Ag and Food Interprets

- Sea lampreys, Great Lakes' fishing menace, yielding to chemical control
- Wider use of climate control chambers helps predict field results
- How to get around phosphoric acid's disadvantages in liquid fertilizer processing
- Grasslands—the next frontier for fertilizer to conquer

Wiping Out Sea Lampreys

New lamprey-killing chemical is the best yet, says Fish and Wildlife Service

The sea lamprey, an eel-like parasite that has killed practically all trout fishing in Lakes Huron and Michigan

POTENT new chemicals are able to reach down into the sand and silt of stream beds to destroy larvae of the predatory sea lamprey. Lampreys are eel-like fish that have been a menace to commercial and sport fishing in the Great Lakes since the early 1930's. By now, they have wiped out practically all the trout in Lakes Huron and Michigan, as well as about half the trout in Lake Superior. If lampreys are not effectively controlled soon, trout fishing in Lake Superior may be doomed in another three years.

A $10-Million Killer

And trout are not the only targets of the marauding sea lamprey. It also kills whitefish, pike, carp, and other fish. In attacking fish, the lamprey first attaches itself firmly to the side of its victim and then bores in with its tooth-lined suction mouth and tongue. The fish gradually declines, and finally dies as the lamprey sucks out its body fluids. By this all-too-effective technique, lampreys kill an estimated $10 million worth of fish a year in the Great Lakes.

But the situation is far from hopeless. The past four years have brought forth three compounds that have shown high toxicity to lamprey larvae, but leave other larvae, fish, and wildlife unharmed.

An important breakthrough came in the fall of 1955 with the discovery of the selective toxicity of 3-bromo-4-nitrophenol. Credit for this finding goes mainly to Vernon C. Applegate of the U. S. Fish and Wildlife Service's Hammond Bay Fishery Laboratory in Rogers City, Mich. To date, he and his coworkers have screened some 6000 compounds as possible lamprey killers.

Too Expensive

The big problem with 3-bromo-4-nitrophenol, however, was that it was extremely difficult to make in uniform purity, and was expensive. The company that supplied the first pound charged a whopping $1640 for it. However, this material provided the vital key to the puzzle—the desirability of investigating other halogenated mononitrophenols as potential lamprey killers.

The next compound to show real promise was 3,4,6-trichloro-2-nitrophenol. Used in concentrations of 20 p.p.m., it killed more than 95% of the larvae. Made by Dow Chemical as Dowlap-30, this compound was tested by Fish and Wildlife last year in a number of lamprey spawning streams in Michigan, and proved highly effective.

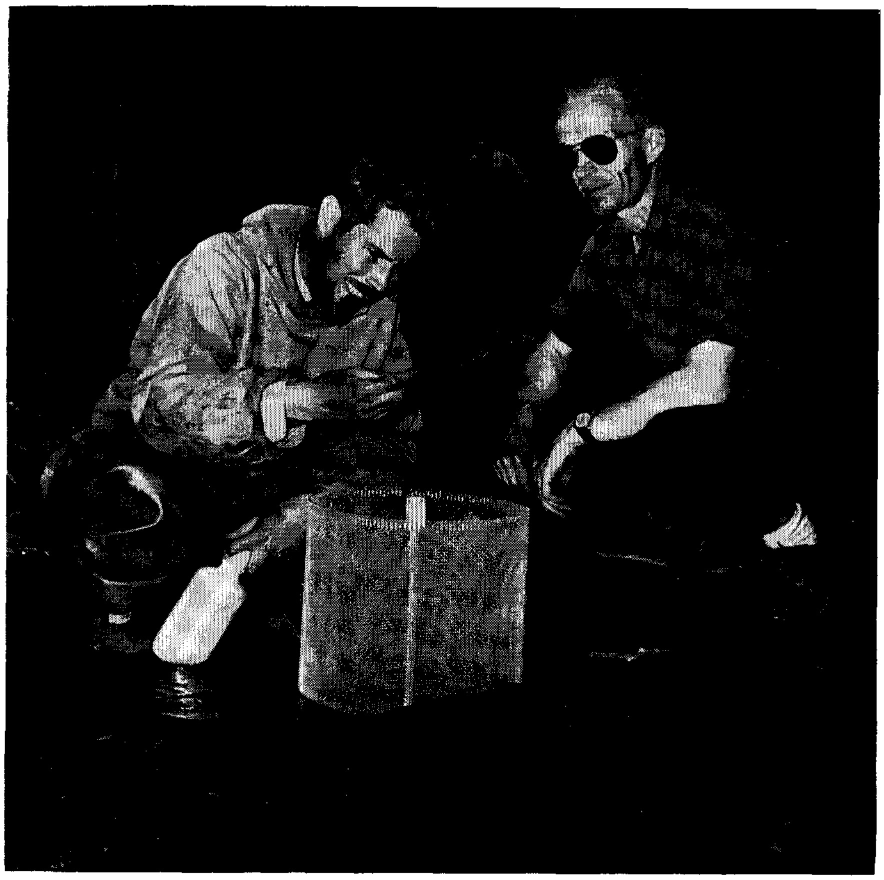
The real comer this year is a new compound, 3-trifluoromethyl-4-nitrophenol. Fish and Wildlife calls it the best material yet discovered for killing lamprey larvae.

One of the prime advantages of 3-trifluoromethyl-4-nitrophenol is its effectiveness at very low concentration. It destroys the larvae at levels of 0.5 to 4 p.p.m. And fish have nothing to worry about unless the concentration rises to 10 to 12 p.p.m. Because much less of the new material is required, it is a much simpler job to handle it in the remote, inaccessible areas where stream treatment usually takes place. Furthermore, with the new material, a much larger percentage error in dosage rate can be tolerated without accidentally killing desirable fish.

This year, workers from the Fish and Wildlife Service have treated 35 streams on the U. S. side of Lake Superior with the new lamprey larvicide. By the end of the year, 13 streams on the Canadian side will also be treated. Extermination of lamprey larvae in streams feeding into Lake Michigan is slated to begin in 1961. Treatment of streams tributary to Lake Huron will start possibly a year or two later.

Original Sample

The first 3-trifluoromethyl-4-nitrophenol tested by Applegate was supplied by Farbwerke Hoechst of Germany through its American representative. Early research and development work on this compound was



On the Mosquito River in Michigan, Andrew Lawrie (left) of Canada's Fisheries Research Board and Vernon C. Applegate, U. S. Fish and Wildlife, inspect caged lamprey larvae to see how many were killed by chemical treatment

done in Germany. Since then, Hoechst Chemical Co. of West Warwick, R. I., has produced larger quantities, sold as Lamprecid 2770.

In one experiment in May 1958, Fish and Wildlife tested some 385 pounds of the compound in a stream in northern Michigan. Within seven and a half hours after the chemical was added, all lamprey larvae in the river bed were killed. All 1000 test lampreys also were killed.

For further experimental work last year, the government purchased 10,000 pounds of 3-trifluoromethyl-4-nitrophenol from Dow Chemical. This year it needed an additional 25,000 pounds, and the contract went to the low bidder, Maumee Chemical of Toledo, Ohio. The Maumee material (sold for less than $4.00 a pound) is now being used extensively in the Lake Superior region. For its own program, the Canadian Government has purchased 35,000 pounds of the Maumee product.

Chemical control of lampreys requires a basic understanding of their life cycle. Lampreys spend the first four to six years of their lives in the larval stage. Ranging in size from a half inch to six inches, and looking like worms, they remain in the sand and silt of stream beds, feeding harmlessly on microorganisms in the water. But once this period is over, they swim into the lakes and for the first time attack fish.

In the 12 to 18 months it remains in the lakes, a single lamprey, seldom weighing more than a half pound, may kill as much as 90 pounds of fish. The lamprey then returns to a tributary stream, spawns, and dies.

First efforts to control lampreys involved setting up electric weirs or other devices near the mouths of the spawning streams. All fish moving upstream were shunted into boxes. The adult lampreys were manually removed and destroyed, while the other fish were allowed to continue upstream.

But this approach required a great deal of manual labor and was costly. Above all, it could not get results fast enough. Preventing an adult lamprey from spawning eliminates only one generation of larvae. But killing all the larvae in the stream beds wipes out four to six generations at once.

To destroy the larvae, workers from Fish and Wildlife pump carefully controlled amounts of the new chemical into the rapids or waterfalls above the last possible stream bed containing the larvae. The fast movement of the water at the injection point speeds up the mixing of the chemical. In cases where the compound may become greatly diluted as it moves downstream, additional amounts may be added farther downstream.

The actual concentration used is varied depending on the temperature and hardness of the water. As hardness increases, for example, the amount of chemical added must be increased.

But even with the availability of potent new chemicals, the lamprey problem will not be solved quickly. It is not just a matter of treating all the spawning streams one year and then promptly forgetting all about lampreys. Applegate believes that all spawning streams will have to be treated on a rotation basis about once every three years. And this may have to be kept up indefinitely.

It's like the control of rodents, he explains. You don't spread rat poison all over the place one year and then assume that the rat problem is licked. There is always the danger of reinfestation. The same is true with lampreys.

Climate Control Chambers

Their wider use helps to show how ag chemicals and fertilizers will behave in the field

THE OLD SAYING that everyone talks about the weather but nobody does anything about it is not exactly true any longer. Not that weather is much more under control than it used to be. But its effects—especially on agriculture—are being cushioned, thanks to the growing use of climate control chambers in agricultural research.

Use of these controlled environment chambers, also called phytotrons or biotrons, isn't new. They have been used over the years by industry for many purposes (shelf-life testing is one example). And they have been used extensively in farm research to study plant and animal breeding and growth. But the past two years have seen many more units installed, new types designed, and refinements added. Major improvements in today's chambers include artificial lighting that closely simulates natural light, and more sensitive temperature and humidity controls.

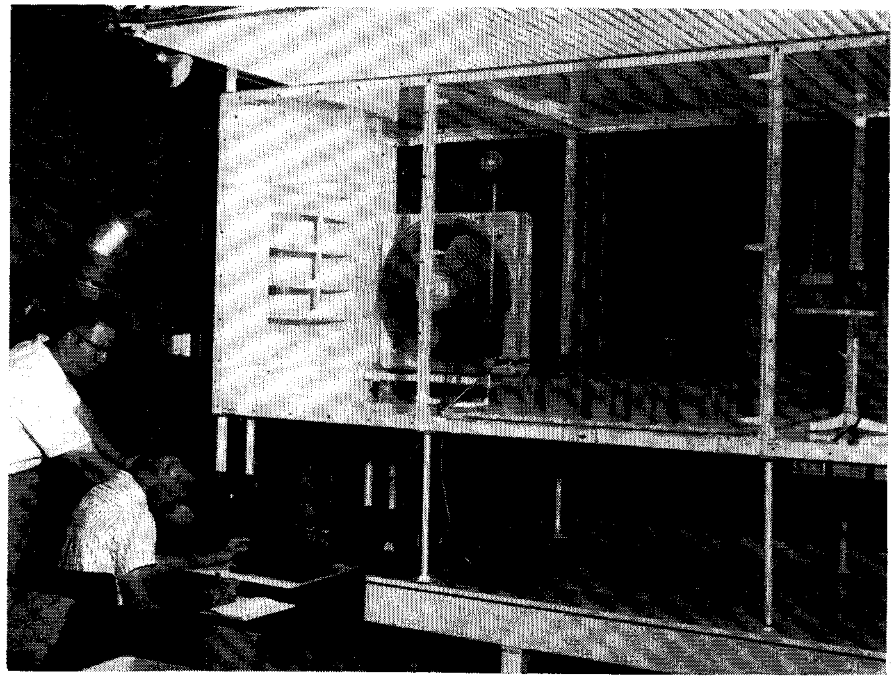
Possibly the newest important wrinkle in phytotron use is studying weather effects on farm chemicals and fertilizers. Monsanto, for example, has four chambers in its new agricultural research laboratory. Major purpose of these units is to study weather effects on Monsanto's chemicals for agriculture. Dow is another agricultural chemicals maker using climate chambers. And the firm's new agricultural chemicals laboratory, construction of which has just begun, will have four walk-in units and a number of smaller ones. The Tennessee Valley Authority has just put in three new chambers for fertilizer research.

Monsanto says that practically all of its climate control work is aimed at learning what weather does to farm chemicals. For instance, the company's herbicides are usually dispersed in volatile carriers. Temperature and humidity have very pronounced effects on the staying power and activity of these agents in the field.

Optimum growing conditions are studied, too. From plant growth data, Monsanto hopes to develop farm chemical formulations "from a biological point of view." Using preemergence herbicides as an example, Monsanto scientists want to determine how weather factors affect the rate of seed germination, and then find the most effective formulation that can be used at just the right stage in different kinds of weather.

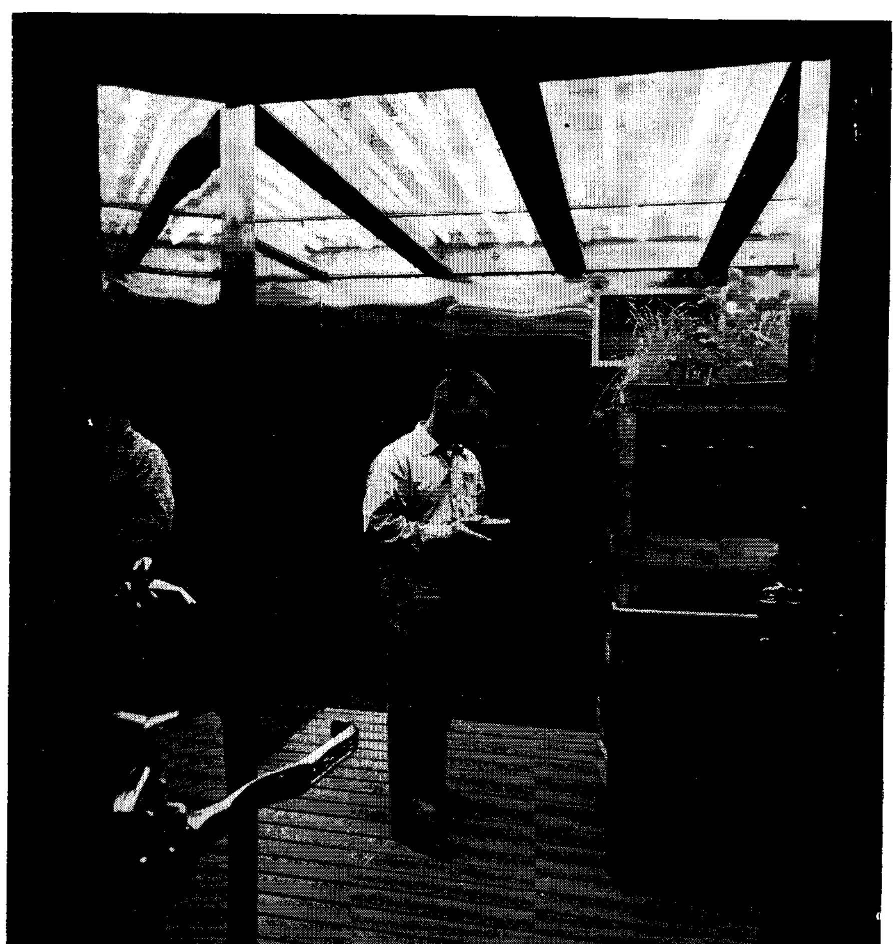
W. R. Grace & Co. uses a light chamber for both fertilizer and pesticide experiments. To determine crop yields in fertilizers, says agricultural chemical research director G. L. Bridger, the light chamber is better than a greenhouse. The chamber gives reproducible results regardless of outside weather, which affects conditions inside a greenhouse. Nematocide screening is also done in Grace's light chamber. This work can be done together with fertilizer studies, in contrast with other pesticide work. Volatile herbicides, for example, cannot be tested in the same room with fertilizers because of possible plant damage.

Meanwhile, TVA is studying the interplay between weather, crops, and fertilizers. One experiment now under way is aimed at learning optimum conditions of light and temperature for maximum fertilizer uptake by plants during short time periods. In the same study, TVA scientists are determining the effects of temperature on phosphorus movement and fixation. In other experiments, physiological



Texas A&M scientists use phytotron to study weather effects on plant response to herbicides

Monsanto has four climate control chambers where an almost unlimited variety of weather can be "manufactured" and maintained for study of agricultural chemicals



characteristics of plants will be studied to learn how these influence nutrient uptake.

University of Florida, which is now designing a plant science research unit, will also study nutrient uptake under different climatic conditions. The plan is to determine how light, temperature, humidity, carbon dioxide, oxygen, and various inorganic and organic chemicals affect absorption of nutrients through leaves and bark. Extensive studies on nematode control are being planned, too.

Just last month, University of Wisconsin received from National Science Foundation a $1.5-million grant for construction of a biotron. UW's unit will provide wide-range, individual control of such climatic factors as temperature, humidity, wind, and light, for basic research on plants and animals.

At Texas A&M, the influence of temperature and humidity on plant response to herbicides is under study. Also of interest are the effects of climate on performance of systemic insecticides and herbicides. The role of light in chemical control of plant growth and flowering with gibberellins and adenine is also under study.

Actually, most climate control programs that use chambers touch on some aspects of vital interest to the agricultural chemicals industry—even if this is not the main intent of the experiments. Such studies invariably call for use of pesticides, plant foods, feed additives, or veterinary chemicals.

Chamber Types Vary

Most climate control chambers used today are built to the user's specifications. They vary in size from laboratory bench models to "walk-ins," or even larger. Purdue University, for instance, is installing one about the size of a walk-in freezer, and another that can house several large animals at a time. National Appliance Corp., Portland, Ore., is selling a series of small modular units. The advantage of these, the company claims, is that they permit many different experiments to be carried on at the same time.

Labline, Inc., of Chicago, also reports increasing interest in all the sizes it makes available. And this interest stems mostly from agronomists and biochemists at universities and in the fertilizer, chemical, food, and drug industries.

Although chamber sizes vary, conditions in them are usually controlled in about the same way. According to Labline, all rooms are thermostatically controlled. Hermetically sealed compressors take care of low temperatures. Lighting is controlled by balancing red and blue wave lengths, with intensities varied by lowering or raising a light canopy, or the plant bed. Adjustable timers help duplicate natural light's time-dependent variations.

Although climate control chambers are valuable research tools, one climatology expert cautions against putting too much faith in data obtained from them. He warns that such data could be erroneous because:

- The proportion of diffuse to direct light, and their spectral composition and intensity, are not always similar to sunlight's. In the field, solar radiation affects plant temperatures which in turn influence growth.
- Presence of walls and abnormal leaf-surface temperatures create an unreal infrared environment, sometimes giving rise to non-typical responses in plants.
- Many chambers have no wind producing unit; wind affects temperature and humidity.

But the general feeling about growth chambers is summed up this way by one experiment station worker: "Our plant scientists have had enough experience (with various makeshift facilities) to be convinced that phytotrons have a real place in biological research."

Changes for Liquids

TVA conference shows progress in adapting superphosphoric and wet process phosphoric acids for liquid fertilizers

PHOSPHORIC ACID'S key role in liquid mixed fertilizers may be in for some changes. The Tennessee Valley Authority, after a long look at some of the headaches caused by the acid, is taking steps to make this essential ingredient easier to live with. Among difficulties TVA associates with the acid are: availability, a comparatively low ceiling on liquid fertilizer grades, and inability to hold minor elements in solution.

At its recent Liquid Fertilizer Conference held at Wilson Dam, Ala., TVA divulged its progress in developing new processes that may ultimately change some of the basic technology used in making liquid fertilizers. The major developments discussed:

- Making liquids with superphosphoric acid (AG AND FOOD, April, pages 233-34) and wet process phosphoric acid.
- Use of potassium hydroxide (together with the super acid) instead of potassium chloride to hike grades.
- Sequestering or suspending impurities in wet-process phosphoric acid.

Superphosphoric acid, which will be made commercially by Central Farmers Fertilizer, has the advantage of a P_2O_5 content higher than that of phosphoric acid—70% more P_2O_5 per unit of volume. According to TVA's M. M. Striplin, Jr., the super acid can be used to make higher analysis liquid mixes. Also, says Striplin, significant amounts of minor elements can be dissolved in liquid fertilizers made with the acid.

Using potassium hydroxide instead of chloride is another way to raise nutrient content, says J. M. Potts. The caustic is higher priced than the chloride, but some crops—tobacco, for instance—need low chlorine fertilizers. For these, potassium hydroxide's cost is justified, Potts feels.

TVA's potassium hydroxide liquid mixes are based on superphosphoric acid. In addition to higher grades, lower salting out temperatures result. Other experiments use mixtures of potassium hydroxide and potassium chloride.

Potts says that the alkali is being used with superphosphoric acid in one commercial plant, and is probably being used with ortho (regular) acid in a few others.

Wet Process Acid Impurities

Wet process phosphoric acid has not yet been accepted for general use in liquid fertilizers, although it costs less to make than does furnace acid. Main drawback to wet acid's acceptance is what Striplin calls "troublesome impurities." Half of these, reports W. C. Scott, are phosphates. Other impurities are calcium sulfate and aluminum, iron, and fluorine compounds.

The impurities precipitate when the acid is neutralized with ammonia. This precipitate settles in storage tanks and tends to clog pipes and spray nozzles. Also, the precipitated impurities tie up phosphate. How much depends on the original content of impurities.

Using acid from various sources, TVA finds that the amount of phosphate precipitated ranges from 5 to 18% of all the P_2O_5 in the acid. Filtering out the settled impurities thus cancels almost all of the economic advantage gained by using wet process acid.

TVA is trying two ways to solve the wet acid impurities problem: sequestering the contaminants with superphosphoric acid or with wet process acid itself, concentrated beyond its normal levels; and suspending precipitated impurities.

Superphosphoric acid is already in industrial use as a sequestering agent, says TVA's J. A. Wilbanks. In one instance, the super acid has been used for a full season as a sequestrant and as the source of about 40% of the P_2O_5 needed.

TVA's sequestering tests use either superphosphoric acid itself or ammoniated acid to furnish 5 to 50% of the final product's P_2O_5. Wet process acid, super acid, and aqua ammonia are caused to react, with water added to adjust the grade.

Storage properties of the sequestered mixes have been determined. Some samples were kept for 7 days at 28° to 32° F., others for 30 days at room temperature. The liquid mixes stay clear under these conditions if 20% of their P_2O_5 is sequestrant (superphosphoric acid). As little as 10% keeps the solution clear for one or two days, while 15% usually does it for a week. Products containing 30% or more P_2O_5 as sequestrant were still clear after a year.

Concentrating wet process acid to get self-sequestering properties is still in early stages of study, M. R. Siegel reports. TVA concentrates the acid batchwise in glass flasks, and continuously in a metal tube heated with a gas flame. Air controls foaming.

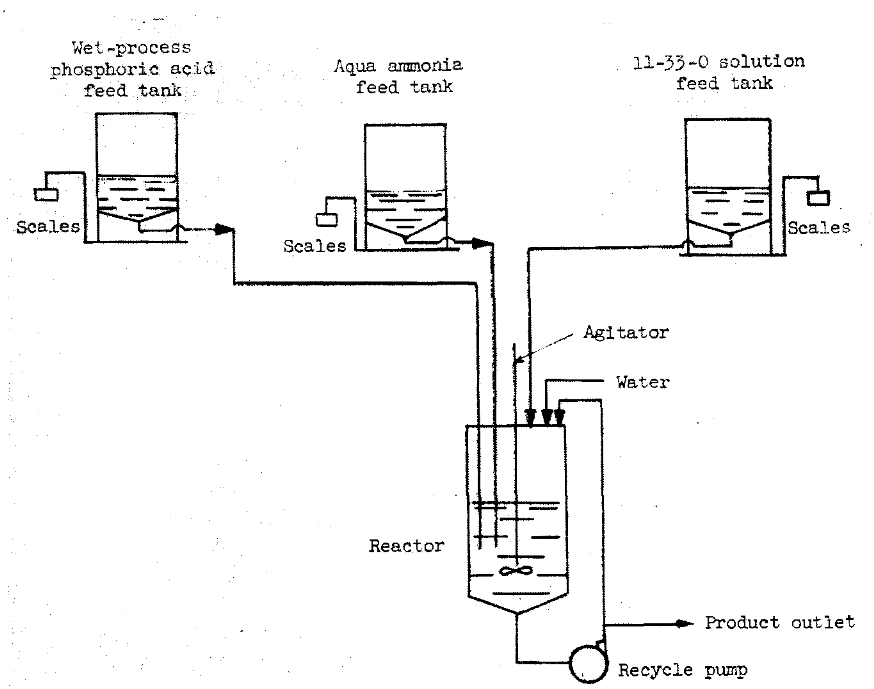
Concentrated acid containing 69% P_2O_5 or less is usually fluid at room temperature, says Siegel. Above that, it's solid or semisolid. In the 61 to 69% range, the acid has no crystals, and little or no sludge or settled solids. All of the concentrated acids are stable for at least a week. At 68 or 69% P_2O_5, the acid remains stable for more than six weeks; sludge forms within a month in less concentrated samples. Liquid fertilizers made with concentrated acid contain no crystals and only a small amount of solids after several weeks' storage.

Suspensions Show Promise

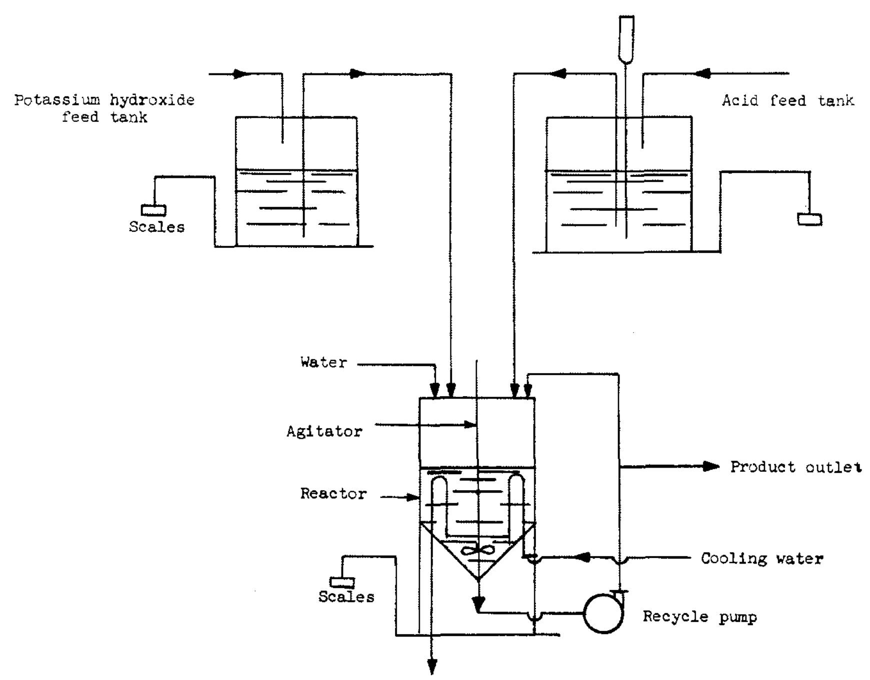
Impurities are of no concern if liquid fertilizers made with wet process acid are used within a few days after formulation. During that period, the contaminants are suspended. After a week or so, though, settling begins. The trick, then, is to keep the impurities suspended indefinitely. But how?

J. M. Stinson says that a variation of the usual acid neutralization process results in better suspensions. Usually, he explains, all the acid is introduced to a reaction tank before ammonia addition is started. A better way, claims Stinson, is to add acid and ammonia at the same time. The rapid reaction causes impurities to precipitate quickly in a finely divided form. Mixes made this way by TVA have acceptable flow properties for a week at 28° to 32° F., for a month at room temperature.

Unit for producing clear liquid fertilizer from wet process acid by sequestering impurities



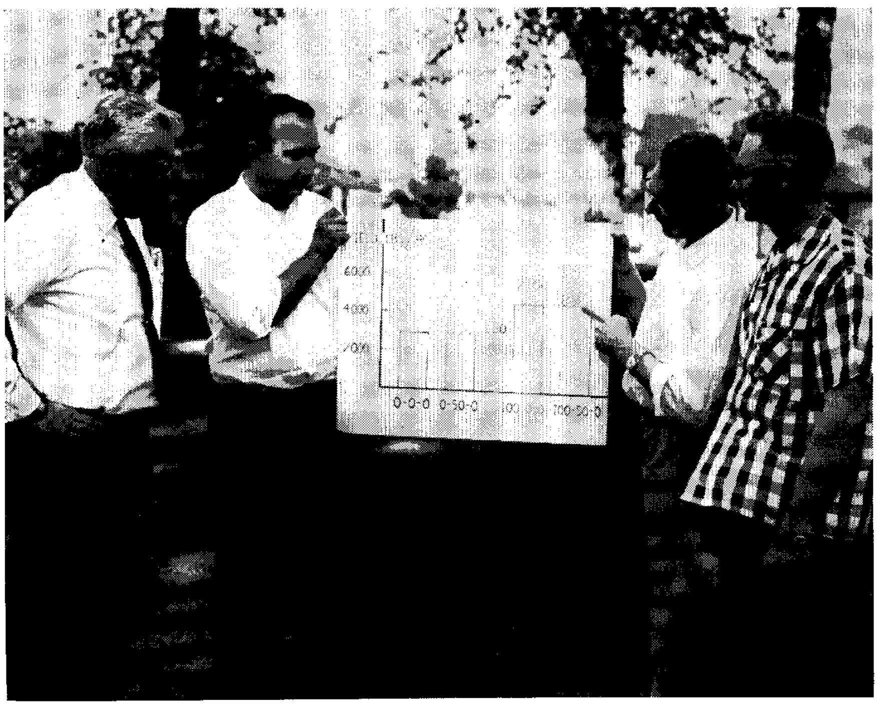
Unit for production of high analysis liquid fertilizer from potassium hydroxide and superphosphoric acid



About 1 to 2% of an attapulgite-type clay improves stability.

Another way to get workable suspensions is to reduce the amount of water from that normally used so that salting out occurs upon cooling. Clay is then added as a suspending agent.

According to H. K. Walters, Jr., the clay not only stabilizes the suspension and minimizes settling, but also inhibits salt crystal growth. Probably, he says, the clay furnishes many nucleation sites. This increases the number of crystals, reducing average size.



These are the results of a fertility research project, supported by NPFI, on native hays in Montana. Inspecting them are: George Mason (left) and Warren Stensland, officers of the Montana Plant Food Association; and Bernie Brown and Harry Kittens, Montana State College soils experts

Grasslands Fertilization

Possibly the U. S.'s last agricultural frontier, grasslands receive increased fertilization in many parts of the country

Sometimes cited as the most backward phase of agriculture is grasslands management. This nebulous term covers many aspects of growing grasses besides their use for meat animal production. It covers such activities as irrigation, control of grazing, control of pests and erosion, and fertilization, to name but a few.

Fertilization of grasslands—pasture or hay crop land—holds out a vast potential for fertilizer use and profit. The practice has been accelerating at a rapid rate each year relative to the limited total acreage previously fertilized, or to the low per-acre use of plant food on grasslands.

However, range fertilization will solve the rancher's feed problems only if certain conditions apply. Among them:

- Range fertility is low at present;
- Climate conditions favor growth at the time increased feed is desired;
- Range cover contains plant species that will respond to fertilizer materials applied;
- The rancher can make changes needed in his management practices to take full advantage of increased growth produced by fertilizer;
- Other, more profitable methods of handling the feed problem are not available.

Importance of any single condition obviously will vary with different parts of the country, with different operator objectives, and with economics.

Acreage Fertilized Is Small

There are wide variations in the extent to which the practice has taken hold. For example, on the basis of 1954 data 81% of the pasture acreage in California's Imperial Valley was fertilized to some extent. At the other end of the scale, less than 1% of harvested pasture acreage in parts of the Great Plains was fertilized. Over-all in 1954, about 10% of the nation's hay and crop grasslands was fertilized. This compares with 97% of the tobacco cropland.

Reasons for the wide variation in use of fertilizers on grasslands are easy to find. Most of them revolve around one major point: the economic advantages of fertilizers cannot always be demonstrated so directly on pasture or range land—particularly that of lower quality—as on land of higher quality used for other crops. Regardless of almost any climatic or plant food condition, some kind of plant will grow to some extent each year on range land.

But to demonstrate the advantages of fertilizing grasslands, the indirect gains from milk or meat, for example, need to be made more clear to most farmers. And realizing those advantages can be a difficult task, as it requires building up herds to use the additional feed. Thus it may require the grower to forego current income for more investment in stock.

Yet, more and more ranchers and agricultural workers recognize that livestock can be produced at lower cost on good than on poor grasslands. Becoming more common, particularly in the West and Southeast, are both short- and long-term demonstrations of the return fertilizer brings on grass. The Western States Potash News Letter of the American Potash Institute reports a return of $2.89 in 1956 and of $3.01 in 1957 for each dollar spent on fertilizer at the Oregon Grassland Demonstration Farm at Hillsboro, Ore. In a Colorado demonstration, nitrogen increased efficiency of water use in grass production as much as four times. In USDA studies aimed at lengthening the green feed grazing period on California ranges, researchers found it generally profitable to increase nitrogen application rates until the increase in dry forage is 40 times the weight of nitrogen added.

Renovating and Fertilizing

In line with one of the conditions for improving forage lands, most agricultural workers recommend renovation and reseeding with more productive species when fertilizing unimproved grassland. Older pastures often benefit from partial reseeding coupled with fertilization programs.

Depending on the types of grasses present or to be grown, and on what a farmer considers he can afford, pastures get a wide variety of fertilizer grades and quantities. Soil tests are used to indicate plant food requirements, and, in many states such as Oregon and Wisconsin, indicate lime needs as well. Grade ratios recommended around the country often include 1-1-1 and 2-1-1 for established pastures. For legumes, generally no nitrogen is recommended, while for pastures that consist chiefly of grasses, ammonium nitrate, ammonium sulfate, or nitrogen solutions, and some phosphorus are recommended.

Reasonable quantities of water are still essential to range grass improvement with fertilizers. All demonstrators qualify interpretation of test results to take into account rainfall or irrigation available to range land.

For cattle, good range or pasture land should be covered with a half-and-half mixture of grass and legumes, according to many experts. The legumes supply both nitrogen for the soil, if allowed to decompose, and increased crude protein for cattle.

But growing both legumes and grass on the same acreage complicates the fertilization picture. For instance, legumes require considerable phosphate. Grasses do also, but they require nitrogen to utilize phosphates. Although grasses need less potash than do legumes, they will take up large quantities of it—luxury consumption—with little gain in growth. They are efficient consumers of potash and often keep legumes from getting enough. Thus, in a grass-legume mixture, a shortage of potash will cause the legumes to suffer first. Also legumes, with greater susceptibility to injury by freezing, insects, and disease, tend more to fade out from a mixture with grass.

For various reasons the legume-grass ratios recommended for pastures differ in different parts of the country. In South Carolina, extension workers suggest that legumes be kept to not more than one third. These workers feel that commercial nitrogen is less expensive than legume nitrogen, and that well fertilized grass supplies as much protein as legumes in general. Then, too, danger of bloat in cattle increases when legumes exceed one third in pastures, says a South Carolina extension official.

Hay, pasture, and range fertilization has been the subject of much recent research. But the complicated food needs of grass and forage plants demand much more research before fertilization efficiency reaches that now practical with such crops as corn, wheat, and cotton.

Fertilization techniques also come in for attention. Aerial application of nitrogen fertilizers to grasslands has been tested in Wyoming with significant increases in forage production. However, with a few exceptions, such as large range areas, or areas too steep or rough for conventional farm tractors, the cost of aerial application exceeds the cost of surface application. Hence aerial application of fertilizers to pastures will find little use in the East, except in mountainous sections, because individual eastern pastures are small. Another need is adequate numbers of landing strips to keep "ferry" time to a minimum. Lack of these strips is expected to limit aerial application in most parts of the West for some time.

Dairying is often cited as an outstanding example of operations in which farmers could lower their costs through growing better and cheaper forage instead of purchasing expensive feed concentrates. But rangeland husbandry—harvesting of grassland crops by animals—must be given more scientific attention by all involved if there is to be worthwhile progress on the "last agricultural frontier."