Volume 25, No. 4

Summer 1969

MINNESOTA SCIENCE

A publication of the University of Minnesota Agricultural Experiment Station

RESEARCH... in a Growing Minnesota

1969 Legislature--A Major Step Forward

In recent issues we have discussed the source of support for the Minnesota Agricultural Experiment Station. In the Fall 1968 issue of *Minnesota Science* we called to your attention the items that were being requested of the 1969 Legislature. We pointed out that this was the largest request ever made for support of the research program.

Friends in the food and fiber industry have long been aware of the needs to strengthen the program of the Minnesota Agricultural Experiment Station during this time of increasing costs. In preparation for the 66th session of the Legislature we emphasized the critical research problems and support needs to keep the food and fiber industry competitive with other states in the region, the nation, and the world. In addition to testimony provided through the several hearings with different committees of the Legislature the seriousness of these needs was made clear to the legislators by individual contact. Many of you took the time to write to your legislator pointing out the impact of the research program on the economy, our environment, and your everyday life.

These efforts and especially the understanding of the legislators resulted in the largest increase in program support ever received by the Agricultural Experiment Station. Over $700,000 of new funds are provided for the first year of the biennium 1969-70, and $137,000 for the second year of the biennium. This is 55 percent of the increase requested for the first year and 24 percent of the increase requested for the second year. This is a major stride forward and we believe that the Experiment Station will not only have the opportunity to strengthen existing programs, but move into some new areas as discussed in the Fall 1968 issue.

In addition to excellent support of the program, new physical facilities have been provided for the total program of the Institute of Agriculture of which the Minnesota Agricultural Experiment Station is a part. At the St. Paul Campus, $2.7 million was provided for the meats program and for planning the remaining phases of the Animal Science complex.

Nearly $4 million was provided for the classroom-laboratory-office building for Agricultural Economics, Rural Sociology, and Agricultural Education. As the student population increases on the St. Paul Campus this building is needed greatly for these three important departments. Funds were also provided to construct a headhouse and greenhouse for Plant Pathology.

Physical facilities at the Branch Experiment Stations will be improved greatly because of 1969 legislative action. Dairy facilities have been provided for the Southern Experiment Station, Waseca and the West Central Experiment Station, Morris. In addition to overall management studies, efforts will be directed to control pollution from animal wastes. At the Northwest Experiment Station, Crookston an additional cattle feeding facility was provided, again with emphasis on pollution control from animal waste.

At Waseca a long-needed program in land drainage for the research areas and large fields will be provided. Also a central grain drying facility was funded. At the Southwest Experiment Station, Lamberton, funds were provided for an office-meeting room building which will enhance the use of this station.

At the North Central Experiment Station, Grand Rapids, funds were provided for potato storage and handling facilities. Four years ago the potato breeding research and early evaluation program was moved from Castle Danger to the Grand Rapids site, and this is a much needed facility.

At the Agricultural Experiment Station, Rosemount, the second phase of swine research facilities was provided. This will make it possible to do our breeding and nutrition research in up to date facilities.

Funds were provided for upgrading the physical facilities at the Horticultura Research Center and Landscape Arboretum, Excelsior, at the Forestry and Biological Station, Itasca, and at the Forest Research Center, Cloquet. At Cloquet funds were provided for a classroom-laboratory building which will enhance the research effort as well as the increased teaching program conducted at this location.

Reflecting on the 1969 session, the Legislature was faced with many critical areas requiring new or additional funds. One of these was the program of the Agricultural Experiment Station. We appreciate the attitude and action taken by legislators as they pondered the many uses for the limited resources. We believe their action indicates not only the faith of the Legislature in the staff of the Minnesota Agricultural Experiment Station, but the support received from those that benefit most from the results of this research.

As we move ahead with program expenditure from the funds made available for this biennium, we must also look ahead to the session that begins in January 1971. Many of the items requested will not be covered in the present budget period. We believe many of these are still high priority, and will probably continue to be for the next several years. For this reason we urge each of you to become increasingly aware of the program of the Station. Be willing to indicate to your legislator your interest and the benefits you receive from this program. Articles included in this and succeeding issues of *Minnesota Science* are only a small part of the total research program conducted at your Minnesota Agricultural Experiment Station. We believe they illustrate the scope of the program and report the progress in solving some of the state's problems.

William F. Hueg, Jr.

MINNESOTA SCIENCE

A publication of the University of Minnesota Agricultural Experiment Station

Minnesota Science is published by the University of Minnesota Agricultural Experiment Station, Institute of Agriculture, St. Paul, Minnesota 55101

Cover photo: Fifth instar larvae of the forest tent caterpillar feeding on aspen leaves. See story on page 11.

CONTENTS

page

Modern Genetic Measures of Dairy Cattle
B. Joseph Conlin 4

Economic Gain from Grass and Clover Breeding
H. L. Thomas 6

Chemical Control of Foliar Diseases of Cereals
H. L. Bissonnette, J. B. Rowell, and L. Calpouzos 8

Insect Disease, an Alternative to Chemical Control
Ashok K. Raheja and Marion A. Brooks 10

Staphylococcal Infections, a Continuing Threat
Robert K. Lindorfer 13

Food for Freedom Program and India
Jitendar S. Mann 14

Index of Articles in Volume 25 15

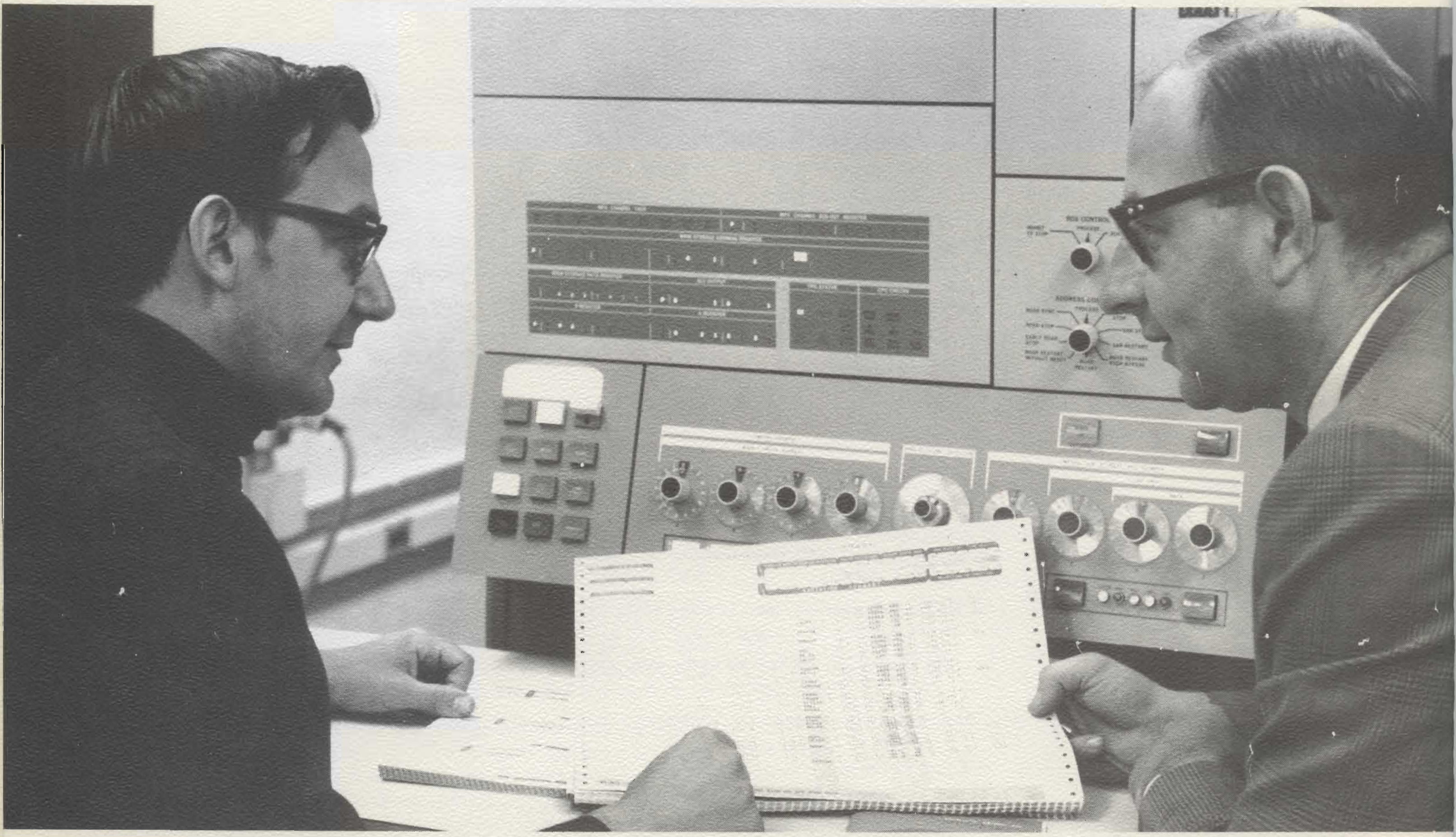
Two New Field Crop Varieties 16

Modern Genetic Measures of Dairy Cattle

B. JOSEPH CONLIN
associate professor, Department of Animal Science,
and extension dairyman

Which bull to use and which cow to cull from the herd! Many Minnesota dairymen base these decisions on information obtained from the University's computers.

But, dairymen must add new terms to their vocabularies before they can use the data effectively. Predicted Difference, Estimated Average Transmitting Ability (EATA), and Estimated Producing Ability are examples of the required terminology.



Mel Sauve, (left) St. Paul Campus Computer Center supervisor, and B. Joseph Conlin discuss the computer printout of a cow ranking and herd summary form.

Predicted Difference (for sires) and EATA (for cows) estimate the genetic contribution for production that bulls and cows transmit to their average offspring. They express an animal's genetic transmitting ability in uniform, easy-to-use, plus-or-minus values that can be compared with other animals' records. They are also much more accurate than previously used genetic measures.

Estimated Producing Ability uses all available performance records to reflect how much profit a cow makes. Ranking all cows in a herd by Estimated Producing Ability quickly identifies the poorest producers to be considered for culling.

Extension Provides Information

University of Minnesota dairy extension specialists routinely provide information based on bulls' and cows' records that have been evaluated by high-speed electronic data processing equipment. More than 5,800 Minnesota dairymen are taking advantage of this relatively new production tool by belonging to the Dairy Herd Improvement program (DHI).

Use of computer-age technology gives participating dairymen a chance to improve the average genetic ability of the cows in their herds as much in one generation as was achieved in two to four generations 10 years ago.

Selection

Selection offers dairymen the best opportunity for genetic improvement. High milk production depends on mating bulls and cows that have the most desirable genes (units of inheritance) for high milk production. The genetically poorest individuals should not be allowed to reproduce. Therefore accurate and objective evaluations of an animal's true genetic merit are essential to select the best animals for mating.

Sire and cow evaluations used before the advent of the computer did not account for major non-genetic or environmental influences. Exceptional performance resulting from special feed and care often was mistaken for genetic ability. Such errors hindered genetic improvement because often genetically inferior animals were making the largest contribution to each new generation.

Accounting for Non-Genetic Factors

Modern evaluation procedures take into account the major environmental influences. Production records are standardized for cows milked twice a day (2X) to a uniform length of record (305 days) and converted to a mature age basis (M.E.). These 2X - 305 - M. E. records for the cow are compared with her herdmates' by subtracting the herdmate average from the cow's own performance and expressing it as a plus or minus value.

Herdmates are the other cows that calved in the same herd during the same season. Cows calving in Minnesota dairy herds in the winter (October through April) produce about 700 pounds of milk and 30 pounds of fat more than cows calving in the summer (May through September). These differences may be as high as 3,000 pounds of milk and 100 pounds of fat in some herds. Production differences between seasons are caused by differences in feeding, management, and weather. Most non-genetic differences between herds, year, and season of calving are removed by expressing each record as a deviation from the herdmate average. So that animals can be compared directly on a standard basis, additional adjustments are made to account for genetic differences between herds and the amount of information used.

Artificial insemination provides the greatest opportunity for genetic improvement because of the intense sire selection. Only the very best sires need to be used in artificial breeding because one sire can produce up to 40,000 calves a year. This is an extensive genetic influence compared with one calf per year produced by the cow. But this influence can be good or bad depending on his genetic quality. Therefore it is especially important that sires be evaluated accurately and that only the best sires be used extensively.

Fortunately bulls can be evaluated more accurately than cows because more information is potentially available. Records of many daughters from many herds provide a more reliable measure of a sire's genetic transmitting ability than the relatively small amount of information available for the cow. The EATA value for a cow is obtained from her records and from the Predicted Difference of her sire.

Because of the importance of accuracy, the repeatability value for these genetic measures provides a guideline for the amount of confidence a user can place on them. For example, Predicted Difference can range from 18 percent for a sire with 10 daughters in one herd up to 99 percent for a sire with 500 or more daughters, each in a different herd. Repeatabilities of EATA's range from 19 percent for a cow with only one record and no sire information to about 45 percent for a cow with 5 or more records and reliable sire information.

Selection of Parents

The Predicted Difference and EATA for sires and cows within a breed can range from above +1000 pounds of milk to less than -1000 pounds. Those in the +1000 or above class are among the genetically elite sires and cows within a breed. Animals with a zero value are breed average.

Bulls and cows with the highest Predicted Difference and EATA are most likely to produce the most desirable offspring. The sum of the sire's Predicted Difference and cow's EATA provide the best estimate of genetic merit of the resulting offspring. While this may not be a very accurate estimate for individual matings it is quite reliable when averaged over a large number of matings.

These genetic predictions reflect the expected profitability of each new generation. At current milk prices the difference in annual gross milk sales would be about $90 per cow in favor of the daughters of a +1000 pound sire over one with a Predicted Difference of -1000.

Predicted Difference can help a dairyman choose a sire of sufficient quality for his breeding program; EATA can help determine if any of his cows are good enough to produce a bull suitable for his herd, to sell for artificial breeding or to another dairyman.

Who's Who In Minnesota A. I. Sires

To help Minnesota dairymen improve their sire selection, the Agricultural Extension Service publishes a newsletter called "Who's Who in Minnesota A. I. Sires" three times a year. All A. I. sires in the state are ranked from high to low on their Predicted Difference milk. Rankings are compiled from computer summaries supplied by the Animal Husbandry Research Division of the USDA. Their evaluations are based on all the DHI performance records of sires' daughters in herds across the nation.

Computerized Breeding Program Analysis

DHI dairymen were introduced to these new evaluation procedures in February 1969 when University of Minnesota extension dairy specialists developed a computerized system. These Estimated Producing Ability reports help dairymen identify their best cows for breeding. Dairymen first received a Cow Ranking and Herd Summary report which ranked the cows from high to low and analyzed their breeding program. For each cow they also received an Individual Cow Lactation Summary slip with a complete performance history that can be filed for easy reference.

The breeding program summary shows the dairyman, the quality of sires used in his breeding program and the progress made by culling poor cows from the herd. Statewide breed averages provide a basis for comparison. The Minnesota program is one of the first in the nation to make this selection information available to dairymen.

Economic Gain From Grass And Clover Breeding

H. L. THOMAS

associate professor, Department of Agronomy and Plant Genetics

Harvesting grass plots at Rosemount.

Reliable and conservative estimates of the economic gain to Minnesota from grass and clover breeding research by the Minnesota Agricultural Experiment Station since 1936 are placed at $20 million or more. Other benefits include scientific and practical information released and the training of graduate students. Total cost of these programs has been a little over one quarter of a million dollars. These estimates are substantiated by the following examples.

The release of Park bluegrass in 1955 started a new industry in Minnesota. Before 1955 wild bluegrass seed was stripped in Minnesota and processed and merchandized by out-of-state industries. However, with the introduction of Park, the farmers of the Northern Bluegrass Growers Association developed methods of culturing bluegrass as a farm crop and built a modern processing plant. The table shows the annual production and farm price of registered and certified Park bluegrass seed produced by the Association.

Year	Acres	Production lbs	Price/lb	Farm income
1957	138	21,000	$.62	$ 13,020
1958	389	49,351	.62	30,598
1959	2,939	355,000	.33	117,150
1960	4,482	1,025,000	.31	317,750
1961	5,000	205,000	.26	53,300
1962	5,000	815,000	.32	260,800
1963	6,000	615,000	.32	196,800
1964	6,500	365,000	.34	124,100
1965	7,000	1,550,000	.28	434,000
1966	7,000	1,550,000	.27	418,500
1967	8,000	1,300,000	.21	273,000
1968	14,000	1,000,000	.24	240,000
			Total	$2,479,018

Hand crosses of selected bromegrass plants.

Inbreeding red clover.

Production by farmers outside of the Association could easily bring the total farm income to $8 million. It may be conservatively estimated that the gain to industry (farm input, merchandizing, etc.) will be equal to the farm income, making a total of $16 million for Park bluegrass.

When the first forage breeding started at the Minnesota Experiment Station in 1936 there were practically no named varieties of grasses or clover available commercially. Farmers purchased seed by species name with no information given on place of origin of genetic strain. This caused crop losses, especially in the case of red clover imported from Europe, for it was poorly adapted here. Based on variety trials conducted at St. Paul, at Rosemount, and at the branch experiment stations, the following recommended varieties have been developed.

Birdsfoot Trefoil	Bromegrass
Empire	Achenbach
Leo (awaiting seed increase)	Fischer
	Lincoln
Medium Red Clover	Fox
Dollard	Timothy
Lakeland	Climax
	Itasca
Biennial Sweetclover	Lorain
Evergreen	Bluegrass
Goldtop	
Madrid	Park

According to USDA statistics, average acreage of clover and grass-clover mixtures for hay in 1954 to 1965 was 590,000, with a production of 903,000 tons. There was also considerable addition as rotation pasture. How much of this production was from recommended varieties is impossible to specify. However, it is known that Lincoln bromegrass has almost completely replaced the old Canadian commercial. Also, Empire, our first variety of trefoil, now occupies most of the trefoil acreage. Climax and Itasca timothy are sold extensively, and the same can be said of Lakeland clover. It would be safe to assume that half of Minnesota's hay production is from recommended varieties. From the test results, increased yields of the recommended varieties is of the order of .1 to .2 tons per acre. Consequently we can write the following formula:

$\frac{590,000}{2}$ acres X .1 (annual increase) X 15 (years) X $10/Ton = $4,425,000 as an estimate of gain from use of recommended varieties. In addition there are the advantages of improved disease resistance and winter hardiness. Also, the improved varieties have made it possible for Minnesota growers to produce and sell certified seed.

Total visible economic gain for the 32 years (1936-1968) is approximately $20 million. New, improved varieties of bluegrass and Ladino are being increased but are not yet released.

Some more intangible results are impossible to evaluate in dollars. Nine graduate students have completed advanced degrees while working on the forage breeding project and are conducting scientific work at other institutions. Forty-six published papers have disseminated valuable information to farmers and particularly to other workers interested in plant breeding methods.

What have these programs cost the taxpayers? From the records kept in the Department of Agronomy and Plant Genetics the following rather accurate estimates are available.

Year	Budget
1936 - 1946	$41,186
1947 - 1956	79,133
1957 - 1966	97,141
1967 - 1968	18,114
	$235,574

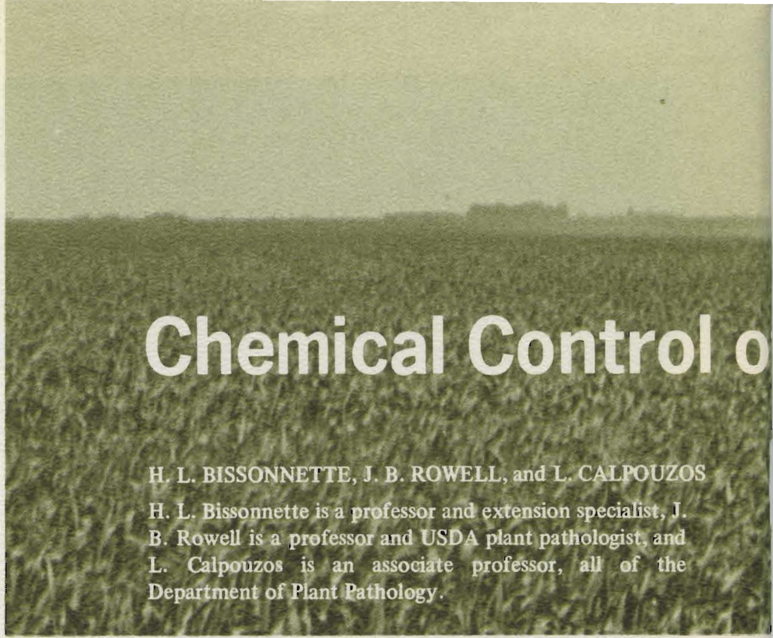
The return has been over 86-fold on the investment. That is, Minnesota has received $20,425,000 income from a $235,574 research expenditure. Farm production cost for the bluegrass seed was approximately $1,000,000. There is no additional cost for forage production, since it costs the same to produce inferior varieties as improved ones, except for a small addition in harvesting the heavier yields.

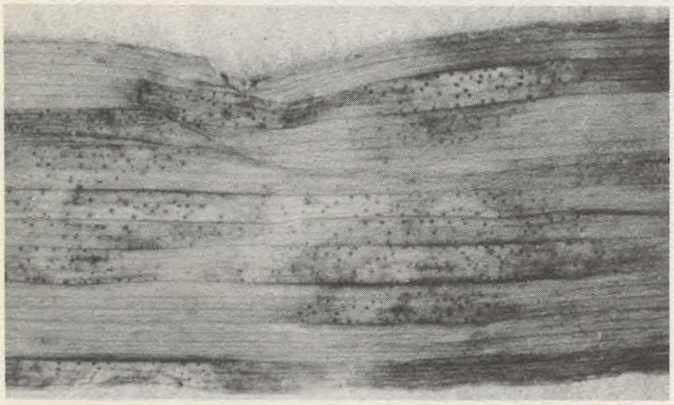
Airplane applying fungicide at 5 gallons per acre to wheat at early heading stage.

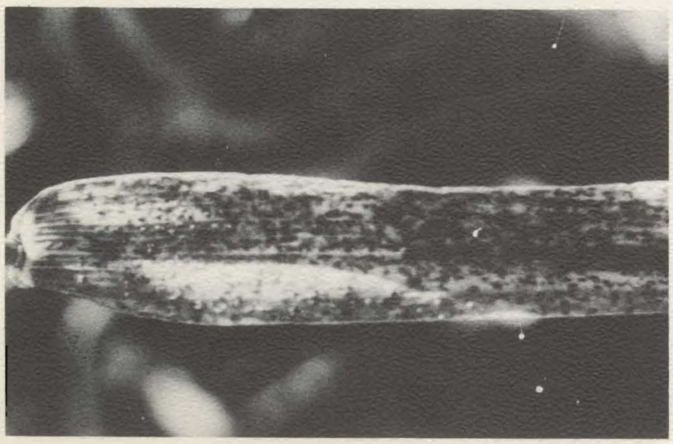
Wheat leaves showing early stage of Septoria leafspot.

Close-up of barley leaf with lesions showing the stage of the fungus-causing Septoria leaf blotch.

Flag leaf of wheat heavily infected with leaf rust.







Chemical Control o

H. L. BISSONNETTE, J. B. ROWELL, and L. CALPOUZOS

H. L. Bissonnette is a professor and extension specialist, J. B. Rowell is a professor and USDA plant pathologist, and L. Calpouzos is an associate professor, all of the Department of Plant Pathology.

Fungicidal control of cereal diseases is not new. For many decades seed grain has been coated with mercury compounds to prevent seedling blight, smut, and bunt.

However, the use of fungicidal chemicals to control cereal leaf and stem diseases is an important new development. During the 1920's and 1930's, sulfur and copper were applied commercially on a few farms to control stem rust of wheat. At that time, however, chemical sprays were considered costly and impractical for controlling cereal diseases when compared with breeding for resistance.

Today, because of improved fungicides and highly developed aircraft spraying, chemicals are practical for controlling foliage diseases of cereals. Airplanes are well suited for applying fungicides to large acreages of cereals rapidly and economically.

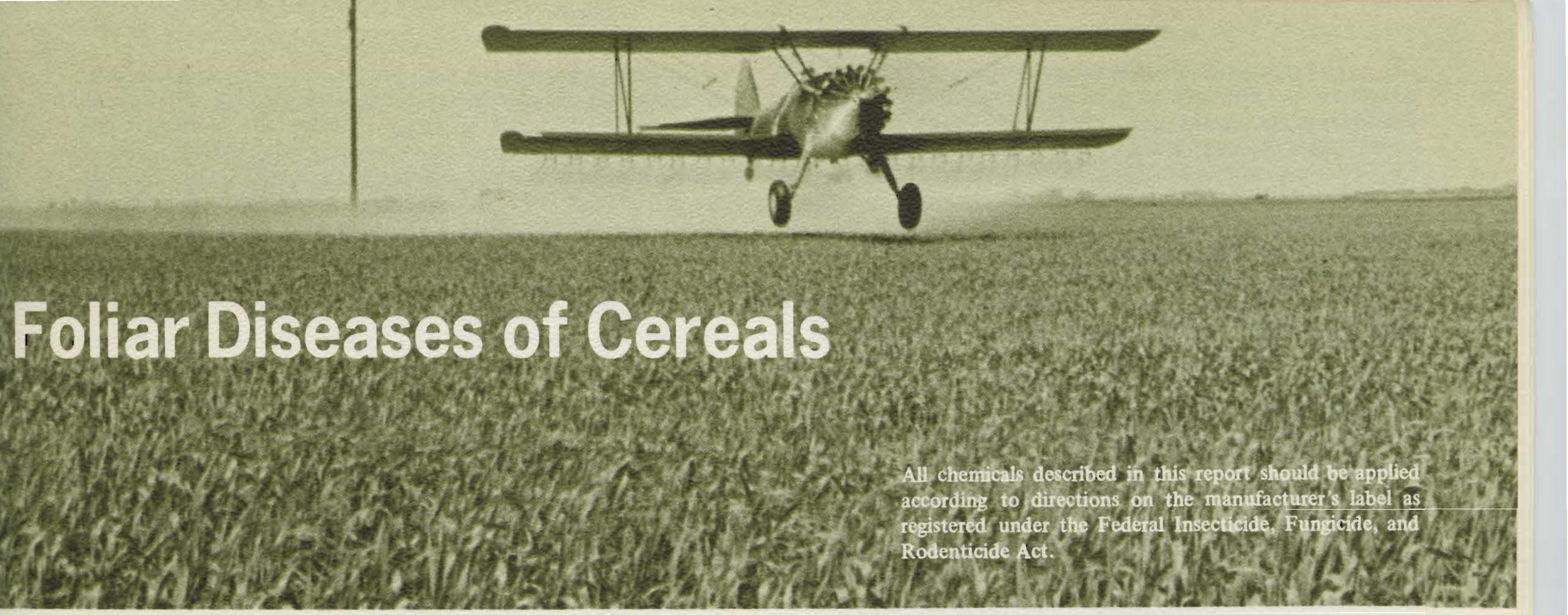
Resistant Varieties Still Important

Chemical sprays will not replace the need for disease-resistant varieties. Plant breeding and chemical fungicides are two important weapons in the war against crop losses due to plant diseases. At present, spring-grown barley and wheat varieties are resistant to the prevalent races of stem rust due to the efforts of plant breeders and plant pathologists. With stem rust under satisfactory control, leaf diseases began to attack the cereal plants. These are not new plant diseases; they have been around for some time. Formerly considered minor, these diseases have become major problems. Septoria leaf blotch, leaf rust, spot and net blotch, are the most common leaf diseases in spring wheat and barley. For many years, drought was blamed for the dying leaves caused by these diseases.

Leaf rust often overwinters in South Dakota and Nebraska and can spread easily to the spring wheat crop in Minnesota. Rust fungus spores which cause the initial infection are blown with the wind from such overwintering areas. The leaf diseases other than rust are also a continuous hazard to wheat and barley because the disease-causing fungi survive from year to year on the infected plant debris left in the field. Regardless of the specific leaf disease, the end result is generally the same – infected leaves turn brown and die long before the plant is mature. Perhaps plant breeders and pathologists will develop varieties resistant to these so-called minor diseases. However, in the meantime, chemical sprays can help improve crop yields.

Valley Trials

In the Red River Valley wheat and barley yields were increased by 0.5 to 17.6 bushels per acre when the crops were sprayed with fungicides. Differences were caused by different



amounts of disease present (see table). Typical cost for two aerial applications of fungicide was approximately $5 to $6 per acre, depending on the fungicide used, the acreage sprayed, and the distance from the landing strip. In most of the commercial trials listed in the table, the grower would have obtained a profitable result from fungicidal sprays. These and similar results from thousands of acres suggest that growers are often losing profits from cereal diseases. Usually these diseases are not readily noticeable since they may be present in relatively small amounts; nevertheless, they are preventing the crop from producing its maximum yield. As growers seek to improve their return per acre, fungicidal control of these diseases is one way to increase farm profits.

Two fungicides have federal approval for control of cereal leaf diseases. Zineb has USDA clearance for use on wheat, and a maneb-zinc complex is cleared for use on wheat and barley. Neither may be used within 26 days of harvest.

Successful chemical control of leaf disease on cereals depends on timing and uniformity of application. Timing is important because these fungicides are protectants; they will not eradicate an established disease infection from the plant. Therefore, they must be applied before heavy infection occurs. The most effective time to apply these fungicides to wheat is when the head is emerging from the boot. A second application is required about 10 days later because these fungicides may break down in sunlight or be washed off by rain. Experience has shown that this timing arrests the development of the disease epidemic sufficiently to increase the growth period of the crop and thus increase yields.

Airplane is Effective

The agricultural-type airplane is the most efficient tool for uniform application of fungicides to cereal crops. Work in North Dakota, South Dakota, and Minnesota indicates that satisfactory application is possible with the aircraft equipment presently available to aerial applicators. An aircraft spray system must be able to deliver 5 gallons of spray per acre. Most aircraft can do this with proper nozzle arrangement and number. Most airplanes will cover a 40-foot swath with a uniform spray by using 40-45 nozzles. Nozzles equipped with spray system D-8 discs and number 45 cores have proved satisfactory. To provide a uniform spray pattern across a 40-foot swath, the nozzles are usually clustered along certain areas of the wing to compensate for the vortices of air around the various structures of the airplane. If the spray equipment is properly adjusted, no curling or gaps in the spray should be observed. Examination of the spray pattern on some of the leaves will indicate whether a uniform application was made. An even distribution of fungicide droplets of approximately 1/32-inch diameter should be found. Even though many areas of the leaf do not appear heavily covered with these visible spots of spray, these areas contain finer spots visible only with a hand lens or microscope. This spray pattern gives the necessary coverage to control leaf diseases and increase yields.

Epidemic Predictions Needed

In the future a greater variety of fungicides and improved application methods will be available to control cereal leaf diseases. Among the promising future developments are reliable disease epidemic forecasts, long-acting systemic fungicides, ultra low volume spray techniques, and seed or soil treatments effective against leaf diseases. These developments should increase production at less cost to the grower by reducing the time and number of treatments needed for effective disease control.

Reliable forecasts are needed by growers to use fungicides efficiently. Presently, a grower gambles when he decides to spray his cereal with fungicides to control leaf and stem diseases. To use the fungicide most effectively, he must apply the first spray before a disease epidemic develops. If the disease fails to develop on unsprayed cereals, the costs of the material and application are an unnecessary investment. A reliable forecast of the probability of disease epidemics and estimates of potential loss in yield would greatly help the grower in his decision to use sprays. Furthermore, projections of the rate of disease development would help him decide when to spray for maximum effect.

In the case of leaf and stem rusts, first infections come from spores that often arrive with spring rains from diseased cereals in southern states. Thereafter, the epidemic develops principally from the spores produced by infections within the crop. With favorable conditions, the rate of increase in the number of infections is very rapid, as great as a million-fold within 30 days. The Cooperative Rust Laboratory at the University of Minnesota recently developed a method to detect spores arriving in the spring rains. Computerized analyses of the data from spore traps appear promising for reliably predicting the rate and severity of regional rust epidemics. In the near future this information will help the grower decide when to use fungicidal sprays most profitably.

Systemic Fungicides For Future

The protective fungicides presently available to growers for the control of leaf diseases are effective only for 5 to 7 days after application. Thus, two or three applications are required for satisfactory control. Disease epidemics on spring wheat oftentimes are initiated in the first month of crop growth, develop rapidly during the second month, and destroy the crop in the final month. More persistent fungicides are needed for better economic control of such diseases. The chemical industries are finding long-acting systemic fungicides that enter the plants and protect them against certain diseases for long periods of time. For example, a single application of some new experimental compounds protects wheat systemically for as many as 80 days against powdery mildew. Ultimately, similar types of materials effective against other foliar diseases of cereals will be found.

Systemic fungicides will reduce the time and costs of application for the grower. Thorough and uniform coverage of the host is less important with these fungicides than with the protectant fungicides. Enough material enters and moves upwards through the cereal leaf from a few spray drops to protect the tissues from the pathogen. Thus, effective systemic materials could be applied by aerial sprays in quantities less than the 5 gallons presently required with the protectant fungicides. Special formulations of systemic fungicides in non-phytotoxic spray oils appear promising in this regard.

The potential minimal spray volume in future developments is indicated by the successful control of the cereal leaf beetle by applying only one pint total volume of spray per acre using malathion. Such effective low gallonage of spray per acre was not possible a few years ago. With these low application rates a plane with a 50 gallon tank can spray 400 acres with one filling compared with 10 acres. Increasing the number of acres covered will increase the efficiency considerably and reduce the cost of aerial spraying.

Yield increases of wheat and barley through fungicidal control of leaf diseases in commercial fields in the Red River Valley

Crop & Variety		Year	Sprayed Yields*	Bushels per acre	Yield increase
Wheat	Selkirk	1962	38.2	34.2	4.0
	Selkirk	1962	35.9	31.0	4.9
	Selkirk	1963	25.8	18.3	7.5
	Selkirk	1966	38.3	37.8	0.5
	Justin	1966	37.0	30.0	7.0
	Justin	1966	42.6	25.0	17.6
Durum		1967	37.5	29.5	18.0
Barley Larker		1967	56.6	46.4	10.2

* Each case represents at least 80 acres.

Seed and soil treatments with systemic fungicides are also a possible future development for controlling leaf diseases. In recent tests, an experimental compound controlled the early stages of epidemics of leaf and stem rusts when the material was applied either as granules in the seed furrow or as seed treatments. Sufficient material was absorbed by the plants to lower disease development 6 weeks later and thereby lessen the severity of the subsequent epidemic. However, the level of control achieved with these soil treatments alone was inadequate to protect the crop against severe disease epidemics. Under such severe conditions, when seed and soil treatments were combined with sprays of protectant fungicides, disease control and increases in crop production were greater than with fungicidal sprays alone. Seed or soil treatment alone would be satisfactory if the early phases of the rust epidemic could be controlled through the first 10 weeks of the growing season. Hopefully control for more than 6 weeks will be attained through improved formulations or the discovery of new materials with longer lasting effectiveness.

In summary, spraying with fungicides on wheat and barley in Minnesota usually increases yields profitably. Custom air spraying is rapid and efficient, relieving the farmer of the time-consuming chore of spraying large acreages with ground equipment. Improved chemicals, equipment, and techniques are in various stages of development at the University of Minnesota and elsewhere. These developments will let the farmer get closer to his goal of reaping maximum yields.

INSECT DISEASE

An Alternative to Chemical Control

ASHOK K. RAHEJA and MARION A. BROOKS

graduate research assistant and associate professor, Department of Entomology, Fisheries, and Wildlife.

"No witchcraft, no enemy action, had silenced the rebirth of new life in this stricken world. The people had done it themselves."

So wrote the late Rachel Carson in *Silent Spring*. Is it just a fable for tomorrow or a frightening reality of today? There are several examples of environmental abuse by man but none perhaps as spectacular nor the subject of as much popular concern as the indiscriminate use of chemical insecticides and other pesticides.

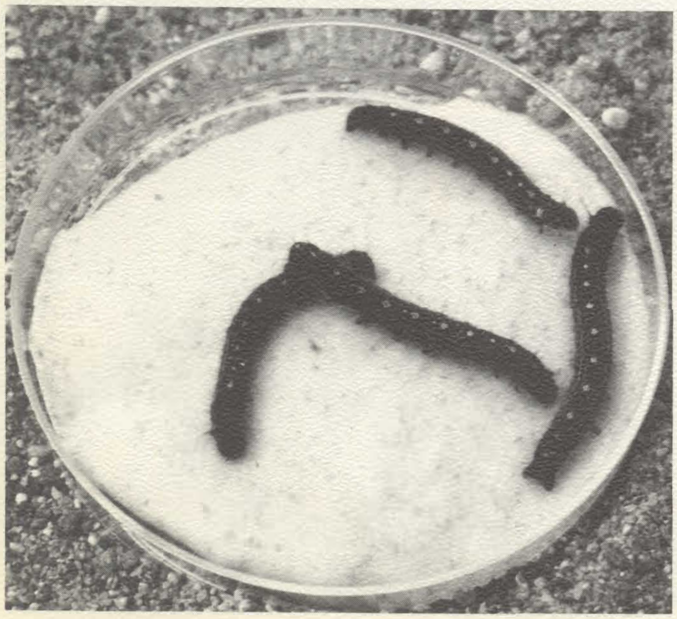
One cannot ignore the importance of insecticides and pesticides in modern times. The development and use of insecticides is a significant chapter in the history of expanding agriculture. Insecticides are very important in improving the efficiency of agricultural production and in protecting the health and comfort of man. Their extensive usage has, however, also created many special problems. Several insect species now resist the chemicals used against them. Chemicals may also harm and destroy beneficial insects, birds, and other wildlife; and if applied directly or carried into lakes, ponds, and streams in sufficient amounts they may kill fish.

Chemicals used to control insects have sometimes destroyed the parasites and predators of harmful insects, and thus upset the balance of nature. To quote Rachel Carson again, "To have risked so much in our efforts to mold nature to our satisfaction and yet to have failed in achieving our goal would indeed be the final irony."

The various natural resources, the forests, ranges, and waters, are living systems capable of change, and only with wise and cautious manipulations will they continue to supply our needs and pleasures. Therefore in forestry, range management, and to a large extent in public health, pest control must depend on environmental control. Chemicals are potentially dangerous and should be used when other methods fail.

Almost since the beginning of the twentieth century scientists have searched for ways to control pests through the use of their natural enemies. However, for too long the apparent success of chemical controls has obviated any need for full comprehension of biological methods. Only in the last decade or so have traditional pest control methods yielded to a new outlook. Research on controlling insects without conventional insecticides offers new hope. Scientists have found new methods to exploit the natural characteristics of insects.

2. Fifth instar forest tent caterpillars on artificial diet used in Minnesota studies.



They have developed new crop varieties less attractive to the pests, released sterile males, lured insects with certain chemicals, bred and released parasites and predators, utilized natural disease organisms of insects, and found other biological controls.

Pathogens Attack Insects

The same major groups of microorganisms that cause diseases in higher animals also infect insects. These include bacteria, fungi, viruses, protozoa, rickettsiae, and nematodes. Perhaps the most attractive reason to use microbes to control insects is that they are not toxic to other forms of life. Most insect pathogens, especially viruses, have a very narrow host specificity which minimizes the damage to useful insects.

Surely, there are certain problems associated with the use of insect pathogens, as is to be expected in any new endeavor. The production, standardization, and evaluation of pathogens are probably the most pressing problems in extensive utilization of the agents. Dosage requirements, tests for safety and specificity, and techniques of formulation are being investigated in various insect pathology laboratories.

The Department of Entomology, Fisheries, and Wildlife is investigating the feasibility of controlling the forest tent caterpillar, *Malacosoma disstria* (cover photo) with a viral pathogen. The forest tent caterpillar is found in northern Minnesota where aspen *(Populus tremuloides)* is common. This insect, frequently called the armyworm, has been reported in Minnesota since 1891. These insects normally cause heavy loss of timber. In addition, caterpillars become a general nuisance by causing discomfort to people, thus adversely affecting the recreational values of these areas. With the significance of aspen as a pulp species throughout the Lake States, the problem is economically important.

Laboratory Research

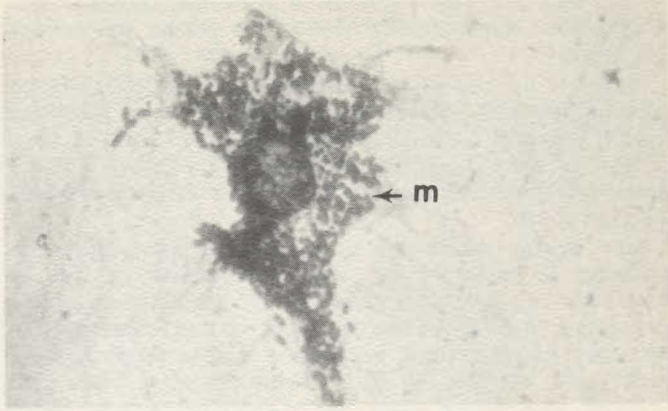
Insect viruses may be broadly classified into two large groups – the occluded and the non-occluded. In the occluded group the individual viral particles are enclosed in proteinaceous capsules. These capsules, which may vary in size and shape, enclose one to ten viral particles, depending on the type of the virus. The proteinaceous capsules resist normal weather conditions, and the viruses may survive in them for several years. The particular virus being studied is an occluded virus and belongs to the type known as "nuclear polyhedrosis." This means that viral rods are enclosed in a polygon–shaped capsule and that the virus multiplies in the nucleus of the cells.

In nature, the tent caterpillars overwinter as eggs which hatch in the spring when the trees are leafing out. In order to rear the caterpillars in the laboratory, an artificial diet is substituted for the natural food. It is an agar-based diet enriched with the necessary nutrients but without natural leaf extract (figure 2).

In addition to the nuclear polyhedrosis virus, the forest tent caterpillar is also susceptible to infection by a protozoan belonging to the order Microsporidia (figures 3 and 4). Of the two, the virus is considered to have greater potential for control. It is highly virulent and the signs of the disease are very spectacular. Infected insects become sluggish and lose appetite within 3 days after infection. Death occurs after 5 to 7 days. The dead insects hang from their prolegs in the shape of an inverted V, their bodies become fragile, loose bags of decomposed tissue (figure 5). The insect bodies readily break, spilling virus polyhedral capsules onto the soil and forest litter.

Minnesota research is designed to investigate the relationship between the virus and its host, and the effect of the environment on this relationship. Questions being studied include the sequence of infection; virus penetration of intestinal cells and entrance into blood and other tissues; the lethal dosage required in terms of number of polyhedra per insect in the different stages of the life cycle; the number of

3. Longitudinal section of a forest tent caterpillar infected with nuclear polyhedrosis virus. View is a 400 times enlargement through a microscope. P on the photo points to the polyhedra in the nucleus of the infected cell.



4. Microsporidian spores (m) in the cytoplasm of an infected cell. View is also enlarged 400 times actual size.

particles found per infected cell; and the possibility of immunity.

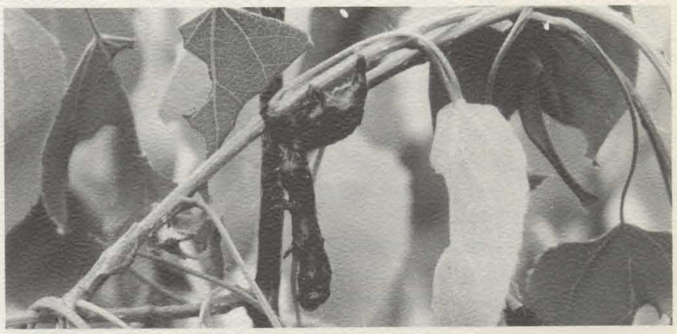
Living Host Required

Both viruses and protozoa are intracellular obligate parasites; that is, they need a living host for their multiplication. Cell culture is an excellent tool to use in studying these relationships at the cellular level. Cell cultures of at least three types of tissues of the forest tent caterpillar have been established. Evidence obtained indicates that these cells can support the growth of the pathogens in cell culture (figures 6 and 7). This technique might be used eventually to mass produce intracellular obligate parasites.

Some scientists believe that all insects are natural carriers of certain diseases. They also believe that the microorganisms carried by insects survive and infect some percentage of the insect population because they are in the environment (soil or foliage) or they may be transmitted from one generation to the next by the mother through the ovaries and eggs. If this carrier thesis is true, it should be possible to control insect populations by manipulating the environment. Many colonies of the forest tent caterpillar have been lost in the laboratory because of a viral infection that appeared spontaneously, indicating that there may have been a latent viral infection associated with the insects. If latent infection is present in natural populations, perhaps the insects could be put under stress to induce the viral disease.

Entomologists have found that the forest tent caterpillar population usually crashes following 2 to 3 years of peak numbers; then in a different area it starts to build gradually. Cycles of 10 years have been recorded. Adverse weather such as a late frost or a heavy rainstorm when the caterpillars are very small sometimes destroys vast numbers of them. When the insects are older these weather factors acting as stressors may induce a viral disease.

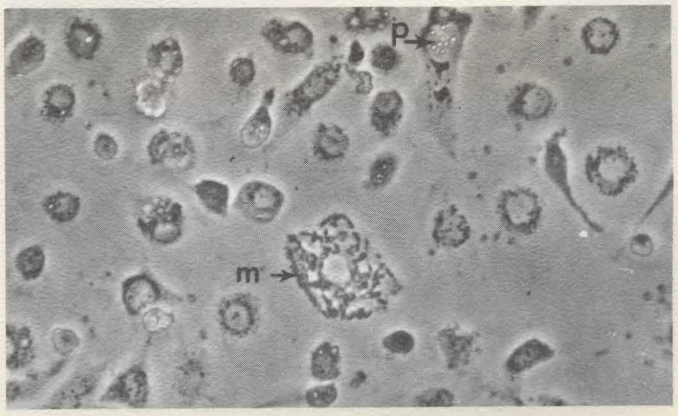
Microbial control is only one alternative to chemical control. As Dr. E.A. Steinhaus of the University of California points out, microbial life is a dynamic force to be suppressed, encouraged, or ignored by man. There are literally hundreds of microorganisms and combinations thereof that should be investigated and tested in the field. The promise of research in this discipline is rich, and the promise to man and his crops is enormous.



5. A dead virus-infected forest tent caterpillar.

6. A culture of healthy cells enlarged 300 times.

7. An infected culture enlarged 300 times. M points to the microsporidian spores (protozoan parasite) in cytoplasm. P is the viral polyhedra in the nucleus.

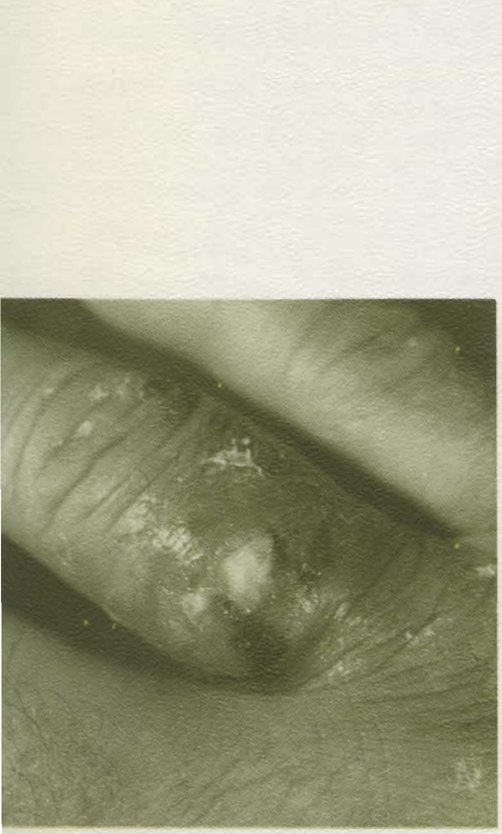


STAPHYLOCOCCAL INFECTIONS

Continuing Threat

ROBERT K. LINDORFER

professor, Department of Veterinary Bacteriology and Public Health, College of Veterinary Medicine



Staphylococcal infection on a man's hand.

The bacterium *Staphylococcus aureus* causes many serious diseases in man and animals. It has been known since the 1870's. In man, staphylococcal infections cause boils, carbuncles, wound infections (see photo), pneumonia, bone infections, heart valve infections, and intestinal infections. The most common food poisoning in man is caused by food in which staphylococci have produced enterotoxin.

Bovine mastitis is probably the most important staphylococcal infection in animals. It has increased in relative importance recently since other types of mastitis are more readily controlled by drugs. Skin infections in dogs are also caused by staphylococci. In some parts of the country staphylococcal infections in turkeys are important. Staphylococci also cause wound infections in other animals.

Continuing Importance of Staphylococcal Infection

Over the past 100 years most bacterial diseases have been brought under control by preventive immunization or by curative treatment with drugs. Contrariwise, physicians and veterinarians have had difficulty controlling staphylococcal infections. These infections are difficult to control for three principal reasons.

First, the staphylococci easily build resistance to drugs. For example, staphylococci become resistant to penicillin in at least seven different ways. When penicillin was first introduced more than 90 percent of the staphylococcal strains were susceptible to it; today less than 20 percent of the strains isolated are susceptible.

A second reason that staphylococcal infections persist may be that their usual infection site is an abscess. In some cases the thick wall and relatively few blood vessels around an abscess may keep either drugs or antibodies out and allow the organisms to persist for long periods.

A third reason for the continuing importance of staphylococcal infections is that many immunizations don't work. The failure of present immunological methods may be directly related to the lack of fundamental knowledge about the causes of staphylococcal infection. Without knowing what factors cause the infection it is difficult to know which toxins to incorporate into an immunizing product. Some immunizations may fail because the invading staphylococcus owes its infectivity to toxins not present in the immunizing product.

Objectives of the Project

A research project in the Department of Veterinary Microbiology and Public Health seeks to develop an immunizing product that would consistently protect against staphylococcal infections. Each of the known staphylococcal toxins should be purified before an immunizing product is developed. Unless a toxin is pure any activity that it seems to have may be caused by other components. Once the toxin is purified its activities and importance in initiating infection can be judged. To date the project has been involved with the three important blood-destroying toxins – the alpha, beta, and delta hemolysins produced by staphylococci.

Staphylococcal Alpha Hemolysin

This toxin has been isolated, purified, and characterized at the University of Minnesota by Drs. W. W. Marquardt, M. Manohar, and S. Kumar. They have found that alpha hemolysin, in addition to destroying red blood cells, also kills rabbits and mice, damages the skin of rabbits, destroys certain white blood cells in man and rabbits, and damages the blood platelets of several species, including man. Since alpha toxin is produced in the animal body and since it destroys a wide variety of cells, it probably plays a role in staphylococcal infection. Therefore, it should be included in any immunizing agent.

Staphylococcal Beta Hemolysin.

S. K. Maheswaran and Kathryn Smith have purified beta hemolysin and studied its action. It seems clear that beta hemolysin acts on red blood cells by breaking down a substance called sphingomyelin, a component of the red blood cell. The red blood cell is then damaged and loses its hemoglobin. In addition, it has been demonstrated that beta hemolysin destroys blood platelets. This means that beta hemolysin could contribute to the ability of an organism to cause infection; therefore, it should be incorporated in an immunizing agent.

Staphylococcal Delta Hemolysin

W. W. Marquardt and C. J. Smith are studying the optimal conditions needed to produce staphylococcal delta hemolysin. Once this hemolysin can be produced in high concentration, attempts will be made to purify this toxin. The importance of delta hemolysin in promoting infection is suspected but not proved.

Conclusion

As a result of this research it is clear that the present methods of preparing immunizing products on the basis of observation and experience must be improved. Although progress has been made in understanding the role of the three important hemolysins in infection, much work remains. It is apparent that each of the staphylococcal products should be purified and characterized before a truly effective immunizing agent can be produced.

Food For Freedom Program and India

JITENDAR S. MANN, a native of India, is a research associate, Department of Agricultural Economics.

India has received more food under the Food for Freedom program than any other country. During the past 18 years more than 30 percent of United States sales for foreign currency were made to India. This food is shipped to meet emergency food situations due to floods, droughts, and other natural calamities. In 1966 food production in India declined sharply, necessitating increased U.S. food shipments.

The Food for Freedom program is carried on under the Agricultural Trade Development and Assistance Act of 1954, popularly known as Public Law 480. Most of the commodities received by foreign countries under the program are paid for in local currency. A major portion of this money is lent to the Indian government for expenditure on programs of economic development.

Originally the program evolved as an instrument for disposing of U.S. surplus agricultural commodities. However, with the drawing down of stocks and the realization of the positive role of food as a tool of economic development, the philosophy behind the program has changed. A recent amendment eliminated the requirement that only "surplus" commodities be shipped. Developing countries making concentrated efforts to improve domestic agriculture will receive priority under the new food aid program.

Over the years the food aid has helped promote economic development in India. These shipments have reduced hunger and prevented famine without requiring India to spend scarce foreign exchange for emergency food imports.

The major contribution of Food for Freedom shipments lies in attacking the Indian food problem on two fronts: (1) raising the existing low levels of food consumption and (2) filling the gap between demand for and supply of food, which is the result of a long race between population and food production. The present dietary levels in India are below the minimum required for normal living. The population has been increasing at the rate of 2.5 percent per annum. Land cultivation, which was carried on with a wooden plow drawn by a pair of bullocks, was not producing enough food for the increasing population.

The supplies of food under Food for Freedom have given the Indian government time to plan for a revolution in the methods of cultivation and introduce measures to increase food production and reduce population growth.

The Indian government has adopted several policies to promote general and agricultural economic development. The production, storage, and distribution of agriculture commodities are being given priority in government programs. In order to stimulate agricultural production, large quantities of chemical fertilizers are being manufactured and imported, crop protection measures are being adopted, irrigation works are being built, and credit is being extended. A rational price policy to provide economic incentive to the farmer has been developed.

These measures aim at increasing the supply of food. On the other front, a comprehensive population policy has been formulated. A massive country-wide family planning program to limit population growth and ensure a higher standard of living has been adopted.

With the help of Food for Freedom commodities, India has been able not only to overcome hunger and famine, but also has been advanced along the path of economic growth.

INDEX – Volume 25

No. 1 (Fall 1968), No. 2 (Winter 1969), No. 3 (Spring 1969), and No. 4 (Summer 1969).

TITLES OF ARTICLES

Those without authors are short items.

Aerial photos reveal ants damage Argentine range by Merle P. Meyer. 3:30.

Aortic rupture in turkeys by Paul E. Waibel, Laverne M. Krista, Jay Sautter, and Robert N. Shoffner. 2:8.

Changing agricultural policy goals in Eastern Europe by Philip M. Raup. 3:28.

Chemical control of foliar diseases of cereals by H. L. Bissonnette, J. B. Rowell, and L. Calpouzos. 4:8.

Condition and storability of export grains by C. M. Christensen. 3:20.

Controversy vs. consensus in community newspapers by P. J. Tichenor, G. A. Donohue, and C. N. Olien. 2:15.

Crownvetch by R. G. Robinson. 2:19.

Economic gain from grass and clover breeding by H. L. Thomas. 4:6.

Financial statement – Minnesota Agricultural Experiment Station. 2:24.

Financing agricultural research by William F. Hueg, Jr. 1:2.

Finnish Landrace sheep from Ireland by W. J. Boylan. 3:3.

Food for freedom program and India by Jitendar S. Mann. 4:14.

Fungicides and disease resistance by Carl J. Eide and R. E. Kroll. 2:4.

Genetics of an edible mushroom, The, by Neil A. Anderson. 1:15.

Has man polluted his environment? by William F. Hueg, Jr. 2:2.

Horticultural research spans the world by Leon C. Snyder. 3:27.

Insect disease–an alternative to chemical control by Ashok K. Raheja and Marion A. Brooks. 4:10.

Let's profit from Europe's forest experience by L. C. Merriam and T. B. Knopp. 3:10.

Livestock disease research by D. K. Sorenson. 2:17.

Mechanized logging in northern Minnesota by Z. A. Zasada and B. A. Brown. 1:4.

Modern genetic measures of dairy cattle by B. Joseph Conlin. 4:4.

Nematodes and roses by D. H. MacDonald, K. P. Patel, and L. H. Fuchigami. 1:18.

Peasants respond to price incentives by Vernon W. Ruttan. 3:4.

Production ecology in trout streams by Thomas F. Waters. 2:21.

Protein gap – the reality of world hunger by Hank L. Stoddard. 3:24.

Research in a growing Minnesota by William F. Hueg, Jr. 3:32.

Research on diseases of poultry by Benjamin S. Pomeroy. 1:13.

Rural modernization – goal for Chile by Dario Menanteau-Horta. 3:13.

Silvertop, the elusive mystery by A. G. Peterson and Elymar V. Vea. 2:12.

Soil factors contributing to atrazine carryover by Russell S. Adams, Jr. 1:9.

Staphylococcal infections – a continuing threat by Robert K. Lindorfer. 4:13.

Tailored flowers by R. E. Widmer. 1:7.

Two new field crop varieties. 4:16.

Two summers a year for plant breeders by J. W. Lambert. 3:16.

U. S. food aid export programs by Robert D. Hunt. 3:18.

Wheat rusts – international threat by L. Calpouzos, R. W. Romig, and M. F. Kernkamp. 3:8.

Wood floor finishes for homes by Robert D. Thompson. 2:10.

You're only one man by George R. Blake. 3:22.

AUTHORS OF ARTICLES

Adams, Russell S., Jr. 1:9.
Anderson, Neil A. 1:15.
Bissonnette, H. L. 4:8.
Blake, George R. 3:22.
Boylan, W. J. 3:3.
Brooks, Marion A. 4:10.
Brown, B. A. 1:4.
Calpouzos, L. 3:8, 4:8
Christensen, C. M. 3:20.
Conlin, B. Joseph. 4:4.
Donohue, G. A. 2:15.
Eide, Carl J. 2:4.
Fuchigami, L. H. 1:18.
Hueg, William F., Jr. 1:2, 2:2, 3:32, 4:2.
Hunt, Robert D. 3:18.
Kernkamp, M. F. 3:8.
Knopp, T. B. 3:10.
Krista, Laverne M. 2:8.
Kroll, R. E. 2:4.
Lambert, J. W. 3:16.
Lindorfer, Robert K. 4:13.
MacDonald, D. H. 1:18.
Mann, Jitendar S. 4:14.
Menanteau-Horta, Dario 3:13.
Merriam, L. C. 3:10.
Meyer, Merle P. 3:30.
Olien, C. N. 2:15.
Patel, K. P. 1:18.
Peterson, A. G. 2:12.
Pomeroy, Benjamin S. 1:13.
Raheja, Ashok K. 4:10.
Raup, Philip M. 3:28.
Robinson, R. G. 2:19.
Romig, R. W. 3:8.
Rowell, J. B. 4:8.
Ruttan, Vernon W. 3:4.
Sautter, Jay 2:8.
Shoffner, Robert N. 2:8.
Snyder, Leon C. 3:27.
Sorenson, D. K. 2:17.
Stoddard, Hank L. 3:24.
Thomas, H. L. 4:6.
Thompson, Robert D. 2:10.
Tichenor, P. J. 2:15.
Vea, Elymar V. 2:12.
Waibel, Paul E. 2:8.
Waters, Thomas F. 2:21.
Widmer, R. E. 1:7.
Zasada, Z. A. 1:4.

Two New Field Crop Varieties

Norman soybeans and Norstar flax have been released by the Minnesota Agricultural Experiment Station. The new varieties were developed by the Department of Agronomy and Plant Genetics and the Department of Plant Pathology in cooperation with the Agricultural Research Service, U.S. Department of Agriculture.

Soybeans

J. W. Lambert, professor of agronomy and plant genetics at the University, selected Norman soybeans from a cross between Acme and Hardome.

Norman matures 4-7 days earlier than Flambeau and 2-3 days later than Portage. It is intermediate to these two varieties in standing ability and height, and has yielded more than Portage and less than Flambeau. Norman has light green foliage, purple flowers, and gray pubesence. Its seeds are medium size, shiny yellow, and with colorless hila. The seed quality and protein and oil contents of Norman are good.

Norman is recommended for east central and northeastern North Dakota and the Upper Red River Valley area of Minnesota. It was named after Norman County.

Flax

Norstar flax matures slightly later than Summit and earlier than Nored and B5128. Norstar is outstanding in seed yield when sown early. It is moderately susceptible to pasmo, resistant to rust and wilt, has good lodging resistance equal to Summit and Windom. Norstar has relatively high oil content and fair quality. The new variety is medium tall in height, has blue flowers, and brown seed of average size.

V. E. Comstock, USDA agronomist and associate professor of agronomy and plant genetics, and Harlan Ford, research agronomist for the USDA, cooperated in its development.

Carl Borgeson, associate professor of agronomy and plant genetics, indicates that seed of Norstar flax was distributed to registered and approved growers in 36 counties and seven counties were allotted Norman soybeans. Seed of both varieties will be available to the public for 1970 planting.

MINNESOTA SCIENCE is published by the University of Minnesota Agricultural Experiment Station. It reports the results of research conducted by the Station, both on the St. Paul Campus, and at outlying branch stations throughout the state.

YOUR COPY of this magazine is sent you by your local county extension agent. He represents the University's Institute of Agriculture in your county and helps make results of University research available to you.