and 1 part K<sub>2</sub>O. Since Kentucky bluegrass responds well to phosphorus, it may require a fertilizer having a 2-2-1 ratio. On the other hand *Poa annua* is favored by phosphorus. Most often our soils are reasonably high in phosphorus, in which case a 2-1-1 may do. If phosphorus is present but unavailable in the soil, it might be made available to the turf by adjusting the pH. Important, however, is the ratio of nitrogen to potash. It has been shown that potassium is involved with nitrogen metabolism within the plant. Potassium is also known as the health element because it decreases disease susceptibility and hardens off the plant of winter. It is now suggested that when applying fertilizer to turf, the ratio of nitrogen to potassium should be 2:1 or 3:2.

Phosphorus and potassium may not have to be applied to turf each time fertilizer is applied. A soil test will indicate if they are needed. Nitrogen perhaps is the most important element for turfgrass growth and is the most expensive. Nitrogen fertilizers differ not only in source but also differ in rate at which they become available to the plant. An ideal nitrogen fertilizer would be one that feeds a plant at a low, steady level so that the plant makes good growth for a long period of time.

Ammonium nitrate, ammonium sulphate, salt-type fertilizers, and urea are quickly available sources of nitrogen. They are water soluble and go into the soil solution soon after they are applied. If not properly applied, they can burn the grass plant, and they are leachable. Nitrifying bacteria convert urea and ammonium to nitrate which somewhat lengthens their availability to the plant.

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Yet nitrate, ammonium, and urea nitrogen will appear in the grass plant within minutes after entering the soil, drawing one to the conclusion that if small amounts of soluble nitrogen fertilizer are applied at one time there will be less loss to leaching. Increasing the number of applications necessary to provide steady plant growth may increase costs, however. Processed sewage sludge, animal and vegetable tankage, are natural organic fertilizers. The rate of nitrogen release from these materials depends upon soil microbial activity, which in turn is dependent upon soil temperature and moisture which can effect fluctuations in nitrogen release. In terms of time, these fertilizers are considered intermediate in their release of nitrogen. These natural organic fertilizers feed grass over a longer period of time than water soluble fertilizers and they contain minor elements.

Ureaforms also known as methylene urea compounds are the long-time slow-release nitrogen fertilizers. Soil microorganisms must work to release their nitrogen for plant uptake. However, they are not totally insoluble; one product is 70% insoluble and 30% soluble while another on the market is 70% soluble and 30% insoluble.

Other slow-release nitrogen fertilizers on the market are IBDU, an isobutylene-diurea, plastic-coated urea, and sulfur-coated urea. All are slow-release intermediates.

Don Waddington of Pennsylvania State conducted a long-term experiment using several nitrogen sources on 'Merion' Kentucky bluegrass. He researched IBDU, an extruded urea-paraffin matrix material, ureaform, plastic-coated urea, sewage sludge, and urea. Results based on grass yield data obtained over seven years showed that fertilizers consisting of water-insoluble nitrogen gave relatively low response the first year or two. Yields eventually approached or equalled those obtained from more soluble sources.

In a second test on Kentucky bluegrass, Waddington tested 12 nitrogen fertilizers, each of which had different

amounts and sources of water-insoluble nitrogen. The experiment included sulfur-coated urea and water-soluble ammonium sulphate. Results based on clipping yields showed that in the first year only one fertilizer yielded as many clippings as ammonium sulphate. The next two years 8 treatments almost equalled or exceeded ammonium sulphate yields. It is possible that the better yields in the second and third year might be attributed to the residual of water-insoluble nitrogen. There may also have been a loss of nitrogen from ammonium sulphate by leaching and/or volatilization. Plants which received sulfur-coated urea gave an intermediate response the first year and uniform growth thereafter. These data certainly show the importance of knowing your fertilizer material.

Fertilizers are not cheap and today's economy is affecting the cost of turf maintenance. If money is a problem it might be advisable to shop and compare costs. When comparing costs, use nitrogen costs as a base. If a single element is being considered, comparing costs will be simple but if a mixed fertilizer N-P-K is under consideration, fix the cost of P and K and compare the cost of nitrogen. Of course other factors such as nitrogen source, number of applications required, etc., may also influence costs. Certainly keeping a close check on turf growth, using irrigation if possible, and testing soils will help to reduce amounts of fertilizer needed and reduce costs.

Still to be considered in any turfgrass fertilization program is time of application. Research conducted by workers at VPI and URI showed that late fall fertilization is most efficient for both Kentucky bluegrass and perennial ryegrass<sup>4,5</sup>. It was suggested that a normal rate of fertilizer be applied in September and another application, but preferably at a double rate, be made after grass growth had nearly ceased in late fall, November, but because the soil froze. Best results were obtained using a soluble source of nitrogen.

Fall nitrogen fertilization when green leaf tissue is alive forces photosynthetic production of carbohydrates.

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Grass respiration rate is low at this time and carbohydrates produced are utilized mainly for root growth and food storage. Bud formation for production of tillers and rhizomes also occurs in the fall. Even after top growth ceases in late fall plants continue to photosynthesize and carbohydrates production continues if adequate fertility is maintained right up to the time the soil freezes.

Early spring fertilization leads to predominant leaf growth. This growth occurs at the expense of the nitrogen applied and from stored carbohydrates while little root and rhizome growth occurs. Kentucky bluegrass fertilized with nitrogen in late fall greens up early and attains a good density early in spring without producing excessive top growth. Soluble nitrogen should be used for late fall fertilization because slow-release nitrogen fertilizers create excessive growth in the spring.

If turf growth slows decidedly in late May, then light fertilization should be applied. Summer dormant bluegrass should not be fertilized. Hot humid overcast days favor nitrogen use by fungi so fertilization at that time is not recommended. Also do not use nitrogen fertilization during long periods of rainfall.

We fertilize Amherst golf course fairways as follows: A light application of a complete fertilizer at the rate of about 1/2 pound of nitrogen per 1000 sq. ft. at the end of May or first part of June. Fertilizer is again applied at the end of August or first week in September at the above mentioned rate. Approximately the third week in November we apply 3/4 of a pound of nitrogen per 1000 sq. ft. Our fairways consist of Kentucky bluegrass, creeping bentgrass, and a predominant amount of annual bluegrass. We have a very limited budget but we do have good playable fairway turf. I have observed that our fairways green up early in spring without excessive top growth of grass. Another item to mention is that late fall fertilization appears to enhance the incidence of grey snow mold, but grasses recover quickly in early spring.

It is obvious that specific fertilizer programs for bluegrasses and ryegrasses were not discussed. To program fertilizer for turf, the turf manager must know his golf course. He must be aware of the soil in which the turf is growing, and its fertility level. He should know the grass specie needs, the character of the fertilizer to be applied, and adjust his turf maintenance practices according to grass requirements. Fertilization should be related to grass growth and environment. The ideal program will provide dense turf, good color, but not excessive top growth.

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## Turfgrass Slide Sets Available

Two 35 mm. slide sets, one of diseases of turfgrass and the other on insects of turfgrass in the northeast, are now available from the N.Y. State Turfgrass Association. These slide sets are a useful tool in the identification and control of diseases and insects of turf and are of educational value to universities, extension agencies and management and maintenance personnel at parks and recreational facilities, golf courses, cemeteries and other green industry facilities.

The 66-slide set on diseases of turfgrass, compiled by Dr. Richard Smiley of Cornell University, pictures the symptoms and effects of snow mold, leaf spot, dollar spot, rust, red thread, slime mold, striped smut, mildew, fairy rings, brown patch, melting-out, fusarium and pythium on turfgrasses. The 76-slide set on insects of turfgrass in the northeast, compiled by Dr. Haruo Tashiro of Cornell University Agricultural Experiment Station, pictures a variety of beetles, chafers, sod webworms, chinch bugs and other insects and the damage they do to turf.

Either slide set is \$20 for New York residents and \$25 for out-of-Staters. The price includes postage, handling and a written key to the slides. Kindly send checks made payable to the N.Y. State Turfgrass Association to Ann Reilly, N.Y.S.T.A. Executive Secretary, 210 Cartwright Blvd., Massapequa Park NY 11762. Please specify which set you are interested in.

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## Neem Tree

# Seed Extracts Repel Japanese Beetles

Japanese beetles will starve before they will eat some plants treated with extracts of the seed from the East Indian neem tree. Three years of research at Wooster, Ohio, has shown good protection of soybean plants by spraying with neem seed extracts.

"Seeds of the tree have long been reputed to repel insects and deter them from feeding," says Thyrl L. Ladd, entomologist and research leader of SEA's Japanese Beetle Research Laboratory at Wooster. "So, we decided to examine extracts of the seeds to determine whether they affect feeding of Japanese beetles."

Japanese beetles are known to feed on about 300 different plants including grapes, roses, birch, elm, rhubarb, and even poison ivy. The grub stage lives in the soil and loves good turf, where it consumes the roots, reducing growth and even killing the grass in severe cases. Turf is especially susceptible to beetle damage in dry whether, Dr. Ladd says.

The beetles are slowly spreading from their present range which runs from southeastern Canada to Georgia and from Delaware to Missouri.

Using sassafras foliage as the test material, SEA scientists tried three different extracts from the neem seed in 1975. They tested five concentrations of each extract, ranging from 0.25 to 10 percent, which were applied to one-half of the leaf. The leaves were then placed in containers with 25 beetles. In an additional test, entire leaves were treated and placed in pots without a supply of untreated leaves for the beetles.

"When leaves were checked 24 to 48 hours later, the treatment showed excellent results," Dr. Ladd said. Untreated leaf halves were completely consumed except for

veins. Treated leaf halves were practically untouched. Only the leaves receiving the lowest concentrations showed slight indications of feeding.

"When beetles were offered only treated leaves, we found occasional small scars on the leaf surfaces," Dr. Ladd said. "Some beetles died rather than consume the treated sassafras leaves."

Because of the successful results, both laboratory and field tests were conducted in 1976 using soybeans. The tests were designed to evaluate the residual effects of the neem seed extracts on beetle feeding.

Beeson variety soybeans were sprayed in the field and leaves were picked and placed in pots in the laboratory with 40 beetles at various intervals over a 17-day period. The leaves were checked for damage after 24 hours.

Beetles rapidly destroyed untreated foliage, Dr. Ladd said, while neem-treated leaflets collected 3 days after treatment remained undamaged. Those collected 12 days after treatment suffered only slight damage, and those tested at 17 days showed only moderate feeding.

Other treated plants were left in the field and checked for damage. Repellency was still protecting the plants 14 days after treatment in the midst of heavily damaged, untreated soybean plants, Dr. Ladd said.

In 1977, the third year of tests, randomly selected plants were treated in the field on a 3- or 7-day schedule. Baits were used to attract beetles to the area. Beetle counts were made on the plants each day and feeding damage was evaluated at the end of the test.

The differences in feeding on neem-treated plants and untreated plants were striking, Dr. Ladd said. Thir-



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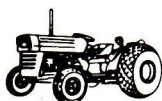
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ty-six times as many beetles were counted on untreated plants as were found on those sprayed on the 3-day schedule with neem extract. Part of the test had to be terminated after 9 days even though plants treated on the 3-day schedule were relatively untouched because the untreated plants were destroyed.

"Our studies show that extracts of neem seeds are uniquely effective as a deterrent to Japanese beetle feeding," Dr. Ladd said. "Since other research has shown these extracts to deter other insect pests, they may be useful in a number of pest management systems."


"We are looking at a variety of approaches to the Japanese beetle problem," Dr. Ladd said. "The neem seed extract looks good so far. It is a natural material and, hopefully, should not be a hazard to the environment."

Research chemist Martin Jacobson, chief of USDA's Biologically Active Natural Products Laboratory, Beltsville, Md., cooperated with Dr. Ladd on the project. Research technician Charles R. Buriff also worked with Dr. Ladd at Wooster. The Beltsville laboratory is continuing its cooperation by isolating the active compounds and providing these to Dr. Ladd for evaluation.

Jacobson says the neem tree is a commercially grown crop in India where the seed oil is used in medications and as fuel in lamps, as well as for repelling insects. For example, in India, the seeds are commonly mixed with grain in storage to keep insects out.

Dr. Thyril L. Ladd, Jr., is with the Japanese Beetle Laboratory, Ohio Agricultural Research and Development Center, Wooster, OH 44691.—R.G.P.

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## Principles of Turfgrass Weed Control II. Perennial Grasses

By K. A. Hurto

Selection of adapted turfgrass species and use of proper cultural practices will aid in the maintenance of a uniform plant community free of undesired species. Turfgrass weeds, however, have evolved unique morphological and/or physiological features which enable them to persist in a turfgrass stand even where climatic conditions or cultural practices do not favor them. Most weed species that invade an established turf can be selectively controlled without adversely affecting the desired plant species. Applications of selective herbicides will control unwanted annual grasses and broadleaf weeds, but there is no herbicide that will selectively remove unwanted perennial grasses from established turfgrass communities.

Quackgrass is a noxious, perennial weed that infests sod fields, lawns, athletic fields, fairways, and roughs in the northeast. It may be disseminated by seeds originating from plants growing in waste areas and along fence rows, but is spread primarily by rhizomes carried on cultivation equipment from infested fields or in topsoil removed from quackgrass-infested land. Once established, quackgrass is difficult to control. Attempts to physically control it by manual removal or cultivation have been ineffective; in fact, mechanical control measures, such as roto-tilling, appear to only disseminate rather than eradicate quackgrass.

Control of quackgrass will require applying an herbicide. Amitrole and dalapon have been used in the past but these herbicides were not completely effective in controlling regrowth from rhizomes; also, residual activity associated with these chemicals can delay replanting of the treated sites up to six weeks. More recently, glyphosate has been recommended for control of quackgrass and other perennial grasses. Glyphosate, like amitrole and dalapon, is a nonselective systemic herbicide; however, it is more effective in controlling perennial grasses and is rapidly inactivated by soil. Consequently, there is no soil residual activity which delays replanting of treated sites.

Although glyphosate is superior in its control of quackgrass, suppression of regrowth is not always complete. Several factors including time of year, climatic conditions, plant maturity, and application rates will affect glyphosate efficacy. Applying glyphosate to quackgrass in the fall is preferred since environmental conditions promote greater translocation of the herbicide through the plant, particularly to rhizomes (Figure 1). Greater translocation and control occurs when applied the morning after the first frost of the fall. Where possible, increasing foliage height by not mowing for several weeks will enhance control due to increased surface area for herbicide contact and absorption. Adding surfactants to the spray solution is not recommended since glyphosate is formulated with a surfactant. In fact, studies have shown indiscriminate addition of surfactants to glyphosate spray mixtures can reduce control.

Creeping bentgrass and tall fescue are two other difficult-to-control grasses. They are disseminated by seed: present as contaminants in seed mixtures or transferred

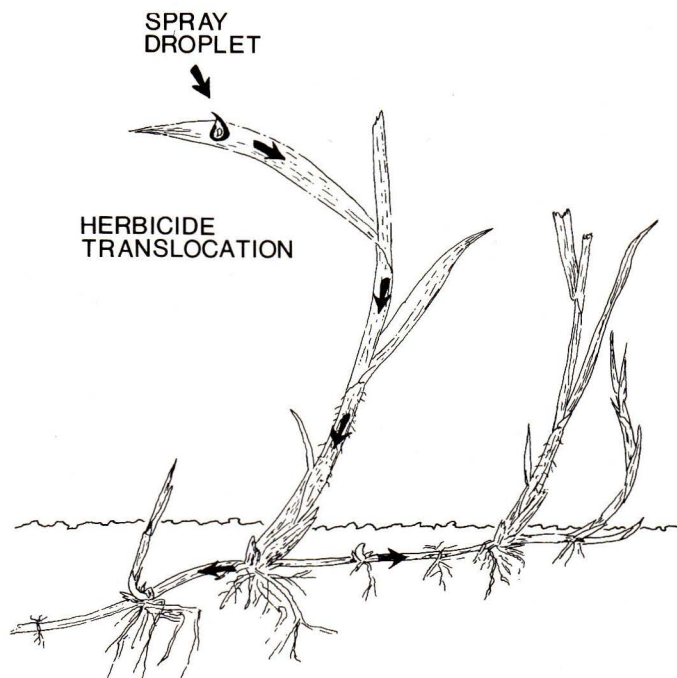



Figure 1. Perennial grasses control must include existing vegetation and regrowth from rhizomes. Downward translocation of the herbicide from the treated leaf to the rhizome must be complete to prevent regrowth from rhizome buds. Do not sever rhizomes until this process is complete.


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to sites by disc seeders and other equipment. Once established, these species will persist as isolated patches in lawn-type turfs.

Glyphosate control of these weeds is good although more than one application may be required. Spot-treatment of isolated patches is an economical and effective method of controlling these grasses. If patches are small reseeding may not be necessary; however where patches are contiguous or large, reseeding is essential to assure recovery of the treated spots by desired turfgrass species.

Where turf sites are severely infested with perennial grassy weeds a decision must be made: spot-treat localized weed patches or treat the entire area which will require replanting of the site. Usually where quackgrass is a serious problem, complete turf renovation is required (Figure 2). Timing of the turfgrass renovation program should coincide with climatic conditions that enhance control of the existing vegetation and establishment of desired turfgrass species. Applications of 2 to 3 pounds (active ingredient) per acre of glyphosate will give satisfactory weed control. Where a second application is required, delay spraying until the 3- or 4-leaf stage of regrowth. Complete translocation requires 48 to 72 hours

TURFGRASS RENOVATION

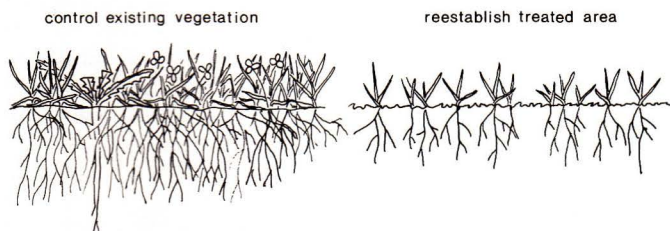


Figure 2. Turfgrass renovation includes controlling the existing vegetation and reestablishment of the treated site by desired turfgrass species.

Table 1. Effects of established method in the development of Penn-fine perennial ryegrass cover following glyphosate treatment at 2 lb/acre of a mature Kentucky bluegrass turf.

Established Method	Percent Stand Cover		
	6 weeks	15 weeks	50 weeks
Disc Seeding (2 lbs/1000 ft <sup>2</sup> )	42.7	86.3	91.6
Vertical Mowing & Broadcast Seeding (6 lbs/1000 ft <sup>2</sup> )	64.5	87.6	98.3
Core Cultivation, Vertical Mowing, & Broadcast Seeding (6 lbs/1000 ft <sup>2</sup> )	67.0	96.5	97.3

depending on growing conditions. Do not sever rhizome prior to this, otherwise regrowth from detached rhizomes will occur. Replanting may be accomplished by several methods. (Table 1). If soil structure is good and thatch is not a serious problem, fairways and lawns can be reestablished using a disc seeder. While this method is fast and economical, percent cover is less than when treated sites are vertically mowed and broadcast seeded. Compacted soils or thatched turfs should be core cultivated, vertically mowed to disperse the soil cores, and broadcast seeded.

Control of perennial grasses is difficult, thus, sanitary practices should be exercised to prevent introduction of these noxious weeds. When purchasing topsoil for construction projects or topdressing, to sure it is free of quackgrass rhizomes. (Another serious weed introduced in this manner is yellow nutsedge. Small nutlets, about the size of a corn kernel, are formed at the ends of its roots; these nutlets will form new plants which persist in turfs.) When tilling fields infested with quackgrass be sure to clean equipment before entering weed-free fields. Bentgrass, other fine-textured grasses, and coarse-textured grasses, such as tall fescue, can be found as contaminants in seed lots. It takes only a few seeds per pound to seriously contaminate a turfgrass planting. Thus, purchase seed that is certified and contains a flagging statement listing the presence of crop seeds, if any, on the label.

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## How Regulation Is Impacting On Pesticide Research

Whether to continue to invest in pesticide R & D is a question being debated in boardrooms around the world. This special report, based on an FC confidential survey of U.S. and international companies and an NACA study of 48 U.S. companies, gives some insight into the changes being made because of the slowdown in registration and mount-regulations.

"Should we continue to expend dollars for pesticide research when it takes upwards of \$20 million and on the average nine years just to get a single product registered and start making any kind of a profit?"

That question continues to be debated in boardrooms of chemical companies around the world. And the answer is not always positive. Some companies have abandoned the search for new products, others are cutting back drastically. Fortunately for agriculture and mankind, the majority of companies are trying to maintain their current research levels, fighting against increasing regulatory requirements and inflation that keep eating away at the research dollar.

To get some insight into the thinking of major companies regarding their research programs, FARM CHEMICALS recently conducted a confidential survey of leading producers from the U.S., Europe, and Japan. A similar study of U.S. companies only has just been released by the National Agricultural Chemicals Associa-

tion, covering research expenditures by 48 different companies.

The results of NACA's survey are presented here, along with the results of FC's confidential survey. To give a more meaningful comparison, the figures have been broken down by U.S.A., representing NACA's findings and Outside U.S.A., representing the composite responses by foreign producers only to FC's confidential questionnaire. Where available, actual dollars spent on pesticide research are presented. Percentages of total investment in R & D are also shown.

There is no question that the regulatory process has come to a virtual halt in the U.S. Only four new compounds were registered in 1976 and just three in 1977 by the 48 U.S. companies participating in the NACA survey. In contrast, companies outside of the U.S.A. registered 19 compounds during 1976-77, a difference of 12 for the two-year period.

Companies outside the U.S. reported a time lag of 76 to 85 months from discovery to first full registration during 1977.

Average elapsed time from discovery to first full registration reported by U.S. companies was a whopping 110 months—just ten months short of 10 years! As emphasized by NACA, "the trend line analysis of data from prior surveys shows that over the past 10 years the average elapsed time has increased from about 58 months to about 100 months, an average growth rate of 5.5%."

In 1977 U.S. companies returned 8.1% of pesticide sales to R & D. Companies outside the U.S. returned 9.8%. U.S. companies reported screening an average of 2955 compounds in 1977, compared to an average of 5375 compounds for companies outside the U.S.

Pesticide R & D expenditures reported by 37 U.S. companies in the NACA survey totaled over \$250 million, and increase of about 14% over 1976. This included \$161 million for new product research, \$58 million for product expansion, and \$40 million for registration and product defense. Cost of rebutting RPAR actions by EPA totaled \$6.8 million.

U.S. companies are spending approximately 65% of their research dollars on new product development, 23% on product expansion, and 12% on registration and product defense. This contrasts to 49% on new product development, 33% on product expansion, and 18% on regulatory maintenance of existing products being invested by companies outside the U.S.

### Little Basic Research

Less than half of the companies surveyed by FC inside the U.S. and outside are engaged in basic research defined as "research conducted without expectation of discovering a new product." Only one company reported spending over 10% of its R & D budget for basic research.

Instead, the bulk of research is still concentrated in four major areas—herbicides, insecticides, fungicides, and growth regulators. An estimated 5% of the R & D budget is being devoted to discovery of chemosterilants,

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### The Registration Process Gets Slower and Slower

#### U.S.A.\* Average Elapsed Time (Months)

	1975	1976	1977
From discovery to first full registration ..	93	74	110
From first submission for registration (temporary or experimental) to full commercial registration .....	30	38	40
From submission of registration petitions to granting of full commercial registration	14	14	29

\*Source: National Agricultural Chemicals Association

#### Outside U.S.A.\* Average Elapsed Time (Months)

	1977
From discovery to first full registration ..	76-85
From first submission for registration (temporary or experimental) to full commercial registration .....	21-33
From submission of registration petitions to granting of full commercial registration	16-21

\*Source: FARM CHEMICALS

### Cost of Rebutting RPAR Actions by EPA

#### U.S.A.\*

	1976	1977
Research and develop- ment expenditures .....	\$1,018,000	\$5,262,000
Other direct costs .....	104,000	1,526,000
<b>Total</b>	<b>\$1,122,000</b>	<b>\$6,788,000</b>

\*Source: National Agricultural Chemicals Association

### Fewer Products Reach Commercialization

#### U.S.A.\* New Compounds Screened

	1976	1977
Average number of com- pounds screened .....	2997	2955

\*Source: National Agricultural Chemicals Association

#### U.S.A.\* New Products Registered

	1976	1977
New compounds registered	4	3

\*Source: National Agricultural Chemicals Association

#### Outside U.S.A.\* New Compounds Screened

	1976	1977	1978 (est.)
Average number of compounds screened	5096	5477	5375

\*Source: FARM CHEMICALS

#### Outside U.S.A. New Products Registered

	1976-1977
New compounds registered	19

\*Source: FARM CHEMICALS

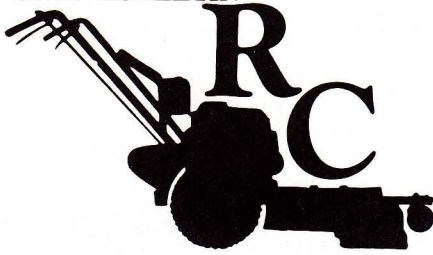
pheromones, viruses, attractants, chitin inhibitors, juvenile hormones, and other biological and so-called third-generation pesticides.

This reflects the ever-increasing cost of research and the need for products with greater sales potential to try to cover these costs. FC asked companies around the world how large a market potential (in dollars) must a product have to bring it to full registration. Their answers varied from a low of \$10 million to a high of \$50 million, with the range close to \$40 million.

"There are many things to consider," one company emphasized. "The possible life span of the product, profit margin, and potential sales volume per year all enter into justification of whether to continue development of a candidate pesticide."

Return on investment and gross profit margin are considered by most companies as more important than the size of the market. As a European-based producer explained. "A product for a potential \$50 million market with a small gross profit margin might be of less interest










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## Pesticide R & D Expenditures—1977

U.S.A.\*  
(Million Dollars)

Type of Expenditure	New Product	Product Expansion	Registration & Product Defense	Total	Percent of Grand Total
Synthesis	25,137	375	14	25,526	10
Screening	27,520	545	25	28,090	11
Sub-total	52,657	920	39	53,616	21
Toxicology					
Mammalian	7,401	1,491	6,523	15,415	6
Environmental	1,671	1,062	1,379	4,112	2
Sub-total	9,071	2,553	7,902	19,527	8
Field plot testing	25,848	21,171	3,658	50,677	20
Metabolism	7,381	2,578	2,224	12,183	5
Environmental chemistry	2,812	1,266	1,266	5,344	2
Residue analysis (includes methods development)	6,549	6,015	4,073	16,637	7
Formulation development	8,841	4,961	1,349	15,151	6
Process development	22,312	10,034	3,498	35,844	14
Registration	1,605	2,910	2,189	6,704	3
Administration	10,108	3,311	2,936	16,355	7
All Other Expenditures	14,134**	2,550	1,349	18,033	7
<b>TOTALS</b>	<b>161,319</b>	<b>58,269</b>	<b>30,483</b>	<b>250,071</b>	
<b>Percent</b>	<b>65</b>	<b>23</b>	<b>12</b>		<b>100</b>

\*Source: National Agricultural Chemicals Association. Total expenditures by 37 different companies.

\*\*Includes other basic research expenditures of \$6,767,000.

### Outside U.S.A.\*

Type of Expenditure	Percent of total		
	1976	1977	1978 (est.)
Synthesis and screening	29	29	26
Field testing and development	25	24	24
Toxicology and metabolism	18	18	19
Formulating and chemical development including process development	20	21	21
Registration	8	8	10
<b>Total</b>	<b>100</b>	<b>100</b>	<b>100</b>

Source: FARM CHEMICALS

because it has "prioritized activities and made other adjustments in R & D operations."

Less than half of the companies are using techniques of molecular biology to "create" compounds rather than synthesis and screening for biological activity. "The classical empirical approach appears more successful at this time," one R & D director explained. Another reported use of molecular biology, pattern recognition, and mathematical modeling, along with empirical methods.

One "short-cut" being widely used, however, is the Ames test and other so-called quick tests for mutagenicity and carcinogenicity. Only two companies said they are not using the Ames or a similar test in their R & D programs. The quick tests are being used to identify potential problem areas and as "predictive models." A positive response to the Ames mutagenicity test, however, is not being accepted by the companies as conclusive. Instead, it is being followed by "another battery of quick tests" or "tests on warm-blooded animals" or "dominant lethal tests."

#### Are Testing Requirements Fair?

Do pesticide companies around the world feel that the current testing requirements, particularly those imposed by the U.S.-EPA are fair? That question in FC's confidential survey provoked considerable criticism of current protocol and interpretation.

"Yes, they are fair inasmuch as the responsibility for risk/benefit evaluation lies with industry," one company acknowledged, adding that "increasing requirements

than a product with a potential market of \$5 million but with an outstanding profit margin."

Risk, idle capacity, and alternative use of funds must also be considered.

There seems to be little question, however, that development of pesticides for minor use in being severely reduced. "Most R & D dollars will be allocated to products that have potential in one or more crops like corn, cotton, and soybeans, rather than products for minor use. The investment is the same, whether it's a major market or a minor one."

The companies surveyed by FC report that inflation has reduced actual dollars spent on R & D by 5 to 20%, with the average about 8%. One company emphasized that actual dollars spent have remained about the same



make registration increasingly expensive and future development of pesticides uneconomical."

"No," another company declared, charging that "there is too much testing required, and the protocols are quixotic and nondefinitive."

Another dissenter points out that the testing requirements are "often too rigid and not enough oriented to special properties, uses, and problems of products." Still another terms many of the testing protocols "misdirected and arbitrary."

"In general we feel that the testing requirements are fair," a European producer explained. "However, the interpretation and long review time give us concern."

A qualified "yes" was given by another European producer who believes they are in general fair "but with some notable exceptions such as lifetime mouse studies and some specific environmental studies such as egg-to-egg fish reproduction, which does not generate clear data and is very dependent upon fish species and methodology."

"Reasonable judgment" could reduce testing in the view of several companies who point out, "Why do photo decomposition studies in soil if light cannot penetrate soil?"

"Probably 20 to 25% of the tests required are unreasonable," a respondent declared. "Unfortunately, that percentage will increase as more requirements are added."

Interpretation of test, particularly toxicological tests, is a grave concern. Not a single respondent to FC's confidential survey is in agreement with the current interpretation of toxicological data based on massive dosages. "Unreasonable and unscientific" seems to be the consensus.

"Chronic testing should be related to expected exposure levels, not maximum tolerated dose," on company maintained.

"Massive dosage results are meaningless," another company declared. "Toxicological effects are best ob-

tained by dose-response testing over the lifetime of an animal."

"Interpretation should reflect the fact that excessive doses saturate the animal and impede normal defense mechanisms," another respondent urged. "There is no consideration being given to overload or to detoxification mechanisms which operate successfully at lower, more realistic dosages."

A practical dosage for chronic studies, based on actual residue data, and recognition of a no-effect level is strongly recommended by the majority of the companies surveyed. "No test that does not establish a no-effect level is acceptable," a U.S.-based company declared.

And still another respondent adds this warning. The current interpretation being used will lead to a total no-risk attitude which will lead to fatal consequences for the chemical industry in general. Science, industry, and regulatory authorities have to develop procedures where quantitative aspects and more problem-oriented approaches play a more important role than they do today."

#### More Consolidation, Licensing Ahead

The participants in FC's confidential survey are unanimous in the opinion that fewer companies will be conducting research for new pesticidal chemicals in the future.

"Only a large established company can afford a research program," one respondent believes. This was seconded by another respondent who adds that "only companies with large resources and long-term commitments in pesticide R & D can afford the investment. The small businesses are going to be excluded."

Others point to the high risk associated with pesticide development now and over the next few years. One answer, in the opinion of a European-based respondent, is reciprocal research agreements where two or more companies share the cost of development and marketing.

Licensing arrangements are also being viewed as a possible means of sharing rising development costs.

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**Pesticide R&D Expenditures as a Percent of Sales**

U.S.A.\*

Type of Expenditure	Percent of Total 1977 Sales
Total synthesis and screening	1.7
Field plot testing	1.6
Toxicology	
Mammalian	0.5
Environmental/wildlife	0.1
Metabolism	0.4
Environmental chemistry	0.2
Residue analysis (includes methods development)	0.5
Formulation development	0.5
Process development	1.2
Registration	0.2
Administration/overhead	0.5
All other expenditures (includes basic research)	0.7
<b>Total</b>	<b>8.1</b>

\*Source: National Agricultural Chemicals Association. Based on companies reporting both R&D and sales.

**Where Companies Are Concentrating Their Research\***

(Both U.S.A. and Outside U.S.A. Companies)

Area	1976	1977	1978 (est.)
Herbicides	38%	39%	39%
Insecticides	40%	36%	34%
Fungicides	14%	14%	14%
Growth regulators	5%	6%	8%
Chemosterilants, pheromones, viruses, attractants, chitin inhibitors, juvenile hormone, etc.	3%	5%	5%
<b>Total</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>

\*Source: FARM CHEMICALS

**Pesticide Sales Returned to R&D**

Outside U.S.A.\*

Year	Percent
1976	9.8%
1977	9.8%
1978 (est.)	9.8%

\*Source: FARM CHEMICALS

Another avenue for reducing costs R & D would be harmonization of pesticide regulations worldwide. As of now, the companies surveyed see little hope of harmonization in the near term. There is no question, however, regarding the desirability of harmonization. As one company emphasized, "If harmonization comes about, we would have more confidence that each development dollar is being usefully spent. Today, too many are being wasted on redundant requirements."

Harmonization is very desirable and in the long term "essential," another company stressed. "More of our research dollars could go to productive use."

A pessimistic view was sounded by a U.S. respondent who says, "Harmonization may come about—probably in 15 or 20 years. Concurrently, new regulatory issues will emerge placing demand on our research resources. We don't anticipate harmonization but it would be nice if ..."

Harmonization would have a positive impact on most companies' research plans. "If it happened, it would encourage our development of pesticides with more specificity and for minor uses," one respondent indicated. "Our ability to bring a new product to the market place would be enhanced," another emphasized.

"Harmonization would liberate more funds for useful research because the risks one must take would be more clearly defined. Now it is very difficult to predict," acknowledged another respondent.

**Government and Research**

How do pesticide companies worldwide see the role of government and of universities in research for new pesticides? One European respondent explains it this way: "The government shall have the responsibility for the registration and safety, and universities can conduct research on special questions in cooperation with the respective companies."

A U.S. respondent sees government and universities "continuing to do research on chemical methods in response to the needs of the agricultural community. As a basic policy, however, more emphasis will be placed on chemical and biological aspects of integrated pest management."

"There is a proper role for collaboration between government, universities, and industry to develop new, safer pesticides instead of wasting effort on idealistic schemes such as integrated pest management," in the opinion of another respondent.

The role of government and universities is seen by another company like this: "Synthesis of chemicals



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## The Importance of World Trade

### U.S. Export Sales of Domestic Production\* Manufacturers' Level (Million Dollars)

	1976	1977	Percent Change
Herbicides	\$ 248,456	\$ 327,592	+ 31.8
Insecticides	235,587	315,557	+ 33.9
Fungicides	61,110	70,338	+ 15.1
Plant Growth Regulators	5,515	6,312	+ 14.4
Nematocides	5,784	13,022	+125.1
Miscellaneous	4,915	6,134	+ 24.8
<b>Total</b>	<b>\$ 561,367</b>	<b>\$ 738,955</b>	<b>+ 31.6</b>

\*Source: National Agricultural Chemicals Association.  
Total of 37 companies participating.

### U.S. Domestic Sales of Domestic Production\* Manufacturers' Level (Million Dollars)

	1976	1977	Percent Change
Herbicides	\$1,251,154	\$1,348,004	+ 7.7
Insecticides	514,017	634,746	+ 23.5
Fungicides	106,594	134,688	+ 26.4
Plant Growth Regulators	28,065	28,131	+ 0.2
Nematocides	42,426	60,205	+ 41.9
Miscellaneous	54,135	50,416	- 6.9
<b>Total</b>	<b>\$1,996,391</b>	<b>\$2,256,190</b>	<b>+ 13.0</b>

\*Source: National Agricultural Chemicals Association.  
Total of 42 companies participating.

### U.S. Domestic Sales of Foreign Production\* Manufacturers' Level (Million Dollars)

	1976	1977	Percent Change
Herbicides	\$ 68,588	\$ 91,378	+ 33.2
Insecticides	24,757	24,973	+ 0.8
Fungicides, Plant Growth Regulators, Nematocides & Miscellaneous**	5,523	3,287	-40.5
<b>Total</b>	<b>\$ 98,868</b>	<b>\$ 119,638</b>	<b>+ 21.0</b>

\*Source: National Agricultural Chemicals Association.  
Total of 26 companies participating.

\*\*Combined to avoid disclosure of individual company data.

should be left to private industry. However, development of data to define use patterns under local conditions should be done by government experiment stations. Large government grants to federal and state research stations to explore non-chemical pest control methods leave these researchers little time to do useful research on chemical pesticides."

A U.S.-based company sees the role of government and universities diminishing "whereas we feel they should be conducting basic research to establish new ground."

Still another believes that USDA should continue to conduct basic research. "They should devote their time and studies to fundamental research of the safe use of pesticides, IPM and other systems, long-range ecological studies, disposal, watershed and water quality, contamination in the atmosphere, etc."

#### Looking Ahead

Crop protection chemical companies around the world are facing ever-spiraling development costs.

In its survey, the National Agricultural Chemicals Association pinpoints this problem:

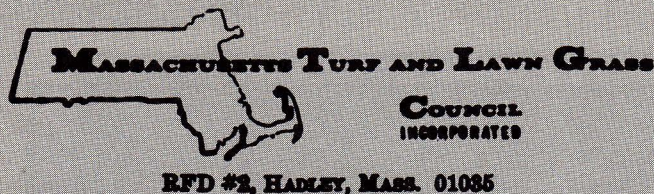
"If one assumes that new product research continues at the 1977 level and results in the annual registration of 10 new chemical structures (historically acceptable but currently very unrealistic), then each new pesticide is costing in excess of \$16 million. Of this, \$5 million covers the cost of synthesis and screening for failures, and the remainder covers direct costs for the product and indirect costs for its share of expenditures for candidates

dropped after being carried part way through development. Additional costs incurred to expand labeled uses and meets registration requirements, although substantial, are not included in this estimate."

A cost of upwards of \$200 million and 7-10 years to first registration is the dilemma facing these companies. But as of now, those companies in the U.S., Europe, and Japan who participated in FC's special survey are continuing to maintain their research activities at current levels, and plan to do so for the immediate future. If costs continue to increase, the decision on whether to continue to invest in pesticide research will again be debated in company boardrooms around the world and the answers are likely to be much less positive.



**FROM**



## University of Massachusetts Turfgrass Research Fund

Research Contributions - June 1, 1978-March 7, 1979

The Upjohn Company	\$700.00
Lofts Pedigreed Seed Inc.	500.00
Cape Cod Turf Managers Assoc.	400.00
Diamond Shamrock Co.	750.00
Country Club of New Canaan, CT	100.00
Turf Specialty Co.	100.00
Paul Christ	50.00
Woodstock Country Club	100.00
Metropolitan Golf Course Supt. Assoc.	450.00
Edgewood Golf Course of Southwick, MA	100.00
Connecticut Association of Golf Course Superintendents Inc.	200.00
Northeastern Golf Course Superintendents Association	150.00
Golf Course Superintendents' Assoc. of New England	121.00
John J. Lynch	25.00
Anthony J. Grasso	50.00
Sherwood Moore	50.00
Chester Drake Sons, Inc.	300.00
Stockbridge Turf Club	200.00

### University of Massachusetts Turfgrass Research Field Day

*When:* Wednesday, July 25, 1979  
raindate: Thursday, July 26

*Where:* South Deerfield Turf Plots

*Contact:* Dr. Joseph Troll, Stockbridge  
Hall, University of Massachusetts,  
Amherst, MA 01003 413/545-2353

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## CHEMICALS

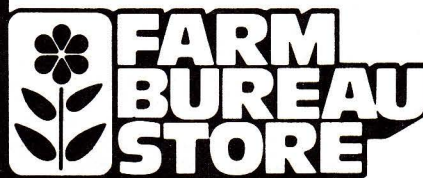
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