properties.

Currently, the fungal and bacterial populations from composts are being characterized and screened for disease suppression. Through successful refinement of the microbial biomass assay, repeatable standard curves from both inorganic phosphate and glycerol phosphate can be generated. During the first half of 1993, over 25 different materials will be assessed for levels of biomass and activity to determine whether this method will be suitable predicting disease suppressive properties of composts.

Iowa State University

Potential for Physiological Management of Symptom Expression by Turfgrass Infected by Bipolaris sorokiniana - Dr. Clinton F. Hodges

Ethylene is generated inside the leaves of *Poa pratensis* in response to infection by *Bipolaris sorokiniana* and contributes substantially to the loss of chlorophyll from the infected leaves. This research project was initiated to determine if the ethylene, or its mode of action, can be manipulated to prevent the loss of chlorophyll in infected leaves and prevent yellowing. Prevention of ethylene induced yellowing could result in the control of symptom expression, specifically yellowing of infected turf, independent of the infection. This could reduce use of fungicides and provide a new approach to disease management.

Research conducted in the last year has concentrated on decreasing ethylene in infected leaves by applying ethylene inhibiting substances to roots of inoculated plants. The following materials have been evaluated for their effectiveness when applied to the soil:

- Aminooxyacetic Acid (AOA)
- Aminoisobutyric Acid (AIBA)
- Benzoic Acid (BNZ)
- Canaline (CAN)
- Carbonyl Cyanide m-Chlorophyenylhydrazone (CCCP)
- Cobalt Chloride (COCL)
- Propyl Gallate (PGA)

Ethylene in healthy leaves ranged from 276 to 321 $\mu L\ L^{-1}$. Ethylene within inoculated leaves increased after 24 hours, peaked at 48 hours (1476 $\mu\ L\ L^{-1}$), and then declined at 72 hours and 96 hours. CAN, AOA, CCCP, and PGA applied to roots reduced leaf ethylene in response to infection.

Of the materials that decreased ethylene, only CAN and AOA prevented substantial loss of chlorophyll. Inoculated leaves of plants treated with CAN and AOA retained 74 and 80 percent of their chlorophyll, respectively. Preliminary results from leaf treatments with CAN and AOA show a greater decrease in the surge of ethylene associated with infection than that achieved with soil treatment. Ethylene levels have averaged 30 percent of that in inoculated controls with as much as a 91 percent retention of chlorophyll.

These observations suggest that manipulation of symptom expression in this host-pathogen interaction (and perhaps others) is feasible. Our 1993, studies will concentrate on the function and control of the senescence processes during pathogenesis. Understanding symptom response at this basic level may help develop new control measures or lead to genetic clues on how to develop resistant varieties.

USDA, Rutgers University, University of California

Biological Control of Turf Pests: Isolation and Evaluation of Nematode and Bacterial Pathogens - Dr. Michael G. Klein, Dr. Randy R. Gaugler and Dr. Harry K. Kaya

The objectives of this project are to obtain new strains and species of nematodes and bacteria, which attack white grub insects and to characterize those with the greatest activity against grub larvae. The current need for better biological control agents for use against grubs, such as the Japanese beetle and masked chafers, creates an opportunity to license promising new pathogens to industries for development and commercialization. This cooperative effort between the U. S. Golf Association and a team of U. S. Department of Agriculture and university scientists in Ohio, New Jersey, and California has generated interest from the media and resulted in increased visibility for the USGA's Environmental Research Program.

During the first two years, more than 125 strains and potential new species of entomopathogenic nematodes (i.e., insect/disease causing) were recovered. Four described species, and several possible new species have been isolated by both Ohio and New Jersey scientists from golf course turf and scarab larvae. Additional strains, and possible new species from the two major genera of nematodes,

have been identified from California. Results from field plots in New Jersey and California indicate that recently isolated strains were more effective in controlling Japanese beetle and masked chafer larvae than commercially available nematodes. The greater pathogenicity of the recent isolates may be due to an increase in the presence of the symbiotic, pathogenic bacteria within those nematode strains. In addition, the new nematode isolates have proven useful in molecular biology studies on the taxonomy of entomopathogenic nematodes in the U.S. and Ireland.

Efforts to identify other bacterial pathogens of white grubs have located the organism responsible for causing "amber disease" in New Zealand. These bacteria are commercially available there, but their strains have no effect on white grubs in the United States. Over 35 strains of bacteria were successfully isolated from Ohio, New Jersey, West Virginia, California, Japan and China. Fourteen isolates have been characterized in the same genus as the New Zealand bacteria. Feeding tests with those strains have been initiated against Japanese beetle larvae in the laboratory. Additional tests to identify recently isolated bacteria are underway.

Major emphasis during the next year will be to establish the identity and pathogenicity of nematode and bacterial isolates already obtained as a result of this project. In addition, efforts to obtain new isolates of both nematodes and bacteria from infected white grubs in golf course turf in Ohio, California, and New Jersey will continue. The effectiveness of all isolates against white grubs will be established in order to determine their commercial value.

University of Kentucky

Damaged Thresholds, Risk Assessment, and Environmentally Compatible Management Tactics for White Grub Pests of Turfgrass - Dr. Daniel A. Potter and Dr. Andrew J. Powell

The objectives of this project are to: 1) establish damage thresholds for root feeding white grubs on cool season turfgrasses, 2) evaluate the compatibility of turfgrass pesticides with beneficial invertebrates, 3) field test a pheromone-based system for predicting white grub densities, and 4) evaluate the potential for reducing white grub populations through non-chemical, cultural manipulations.

The impact of varying densities of Japanese beetle or masked chafer grubs on root and foliar growth and aesthetic quality of six different turfgrasses was measured in field tests using sunken enclosures and rooting boxes. Grub feeding preferences and tolerance of turf under differing management regimes were also evaluated in field and greenhouse tests. Masked chafer grubs are more damaging than Japanese beetle grubs at equal densities, however, our results show that healthy turf can tolerate at least 20 masked chafer grubs or 30 Japanese beetle grubs per ft^2 before showing visible damage.

Kentucky bluegrass is relatively susceptible, and tall fescue is relatively tolerant of grub damage. The tall fescue endophyte does not confer resistance to grubs of either species. Fall irrigation increased rooting strength and hastened recovery of turf from grub damage. Spring fertilization did not affect expression of grub damage the following fall. Japanese beetle grubs showed significant preference for perennial ryegrass, whereas masked chafer grubs showed no preference among grasses. Presence of one grub species did not affect the distribution of the other. These studies indicate that damage thresholds for white grubs are higher than previously thought, and that remedial irrigation should mask the injury from all but very severe infestations.

The impact of pesticides and growth regulators on earthworm populations was evaluated in two field tests conducted in spring and fall 1992. Of more than 40 products tested so far, only two fungicides (benomyl and thiophanate-methyl) and five insecticides (bendiocarb, carbaryl, ethoprop, diazinon, and fonofos) had significant impact on earthworms. This shows that most of the pesticides and related products used on golf courses are compatible with these beneficial elements of the soil fauna.

Studies were initiated in 1992 to compare the abundance and diversity of predatory insects and spiders in meadows, lawns, and golf course roughs. Preliminary sorting of samples suggests that golf courses support populations of predators at levels similar to those found in lawns and meadows. Feeding studies confirmed that many of the more abundant predators readily consume eggs and larvae of turfgrass pests.

Efforts to identify the sex pheromone of masked chafers were bolstered by initiation of collaboration with Dr. J. Meinwals, one of the preeminent natural products chemists in the world. While collecting virgin females for analysis, we observed and then confirmed experimentally that the adult